# *Fifty years of Research on Accuracy of Capital Expenditure Project Estimates: A Review of the Findings and their Validity.*

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# Fifty years of Research on Accuracy of Capital Expenditure Project Estimates: A Review of the Findings and their Validity.

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**Abstract**

Capital budgeting research has traditionally focused on ever improving the methods used for evaluating projects. Since it seems futile to use sophisticated evaluation techniques if their input data – that is, estimates of cash inflows and outflows – are of inferior quality, it is justifiable to call this focus into question by exploring forecasting accuracy. In order to do so, the article analyzes the empirical findings on estimation error gathered in 35 studies published between 1954 and 2002.

As the review shows, over-optimism seems to be a relevant problem in capital expenditure project forecasting. This calls the traditional research focus into question. More research effort targeted at the misestimation bias in capital budgeting and at ways to improve forecasting accuracy seems necessary.

Keywords: Capital budgeting; Capital Expenditures; Estimation Accuracy; Forecasting.

## *1. Introduction*

Capital expenditures have a huge impact on the future profitability and value creation of a company and are among the most important managerial decisions.[1] Consequently, capital expenditures and capital budgeting have been researched extensively over the past 50 years.[2]

To facilitate this research, it has become customary to subdivide the capital expenditure process into several steps: (1) problem definition, (2) idea generation, (3) forecasting, (4) evaluation of alternatives, (5) pre-approval checking for accuracy, (6) decision making, (7) implementation, (8) monitoring during implementation, (9) start of operations, (10) use of equipment, (11) post-completion auditing, and (12) retirement.[3]

However, the level of research effort directed at these steps has been quite different.[4] In fact, research has focused on the fourth step: the evaluation of alternative investment projects.[5] Consequently, numerous evaluation methods have been presented and discussed in the theoretical literature.[6] At the same time, researchers have thoroughly investigated the application of these evaluation methods, and whether companies relying on “sophisticated” evaluation techniques are more successful than their counterparts that employ “old fashioned”

instruments. Research into project evaluation methods, in fact, has been so exhaustive that "probably more surveys have been undertaken on the use of capital budgeting techniques than on any other accounting and finance topic."[7]

The other steps in the capital expenditure process have received comparatively less attention from theoretically- and empirically- oriented researchers. Idea generation, forecasting, pre-approval reviews, monitoring and post-completion audits have been conspicuously overlooked.[8] Nevertheless, they are typically considered essential steps in an effective capital budgeting process.[9]

The lack of research into the idea generation and the forecasting phases is especially surprising; if no (or too few) investment alternatives are generated, then there is nothing to be evaluated. Furthermore, it seems futile to use sophisticated evaluation techniques if their input data – that is, estimates of cash inflows and outflows – are of inferior quality.[10]

Therefore, it seems justifiable to call the traditional focus of capital budgeting research into question by exploring idea generation and forecasting. If the traditional focus of research is correct, then there should be no significant problems in either of these phases. If, however, such an analysis revealed that practitioners do encounter significant problems in one or both of these steps, then capital budgeting researchers should consider shifting their focus to one or both of those steps.

To the author's knowledge, there is no review of the findings and the validity of 50 years of empirical research on the efficiency of companies' idea generation or forecasting in capital budgeting. This article intends to reduce this gap by analyzing the empirical findings on forecasting accuracy, i.e. on the presence, direction and magnitude of errors and biases in capital expenditure project estimates.[11] In order to do so, it will present and discuss the findings from 25 empirical studies.

## *2. Method of data collection and analysis*

A three- step method of data collection was used to compile the 25 studies included in this review:

(a) *Systematic journal search:* In a first step, several journals on management, management accounting and capital budgeting were looked through article by article for publications dealing with forecasting accuracy in capital expenditure project plans.[12]

(b) *IT-based literature search:* Based on the titles found and keywords used in the first step, specialized databases (ABI-Inform, DIGIBIB, EBSCO, Emerald-Fulltext, GBI – Wiso-Net, and the Proquest/UMI database of dissertations) and the internet were searched.[13]

(c) *References-based search:* The third step consisted of a systematic review of the references cited in the empirical studies uncovered in Steps One and Two.

This process yielded 25 empirical studies on estimation accuracy in capital expenditure project plans.

These studies, which are described in Table 1, come from Cyprus, Finland, Germany, Switzerland, the United Kingdom, and the United States. They cover a time from the early 1950s to the year 2002. Sample sizes vary from single company studies to large scale analyses of up to 500 corporations. Methods used for data collection include postal surveys, personal interviews, documental analyses and self-reports of the respective author's practical experiences.

As can be seen from Table 1 the majority of empirical studies on investment planning accuracy does not lend itself to a quantitative meta-analysis. As a consequence, this article will consist of a qualitative review of the major findings and the methodology of the studies.[14]

**Table 1: Studies on Capital Expenditure Forecasting Errors and Biases**

| Author(S) and Date of Publication | Period of Data Collection | Country Surveyed | Type of Businesses | Company Size(S) | # of Companies Approached | # of Companies Responding | Method(S) Used for Data Collection |
|---|---|---|---|---|---|---|---|
| Dean (1954) | ? | USA | ? | ? | ? | 1 | I, D |
| Carter/Williams (1958) | 1955 - 1956 | UK | V* | A | 269 | 246 | I |
| Zoeller (1959) | ? | USA | I | L | 1 | 1 | P |
| Helfert (1960) | ? | USA | I | L | ? | 3 | I, D |
| Scheffler (1961) | ? | GER | I | A | ? | 31 | ? |
| Williams/Scott (1965) | 1956 - 1965? | UK | V* | L | ? | 14 | I, D |
| Honko (1966) | 1964 - 1965 | FIN | I* | M?, L | 55 | 38 (40) | I, Q |
| Myers (1966) | ? | USA | I* | L | ? | 1 | D |
| Kempster (1967) | ? | USA | I | L | ? | 28 | I |
| Terborgh (1967) | ? | USA | I | L | 1 | 1 | D |
| Bower (1970) | 1965 - 1967 | USA | I | L | 1 | 1 | I, D |
| Carter (1971) | ? | USA | I | M | 1 | 1 | I, D |
| Henderson (1971) | 1968 | USA | I | L | 500 | 500 | D |
| Dillon (1974) | ? | USA | I | L | ? | 76 | I, Q |
| Honko/Virtanen (1975) | 1973 | FIN | I | L | 50 | 46 | F |
| Viafore (1975) | 1972 - 1974 | USA | V* | L | 79 | 4 (23) | I, D |
| Van Vleck (1976) | 1973 | USA | V* | L | 650 | 241 | Q |
| Merrow/Phillips/Myers (1981) | 1978-1980 | USA | I* | A | ? | 34 | D |
| Honko/Prihti/Virtanen (1982) | 1981 | FIN | I | L | 30 | 30 | I |
| Arnold (1986) | 1982 | USA | I | L | 1 | 1 | ? |
| Bromiley (1986) | ? | USA | I* | ? | ? | 4 | I, D |
| Pruitt/Gitman (1987) | 1986 | USA | I | L | 500 | 121 | Q |
| Weber/Linder/Spillecke (2002) | 2001 | GER | V* | L | 4 | 4 | I, D |
| Pieroth (2002) | ? | CH | I | L | 1 | 1 | P |
| Lazaridis (2002) | 2002 | CYP | ? | M, S | 120 | 100 | Q |

