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Efficiency and Cost Implications of Capital Allocation Mechanisms - A Contribution to the Market-versus-Hierarchy-Discussion

by

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Efficiency and Cost Implications of Capital Allocation Mechanisms
A Contribution to the Market-versus-Hierarchy-Discussion

Jens-W. Hinrichs and Stefan P. Klein

Abstract

The progress in modern information technology (IT) leads to changes in the organization of economic activity and enables new and innovative organizational structures. One example is the emergence of electronic markets. Electronic markets at the moment are primarily seen as a substitute for conventional markets. But there is also a tendency that electronic markets, because of sinking transaction costs, will break up - or even replace - hierarchical structures as well. This paper investigates whether the incorporation of an internal electronic market into an existing hierarchy can lead to an allocation of scarce resources which is superior to the allocation resulting from a conventional budgeting process. We compare this internal market with different simplified capital allocation mechanisms with respect to their ability to allocate scarce investment capital efficiently and with respect to the costs of these mechanisms. The analysis shows that under certain conditions internal electronic markets have significant advantages compared to conventional allocation mechanisms.

Moderne Informations- und Kommunikationssysteme ermöglichen zunehmend neue und innovative Organisationsformen wie z.B. elektronische Märkte. Dieser Beitrag untersucht, in welcher Form sich ein interner Markt in eine bestehende Hierarchie eingliedern läßt und vergleicht die Ergebnisse und Kosten einer marktlichen Allokation knapper Investitionsmittel mit denen konventionellen Budgetierungsverfahren. Als Ergebnis läßt sich zeigen, daß ein interner Markt unter bestimmten Bedingungen deutliche Vorteile gegenüber konventionellen Verfahren haben kann.

1 Introduction

In an increasingly competitive business environment the efficient identification and evaluation of investment opportunities becomes more and more important for large globally operating firms. Prospective investment projects need to be evaluated quickly for being able to cope with the rapidly changing market conditions. Additionally, the trend towards globalization creates the need for most companies to evaluate a growing number of investment opportunities. Being in this situation, investment capital is usually a scarce resource. To cope with those problems large companies reorganize themselves and spin off profit or investment centers under the roof of the central authority. Those decentral units are equipped with budgets and local decision autonomy. Due to their size and heterogeneity of activities globally acting companies with decentralized business units face problems of asymmetric information. This asymmetric information stems from the fact that the business units have specific and more detailed information about the markets they are operating in and thus are better informed about the possible investment projects than the headquarter. But usually business units have to apply for receiving capital from the headquarter. The detailed evaluation of investment projects and the subsequent allocation of capital into its optimal use requires extensive resources and is thus costly. Due to these problems firms must develop mechanisms which facilitate an optimal allocation of capital at low costs (Scott/Petty, 1990). In this paper we are going to evaluate different mechanisms with respect to their ability to allocate capital efficiently and with respect to the costs that occur when a mechanism is implemented. As a reference a first-best-solution under perfect information is used (Section 2.3). We analyze two forms of mechanisms to determine investment budgets: First, a heuristic mechanism, where the budgets are determined by simple rules (Section 2.4). And second, a more sophisticated mechanism, where the central authority fixes the budgets after evaluating the business units applications for investment (Section 2.5). As a third alternative for the allocation of the scarce resources an internal market is considered (for other possible alternatives see Ochsenbauer, 1989) (Section 2.6). The results of the internal market allocation are compared to the budgeting approaches for answering the question whether the use of a market inside the hierarchy can improve the allocation situation and/or lower the costs of the allocation process (Section 3).

2 Comparison of Capital Allocation Mechanisms

2.1 Assumptions

The comparison is based on the following assumptions:

(A1) We consider an organization consisting of one central authority, referred to as headquarter (HQ), and I decentral business units (BU_i) with $i = 1, ..., I$.

(A2) Every business unit BU_i may take advantage of N_i possible investment projects IP_{in} with $n_i = 1,..., N_i$. For sake of simplicity the investment opportunities are assumed to have one cash outflow $c^0 < 0$ at t = 0 and positive cash inflows $c^t > 0$ in the periods thereafter (t > 0). All cash flows are assumed to be deterministic and the initial investment amount c^0 is assumed to be identical for all projects.

