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The Bass Diffusion Model as a Basis for Investment Decisions

Philipp Duscha[1], Vida Davidavičienė[2]
[1]Department of Business Administration, especially innovation and financial management, Faculty of Business, Otto-von-Guericke University, Magdeburg, Germany
2Department of Business Technologies, Faculty of Business Management, Vilnius Gediminas Technical University, Vilnius, Lithuania
E-Mail: [1]philipp.duscha@gmail.com; [2]vida.davidaviciene@vgtu.lt

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Abstract: This study explores previous research studies in the area of the diffusion theory and under this issue, the importance for any investment decision. Moreover, it is shown how a decision-maker on the basis of the product life cycle of an innovation, and the diffusion curve can make a decision based on investment NPV. It will be explained which particular significance the diffusion process on an investment NPV has. To involve investment risks, the Real Option theory was used for the NPV. The paper firstly defines the central theories of issues. Furthermore, the studies are analysed on set criteria on the background of the influence of factors. For the analysis, the literature of the different areas of expertise was systematically examined and evaluated according to the set criteria. The factors identified in this paper show that the innovation and imitation coefficient, initial purchases, investment amount, and time of investment have the greatest effect on an investment. Furthermore, the shown decision path enables a reduction of investment risk and a higher planning flexibility.

Keywords: diffusion process, Bass model, product life cycle, innovation, investment decision, real option, optimal investment behaviour, net present value.

1. Introduction

Innovations can be found in the fields of economy, politics, society and science. An indicator for measuring the innovative development of an economy or a business is the number of registered patents. Germany notified in the field of Technology during the 2014 the most patents with 32,000 patent applications. Germany is therefore compared with other European countries far ahead of the second place France (Bundesgerichtshof, 2015). The company with the highest spending on research and development (R & D) in the international ranking was the Volkswagen Group , with R & D expenditure of 11.4 billion US dollars (Booz & Company, 2014).

But what happens after the R & D process with the new technologies and innovation? Imply the new findings for a company economic success they will be introduced innovations in the market. Raymond Vernon published in 1966 his theory for the course of the product life cycle, which describes a function of time and sales, as developed a product on the market. Frank M. Bass illustrated a few years later with his work in 1969 to the diffusion theory, how is it mathematically possible to estimate the market development with reference to the original purchaser of innovative products. Rogers extended the diffusion model in 1983 and did more on the aspect of innovation of the whole diffusion process. This development in the market is decisive for success or failure of the product or even the entire company.

As a consequence companies are faced with far greater tasks relating to the launch and the phase-oriented course of the product life cycle. In this context, companies need to make investment decisions again and again. A theoretically based approach for this is the Real Option theory, which takes into account not only the performance of an investment, depending on the cost, but also fluctuating market risks in the review involving such which was shown by Dixit and Pindyck in 1994. Another basis for decisions on an investment represents the net present value (NPV) method. This theory is mostly used in practice.

In literature different explanations can be found, which affects an investment decision. This paper focuses on the impact of the diffusion of products during an investment decision in a company. The basis for decision is in general based on the classic NPV method, but it is rather carried out using the Option theory. In contrast to standard valuation techniques such as the NPV method, the Real Option analysis tries to take account of the changes of the risk during a project, and that the undertaking has the opportunity to respond. This is in direct context of diffusion theory, since the combined techniques provide a more accurate value and thus provide a more accurate basis for decisions on investments. Therefore, this theory provides the company a fortuitous planning flexibility and deviates from the results of the classic NPV method.

From this background, the aim of this paper is to describe a mathematical decision path, which gives the decision makers of a company more planning certainty and involves investment risk in the underlying decision aid. This decision aid should serve using only one formula to make that decision based on the NPV. To derive this mathematical formula, first the relevant literature was analysed on the participating disciplines according to the list of criteria and defines and interprets the key issues. Furthermore, an attempt was made based on the acquired expertise to derive a mathematical fact. Afterwards a discussion was carried out, which aimed to identify relevant factors that might influence the investment decision in a company, in connection with the diffusion of innovative products and services.

In this manner, a method for decision-making basis of investments has been cre-

ated, with which it is possible to carry out a forecast of the underlying NPV, and to make an investment decision by using the properties of the NPV. This paper will focus on this background with the following question: Does the diffusion of products affect the optimal investment behaviour of decision-makers in a company? It will be shown, which factors on the basis of this new Decision Methods influence an investment decision.