**Country Surveyed:** CH = Switzerland; CYP = Cyprus; FIN = Finland; GER = Germany; UK = United Kingdom; USA = United States of America; **Type of Business Surveyed:** V = both, industrials (including utilities) and service companies; I = only industrials (including utilities); D = only service companies; * = only some businesses out of all industry or respectively services business fields; **Company Size:** A = all sizes; L = large companies; M = medium sized; S = small firms; **Method(s) Used:** I = interview; Q = questionnaire; D = document analysis; P = self-report.

A question mark (“?”) denotes missing information.

## *3. Results*

### 3.1. First empirical evidence from the 1950s

Dean (1954) might have been the first to analyze the accuracy of capital expenditure estimates. His study deals with the capital budgeting practices at an unspecified U.S. company. In approximately one third of that company's investment projects, actual values deviated from expected ones by about 25 percent.[15] However, Dean (1954) neither specifies the direction of these deviations, nor provides further details on the forecasting errors.

A more detailed analysis is included in a study by Carter and Williams (1958). They surveyed 246 British companies of varying sizes and looked at the relationships between forecasted and realized earnings as well as between expected and actual costs. Their study shows that in almost three- quarters of the companies surveyed, actual and planned earnings deviated from each other by more than 50 percent. In about a quarter of the companies analyzed, the deviations exceeded 100 percent ![16] As a result, the correlation of expected and realized earnings is as low as 0.13.[17] With regard to the direction of deviation, Carter and Williams (1958) arrive at an almost even split between earnings over- and underestimations.[18] Their study, therefore, suggests a lack of knowledge on the part of the planning personnel as the root cause of these deviations, not an asymmetric (thoughtful or unaware) biasing of estimates. However, Carter and Williams (1958) also point out that there is a tendency in some of the companies "to estimate 'hopefully' and [in] others to estimate 'conservatively.'"[19] The study neither elaborates upon this point nor takes a closer look at the influence of company size, business fields, or similar factors. It does, however, identify a similar tendency of estimation errors in cost forecasts; once again "some companies persistently under-estimate the cost of their projects [...]. Other companies obtain a very close agreement with estimates – errors or [sic!] less than 2 per cent, being common."[20] But as for the errors in projected

earnings, the study neither includes a further breakdown of the results by different business fields nor provides any exact data on the spreading and size of errors.

Zoeller (1959) chooses an approach quite different from that of Carter and Williams (1958): He limits his analysis to a careful review of the capital expenditure planning accuracy of a single U.S. company: Allis-Chalmers Manufacturing Co. His study shows that the results obtained from the individual investments deviated by as much as minus 269 percent to plus 233 percent from the expected values.[21] Even though, some of the realized investments' actual values come very close to the planned ones, Zoeller (1959) notes that the realized economies from all capital expenditure projects generally remained about 5.6 percent behind the expected ones.[22]

### 3.2. More detailed evidence from the 1960s and 1970s

The first study of capital expenditure planning accuracy in the 1960s was conducted by Helfert (1960). He compares actual to planned profitability of the investments implemented at three large U.S. industrials. At the first company his analysis extends over 150 capital expenditure projects that had been undertaken over the previous nine years. In these 150 projects actual profitability reached 99.1 percent of expected (i.e. planned) profitability.[23] In the second company, Helfert (1960) reviews the profitability of 71 projects implemented the year before. Here, the actual profitability attained only 76.7 percent of the planned one. For the third company (some 60 projects over the previous two years) Helfert's (1960) study yielded an actual profitability of 95.8 percent.[24]

The second study from this decade was written by Scheffler (1961), who studied 31 German industrial companies of varying sizes. While his analysis does not include any detailed information on the spreading and direction of errors or biases, Scheffler (1961) points

out that over- and underestimation of planned values ranged typically in the area of 10 percent.[25]

Williams and Scott's (1965) analysis of fourteen large British companies from various industries found, that negative deviations (i.e. deviations due to over-optimism) outnumber the positive ones.[26] While they do not provide the reader with a detailed quantitative review of the magnitude of the disparities, they interviewed the responsible personnel from the fourteen companies to discern the reasons. Several of the reasons indicated over-confident or over-optimistic planning.

In contrast to Helfert (1960) and Williams and Scott (1965), Honko (1966) shows that the overwhelming majority (75 percent) of the responding 38 Finnish industrials typically managed to attain actual results that were superior to the initially forecasted ones.[27] Only nine percent of the firms reported that their original forecasts are "always" or "often" better than the results finally obtained from an implemented investment project.[28]

Myers (1966) concludes from an analysis at a U.S. chemical company, that investment proposals relating to equipment necessary for new product introductions can be described as conservative. While this conclusion is more or less consistent with the Honko's results (1966), it seems inconsistent with the review of U.S. practices by Helfert (1960). Unfortunately, Myers (1966) does not provide any quantitative analysis or details of the deviations .