(A3) Investment decisions are made on the basis of net present value (NPV). The discount rate r represents the opportunity costs of capital at the external market and is assumed to be identical for the headquarter and all business units. Each project has a unique NPV and only investment projects with positive NPVs are being considered.

(A4) The headquarter has a limited amount C of free capital resources available which it intends either to put at the business units' disposal for decentralized investment or to invest at the external capital market. The profit centers have no access to the external capital market. Given c^0, with the amount C exactly m (with $m < \Sigma_i N_i$) projects can be completely implemented, i.e. $C = m \times c^0$.

(A5) Because of information asymmetries the headquarter has no reliable information about the possible investment projects. The business units do have complete information about their own projects, but possess no knowledge about the projects of other business units.

(A6) For its own investment opportunities each business unit can rank the projects with respect to their NPVs. The evaluation costs for this ranking are assumed to be identical for all investment projects and thus will be neglected in the remainder of this paper. A more sophisticated evaluation with a detailed project description and NPV-estimation suitable for external judgment leads to extra costs k^+ per project.

(A7) The investment projects are assumed to be independent of each other.

(A8) All investment projects are assumed to be executable in fractions $f \in [0,1]$.

(A9) In the case of decentralized organizations decision rights are assigned to the business units. Given this autonomy the business units are able to pursue their own objectives. Under asymmetric information their behavior cannot be monitored by the central authority. This creates a problem if the decentral goals are in conflict with the headquarter's objective function. In this case the business units may increase their own utility to the detriment of the headquarter's objectives. Thus, a mechanism has to be found which avoids this behavior and leads the business units to act in accordance to the central goal. This can be achieved by using compensation schemes which are truth-inducing and incentive-compatible. Such schemes tie the decentral decision maker's compensation to the welfare position of the delegating central authority. For Section 2.4, where the business units have to apply for investment capital, it is assumed that a truth-inducing compensation scheme (e.g. the Groves-Scheme (Bamberg/Locarek, 1994) or the Weizmann-Scheme (Arbeitskreis, 1994)) will cause the business units to report their NPVs correctly. For Section 2.5 an incentive compatible compensation scheme is assumed in order to induce the decision makers to select investment projects with the highest NPVs. To be incentive compatible the compensation has to be strictly monotonously increasing with an increase in the central objective function (Laux, 1995). In the following, it is assumed that the decision makers' compensation is linearly related to the NPVs of the investment projects. Such a scheme gives the opportunity to neglect the explicit consideration of decision makers goals and to focus the illustration on the NPVs alone without loss of generality.

2.2 Desired Properties of Allocation Mechanisms: Efficiency at Minimal Costs

In the following comparison of capital allocation mechanisms we address two key questions. The first question is whether the mechanism leads to an efficient allocation. Under the assumptions given, allocational efficiency can be understood as a state in which no reallocation of the scarce resource capital increases the sum of NPVs of the implemented investment projects. To determine an efficient allocation the following general algorithm can be applied:

Let $\boldsymbol{p}$ denote the set of all possible investment projects IP_{in}. To achieve an optimal allocation it is necessary to identify the set of optimal projects $\boldsymbol{o}$ out of the possible projects $\boldsymbol{p}$. The dimension of $\boldsymbol{p}$ is N, which is the total number of projects of all business units (with $N = \Sigma_{\text{i}} N_{\text{i}}$). The dimension of $\boldsymbol{o}$ is only m, which represents the number of projects to be implemented with the resources given. An optimal selection of projects for the existing resources can be reached in two steps:

1) Rank the possible projects with respect to their NPV in descending order with $\text{NPV}_1(IP_{\text{in}}) > \text{NPV}_2(IP_{\text{in}}) > ... > \text{NPV}_{\text{N}} (IP_{\text{in}})$. This yields the set of *ranked* possible projects $\boldsymbol{r}_{(N)}$.

2) Select the m best projects, starting from $\text{NPV}_1(IP_{\text{in}})$. This results in the set of optimal projects $\boldsymbol{o}_{(m)}$.

The allocation mechanisms we are going to analyze in the following sections can be interpreted as specific organizational implementations of the simple algorithm described above. The second question to address, is how much it costs to apply a certain allocation mechanism. Our analysis focuses on two types of costs: misallocation costs and costs for capital acquisition.

