University of Augsburg
Prof. Dr. Hans Ulrich Buhl
Research Center
Finance & Information Management
Department of Information Systems
Engineering & Financial Management

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Intra-Bank Electronic Capital Markets and Hierarchical Coordination: Searching for the Optimal Mixed Mode Banking Operation

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Hans Ulrich Buhl, Klaus Sandbiller

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Universität Augsburg, D-86135 Augsburg
Visitors: Universitätsstr. 12, 86159 Augsburg
Phone: +49 821 598-4801 (Fax: -4899)
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Hans Ulrich Buhl and Klaus Sandbiller

University of Augsburg
Department of Information Systems and Banking
Business School
D-86135 Augsburg
Germany
email: {Hans-Ulrich.Buhl | Klaus.Sandbiller}@wiso.uni-augsburg.de
phone: ++49 (821) 598-4140
fax: ++49 (821) 598-4225

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Abstract

Information technology (IT) is enabling financial services companies and particularly banking firms to create new forms of organizations. Both globalization of markets and more rigorous regulation throughout the European Union such as recently the implementation of the European Capital Adequacy Directive put pressure on the banking firm to either spend ever more money in coordinating business activities in the traditional hierarchical ways or to employ new forms of organizations enabled by (reduced costs of) IT. Holland et al. [1994] and Lockett and Holland [1996] have analyzed these developments. Our vision sketched in this paper is to partially substitute and partially complement hierarchical coordination with an Intra-Bank Electronic Capital Market. Observing that allocation of equity capital among decentral units in accordance with tightening regulation rules requires considerable effort, we analyze which suitable implementation of an internal electronic market for capital allocation - compared to traditional hierachical coordination - is most competitive. It turns out that - depending on the crucial parameters of the banking firm - pure market coordination or pure hierarchy coordination may be optimal. But in many relevant cases the optimal operation is mixed mode (as described by Holland and Lockett [1997]), i.e., part of the coordination problem is solved via the internal market while the remainder is done in a hierarchical manner. Thus, our analysis also constitutes a contribution to the „move to the market" versus „move to the hierarchy" debate in specifying when the „move to the middle" solution is optimal in the analysis.

1. Introduction

While globalization of financial services markets is still continuing, the emerging European banking market still shows specific characteristics essentially affecting the competitiveness of the market participants. With the creation of a single market in financial services and the free access to domestic markets for all members of the European Union (EU), a variety of changes in the regulatory framework as well as new competitors enforce pressure on European banks to increase their flexibility. Moreover, uncertainty arises from new emerging markets in the Eastern European countries with their large demand for venture capital. For acting successfully in these volatile and changing markets, the bank has to cope with heterogeneity of e.g., tax legislation and institutional characteristics in the EU member countries. Recently, the implementation of the European Capital Adequacy Directive imposed more rigorous risk-

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based capital requirements upon the banking firm, thus adding further complexity to the framework the European banking firm is acting in. Compared to e.g. the United States with banking restricted both geographically and functionally (separating commercial from investment banking), banks in the EU are free to engage EU-wide in nearly the whole financial services field. Especially German universal banks take advantage of the corresponding opportunity to offer a wide range of products for reasons of risk diversification, bundling of services and cross-selling.

Thus the European and particularly the German banking market is dominated by large banking firms. Due to the large size and diversified nature of firms in the European banking industry there is a strong need for efficient coordination and controlling instruments with large-scale applicability. So far, capital budgeting instruments (see Figure 1) were implemented mainframe-based, hierarchically organized and thus both expensive and inflexible. The development of information technology now allows for cheaper client/server- and network-based options helping to shape more flexible organizations. Since banking is a technology-driven business, there are shifts resulting from these developments. Given the conditions sketched above, the inefficiencies of hierarchical coordination instruments and the corresponding system support used by major banks become apparent: Volatility, permanent changes and heterogeneity of the markets reduce the efficiency of central business planning. We observe information losses within multi-stage hierarchies, agency problems, slow decision making processes, and lack of flexibility.