Some years after the report by Zoeller (1959), the Allis-Chalmers Corporation is once more the focus of research on planning accuracy: Terborgh (1967), looking at the results from fiscal year 1965, notes that even though forecasted and actual values seem to be in line, the actual profits obtained from individual investments may well lie up to 189 percent above or up to 76 percent below expected profits.[29]

Kempster (1967) concludes from a review of capital expenditure sums planned vs. actually required at 28 large U.S. industrial companies, that "it is quite common for project

estimates to be exceeded when the actual expenditures are made."[30] He does not, however, provide any more explanation.

In contrast to Kempster (1967) Bower (1970) looks at 50 capital expenditure projects of a single, large industrial company.[31] For the actual values of production enlargement projects included in this sample, Bower (1970) arrives at a meager 60 percent of expected values.[32] And in the case of investments related to new products, actual values amounted to only 10 percent of forecasted ones. Only in the case of capital expenditure projects targeted at reducing costs or rationalizing production, the realized values exceeded the forecasts by 10 percent.[33]

Once again limited to one company is Carter's (1971) review of capital budgeting at a start-up company in the computer industry. He concludes that there seems to be enthusiasm and rather dubious cash flow forecasts at that company.[34] However, his study does not provide us with any (quantitative) details on the errors.

Henderson (1971) chooses a somewhat different approach. Based upon publicly available data he calculates the respective returns on invested capital of the Fortune 500 industrials and compares them to common minimum hurdle rates for each industry. Adjusting the published figures for cost of outside financing, he arrives at an actual total return on invested capital of about 8 percent.[35] Considering the fact that most companies have hurdle rates of about 15 percent, Henderson (1971) concludes that "it does seem illogical that businessmen have planned for a return of only 6 to 8 per cent, especially when a number of guaranteed bonds now provide this level of return. This leads to a very strong suspicion, if not actual proof, that there is a massive failure among capital expenditure plans in North American industrial companies to provide the returns on investment which have been forecast or budgeted."[36]

Dillon (1974) does not look directly at the spreading and magnitude of flaws in capital expenditure plans, but rather focuses on the reasons why a capital expenditure project might

fall off its forecasts. He concludes that "overestimation of potential profitability or cost savings"[37] is the most common reason for projects to fall off their expected values. The second most common reason are faulty assumptions about the factors and parameters influencing the future cash flows of a project.[38] Both reasons point to errors in initial capital expenditure planning forecasts.

About ten years after the first study on capital expenditure practices in Finland, Honko and Virtanen (1975) reexamined Finland's industrial firms. About 85 percent of the 46 large companies surveyed (one quarter of which had already been interviewed in the earlier study) reported that the actual initial expenditures for a capital project often exceeded the planned ones.[39] Only a slight negative tendency could be established for the costs of individual projects while in operation. However, Honko and Virtanen (1975) also conclude that the benefits derived from an investment are underestimated in about 70 percent of the surveyed companies. Comparing their results with those of Honko (1966), they identify a small increase in (negative) deviations between expected values and actual ones.[40]

Limited to four large U.S. companies, a study by Viafore (1975) arrives at a result similar to that of Henderson (1971): between 1972 and 1974 actual values remained typically around 10 percent below pre-acceptance cash flow estimates.[41]

Van Vleck (1976) conducted a large and extensive study of capital expenditure planning accuracy. The study is based upon questionnaires completed by 241 large U.S. companies in 21 different fields and tries to answer the question about planning accuracy by means of several distinct sub-analyses. In the first analysis of the planned and realized earnings at all 241 firms, Van Vleck (1976) demonstrates that "corporations tend to be optimistic when they forecast yields on capital projects."[42] By splitting up the reasons for discrepancies, he shows that deviations due to optimistic planning (i.e. overestimation of earnings and/or underestimation of actual outlays) occurred nearly three times as often as did those that were due to pessimistic planning. Furthermore, while deviations due to under-

optimism are typically in the range of 5 to 10 percent, those which can be traced to over-optimism lie between 5 and 15 percent.[43] However, only a relatively small number of companies reported that errors exceeding 15 percent occurred rather often.[44]

In a second analysis, Van Vleck (1976) breaks down the figures on the 21 different business fields. His data shows that in none of these 21 fields did errors resulting from pessimism outnumber those due to over-optimism.[45] The largest deviations between planned and actual values for capital expenditure projects took place in the electronics and home appliances, chemicals, glass, concrete, metals, mining, and textile businesses.[46] The pharmaceutical industry produced the smallest errors.

A third analysis, which tries to establish a correlation between company size (sales) and error magnitude, yields no significant results.[47]

In a fourth analysis, Van Vleck (1976) tests the influence of capital expenditure planning accuracy on company profitability. But once again, the analysis yields no conclusive relationship.[48]

Van Vleck's (1976) fifth analysis attempts – just like Henderson (1971) – to draw conclusions on planning accuracy based upon the relation of total return on invested capital (after taxes) and the companies' minimum hurdle rates. The results show that in most business fields, actual returns on investment are lower than the respective hurdle rates.[49] In fact, companies as diverse as aeronautics, electronics and home appliances, chemicals, nutrition, glass, concrete, metals, paper products, rubber, ship-building and railroad supplies, and textiles did not reach their respective minimum hurdle rates.[50] Since it seems unlikely that the management of these companies approved capital projects that did not (according to the respective forecasts) meet the minimum hurdle rates, Van Vleck (1976) assumes that the profit potential of the capital expenditures or the capital outlays necessary had been miscalculated. This conclusion is compatible with the reasons for discrepancies mentioned by the companies in Van Vleck's (1976) sample. The three most often cited factors responsible

for the deviations are an underestimation of project costs, an underestimation of cost while in operation and an overestimation of profit potential.[51]