Misallocation Costs

If a mechanism fails to select the m optimal projects, only a suboptimal solution of the allocation problem occurs. Such a solution could be denoted as $\boldsymbol{s}$ and the respective loss can be quantified as

$$\text{MC} = \Sigma_{i=1,\dots,m}(\boldsymbol{o}_i - \boldsymbol{s}_i).$$

In this equation the NPVs of the projects selected in the suboptimal solution are being compared to the ones of the optimal solution. MC is the loss in NPV which is caused by the misallocation. This value can be used as a measure for the efficiency of the respective mechanism.

Capital Acquisition Costs

If a business unit has more investment projects than investment capital available it has to obtain additional financial resources from other units within the company (i.e. from the headquarter or other business units). The potential supplier of this capital usually has no expertise in the respective market to which the capital requiring projects belong. Thus, he has to be convinced, that the project is worth being implemented and the payback is certain. Therefore a detailed description of the project and the estimation of cash-flows is needed. This description has to allow a consistent inter-subjective comparison between projects which belong to heterogeneous markets. It causes extra costs per project k^+ in addition to the normal costs of IP-evaluation (for empirical results see e.g.Wehrle-Streif, 1989).

An optimal allocation mechanism minimizes the sum of both, misallocation and capital acquisition costs. In the next four sections we analyze the allocational efficiency and the costs of four mechanisms: a first-best-solution, which will serve as reference with respect to the other solutions, a simple and a sophisticated budgeting framework and the allocation via an internal electronic market.

2.3 First-Best-Solution: Central Planing with Perfect Information

This section's objective is to construct a measure which allows an assessment of the quality of the capital allocation processes. We skip Assumption (A5) and suppose that the headquarter has no disadvantage compared to the business units concerning its access to information. It is assumed to be able to collect and process all necessary information about *all* possible investment projects itself. In this framework business units are only needed for operational purposes and for efficient execution of central investment decisions.

The objective of the headquarter is to maximize the sum of NPVs (NPV^{HQ}) by selecting those investment projects with the largest NPV^{IP} up to the limiting financial restriction.

The allocation problem can be stated as follows:

$$NPV^{HQ} = \sum_{i=1,\dots,I} \sum_{n=1,\dots,N} x_{in} \cdot NPV^{IP}_{in} \rightarrow \max!$$

s.t.

$$\sum_{i=1,\dots,I} \sum_{n=1,\dots,N} x_{in} \cdot (-c^{o}_{in}) \leq C$$

$$0 \leq x_{in} \leq 1 \qquad , \forall i, \forall n_i$$

Allocation Efficiency and Misallocation Costs

As stated in Assumption (A4) the given amount C finances exactly m projects, each with an investment volume of c^0. Since each project has a unique NPV it will be either fully realized or not implemented at all. This is due to the fact that if two different projects were realized in fractions only, shifting the capital to the project with the higher NPV would always increase the value of the objective function. As a result, the x_{in} which are potentially $\in [0, 1]$ will in fact be exactly equal to one (for the *m* "good" projects) or zero (indicating the *N-m* "bad" projects) maximizing the objective function. The selected projects constitute the set ***s*** described above. Since the linear programming algorithm is the mathematically exact mechanism to select a maximizing combination under the given constraints, ***s*** will be equal to ***o*** and thus MC will equal zero. In this case, when all projects are known to the decision maker, an efficient allocation of investment capital will be achieved. We call this allocation *first-best-allocation*. It has misallocation costs of zero, thus

$$MC^{first} = \Sigma_{i=1,\ldots,m}(\boldsymbol{o}_i - \boldsymbol{s}_i) = 0.$$

Capital Acquisition Costs

Since the capital is allocated correctly by the headquarter no additional capital will have to be acquired by the business units, thus

$$AC^{first} = 0.$$

In absence of information asymmetries the first-best-allocation can be attained with no costs. We call this a *first-best-solution* of the allocation problem. This solution is of course hypothetical. Still, it can serve as an idealistic reference. Given asymmetric information, the following, more realistic mechanisms can be compared with respect to the quality of the solution, in order to identify a second best mechanism.