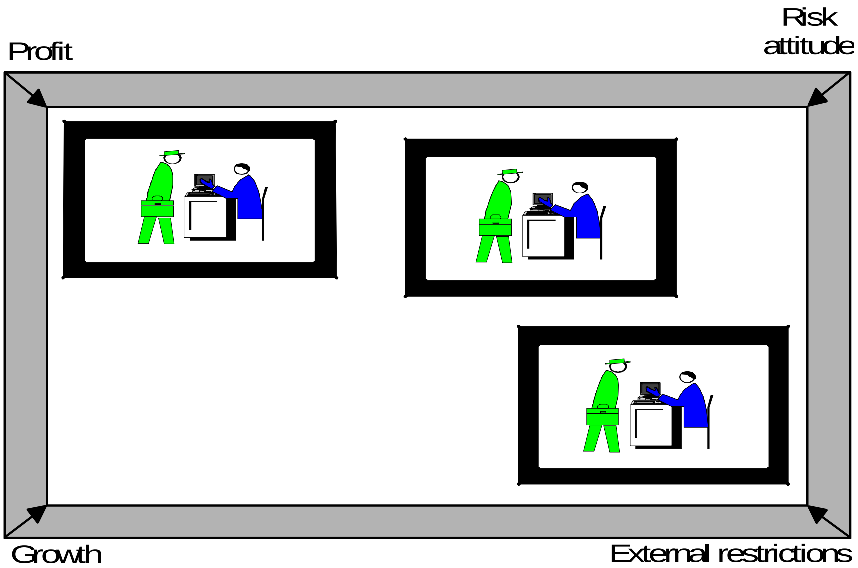

Figure 1: The Scarce Resource Equity Capital in Banks - Hierarchical Allocation

E.g., the increased capital requirements mentioned above - to be met at any time - result in increasing capital reserves held by the single subunits and hierarchy levels (see Figure 1).

Thus, an increasing amount of capital is withdrawn from productive use resulting in reduced competitiveness. Our general hypothesis is that intra-bank electronic capital markets - due to IT development - compared to hierarchical solutions are becoming more competitive and their suitable implementation will lead to

- better allocation of scarce (equity) capital to autonomous business units with simultaneous observance of regulation principles,
- better market responsiveness by stronger ability to reallocate financial resources dynamically,
- improved use of local knowledge (given incentive-compatible payment schemes and long-term accountability of results of local decisions).

Applying market mechanisms to the problem of equity capital allocation within the banking firm successfully, an intra-bank market has to meet the following requirement: The bank must not fall below a certain minimum ratio of capital to weighted risky assets at any time. Dependent on both the actual amount of equity capital of the bank and the regulatory minimum ratio a certain amount of equity permits will be issued and distributed among the decentralized business units. Each permit enables the present holder (i.e., a profit center) to do profitable transactions (i.e., make risky businesses), which require the corresponding amount of equity capital certificated by the permit. The crucial point is the tradeability of the equity permits: Those business units with less profitable business opportunities have an incentive to sell their permits to units with more profitable business prospects. As a result, an intra-bank market for equity is established where the price for the use of equity is endogenously determined (see Figure 2). From the banking firm's point of view, the limited resource equity is used most productively with the simultaneous observance of regulation principles. Moreover the actual scarcity of equity is expressed by the internal market price at any time. This enables the management to improve decisions like e.g., timing and volume of issuing new shares.