### 3.3. Newer evidence from the 1980s and onwards

While the study by Merrow, Phillips and Myers (1981) focuses only on pioneer plant investments in the chemical process industries (of oil, chemicals, minerals etc.), it indicates that cost estimates established at the beginning of the construction period of the 44 pioneer process plants in review, covered usually only 93 percent of actual costs.[52] Cost estimates completed during the project engineering phase accounted for only 78 (early in engineering) and 83 (later in engineering) percent of actual cost.[53] Consequently, Merrow, Phillips and Myers (1981) conclude that "the experience of the plants in our database reveals a pattern and magnitude of misestimation that stands in sharp contrast to the usual expectation that actual costs will fall symmetrically within established and relatively limited ranges of estimated costs."[54] Deviations of estimated from actual costs were largest for new technologies i.e. first-of-a-kind plants.[55] In fact, most of the variation found in cost-estimation error can be explained by three factors: "(1) the extent to which the plant's technology departs from that of prior plants, (2) the degree of definition of the project's site and related characteristics, and (3) the complexity of the plant."[56] Similarly, with respect to the performance of the projects, the study of Merrow, Phillips and Myers (1981) shows that "the routinely high performance assumed for pioneer process plants when financial analyses are done is unrealistic. Over 50 percent of the plants in our sample failed to achieve their production goals in the second six months after start-up."[57] Once again, there is a positive link between the measures of new technology and size of the misestimation.[58]

The second study from the 1980s deals with practices in Finland. Honko, Prihti and Virtanen (1982) conducted another study of investment processes in 30 large industrial companies. Even though they did not ask the interviewees explicitly about the spreading and magnitude of deviations between planned and realized values of individual capital expenditure projects, their investigation of the reasons for unsuccessful investments nevertheless gives us some idea about the topic in question. They arrive at "one-sided planning assumptions"[59] as a central reason for investment failures.[60] However, they also point out that "the 87 investment failures are not a very significant proportion of the enterprises' total number of investments."[61]

Arnold (1986) describes the case of Cloud Tool Company, a large oil-field equipment manufacturer, that experienced serious economic troubles after a large plant expansion project turned out to be far less profitable than expected.[62] However, he does not elaborate in more detail on capital expenditure estimation accuracy at Cloud Tool Company.

Bromiley's (1986) study is concerned with the overall sum of capital outlays (planned versus actual) and total income from these investments (forecasted vs. actual) at three U.S. heavy manufacturing firms. Based on extensive interviews with employees of different levels and functions he noted that "interviewees agreed that many of their forecasts were biased in the statistical sense. Many said forecast investment was from 5 to 10 percent above what would actually be spent. Many reported that forecasts of income would be conservative."[63] While these statements point to clear pessimism or "conservatism" in capital expenditure plans, Bromiley (1986) also discovered that "some corporations maintained several different sets of forecasts: optimistic ones to motivate lower-level managers, 'accurate' ones for top management, and conservative ones for finance purposes and for discussions with the finance and banking communities."[64] If this were a common practice among most companies, the divergent results of empirical studies of capital expenditure planning accuracy could well be

explained by differences in the respondents (different hierarchies, different functions) and their respective different "forecasted values."[65]

A large scale study of U.S. American practices is provided by Pruitt and Gitman (1987), who surveyed the Fortune 500 industrials (121 responses). In their study, 80 percent of the respondents stated, that according to their experience the earnings potentials of capital expenditure projects are typically overestimated.[66] Additionally, 43 percent of the respondents claimed that the outlays for purchasing or implementing a capital expenditure project were generally underestimated.[67] Misestimation of necessary capital outlays seems especially common with investments in advanced technologies and new processes.[68] The study, however, does not provide any detailed (quantitative) data on the magnitude of these discrepancies.

In a study of capital budgeting processes at four large German companies (three industrials and one service company) Weber, Linder and Spillecke (2002) state that their interviewees complained about over-optimism and manipulations in capital expenditure planning.[69] However, their study does not provide any quantitative figures on these errors or biases in forecasts.

Similarly Pieroth (2002) discusses a problem with over-optimism at a multinational consumer products company but does not offer any quantitative data.[70]

The most recent large empirical investigation of investment forecasting accuracy was conducted in Cyprus by Lazaridis (2002). In contrast to the other studies presented and discussed in this article, Lazaridis focuses on small and medium sized companies. Of the 100 responding companies, 33.7 percent managed to reach the initially forecasted values within an interval of plus or minus 5 percent. The majority of the enterprises, however, faced larger deviations of 6 to 10 percent (31.6 percent of respondents), 11 to 15 percent (23.5 %), percent), 16 to 20 percent (5.1 %) and of over 20 percent (6.1 %)![71] Unfortunately, the study

does not include any information on the direction of these deviations and whether company size plays any role.

## *4. Discussion of Results*

Overall, the findings of the various empirical studies from the past 50 years draw a rather unpleasant picture both of investment planning accuracy[72] and of the research into this topic.

Most studies show deviations between forecasted and realized values, which – at least according to some of the studies – can be quite significant.[73] Furthermore, many studies found that these deviations are probably less a consequence of bad luck or random influences than of lopsided planning.[74] In fact, over-optimism could be a serious problem in capital expenditure project forecasting.

However, even after fifty years of empirical research, the evidence on the misestimation phenomenon, does not provide a precise answer about the magnitude of over-optimism in capital expenditure forecasting.[75] Nor does it permit valid conclusions on the impact of this inaccuracy on corporate performance. In fact, eight major problem areas account for the current lack of knowledge on inaccuracy in capital expenditure planning estimates:

a) *Unsatisfactory sampling procedures and sample sizes*: Even when excluding the anecdotal evidence by Dean (1954), Myers (1966), Carter (1971), Dillon (1974), Weber, Linder and Spillecke (2002) and Pieroth (2002), the sampling procedures and sample sizes remain weak spots in the currently available empirical studies. With the exception of Carter and Williams (1958), Honko (1966), Henderson (1971), Honko and Virtanen (1975), Van Vleck (1976), Merrow et al. (1981), Pruitt and Gitman

(1987), and Lazaridis (2002), the studies are based on samples too small to be representative of the respective populations.[76] Since sample sizes in many other research areas are typically larger,[77] it seems improbable that researchers would not have preferred larger samples in the field of assessing estimation accuracy. Consequently, it is hard to imagine any other reason for the small sample sizes than an unwillingness of the companies to participate in the studies.[78] While one can only speculate about the reasons, a fear of "loss of face" as a result of low estimation accuracy cannot be discounted.