2.4 Decentralized Planning and Asymmetric Information: Heuristic Budgeting

In reality the headquarter does not have all necessary information, especially when the investment projects stem from heterogeneous markets. Specialized business units have better and faster (cheaper) access to market information than the headquarter or other business units. In addition the information is usually business unit-specific and each business unit has specialized information processing capacity (experience, trained staff ...). The project evaluation can be done faster, better and with less detailed information by the specialized unit than by any other unit. To improve the efficiency of information collecting and processing, business units are therefore equipped with budgets and the right to make investment decisions on their own. As another extreme, it is assumed in this section, that the headquarter has no reliable information about the current investment opportunities of the business units at all. Individual investment budgets C_i may therefore be fixed heuristically. Examples for such a heuristic distribution could be e.g. uniform budgets (with $C_i = C/I$) or an extrapolation of historic budgets (with $C_i^t = \alpha \cdot C_i^{t-1}$ ($\alpha \in R$)). The business units are locally optimizing their individual NPV^{BU}_i using the approach described in Section 2.3. The headquarter is simply adding the resulting NPV^{BU}_{i} of the business unit. The formal description of the problem simply changes in the following way:

$$NPV^{HQ} = \Sigma_{i=1,\ldots,I}\, NPV^{BU}_{i}$$

with

$$NPV^{BU}_{i} = \Sigma_{n=1,\ldots,N}\, x_{in} \cdot NPV^{IP}_{in} \rightarrow \max!$$

s.t.

$$\Sigma_{n=1,\ldots,N}\, x_{in} \cdot (- c^{o}_{in}) \leq C_i$$

$$0 \leq x_{in} \leq 1 \qquad , \forall n_i$$

Allocation Efficiency and Misallocation Costs

By solving the linear program each business unit discovers its (locally) optimal set of investment projects. Again, to measure the costs of misallocation these sets of locally optimal projects $\boldsymbol{o}^{loc}_{i}$ can be aggregated into the set denoted as $\boldsymbol{s}^{simple}$. This set contains the solution of the heuristic budgeting process. Usually the aggregation of all locally optimized sets will be different from the overall optimal set $\boldsymbol{o}$ discovered in the first-best-solution. No difference will exist only by chance and in the case, when the initial (heuristic) allocation of investment capital corresponds perfectly with the optimal equipment of each business unit with capital. The probability of such an occurrence decreases with an increasing number of business units and an increasing number of potential projects. From an enterprise-wide point of view efficient allocation is not attained systematically and misallocation costs occur. The costs of misallocation can be quantified as

$$MC^{simple} = \Sigma_{i=1,\ldots,m}(\boldsymbol{o}_i - \boldsymbol{s}_i^{simple}) \geq 0.$$

Capital Acquisition Costs

Since investment capital is solely allocated heuristically and no possibility for an explicit exchange of capital exists, the business units will not spend additional costs for any capital acquisition. Thus,

$$AC^{simple} = 0.$$

As a result of this section we can state that the decentralization of investment decisions alone is not sufficient to achieve an efficient capital allocation systematically. This is even true if the evaluation of investment projects is done better by business units than by the headquarter and decision makers are compensated incentive compatibly. The reason for that is that financial interdependencies between business units are not taken into account. The capital allocation process has therefore to be extended. Section 2.5 examines the conventional approach of overcoming information asymmetries by passing information from the business units to the headquarter.

2.5 Central Planing with Asymmetric Information and Information Passing: Sophisticated Budgeting

In this section the situation is modified as follows: Information about the projects is still gathered by the business units. The units process and aggregate the information and send investment applications up the hierarchy. The final investment decision is made by the headquarter on the basis of these applications (Loeb, 1975). Following Assumption (A9) the applications will be correct. The formal description of the allocation problem remains unmodified compared to Section 2.3.

$$NPV^{HQ} = \Sigma_{i=1,...,I} \Sigma_{n=1,...,N}\, x_{in} \cdot NPV^{IP}_{in} \rightarrow max!$$

s.t.

$$\Sigma_{i=1,...,I} \Sigma_{n=1,...,N}\, x_{in} \cdot (- c^{o}_{in}) \leq C$$

$$0 \leq x_{in} \leq 1 \qquad , \forall i, \forall n_i$$

Allocation Efficiency and Misallocation Costs

Since the headquarter can rely on the information it obtains from the decentral units, it will be able to identify the optimal projects and the its selection will result in the set $\boldsymbol{s}^{soph}$ which will be equal to the optimal set $\boldsymbol{o}$. Thus, misallocation costs do not occur, thus

$$MC^{soph} = \Sigma_{i=1,...,m}(\boldsymbol{o}_i - \boldsymbol{s}_i^{soph}) = 0.$$