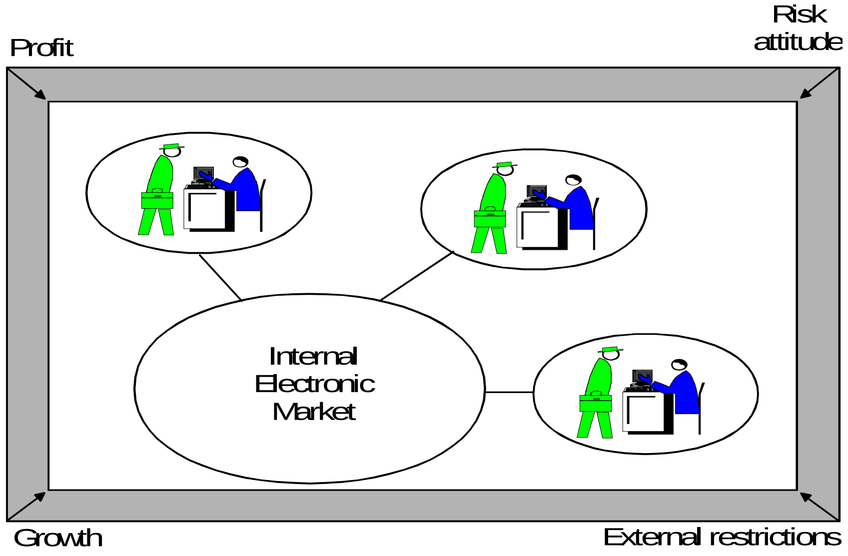

Figure 2: The Scarce Resource Equity Capital in Banks - Coordination via Market

For more details on the idea of establishing an internal electronic capital market for allocation of equity capital within the banking firm, see Sandbiller [1996]. As outlined there and above, however, suitable implementations are necessary to make sure that advantages from decentralization are not overcompensated by losses from insufficient coordination, reduction of central objectives and violations of central restrictions. E.g., for making sure that decentral participants of an Internal Electronic Capital Market act in the company's interest, payment schemes for incentive-compatibility need to account for differences in planning horizons, preference rates etc.; moreover the dealing rules are to be designed in such a way that first-best allocations can be (guaranteed to be) attained. In Klein and Hinrichs [1996], Hinrichs and Klein [1997], Sandbiller and Will [1996], and Sandbiller et al. [1997] such questions are addressed.

In this paper we concentrate on the problem of (equity) capital reserves, i.e., precautionary capital held by decision units for reasons of uncertainty of future business volume and thus uncertainty w.r.t. equity capital resources needed for conducting the business[1]. If future resource demand is uncertain[2], to hold such precautionary capital makes sense no matter whether these decisions are made centrally[3], decentrally or intermediate. The problems

1 Due to regulation, equity capital is linked to different banking businesses via different factors; hence any business - dependent on its volume and risk class - requires a certain amount of corresponding equity capital. Thus any business conducted today may reduce the opportunity to make (possibly more profitable) business tomorrow.

2 For example, uncertainty arises from the fact that the prospective utilization of committed loan limits or credit lines cannot be perfectly predicted by the bank.

3 In favor of hierarchical coordination we assume that in the whole hierarchy no more equity capital reserves are held than are optimal for the hierarchy as one perfect decision unit. *Hierarchical*

associated with that, however, are quite different: While central decisions (see Figure 3a) suffer from insufficient knowledge of future business prospects due to agency and information processing problems and thus the quality of the relevant parameters for the central decision authority is not as good as available decentrally, in case of decentral decision making (Figure 3b) the problem is somewhere else: The knowledge about the customers and thus on parameters representing future business prospects at the decentral level assumes maximum quality available in the company; but there is no knowledge (and maybe no incentive to care) about relevant parameters of other decision units. In the case of holding precautionary equity capital this implies that each unit optimizes locally and thus - due to foregone pooling advantages - in total we usually have a much higher level of precautionary capital than is optimal for the banking firm as a whole.

Central Decision Making *Decentral Decision Making*

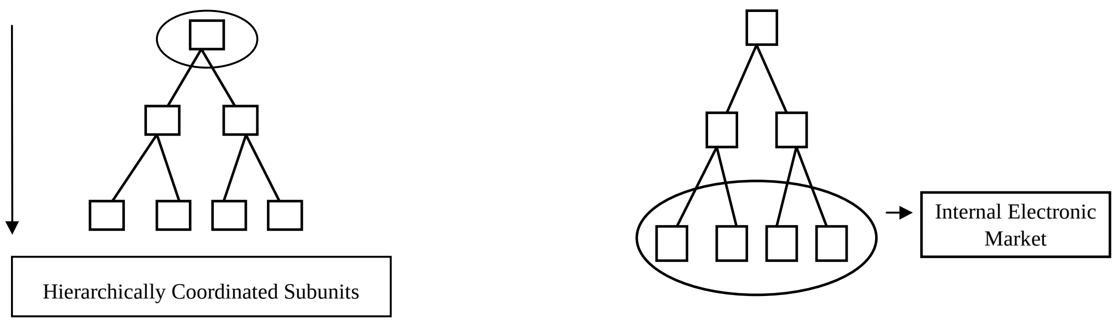

Figure 3 a) and b): Hierarchical and Market Coordination

If decisions are made on some intermediate level (see Figure 3c) - implying that we have a mixed mode banking operation with intermediate participants being coordinated via the Internal Electronic Market and coordinating their subunits hierarchically (see Holland and Lockett [1997] and Klein [1996a, 1996b]) - the problems arising constitute a mixture of the ones discussed above. Still, such an intermediate solution may be optimal for the bank if it constitutes a suitable tradeoff between (equity capital) pooling advantages and the losses from inefficiencies (e.g. due to lacking customer/market knowledge) in hierarchical coordination.

misallocations, reserves, etc. in the analysis will be all covered by an (inefficiency) parameter to be introduced in the next section.