b) *Possible respondent bias*: As Bromiley (1986) shows, it cannot be excluded that the results obtained in the studies will differ with the hierarchical level and function of the respondents.[79] Further investigation into this topic (e.g. by means of a multi-trait-multi-method study) would be necessary to determine whether this finding can be generalized and how large the possible error from asking just one respondent might be.

c) *Unsatisfactory data analysis:* It is startling that some of the studies neglected to investigate the direction and magnitude of deviations. For example, the survey by Lazaridis (2002), which showed that deviations exist not only for very large corporations but also for small- and medium sized corporations,[80] unfortunately does not indicate the direction of these deviations. Therefore, it does not answer the question of whether misestimation is symmetrical or not – thereby limiting the value of the study. The study by Pruitt and Gitman (1987) demonstrates the tendency of some studies to rely solely on verbal statements of estimation error and to omit asking the respondents for the exact magnitudes of deviations (and the respective proportion of these deviations of the total of the investments undertaken).

d) *No clear separation of different project types in the studies:* As shown in the analyses by Bower (1970), Merrow, Phillips and Myers (1981), and Pruitt and Gitman (1987),

forecasting reliability is likely to be lower for first-of-a-kind capital expenditures than for replacement projects.[81] Therefore, an analysis of forecasting accuracy should differentiate between these two types of projects. However, the overwhelming majority of existing studies does not account for a separate analysis of these two groups of projects.

e) *Doubtful suitability of time period used for calculating actual values:* Several authors like Carter and Williams (1958) limit their analysis of actual values to an excerpt of the total life span of the respective investments. While this may not significantly distort the cost data, it might introduce significant error in the earnings figures, since the time necessary for new equipment or plants to reach normal operation is not the same for all projects and industries and since revenues from production in many industries (especially manufacturing) are more volatile or cyclical than costs.[82] The limitation of the analysis to just a couple of months or years after start of operations could therefore lead to figures that misrepresent the success or failure of a project over its total life span. This in turn, could cause wrong conclusions about the existence, magnitude and direction of errors in expected earnings from an investment.[83] While it cannot be determined, if the results of the existing studies suffer in a statistically significant manner from the limitation of the time period used for establishing the actual outcomes of the projects, an analysis covering all or at least most of the lifespan would surely be a more precise and reliable basis for drawing conclusions about estimation accuracy.

f) *Questionable test for relationship between forecasting accuracy and company performance*: The only author who tried to establish a link between forecasting accuracy and company performance is Van Vleck (1976). While his attempt is laudable, some critical words about his analysis, nevertheless, are necessary. Relying on profitability as a sole proxy of company performance can be criticized, since purely

financial indicators may not be representative of overall (long-term) corporate performance.[84] In recent discussions of balanced indicator systems (like e.g. the Balanced Scorecard) most authors emphasized the one-sidedness of traditional financial indicators and the need for a more balanced view of competitive performance.[85] Moreover, limiting the profitability analysis to a single year, 1972, while problematic due to cyclical up- and downturns, is especially ill-suited to capital expenditure management, which will typically have a longer term impact on company performance. While this limitation was probably the only viable solution to exclude the "exceptional"[86] years of 1973 and 1974 from his analysis, it nevertheless remains problematic. In fact, the limitation of the analysis to jus the profitability of 1972 could explain why Van Vleck's (1976) survey only yields insignificant results for the relationship of estimation accuracy on corporate performance.

g) *Lack of quality checking of results:* Most authors neglected to check their results for statistical significance and freedom from bias. Carter and Williams (1958), for example, did not check their result of equal distribution of over- and underestimation for statistical significance. Furthermore, in the existing empirical research on estimation accuracy, the samples were not adequately checked for a possible non-response bias.[87]

h) *Lack of up to date studies:* Quite surprisingly, the review did not uncover any empirical study on planning accuracy for the 1990s.[88] Furthermore, while planning accuracy in capital expenditure management was conducted predominantly by researchers from the U.S. from the 1950s to the early 1980s, interest in the topic waned in the late 1980s and 1990s. The last U.S. study to deal with the topic was conducted by Pruitt and Gitman (1987). Since then, no further investigation of planning accuracy in capital budgeting has taken place in North America. Similarly,

when excluding the anecdotal evidence of Pieroth (2002) and Weber, Linder and Spillecke (2002), the only recent study at all is the one by Lazaridis (2002).

## *5. Conclusions and implications for future research*

The review of the existing empirical evidence on errors and biases in capital expenditure project forecasts yields two rather unpleasant results:

Firstly, the review of empirical evidence from the past 50 years showed that most studies discovered deviations between forecasted and realized values. Furthermore, a large number of the studies found that these deviations resulted not from bad luck or pure random influences, but from one-sided (optimistic) biasing of forecasts. This calls the traditional assumption of freedom from biases into question. In fact, over-optimism is a relevant problem in capital expenditure project forecasting, and one that merits more research effort.

Secondly, the review yielded a mixed picture about the existing empirical studies. In fact, empirical research in this field is characterized by unsatisfactory sampling procedures and sample sizes, possible respondent biases, unsophisticated data analysis, a lack of analysis of different types of capital expenditure projects, an absence of checking of results for accuracy, a dubious time period used for calculating actual values, a questionable test for a relationship between forecasting accuracy and company performance, and a general lack of up to date research. The *status quo* of empirical research on forecasting accuracy, therefore, is rather crude. A more thorough empirical investigation of the existence, direction and magnitude of discrepancies between planned and realized values on the one hand, and their impact on overall company performance, on the other, is a prerequisite for future research dealing with the reasons of these biases in order to overcome or at least minimize them.

The results of this review point to three major areas of future research. Researchers should explore more through the existence, direction and magnitude of discrepancies between planned and realized values and the impact of these deviations on corporate performance. Using this knowledge, researchers could search for the reasons that led to the forecasting errors and biases. Agency theory, game theory and theories drawn from the behavioral sciences, for example, might be fruitful avenues for determining the causes of the misestimates. Since, research in business administration has the ultimate objective of improving companies' performance, a third arena for future research would be the development of concepts and tools that will reduce the biases and errors in capital expenditure estimates. Pre-approval reviews and post-completion audits, can lead to an increased work effort and individual and collective learning effects.[89] These, in turn, may allow for better future planning, and make it possible to curb forecasting inaccuracies.