Capital Acquisition Costs

In this setting the relevant information about the investment projects is gathered on the lowest level of the hierarchy, the decision is made on the top level. In order to come to an efficient allocation all *N* projects will have to be taken into account. Thus, each business unit has to process information about all projects it can identify and write applications for them. Assumption (A6) states that in this case extra costs k^{+} for the preparation of reliable documents occur. Those are needed to give the capital suppliers the necessary information to evaluate and compare the differing investment opportunities on an objective basis. The capital acquisition costs in this case amount to

$$AC^{soph} = k^{+} \cdot \Sigma_i N_i.$$

As a result of this section we can state that the mechanism will lead to misallocation costs of zero, thus achieves a first-best-allocation. The costs of capital acquisition though, are relatively high. These costs stem from the necessity to conduct a thorough evaluation and application for all *N* projects which can be identified. The following Section 2.5 presents an internal market approach and examines whether a first-best-allocation can be reached with capital acquisition costs lower than those of the sophisticated budgeting approach.

2.6 Decentralized Planing and Internal Markets

In this section we are going to consider a mechanism to improve the solution from 2.4 and 2.5. In this approach, the local knowledge of the business units will be again used locally, to avoid the high costs of information preparation for the headquarter. In addition, the information about the overall investment situation and the scarcity of investment capital will be implicitly incorporated into the business unit's calculation. We install an internal market and investigate its effects on misallocation and capital acquisition costs. In this setting, like in Section 2.4, the investment capital is allocated heuristically in the first place and each business unit is ranking its projects maximizing its local sum of NPVs. The business units know, that the initial allocation of investment capital is (probably) sub-optimal and individual improvements are possible via a market-based reallocation. Given the compensation scheme described in Assumption (A9), each business unit is incited to participate in the internal market with its projects. This is due to the fact that the internal market gives the opportunity to increase the sum of net present value of the compensation payments for market participants. This is achieved by a sharing rule, which is applied when a market transaction takes place: In each transaction the amount c^0 is exchanged between buyer and seller. This gives the buying business unit the opportunity to carry out a project, which would not be executable without the additional capital. With this new project the unit will thus receive an additional payback depending on the project's NPV. Since the business unit aims to maximize the net present value of its compensation payments, it will be willing to pay a price to obtain the capital for this marginal project. The unit will be interested in buying the additional amount of capital as long as the price is lower than the additional compensation it obtains. The same applies for the seller vice versa. The compensations stemming from the seller's and the buyer's marginal project constitute an interval. If the market sharing rule determines an actual "price" in between the limits of this interval, both units take advantage of the market transaction and hence will engage in it. Since the compensation scheme is a strictly positive monotonous function of the project-NPV, all market transactions are also in the interest of the central authority.

The considered reallocation process consists of five steps which are specified as follows:

1. In a first step each profit center obtains one or more portions c^0 of investment capital. Under the given assumptions the initial distribution of the capital over the profit centers is irrelevant for the efficiency of the final allocation (Coase, 1960).

2. Then each profit center ranks its investment projects according to the respective NPVs.

3. Given the capital budget the profit centers can identify two "marginal" projects: *S* is the project with the smallest NPV still being carried out. The project *D* is the first project which can not be realized because of the financial constraint.

4. In a fourth step each profit center formulates its demand and supply strategy. The profit center demands capital for the project *D* and thus gives a *limited ask-order* into the market, with the limit set to the NPV of the project *D*. The unit also acts as a supplier for its capital otherwise tied to project *S* and formulates a *limited bid-order* with the NPV of its project *S*.

5. In the fifth step, the market mechanism matches supply and demand in order to determine the market price: Since the *I* profit centers specify supply for their project *S* and demand for their *D* there are exactly *I* ask-prices and *I* bid-prices in the market. The profit center with the highest bid-price and the one with the lowest ask-price (with bid-price > ask-price) are determined to exchange the investment amount c^0. After the transaction these two participants have to evaluate one new marginal project. The marginal projects of the other units are left unchanged.

Steps four and five are being repeated until no further transaction occurs. This signals the end of the reallocation process.