Decision Making on an Intermediate Level

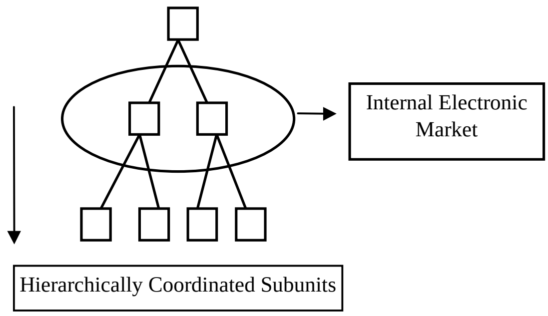

Figure 3c): Mixed Mode Banking Operation

For being able to analyze such questions in more detail, we proceed as follows: In Section 2 - after presenting the notation and basic assumptions - we start out by illustrating a simple, but fairly general model for determining optimal precautionary capital due to Whalen [1966]; this model is described sufficiently general to be applicable for decentral, central and intermediate decision making. This enables us to apply the model in Section 3 to the case when (equity capital) resource demands are assumed to be random variables with strictly positive variance, but pairwise independent; thus the correlation between any two demands is zero implying a linear increase of variance in case of pooling and thus strong pooling advantages. In Section 4 we relax the independence assumption and allow for arbitrary correlations. In the worst case of perfectly correlated demands this implies a quadratic increase of variance and thus smaller, but still existing pooling advantages. In both sections these pooling advantages in case of hierarchical coordination are compared with the corresponding disadvantages (i.e., coordination costs and inefficiency losses). It turns out that - depending on the values of the relevant parameters - anything may be optimal, i.e.; totally decentral participation on the Internal Electronic Market without hierarchy coordination, central planning without making use of electronic market coordination, and intermediate solutions taking advantage of both, hierarchical and electronic market coordination. A summary and prospects for further research in Section 5 conclude the paper.

2. A Model for Determining Precautionary Equity Capital

The model is constituted by the following assumptions:

(A1) *Equity Capital Resources*: The banking firm's decision unit is assumed to have equity capital resources R available. The demand D for these resources implied from conductable business is a random variable with a symmetric density distribution[4] and strictly positive variance σ^2. The bank may decide to employ an amount $r < R$ for doing business implying that it holds precautionary equity capital $l = R - r$ for meeting uncertain future demands.

(A2) *Illiquidity Costs*: If l is not sufficiently large such that demand exceeds the precautionary capital and thus profitable business cannot be conducted any more, we assume that there exists a fixed illiquidity cost $\alpha > 0$.

(A3) *Proceeds*: If the banking firm's decision unit decides to employ equity capital resources r for doing business, the corresponding proceeds are given by $ri\beta$, where $i > 0$ denotes the return rate and $\beta \leq 1$ denotes a strictly positive efficiency parameter accounting for coordination costs and losses from inefficiency e.g., due to increasing market inefficiency or inefficient hierarchy coordination and the like.

(A4) *Objective Function*: The banking firm seeks to maximize a profit function accounting for proceeds from employing equity capital resources r minus expected illiquidity costs depending on $l = R - r$.

(A5) *Worst-Case-Assumption*: Since we do not want to restrict the analysis to some specific demand distribution function, we work with the upper bound of the Tschebyscheff-inequality.

(A5) implies that the probability of more than expected demand exceeding[5] σ by some factor λ is at most be given by $\frac{1}{2\lambda^2}$. Letting $\lambda = \frac{l}{\sigma}$, we can determine the maximum probability of demand exceeding l:

(1) $$prob(D > l) = \frac{\sigma^2}{2l^2} \quad .$$

If we multiply this probability with the fixed illiquidity costs α, we obtain the expected illiquidity costs for the Worst-Case-Distribution-Assumption (A5). Thus, given Assumptions (A1) through (A5), the banking firm's / decision units' profit function can be specified in the following way:

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4 To simplify the analysis, in accordance with Whalen [1966] we let *E(D) = 0* , i.e., we only account for the demand exceeding the expected value explicitly in our analysis.