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1 Cf. Charles F. Carter and Bruce R. Williams, *Investment in Innovation*, Oxford University Press, London, U.K., 1958, p. vii; P. Lilleyman, "Capital Budgeting: Current Practices of Australian Organizations," *The Australian Accountant*, Volume 54, 1984, p. 130.

2 See for example Joel Dean, *Capital Budgeting*, Columbia University Press, New York, NY., 1951; Horst Albach, *Wirtschaftlichkeitsrechnung bei unsicheren Erwartungen*, Westdeutscher Verlag, Cologne, Germany, 1959; Pierre Massé, *Le choix des investissements: critères et méthodes*, Editions Dunod, Paris, France, 1959; George Terborgh, *Business Investment Management: A MAPI Study and Manual*, MAPI, Washington, D.C., 1967; Klaus Lüder, *Investitionskontrolle*, Gabler Verlag, Wiesbaden, Germany, 1969; Robert W. Scapens and J. Timothy Sale, "Performance Measurement and Formal Capital Expenditure Controls in Divisionalized Companies," *Journal of Business Finance & Accounting*, Volume 8, 1981, Issue 3, pp. 389-419.

3 While this process outlines the theoretically necessary steps or sub-processes in the capital expenditure process, a capital expenditure process may not always strictly follow the above described sequence in practice. Some of them may overlap each other, some others might to have been run through several times. See also Eberhard Witte, "Phasen-Theorem and Organisation komplexer Entscheidungsverläufe," *Zeitschrift für betriebswirtschaftliche Forschung*, Volume 20 (new series), 1968, pp. 625-647. The 12 step process described nevertheless facilitates theoretical analysis of the capital expenditure process. For alternative process schemes see e.g. Chandan Gurnani, "Capital Budgeting: Theory and Practice," *The Engineering Economist*, Volume 30, 1984, Number 1, p. 36.

4 Cf. e.g. Paul King, "Is the Emphasis of Capital Budgeting Theory Misplaced?" *Journal of Business Finance & Accounting*, Volume 2, 1975, Issue 1, p. 70; Ioannis T. Lazaridis, "Cash Flow Estimation and Forecasting Practices of Large Firms in Cyprus: Survey Findings," *Journal of Financial Management and Analysis*, Volume 15, 2002, Issue 2, p. 62.

5 Cf. e.g. Chandan Gurnani, 1984, p. 35.

6 See for example Dean, 1954; Albach, 1959; Terborgh, 1967; Lenos Trigeorgis, *Real Options: Managerial flexibility and strategy in resource allocation*, MIT Press, Cambridge, MA., 1996.

[7] C. Drury and M. Tayles, "UK capital budgeting practices: some additional survey evidence," *The European Journal of Finance*, Volume 2, 1996, p. 371.

[8] See for example King, 1975, p. 70; Masahiro Yamamoto, "Strategic Decisions and Corporate Governance in Japan," in: Vassilis Papadakis and Patrick Barwise (eds.), *Strategic Decisions*, Kluwer Academic Publishers, Dordrecht, The Netherlands, p. 147; Gérard Charreaux, "Introduction," in: G. Charreaux (ed.), *Images de l'investissement*, Librairie Vuibert, Paris, France, 2001, p. 1n.

[9] Cf. e.g. James C. Mao, „Survey of Capital Budgeting: Theory and Practice," *Journal of Finance*, 1970, May, p. 359; Edward W. Merrow, Kenneth E. Phillips, and Christopher W. Myers, *Understanding Cost Growth and Performance Shortfalls in Pioneer Process Plants*, Rand Corp., Santa Monica, CA, 1981, p. 29; George E. Pinches, „Myopia, Capital Budgeting and Decision-making," *Financial Management*, Volume 11, 1982, Issue 3, Autumn, p. 13.

[10] Cf. Mao, 1970, p. 359; Merrow et al., 1981, p. 29.

[11] It is of course acknowledged that it might seem more natural to start with an analysis of the idea generation step first and look at the forecasting phase later. However, since capital expenditure research is still focused on the evaluation phase, and since the evaluation methods typically assume unbiased capital expenditure forecasting data, the author preferred to have a critical look at this central assumption of capital expenditure evaluation methods (and capital expenditure research as well).

[12] This analysis extended over the *Academy of Management Review*, *Die Unternehmung*, *Harvard Business Review*, *International Journal of Business*, *Journal of Business Finance & Accounting*, *Journal of Cost Management*, *Journal of Management Accounting Research*, *Kostenrechnungspraxis*, *Management Accounting* (UK), *Management Accounting Quarterly*, *Strategic Finance*, *Review of Accounting and Finance*, *Review of Accounting Studies*, *Revue Finance Contrôle Stratégie*, *Zeitschrift für Betriebswirtschaft*, *Zeitschrift für betriebswirtschaftliche Forschung*, and *Zeitschrift für Planung*. Analysis started with first issue of 1980 of a journal or, in case the journal was founded later than 1980, with the respective first volume and issue of the journal. In all cases the journal review ended with the respective, most recent journal issue available in July 2004.

[13] In both cases keywords included in the research were "capital expenditure planning (accuracy)", "capital expenditure forecasting", "investment forecasting accuracy", "post-completion auditing", "post mortem", "capital expenditure management", "capital expenditure control" "forecasting accuracy", and "Prognosegüte", "Investitionsplanungsgüte", "Prognosegenauigkeit", "Hockey-Stick-Effect".

[14] Qualitative reviews are always subjective. However, as the vast majority of studies on forecasting accuracy does not provide the necessary quantitative input data for a meta-analysis and since it was the author's aim to provide as broad an overview as possible, relying solely on a qualitative summary of the studies' findings seemed acceptable.

[15] Cf. Joel Dean, "Measuring the Productivity of Capital," *Harvard Business Review*, Volume 32, 1954, Issue 1, p. 122.

[16] Cf. Carter and Williams, 1958, p. 89.

[17] *Ibid*, p. 90.

[18] *Ibid*, p. 90.