In the first part of this paper, the model of the product life cycle will be presented and a determination of the innovation concept is made. Further, the theory of diffusion described and carried out the mathematical formulation of the Bass diffusion model under this point of view. In addition, a brief definition of the Option theory is performed. In the middle section the methodological approach for this work is described. In the last section, the value-based development and the investment behaviour of decision-makers, including the real option theory is considered in the context of the product lifecycle, which is closer concluded.

2. Methodical Approach

The following chapter will provide an overview of the methodological approach and the resulting selection of literature corresponds to this paper. Moreover, are to be determined factors that affect the investment behavior.

Approaches Influencing Investment Decisions

An investment decision is a binding agreement about which the investment project is to be realized. Thus an investment decision is not an arbitrary act, but presents a certain extent the result of a planned designed problem solving process. The result of an investment decision is determined by a various number of factors, for example, by the oriented to corporate goals investment purposes, by personal characteristics of the decision-makers and by the information available on the project. The investment decision is preceded by a decision-making process. These decisions are forward-looking and therefore are generally based on data that are subject to uncertainty (Al-shammari & Masri, 2015).

The main factors influencing the investment include interest, the current income and current production and future expectations of investors (Kumar & Lim, 2008). Investments are funded from depreciation counter values. Only when the investment is greater than the depreciation, there is an increase in the capital stock (Žižlavský, 2014). In this study, it is primarily of interest which influence the product diffusion to the investment decision has. It will be shown that the diffusion follows the cash flow development, and thus has a direct impact on the investment. Premachandra (2004) has already been shown that the diffusion has a decisive influence on the cash management of an enterprise. DeFond and Hung (2003) has further shown how it is possible by a simple calculation of the diffusion, to calculate the cash flows of a

company.

The cumulated and discounted cash flows are the bases for the NPV calculation and the thereon based investment decision. To carry out the calculation more accurately, the risk is to be included. Pringles et al. (2015) show how it is possible to calculate the NPV by a simulation based on the Real Options Theory. Moreover demonstrated Lukas and Welling (2014) how the real options theory is connected to the game theory and how it is possible to derive in this situation the NPV. Now should be included using the real options theory a cash flow forecast based on the diffusion model.

Investment decisions will affect the company's development sustainable. Due to the associated long-term capital commitment, investment decisions are ahead of most correctable only at the expense of considerable financial disadvantages. By investing an increase in fixed costs of the company is connected, whereby the employment risk increases. The disclosed method should, in the long term, reduce the investment risk for a company

Conceptual Framework and Critical Review Criteria

First, the aim of the literature review is to identify factors that drive the optimal investment behavior in general. For the selection step, used the following method was used. First, a keyword search was conducted for articles that contained to the topic and all sub criteria. Next, the full articles were assessed whether diffusion or investment decisions on the base of the NPV were their central subjects. If this criterion was not satisfied for a given article, that article was not maintained for the final review analysis. Inclusion criteria for each paper were as follows: (1) includes or explores the drivers of diffusion, (2) focuses on diffusion and investment processes and not on general or solely on drivers of investment decision based on the NPV. This set of publications was then critically appraised and evaluated, with a focus on identifying factors that positively affect investment decision in companies. Furthermore, not only central factors should be identified, but also the central models of the subject areas, as well as the pioneer of the individual subject areas. Based on this research, the central models have been analysed and interpreted, and considered further developments and review of existing models more accurate. It was then attempted to summarize the various theories and models in a mathematically formula. After this final step, the factors identified in the literature search with the influencing factors in the formula were compared and evaluated. Subsequently the findings were compared with the existing research question and discussed.

Diffusion in the Product Life Cycle of innovative Products

The decision maker of a company is in accordance with the development of a new product in the situation to make a decision. They must decide to continue to invest in the product and introduce it to the market or to cease further research and devel-

opments. The following subchapter will clarify involves defining the concept of the product lifecycle, innovation and the diffusion.

The Product Life Circle and the Role of Innovations

The product life cycle is an ideal-type model, which represents the sales development of a product over time. In this context, the development of profits is shown. One of the founders of the model was the scientist Raymond Vernon, who published his theory on this topic in the year 1966th. The relation, shown in the model, has an S-shaped curve, and can be divided into various phases. This ideal typical course is due to the diffusion and adoption of innovations in a social group (Aumayr, 2006). The graphic below shows the S-shaped curve of the product life cycle.