Allocation Efficiency and Misallocation Costs

The market mechanism is designed in such a way, that the exchange of the capital portion c^0 is always directed from the least best still executed project to the best not executed project. This results in the maximum reduction of misallocation costs in each iteration. An efficient allocation will be achieved after a maximum of *m* iterations: Each business unit *i* is able to specify its m_i projects that can be carried out with the given capital budget and the N_i-m_i projects which cannot be realized. The *m* potential projects of all business units can be ranked by NPV, which results in the set ***r***. The other projects, which will not be realized under the given capital allocation can be ranked into the set ***r’*** . The market mechanism leads to an exchange between these two sets in a way, that in every step, the least best project in ***r*** is substituted by the best project in ***r’***. Since the set ***r*** has the dimension *m* it follows, that the maximum number of market transactions is limited to *m*. This maximum of market transactions will occur in the situation, when all *m* projects have to be exchanged. This is the case, when the set of elements of set ***r*** is perfectly disjunctive from the set of elements of ***o***, the set of optimal projects. In this case all *m* "bad" projects have to be substituted by "good" projects, which takes exactly *m* iterations. Because every business unit has an incentive to perform market transactions it will evaluate new projects and take them to the market. Thus the reallocation process will not stop as long as a project from ***r’*** can be exchanged by one of ***r*** increasing the sum of NPVs.

Capital Acquisition Costs

As mentioned above, decision makers are incited to act on the internal capital market. On the one hand, capital demand can be interpreted as application for investment capital comparable to the situation in Section 2.5. In this case the supplier is not the headquarter, but another business unit which has no expertise about the specific market to which the capital demanding project belongs. As has been mentioned in Section 2.2, a detailed, "provable" description of the project and the estimation of cash flows has to be elaborated. The sum of extra costs k^+ is then determined by the number of projects that go into the market clearing process as capital demand. On the other hand, specifying capital supply causes no extra costs, because the capital taker will receive the amount c^0 for which no necessity for elaborated documentation exists.

Supposing that the initial allocation is optimal, no market transaction occurs and the process terminates. In this case costs are restricted to (*minimum* costs)

$$AC^{market} = I \cdot k^+.$$

After each market transaction one new project has to be evaluated and described at costs of k^+ on the *buyers* side. As has been shown above, the maximum number of market transactions is limited to m. Thus, the *maximum* costs are

$$AC^{market} = I \cdot k^+ + (m-1) \cdot k^+.$$

These maximum costs occur if the initial allocation is such, that no project of the globally optimal solution can be executed with the given budgets. With the exception of this case, the evaluation costs for the market transactions are always much lower. As a result we can state that a market mechanism can facilitate a reallocation, which systematically substitutes "good" for "bad" projects.

3 Conclusions

As conclusion we can state, that no mechanism reaches the first best solution. The heuristic budgeting approach does not even reach a first-best-allocation systematically. Only by chance, when the applied heuristic matches the capital requirements very well, the capital is allocated efficiently and the misallocation costs approach zero. If not, the misallocation costs depend on the differences between the NPVs. In an environment with rapidly changing external market conditions heuristic budgeting tends to be more and more costly since investment opportunities and capital needs will be changing in unpredictable ways. Both other mechanisms reach a first-best-allocation. Still they require costly capital acquisition procedures. The sophisticated budgeting mechanism causes capital acquisition costs depending on N, the number of investment projects that can be identified in the business environment. N tends to rise with a globalization and diversification of the firm, making this mechanism more costly. The internal market also causes capital acquisition costs which depend on I and m. Both parameters depend on the size of the company and its ability to realize investment projects. In the case of globally operating firms, the sum of I and m will be much lower than N. This is due to the fact that out of the multitude of possible investment projects international corporations are facing only a fraction of projects can be realized with the scarce investment capital. For the internal market not all possible projects need to be evaluated intensively but only those which go into the market clearing process. Thus, an internal market is most likely to reach a first-best-allocation at the lowest costs. In this setting it can be therefore identified as the second best solution.

4 Limitations and Prospects for Further Research

There are a number of limitations in our analysis. One is that the total amount of investment capital is fix. This is questionable, because in general access to external capital markets is possible. Thus a connection of internal and external markets will have to be considered. Another important aspect is to skip the assumption of deterministic cash flows. This assumption is justifiable for reasons of simplicity of illustration, but seems not to be very realistic. An approach, which takes risk and uncertainty explicitly into account, has to deal with different individual risk attitudes and different individual expectations about the future. Extending the model in those respects is subject to ongoing research.

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