[19] *Ibid*, p. 90; cf. also p. 103.

[20] *Ibid*, p. 91.

[21] Cf. Fank H. Zoeller, "Procedures for Comparing Actual with Expected Economies from Equipment Replacement", in: Arthur Lesser Jr. (ed.), *Planning and Justifying Capital Expenditures*, Stevens Institute of Technology, Hoboken, NJ., 1959, p. 24.

[22] *Ibid*, p. 24.

[23] Cf. Erich A. Helfert, "Checkpoints for Administering Capital Expenditures," *California Management Review*, Volume 2, 1960, Issue 3, p. 97.

[24] *Ibid*, p. 97.

[25] Cf. Hans E. Scheffler, *Investitionen und ihre Wirtschaftlichkeit: Die Wirtschaftlichkeit der betrieblichen Investitionstätigkeit und ihre Prüfung*, C. Albrecht Verlag, Bremen, Germany, 1961, p. 170.

[26] Cf. R. B. Williams and W. P. Scott, *Investment Proposals and Decisions*, George Allen & Unwin, London, U.K., p. 64.

[27] Cf. Jaako Honko, *On Investment Decisions in Finnish Industry*, Oy Weilin & Göös Ab, Helsinki, Finland, 1966, p. 71.

[28] *Ibid*, p. 71.

[29] Cf. Terborgh, 1967, p. 259n.

[30] John H. Kempster, *Financial Analysis to Guide Capital Expenditure Decisions*, Research Report No. 43, National Association of Accountants, New York, N.Y., 1967, p. 80.

[31] Joseph L. Bower, *Managing the Resource Allocation Process: A Study of Corporate Planning and Investment*, Harvard Business School Press, Boston, MA, 1970, p. 12.

[32] *Ibid*, p. 13.
[33] *Ibid*, p. 13. He traces this lower discrepancy between expected and realized values back to an easier estimation of cost reductions in comparison to a more difficult forecasting of prices and volumes sold (p. 20n).
[34] Cf. E. Eugene. Carter, "The behavioral theory of the firm and top level corporate decisions," *Administrative Science Quarterly*, Volume 16, 1971, Issue 4, p. 416-418.
[35] See Ross Henderson, "Improving the Performance of Capital Project Planning," *Cost & Management*, Volume 45, 1971, September-October, p. 34.
[36] *Ibid*, p. 35.
[37] Ray D. Dillon, *An Empirical Evaluation and Extension of the Postaudit of Capital Expenditures*, D.B.A dissertation, Texas Tech University, 1974, p. 89.
[38] *Ibid*, p. 89.
[39] Cf. Jaako Honko and Kalervo Virtanen, *The Investment Process in Finnish Industrial Enterprises*, Helsinki School of Economics, Helsinki, Finland, 1975, p. 108.
[40] *Ibid*, p. 108n.
[41] Kenneth M. Viafore, *A Survey of Capital Expenditure Procedures and Practices in Industry: Their practical application and effectiveness*, dissertation, Stanford University, 1975, p. 148.
[42] Richard W. Van Vleck, C*apital Expenditure Practices in Large American Corporations*, doctoral thesis, School of Government and Business Administration, The George Washington University, 1976, p. 200.
[43] *Ibid*, p. 201.
[44] *Ibid*, p. 201.
[45] *Ibid*, p. 202.
[46] *Ibid*, p. 203.
[47] *Ibid*, p. 202.
[48] *Ibid*, p. 205.
[49] *Ibid*, p. 208.
[50] *Ibid*, p. 209.
[51] *Ibid*, p. 214 and p. 219.
[52] *Ibid*, p. 38. The interval of plus or minus one standard deviation amounted to 85-101 percent of actual costs.
[53] Edward W. Merrow, Kenneth E. Phillips, and Christopher W. Myers, *Understanding Cost Growth and Performance Shortfalls in Pioneer Process Plants*, Rand Corp., Santa Monica, CA., 1981, p. 38.
[54] *Ibid*, p. 36.
[55] *Ibid*, p. 50.
[56] *Ibid*, p. VI.
[57] *Ibid*, p. VI. Cf. also p. 68n for details.
[58] *Ibid*, p. 71.
[59] Jaako Honko, Aatto Prihti and Kalervo Virtanen, *Critical Areas in the Capital Investment Process of Enterprises: A Study of the Success and Failure of Strategy and Capital Investments in the 30 Largest Finnish Industrial Enterprises*, The Helsinki School of Economics, Helsinki, Finland, 1982, p. 99.
[60] Unfortunately their study focuses only on unsuccessful investments (investment failures) and does not cover investments which just fell short off the initial plans. Therefore, their results do not lend themselves readily to any comparison with other studies in this article, particularly since they do not define exactly the term "investment failure".
[61] Honko, Prihti and Virtanen, 1982, p. 117.
[62] Cf. Jasper H. Arnold III, "Assessing capital risk: you can't be too conservative," *Harvard Business Review*, 1986, September-October, p. 113.
[63] Philip Bromiley, *Corporate capital investment: A behavioral approach*, Cambridge University Press, Cambridge, U.K., 1986, p. 126.
[64] *Ibid*, p. 129.
[65] Cf. also Bromiley, 1986, p. 129 for this point.
[66] Cf. Stephen W. Pruitt and Lawrence J. Gitman, "Capital budgeting forecast biases: Evidence from the Fortune 500," *Financial Management*, Volume 16, 1987, Spring, p. 47.
[67] *Ibid*, p. 49.
[68] *Ibid*, p. 49.
[69] Cf. Juergen Weber, Stefan Linder and Dennis Spillecke, "Stand der Planung und Kontrolle betrieblicher Investitionen," *Kostenrechnungspraxis*, Volume 46, 2002, September-October, p. 294.
[70] Cf. Guido Pieroth, "Zum Umgang mit Irrationalität – ein Erfahrungsbericht," *Kostenrechnungspraxis*, Volume 46, 2002, November-December, p. 344.
[71] Cf. Lazaridis, 2002, p. 67.