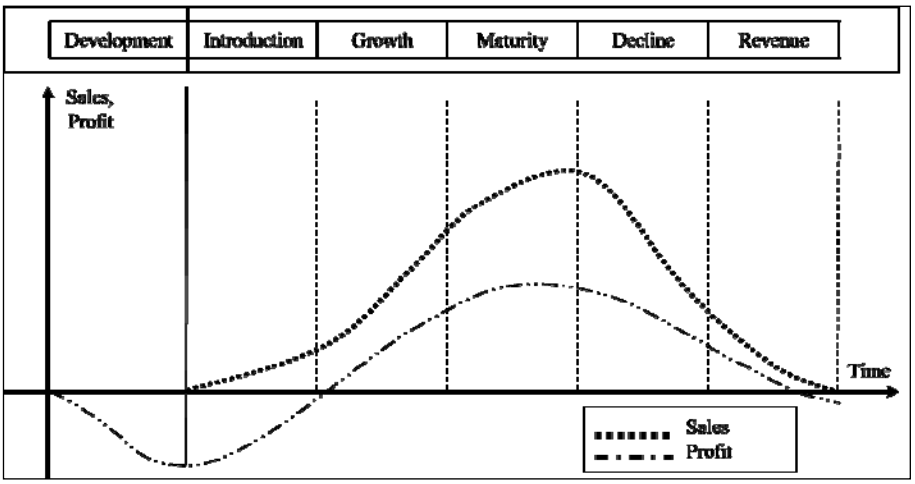

Fig. 1. Phase model of the product life cycle. Prepared by Aumayr (2006, p. 283).

As can be seen in the figure, the curve is divided into six phases. Overall, the performance and the expression of the phase are subject to uncertainty. The company is striving by forecasting methods to minimize the uncertainty in which they are estimated the curves. This is primarily for direct investment of great importance, as this example, the optimal investment timing is determined and thus the risk of default for investors can be minimized.

The stages of the product life cycle have, depending on the product and market, different expressions and timings. Due to the exact phase identification, it is possible to coordinate the financial management more efficient and to make investment projects targeted. The company may use the financial instruments phase accurately and maximize profits and thus minimize the investment risk (Aumayr, 2006).

Closely related to the product life cycles, and the thereby associated diffusion process, are innovations. Innovations are at each beginning of a new incipient product life cycle. Therefore, innovations are for new products or services that will be

introduced on the market. In the literature diverse definitions due to various differentiation possibilities of the concept of innovation can be found. As one of the foremost researchers in the field of diffusion and innovation theory is Everett M. Rogers. He defined innovation as follows: „An innovation is an idea, practice or object that is perceived as new by an individual or other unit of adoption (Rogers, 1983, S. 11)."

The above definition suggests different approaches that may lead to the emergence of an innovation. An innovation is generally subject to a technical change, which is attributable to the application of new technologies. In order to segment the innovation of market and corporate vision, they can be differentiated about the type, the source and the change extent (OECD/Eurostat, 2005). As you can see, the differentiation of the innovation concept is carried out via four dimensions. These dimensions influence different market acceptance on the demand side or the corporate strategies on the supply side. The underlying new generation can take place both on producer or consumer level or at two levels. The innovation process can therefore be summarized as the totality of all R & D activities and the associated launch and market acceptance. If the innovation accepted in the market is being built on the consumer level, a new and personal benefits increase. The increase in utility or benefits fall to corporate level can be estimated only after the market launch. To perform this estimate, however, the need of other methods is required.

3. Explanation of the Bass Diffusion Model

In the previous chapter it was explained how after an innovative development process after the launch of the product arise a product life cycle. In the following chapter the diffusion process is represented, in order to explain how the idealized course of the curve is produced.

Determining the Process of Diffusion

The diffusion is the process of the dissemination of an innovation through different communication channels in a social system. In these channels, new information will be created or shared in order to create a mutual understanding of the innovation by the participants in the system. This understanding is necessary, because the process of market launch is characterized of uncertainty for market participants and the flow of information will reduces this. This contributes, among other things, also to the fact that the innovation will not be accepted by the market participants at the same time but at different time (Rogers, 1983).

The aim of the diffusion model is to describe the market spread of innovation from the beginning of the introduction by the amount of potential users over the time. Using the Bass diffusion model the time of adoption of the individuals can be determined in the market. It is one of the most famous models to describe product

growth and will still often used in a modified form of application. Due the calculations it is possible to derive the product life cycle. Thus, the diffusion theory forms the interface between the innovation and its related development by the market acceptance within the product life cycle (Mahajan & Muller, 1979). The adoption describes the process of first contact of potential buyers with the innovation. Altogether this process includes the first contact between the innovation and the buyer, as well as acceptance and purchasing the product (Rogers, 1983).1 The diffusion process is therefore the totality of all adoption processes. The graphical representation is shown in Figure 2.