5 Due to the footnote above we have *E(D) = 0* . Thus this states that demand exceeds the expected value by $\lambda\sigma$.

(2) $$P = ri\beta - \frac{\alpha}{2}\frac{\sigma^2}{(R-r)^2} \ ,$$

where the first expression denotes proceeds from employing r and the second one represents the corresponding expected illiquidity costs.

Maximizing Objective Function (2) w.r.t. r we obtain from the first order condition (with the second order condition obviously satisfied)[6]

(3) $$r^* = R - \sqrt[3]{\frac{\alpha\sigma^2}{i\beta}}$$

and thus

(4) $$l^* = R - r^* = \sqrt[3]{\frac{\alpha\sigma^2}{i\beta}} \ .$$

Note that for positive illiquidity costs and variance of demand for the decision unit it is optimal to hold precautionary equity capital and thus not to employ total resources R. Plugging in the optimal value of r^* in Objective Function (2) we obtain

(5) $$P^* = Ri\beta - \frac{3}{2}\alpha^{\frac{1}{3}}(i\beta)^{\frac{2}{3}}\sigma^{\frac{2}{3}} \ ,$$

which for sufficiently large

(6) $$\beta > \left(\frac{3}{2}\frac{\alpha^{\frac{1}{3}}\sigma^{\frac{2}{3}}}{Ri^{\frac{1}{3}}}\right)^3$$

is strictly positive. If Inequality (6) holds with equality or $\beta = 0$, we have optimal profits of zero; in between, they are negative.

In the next sections, we will apply this model to decentral, central and intermediate decision making. In Section 3 we assume that (equity capital) resource demands are random variables

6 We assume that available capital resources are sufficiently large, such that $R > \sqrt[3]{\frac{\alpha\sigma^2}{i\beta}}$ holds. This implies that r* is positive.

with strictly positive variance, but pairwise independent. In Section 4, we relax the independence assumption and allow for arbitrary correlations.

3. Optimal Mixed Mode Banking Operation for Independent Demands

Suppose the banking firm has n decentral units facing equity capital demands D_i, $i = 1,\ldots,n$, for being able to conduct their business. For sake of simplicity we assume that all these demands are identically distributed (pairwise) independent random variables with Assumptions (A1) through (A5) satisfied, i.e., all have (or can make) identical equity capital resources $R_i = R$ available. Thus all demands D_i have an identical variance σ^2. From the independence assumption it follows that all (pairwise) covariances are zero and thus

(7) $$Var(\sum_{i=1}^{n} D_i) = \sum_{i=1}^{n} Var(D_i) = \sum_{i=1}^{n} \sigma^2 = n\sigma^2 \ .$$

Hence the zero covariance between any two demands implies a linear increase of total variance. Thus, the standard deviation increases with the square root of n.

If decisions are made on a higher level of the hierarchy and subunits are coordinated hierarchically, we have coordination costs for hierarchy coordination and inefficiencies resulting from it such as agency and information processing costs and losses from inferior local customer/market knowledge. It seems natural to assume, that these costs are increasing with the hierarchy level employed as decision unit. Thus we let our inefficiency parameter be given by $\hat{\beta}$, such that this $\hat{\beta} = 1$ in the case of decentral decision making and $\hat{\beta} < 1$ in the case of central decision making.

If all the decision units act independent of each other, each unit determines equity capital resources employed and precautionary capital according to Formulas (3) and (4) from Section 2. Thus the banking firm's total profit function in case of decentral decision making, P_D^*, is given by the sum of the n decentral profit functions

(8) $$P_D^* = nRi - \frac{3n}{2} \alpha^{\frac{1}{3}} i^{\frac{2}{3}} \sigma^{\frac{2}{3}} \ .$$

In case of pooling n decentral units together[7] (and thus deciding centrally) due to this section's independence assumption we have strong pooling advantages: Total variance of