[72] Whether or not the observed deviations of actual values from expected ones are due to faulty planning or improper implementation can, of course, be discussed: "it is not necessarily possible to distinguish between errors of estimation and errors of implementation. It is always possible when the initiator and the implementor are not the same, to argue that the estimate was all right but that the person who implemented the project did a poor job." (John M. Boersema, *Capital Budgeting Practices including the Impact of Inflation*, CMA, Toronto, 1978, p. 36). The author's argument would be to consider all of them as planning errors, since "good" capital expenditure plans should take internal factors (like the company's ability to implement a certain project) just as much into account as external factors.

[73] Cf. e.g. the studies by Dean, 1954; Carter and Williams, 1958; Zoeller, 1959 or Merrow, Phillips and Myers, 1981.

[74] See for example the studies by Helfert, 1960; Henderson, 1971; Van Vleck, 1976 or Merrow, Phillips and Myers, 1981.

[75] Furthermore, it is impossible to determine based on the existing evidence whether this over-optimistic one-sidedness is the result of explicit manipulation of data or rather a consequence of some implicit (unplanned) way of thinking or some human cognitive biases.

[76] For the purpose of the research topic in question, sample sizes of less than 50 companies will be considered too small to yield valid results. The only two exception to this rule will be made for the Finnish studies due to their high response rates, thereby allowing for a good representation of the total of the roughly 50 large Finnish enterprises and for the study by Merrow, Phillips and Myers (1981) due to its focus on just one industry, which is – according to the authors – represented quite well by their study (cf. Merrow, Phillips and Myers, 1981, p. 21n). However, it is evident that larger sample sizes (i.e. 100 to 400 firms) will typically lead to much more reliable results and smaller error percentages (i.e. higher confidence levels).

[77] See e.g. Thomas Klammer, "Empirical Evidence of the Adoption of Sophisticated Capital Budgeting Techniques," *The Journal of Business*, Volume 45, 1972, July, pp. 387-397, who surveyed 184 firms; Suk. H. Kim and Edward J. Farragher, "Current Capital Budgeting Practices," *Management Accounting (U.S.)*, Volume 62, 1981, June, pp. 26-30, who collected responses from 200 companies; Roger W. Mills, "Capital Budgeting – The State of the Art," *Long Range Planning*, Volume 21, 1988, Issue 4, p. 76-81, whose study is based upon 131 group accounting respondents and 216 divisional respondents; Thomas Klammer, Bruce Koch and Neil Wilner, "Capital Budgeting Practices – A Survey of Corporate Use," *Journal of Management Accounting Research*, Volume 3, 1991, Fall, pp. 113-130, that analyzed one hundred companies.

[78] See also Merrow, Phillips and Myers 1981, p. 20; Honko, Prihti and Virtanen, 1982, p. 7: "The idea has been put forward in various connections that problems concerning the success or failure of capital investments and their background factors cannot be studied empirically at all, because of the delicate nature of the questions and the difficulty of obtaining material, among other reasons. The almost complete lack of studies, even when viewed internationally, dealing with this group of problems only goes to confirm this idea."

[79] Cf. Bromiley, 1986, p. 129: "Surveys of investment plans that direct their questions to a treasury official may obtain the results from the finance plan, which is normally more conservative than the general management assumptions of the firm. Alternatively, different surveyors might address their questionnaires to different functions in the corporation and so obtain different answers."

[80] Further support to this impression lends an *ad hoc* inquiry by the author at five small- and medium sized German manufacturing companies. These enterprises, which had on the average 260 employees, gave answers consistent with those of Lazaridis (2002) when asked about their capital expenditure planning accuracy.

[81] Cf. Merrow, Phillips and Myers, 1981, p. 4, p. 50, and p. 71.

[82] It is assumed here that it is easier for the companies in an industry to change prices than to increase or decrease their work force, scale down their production facilities etc. It is, however, acknowledged that in some industries like petrochemicals the costs for inputs as oil or gas will often be very volatile, while revenues may be fixed due to fierce industry competition hindering any price changes.

[83] Carter and Williams, 1958, p. 89, mention this (possibly) weak spot of their survey.

[84] Cf. Robert N. Anthony, "Some Fruitful Directions for Research in Management Accounting," in: Nicholas Dopuch and Lawrence Revsine (eds.), *Accounting Research 1960-1970: A Critical Evaluation*, Center for International Education and Research in Accounting, University of Illinois, 1973, p. 47.

[85] Cf. Robert S. Kaplan and David P. Norton, *The Balanced Scorecard*, Harvard Business School Press, Boston, MA., 1996, p. 6n.

[86] The term "exceptional" is used here, since the two years were marked by tremendous economic changes like the switch over from fixed exchange rates to quasi free-float from January to March 1973 and the first oil crisis in 1973/1974.

[87] The so- called non-response bias is caused by (possible) differences between respondents and non-respondents in empirical studies, which limits the overall representativeness of the results obtained from the

respondents. For a detailed description and testing methods see J. Scott Armstrong and Terry S. Overton, "Estimating Nonresponse Bias in Mail Surveys", *Journal of Marketing Research*, Volume XXIV, 1977, August, p. 396-402; David A. Aaker, V. Kumar and George S. Day, *Marketing Research*, 6th edition, John Wiley & Sons, New York, N.Y. 1998, p. 219n.

[88] However, the fact that in 1994 a joint committee of German practitioners and researchers was set up to develop ideas and procedures for reducing biases in capital expenditure proposals, points to the existence of some errors or biases in these proposals during the early 1990s. Otherwise, if there were no problems with the accuracy of capital expenditure plans, it would seem rather hard to imagine that practitioners from ten large German corporations would have joined the committee. For details on the joint project see Arbeitskreis 'Finanzierung' der Schmalenbach-Gesellschaft, "Investitions-Controlling – Zum Problem der Informationsverzerrung bei Investitionsentscheidungen in dezentralisierten Unternehmen," *Zeitschrift für betriebswirtschaftliche Forschung*, Volume 46 (new series), 1994, p. 899-925.

[89] Cf. e.g. Lüder, 1969; Boersema, 1978, p. 35; Ray Dillon and James C. Caldwell, "A System for Postauditing Capital Projects," *Managerial Planning*, 1981, January-February, p. 30; Gurnani, 1984, p. 39.