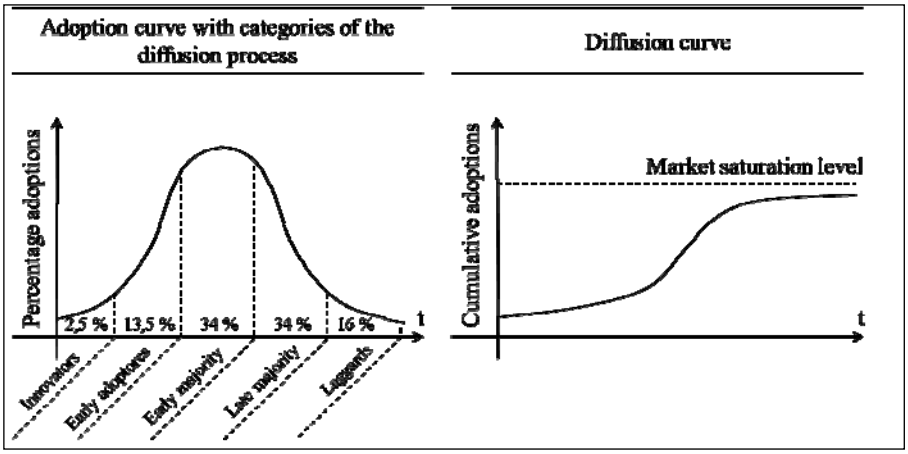

Fig. 2. Adoption and diffusion curve in comparison. Prepared by Hensel and Wirsam (2009, p. 33) and Rogers (1983, p.247).

The diffusion curve represents the cumulative adoption processes over time, as seen in the figure above. The adoption curve, however, specifies the time of adoption of innovation again and represents the typical course of total diffusion process. The diffusion process can be further divided into a time competent. This describes, in terms of time at a specified interval, as long as the individual players in the market need to adopt the innovation. For this situation the speed of the adoption process can be derived and a time horizon for the product life cycle is defined. This means for the product life cycle, that the diffusion indicates the distribution of sales over time (Hensel & Wirsam, 2009). The time of acceptance can be characterized by five customer groups: 1st Innovators; 2nd Early adopters; 3rd Early majority; 4th Late majority and 5th Laggards. The aforementioned groups are sorted by the time of product acceptance. They represent customer groups differs in their income, their interest in innovations and their position in the social network and the associated

[1] The acceptance or rejection is preceded by a process which is designated in the literature as the innovation decision-making process. It is divided into knowledge-, persuasion-, decision-, implementation- and confirmation phase. For a detailed description of these phases, see: Rogers, E.M., 1983. Diffusion of Innovations, 3rd ed., New York: Free Press, pp.163-206.

therewith access to information (Rogers, 1983).

Explanation of the theoretical Approach of the Bass Diffusion Model

The Bass diffusion model assumes that there are market actors who accept innovations independent of external influences from their own inner impulses. This group is referred by Bass as the innovators. The compulsion to purchase is determined in this group of buyers not by the increasing constraint, but due to increasing buyer numbers. This is quite different with the buyer group 2 to 5. They are driven by compulsion just described to adopt the product and ultimately to buy. They are called imitators.2 According to the calculations of Bass the innovators are the first 2.5 percent of buyers, the remaining 97.5 percent will be determined by the imitators, like shown in Figure 2 (Bass, 1969).

To make a formulation of the theoretical facts of the case, (Bass, 1969) made some basic assumptions, on which is oriented in the following explanations. The classical diffusion model assumes a normal distribution density function that results in the graph to the bell-shaped form. Given the likelihood that a new purchase is made at time t, and up to this time, no purchase was made yet, current buyers are a linear function of the following form:

$$P(t) = p - (q / M) * Y(t). \quad (1)$$

This formula represents the number of initial purchases by the innovators. The overall market is designated by M. $Y(t)$ is the number of previous buyers. The coefficient p indicates how many adoptions were made by innovators and is also known as innovation coefficient. The product $(q / M) * Y(t)$ represents the number of purchases by the imitators, where q is called the imitation coefficient (Bass, 1969). In order to derive the entire diffusion equation, the likelihood of the purchases will be at time t, assuming that no recent purchases were made formed in the next step:

$$[f(t)]/[1 - F(t)] = P(t) = p + (q / M) * Y(t) = p + q * F(t). \quad (2)$$

For the probability of purchase at the time t and the hypothesis that $F(0) = 0$ applies $F(t) = \int_0^t f(T)\, dT$. If we now form assuming that t the final moment of the interval is and m the number of sales in that period, the density function over the period $[0, t]$ makes the integral and solves this product, you get the Bass diffusion equation and therefore the entire first demand in this period (Bass, 1969):

$$N(t) = p * M + (q - p) * Y(t) - (q / M) * [Y(t)]^2. \quad (3)$$

By the Bass diffusion model it is possible to reduce the uncertainty of investment decisions, since it permits a forecast of the market situation. A forecast is only pos-

[2] *„Imitators are influenced in the timing of adoption by other members of the social system (Heller & Hustad, 1980, p. 1).”*

sible using historical data sets and the estimation of the innovation and imitation coefficient and the market potential. The market potential remains in forecasting a constant magnitude and does not change over time. By regression analysis it is possible to estimate these parameters. The temporal distribution of the predicted initial purchases now forms the diffusion curve. Especially in marketing and product launch with a high degree of innovation will make use of the model. Companies can make such an estimate of the sales planning and coordinate financial policies with respect to the curve and of the market penetration of the product efficiently.

Value-based development and optimal investment behavior

In the previous chapters the product life cycle of an innovative product and the related development of sales already been examined in more detail. In the following, the value-based development is to be examined more closely, depending on the previously examined facts and this context, the real option theory are introduced as a decision tool for investing.

4. The Relationship between the Diffusion Model and an Investment Decision

In the previous chapters, the mathematical derivation for forecasting of first sales was explained. Well, shall be determined by this model, the expected value of the total demand. For the mathematical calculation of the initial sales will be descripted by x_t. Furthermore, must the logistic diffusion curve be used, to calculate a continuous time series with the diffusion model. This formula has the following form (Simon & Sebastian, 1987):

$$x_t = \frac{\overline{N}}{1 + \frac{\overline{N} - A_0}{A_0} * e^{-\alpha * \overline{N} * t}} \quad (4)$$

With formula (4) can now the number of initial sales at time t under estimate the growth rate α and the estimation of the initial stock A_0 calculate. It is assumed that the initial stock represents the buyer who bought a product before the observation date. $\overline{N}$ in this case represents the remaining potential buyers. With the described formula, it is possible the cash flows of the company over time to determine. It is assumed that the company has in the interval considered constant variable costs of production c and constant prices p in each period. In addition, no fixed costs incurred. To obtain the actual sales in the period under must be x_t deduced by t. For the cash flow CF of the first sales at time t, the function has the following form:

$$CF(t) = \left[\frac{\bar{N}^2 (\bar{N} - A_0) e^{-a\bar{N}t} a}{\left(1 + \frac{\bar{N} - A_0 e^{-a\bar{N}t}}{A_0}\right)^2 A_0} \right] (p - c). \tag{5}$$

Through historical data of an industry or product type, the parameters of the formula can be estimated by a regression analysis. A market analysis of the price and the cost can be determined. Now it is possible to calculate the company's initial purchases and product life. Then the lifetime and returning cash flows from production can be determined.

The diffusion process is responsible in his basic idea on an innovative step at the product level. The associated R & D process represents the first investment in the product for a company. The following development within the product life cycle is characterized by uncertainty with respect to the sales figures and market acceptance. This development makes a significant impact on production planning, which represents the second investment for the company. A result of the forecast by Bass diffusion model, this uncertainty can be reduced because as the adoption timings and the associated initial purchases may be allocated to the individual product life phases. The cash flow forecast provides the company planning flexibility with regard to financial management, production planning and related corporate capacity and sales volumes. The empirical life can be determined as well. In this context, the market saturation level and the diffusion curve can be determined by the cumulative adoptions to determine, for example, the time for a change of product. Until this change, the company needs to invest in the current production.

The Option to Investment and the Product Life Cycle

The real option theory is concerned with the determination of the favorability of projects where an investment is necessary. The possibility of investing gets thereby an option character, similar to the valuation of stock options. The option theory consists in that an investment in this stage, to a later or not at all can be realized. Under the consideration of these possibilities and fluctuating market risks that may relate to changes in the tax situation, price volatility or price fluctuations, the cost of the project will be formed depending on the sunk costs and the returns from the project. This is in contrast to the decision-making basis of the net present value method, in which applies the simple decision rule: is the net present value greater than zero - then invest (Dixit & Pindyck, 1994).