[7] We may view this pooling of demands as an application of the risk sharing principle as Milgrom/Roberts [1992, p.211] put it: „The principle of risk sharing - that sharing independent risks reduce the aggregate

demands increases linearly with n and due to Equation (4) precautionary equity capital increases only with $n^{\frac{1}{3}}$. Thus total profits for the case of pooling n units together are given by

(9) $$P_C^* = nRi\hat{\beta} - \frac{3}{2} n^{\frac{1}{3}} \alpha^{\frac{1}{3}} (i\hat{\beta})^{\frac{2}{3}} \sigma^{\frac{2}{3}} \text{ .}$$

Observe that for $\hat{\beta}$ sufficiently close to 1 decentral decision making is less profitable than pooling units together and decide centrally. If $\hat{\beta}$ is sufficiently small, however, the pooling advantage is overcompensated by increasing inefficiency due to hierarchical coordination.

In addition to the two alternatives of central or decentral decision making, the banking firm faces a third option to allocate decision rights w.r.t. equity capital resources. If decisions are made on some intermediate level (see Figure 3c), this implies a mixed mode banking operation with intermediate participants being coordinated via the Internal Electronic Market and coordinating their subunits hierarchically. Such an intermediate solution may be optimal for the bank if it constitutes a suitable tradeoff between (equity capital) pooling advantages and the losses from inefficiencies (e.g., due to lacking customer/market knowledge) in hierarchical coordination.

To analyze this case, we introduce further assumptions to characterize the organizational structure of the banking firm considered. If each decentral unit of the banking firm is a decision unit acting independently of the other ones on the Internal Electronic Market without any hierarchical coordination, i.e., we say decisions are made on level m in the banking hierarchy, then we have a maximum number of market participants. For the case of a unique span of control z and a hierarchy depth of m the number of participants is then given by z^m. If decisions are made higher up in the hierarchy on level $k < m$ and subunits are coordinated hierarchically, the number of market participants z^k decreases resulting in increasing inefficiency of the Internal Electronic Market (see Weber [1995], Clemons and Weber [1996]). In addition we have coordination costs for hierarchy coordination and inefficiencies resulting from it such as agency and information processing costs and losses from inferior local customer/market knowledge. It seems natural to assume, that these costs are increasing with decreasing hierarchy level k employed as decision unit. Thus we let our inefficiency parameter be given by $\hat{\beta} = \beta^{m-k}$, such that this $\hat{\beta} = 1$ in case of decentral decision making ($k = m$) and $\hat{\beta} < 1$ in the case of intermediate ($0 < k < m$) and central decision making ($k = 0$).

costs of bearing them - is the basis of all financial insurance contracts“. The analysis in Section 4 will show that the cost reduction also holds for demands being not independent.

Given these parameters, the maximum profit for each decision unit $j = 1,\ldots,z^k$ can be specified in the following way:

$$(10) \qquad P_j^* = z^{m-k} Ri\beta^{m-k} - \frac{3}{2}(z^{m-k})^{\frac{1}{3}} \alpha^{\frac{1}{3}} (i\beta^{m-k})^{\frac{2}{3}} \sigma^{\frac{2}{3}} \quad , \quad j = 1,\ldots,z^k \; .$$

Thus the banking firm's total profit function is given by the sum of the z^k decision units' profit functions

$$(11) \qquad P_k^* = \sum_{j=1}^{z^k} P_j^* = z^m Ri\beta^{m-k} - \frac{3}{2} z^k (z^{m-k})^{\frac{1}{3}} \alpha^{\frac{1}{3}} (i\beta^{m-k})^{\frac{2}{3}} \sigma^{\frac{2}{3}} \quad .$$

Observe that for β^{m-k} sufficiently close to 1 with a suitable choice of k decentral decision making is less profitable than pooling units together and decide (participate in the market) on an upper hierarchy level $k < m$. If m is sufficiently large and thus β^{m-k} is sufficiently small, however, the pooling advantage is overcompensated by increasing inefficiency due to hierarchy coordination. The following examples illustrate that in the optimal solution this tradeoff does (and usually will) result in an intermediate mixed mode banking operation.

Example 1: We consider a banking firm consisting of a headquarter (decision level k = 0) and two divisions (decision level k = 1). Each division consists of 2 branches operating at the customer market (decision level k = 2). Thus, the structure of the banking firm is given by Figure 3. For this case, the unique span of control is 2 ($z = 2$), the hierarchy depth m equals 2, and, hence, the total number of decentral units is $z^m = 4$. Each decentral unit i (i = 1,...,4) is assumed to have equity resources $R_i = R = 100{,}000$ Monetary Units (MU) available. The demands $D_i = D$ for these resources implied from conductable business are pairwise independent random variables with a symmetric density distribution and strictly positive standard deviations $\sigma = 5000$ MU. If demand exceeds the precautionary capital and thus profitable business cannot be conducted any more, the banking firm faces a fixed illiquidity cost $\alpha = 4000$ MU. The return rate on employed equity capital resources is $i = 16\% = 0.16$. The efficiency parameter β equals 0.95 . In this setting, three alternatives of decision making w.r.t. the employment of equity capital resources exist: totally decentral participation on the Internal Electronic Market without hierarchy coordination ($k = 2$), central planning without making use of electronic market coordination (pooling all, $k = 0$), and intermediate solutions taking advantage of both, hierarchical and electronic market coordination ($k = 1$). Applying Equation (11) we are able to compute the maximum profit for all three alternatives and find, that the mixed mode banking operation is the optimal solution with $P_1^* = 55{,}803$ MU. Applying pure hierarchical or market coordination yields lower maximum profits, namely $P_0^* = 54{,}718$ MU and $P_2^* = 55{,}792$ MU, respectively.

4. Optimal Mixed Mode Banking Operation if Demands are not Independent

We now relax the independence assumption, but - for sake of simplicity - assume furtheron, that all demands are identically distributed random variables with Assumptions (A1) through (A5) satisfied, i.e., all demands D_i have an identical variance σ^2. From that it follows that the total variance is given by

$$
\begin{aligned}
(12) \qquad Var\left(\sum_{i=1}^{n} D_i\right) &= \sum_{i=1}^{n} Var(D_i) + \sum_{i \neq j}\sum Cov(D_i, D_j) \\
&= \sum_{i=1}^{n} Var(D_i) + \sum_{i \neq j}\sum \rho_{ij}\sigma_i\sigma_j \\
&= n\sigma^2 + \sigma^2 \sum_{i \neq j}\sum \rho_{ij} \ ,
\end{aligned}
$$

where the ρ_{ij}'s denote the (pairwise) correlation coefficients.

In the worst case of perfectly correlated demands ($\rho_{ij} = 1$ for all i, j) as an upper bound we obtain by observing that there are $n(n-1)$ correlation coefficients, each being at most equal to 1

$$
(13) \qquad Var\left(\sum_{i=1}^{n} D_i\right) = n\sigma^2 + n(n-1)\sigma^2 = n^2\sigma^2 \ .
$$

This implies a quadratic increase of variance and thus an at most linear increase of standard deviation.

For the case of decentral decision units acting independently nothing changes compared to Section 3. For the banking firm as a whole we still obtain total profits to be given by Equation (8).

In the case of pooling all n units together, however, the situation changes. Since total variance of demands increases now quadratic with n^2 and thus due to Equation (4) precautionary equity capital increases now with $n^{\frac{2}{3}}$, pooling advantages are smaller than in Section 3, but still exist. Total profits for the case of central decision making (i.e. pooling n units together) are in the worst case of perfect correlation given by

(14) $$P_C^* = nRi\hat{\beta} - \frac{3}{2} n^{\frac{2}{3}} \alpha^{\frac{1}{3}} (i\hat{\beta})^{\frac{2}{3}} \sigma^{\frac{2}{3}} \quad ,$$

which checks with Equation (9) except for the exponent of n being now 2/3 instead of 1/3.

Note that in the case of all correlation coefficients being positive, n^2 constitutes an upper and n a lower bound for the increase of variance. Thus Formula (14) is a lower bound for the objective function and Formula (9) is an upper bound.

In the case of arbitrary correlation coefficients (i.e. some being sufficiently negative) total variance (12) may become zero and thus the second term in the Objective Function (14) may vanish.

Similarly to Section 3, we can now consider the intermediate mixed mode case for $\rho_{ij} = 1$ and obtain for a decision unit *j* on level *k*

(15) $$P_j^* = z^{m-k} Ri\beta^{m-k} - \frac{3}{2} (z^{m-k})^{\frac{2}{3}} \alpha^{\frac{1}{3}} (i\beta^{m-k})^{\frac{2}{3}} \sigma^{\frac{2}{3}} \quad , \quad j = 1, \ldots, z^k \, .$$

Thus the banking firm's total profit function is given by the sum of the z^k decision units' profit functions:

(16) $$P_k^* = \sum_{j=1}^{z^k} P_j^* = z^m Ri\beta^{m-k} - \frac{3}{2} z^k (z^{m-k})^{\frac{2}{3}} \alpha^{\frac{1}{3}} (i\beta^{m-k})^{\frac{2}{3}} \sigma^{\frac{2}{3}} \quad .$$

The following example illustrates the results with the parameter values from Section 3.

Example 2: We consider the banking firm of Example 1 above. The parameter values remain unchanged. But in contrast to Section 3 we now assume that the demands are not independent, but perfectly correlated. Thus, pooling advantages are smaller than in Section 3, but still exist.

In this setting, again three alternatives of decision making w.r.t. the employment of equity capital resources exist: totally decentral participation on the Internal Electronic Market without hierarchy coordination ($k = 2$), central planning without making use of electronic market coordination (pooling all, $k = 0$), and intermediate solutions taking advantage of both, hierarchical and electronic market coordination ($k = 1$). Applying Equation (16), we are able to compute the maximum profit for all three alternatives.

For the case of decentral decision units acting independently nothing changes compared to Section 3. For the banking firm as a whole we still obtain total profits $P_2^* = 55.792$ MU. Due to decreasing pooling effects, however, applying pure hierarchical or intermediate decision making yield lower maximum profits than for the case of independent demand, namely $P_0^* = 52.931$ MU and $P_1^* = 54.504$ MU, respectively. As a result, the optimal solution has shifted from intermediate to decentral decision making. For sufficiently small positive correlation coefficients, the intermediate mixed mode solution may become optimal again; and for some correlations being sufficiently negative, the central alternative may be optimal.

5. Conclusions and Prospects for Further Research

In Sections 3 and 4 it has been shown that - depending on the values of the relevant parameters - anything may be optimal for the banking firm, i.e. totally decentral participation on the Internal Electronic Market without hierarchy coordination, central planning without making use of electronic market coordination, and intermediate solutions taking advantage of both, hierarchical and electronic market coordination. As key parameters favoring pooling demands and thus hierarchical coordination we have identified small correlations (particularly if correlations with adverse signs lead to zero total variance), small coordination inefficiency (i.e. $\hat{\beta} \to 1$) and flat hierarchies (i.e. small m). The opposite properties on the other hand are favoring Internal Electronic Market coordination and thus decentral decision making. Obviously, this applies particularly for large firms with strongly correlated businesses.

While development of information technology for suitable designs may reduce coordination costs such as information processing costs (thus increasing $\hat{\beta}$) for electronic hierarchies and electronic markets, it is questionable whether this is true to the same extent. As particularly questionable we consider the relation between agency costs in hierarchies and technological development. Inefficiency may also result from reducing the number of market participants in case of (partial) hierarchical coordination. As our analytical analysis indicates, such factors and developments usually neither imply a superiority or inferiority of pure market or pure hierarchy solutions, but rather influence whether decisions should be made on a more upper or lower hierarchy level (but neither at the top of the hierarchy nor at the bottom).

Limitations of our simple analytical analysis are of course numerous. One severe limitation certainly is, that we have just assumed a certain level of coordination costs and inefficiency in case of hierarchical coordination via the factor $\hat{\beta}$, but have neither explained why it occurs nor even differentiated between different sources of costs and inefficiency. The model for determining precautionary equity capital took into account only fixed, but no variable illiquidity costs, although in reality we usually will have both. Less severe seems to us the assumption of all units being equal w.r.t. demand and thus resources; if they are not, most results can still be deduced, but with much more analytical effort.

Need for further research we see particularly in an improved understanding in the sources of inefficiency in both (electronic) hierarchies and electronic markets (e.g. Reimers [1996]). While analytical modeling may help in understanding which factors are key and which are of minor importance, a lot of experimental and empirical work in these areas needs to be done for understanding which costs and inefficiencies vanish due to technological development, which ones can be reduced or even avoided by suitable designs and which ones resist (or are even fueled by) information technology development.

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