Within the product life cycle stages from a business perspective can be tracked different objectives. During the induction phase the objective is focused on the implementation of the first purchases, whereas in the growth phase, the primary goal is to gain market share. In the maturity stage and phase of decline the focus is on prof-

it optimization and finally the revenue phase, reduce costs (Aumayr, 2006). The performance in each phase behaves in the optimal case proportional to the development of paragraphs. The development, however, could be determined by the different target tracking in phases. The real option theory in this case represents an important instrument to coordinate on investment in relation to the objective relations in the individual phase's optimum.

Basically, it is assumed that the company wants to maximize its NPV over time. The net present value is primarily on the development of cash flows and the discount rate, which is determined by the internal rate of return. So in order to maximize the NPV the sum of all quotients of cash flow and discount rate are maximized (Wiesemann et al., 2010).

Thus, the value of an investment in the context of the capital value maximization can be determined, first, some assumptions must be made. The investment is regarded as final. Furthermore, the company has always waiting option and to make the investment to another time or not at all in order to gain better market information and thereby reduce the resulting opportunity costs. The NPV usually not considered this possibility. Because is valid invest when the NPV is dependent on its cash flows greater than its costs. The opportunity costs are not considered here, but they would be part of the investment costs (Dixit & Pindyck, 1994).

To determine the value of the investment, the investment costs I be maximized depending on the value-based development of the project cash flow. The performance of the project is dependent on the development of cash flows. This cash flow development follows a geometric Brownian motion and is afflicted in the empiricism with high uncertainty. The expected value of the project at the time T as part of the geometric Brownian motion, so results from the maximizing the difference of CF_T and I multiplied by the exponential of Brownian motion that is a function at the time t and the discount rate ρ. To make a determination of the project value, hereinafter the uncertainty σ is the Brownian motion neglected. First, however, must be the integral of the function $dCF = \alpha * CF\, dt$ be formed within the limits of CF_0 and CF from 0 to T. Now we get the value growth of the project function of the form $CF = CF_0 * e^{\alpha t}$, α here describes a coefficient of Brownian motion. Afterwards the integral within the limits from 0 to T must be formed. A primitive function newly formed is now being used in the formula of the expected project value; we obtain the value of the option to invest in response to the development of the cash flows of the following form (Dixit & Pindyck, 1994):

$$F(CF_t) = (CF_t * e^{\alpha T} - I) * e^{-\rho T} \tag{6}$$

In order to generate continued growth and thus make NPV maximization, the formula can be taken that the cash flow development must be greater than the in-

vestment. The by formula (5) calculated cash flows can now be used in formula (6). Thus, the expected NPV depends not only from a simple cash flow estimate, but is subject to a precisely calculated diffusion curve, and takes into account the real options theory, the risk of the investment.

5. Discussion of the Determinates of Optimal Investment Behavior

Basically, the optimal investment behaviour of an undertaking depends by many factors. By a decision aid as the real option theory, the investment risk is however mitigated and investment behaviour can be approximated to the optimum, so that the NPV of a project and the company can be maximized. The choice of the optimal investment timing and volume of investment significantly contributes to this maximization. Dixit and Pindyck (1994) have shown how it is possible, the option to invest and additionally environmental risks, included in the calculation of the NPV. The option to invest and the environmental risk are the first factors influencing investment decisions.

Essentially, the investment decision depends in connection with the capital value maximization of the expected recoveries of the project, as they should promise a greater value than the investment over the planning period. The future value of the investment depends on the development of the cash flows that follow the course of the product life cycle, as this represents the ratio of sales over time of a product. With the Bass diffusion model (1969)and the model of Simon and Sebastian (1987) this future development of the paragraph on the basis of the initial purchases can be determined. The model depends largely on the innovation and imitation coefficients which are representative of the adoption of the two groups of buyers. The product diffusion and the associated initial purchases are thus more determinants.

The adoption process is highly uncertain and therefore difficult to estimate for the company. The acceptance of a product within a social system has significant influence on the future development of cash flows and thus on the value of the investment. It thus represents one of the greatest determinants of optimal investment behaviour.

Furthermore, the future cash flow development of the fixed and variable costs of production and the product price in the relevant period is affected. Logically, the level of investment has always been an influence on whether or not it should be invested. Therefore, it is of great importance for the company, this investment in terms of future cash flow development to put in the relation therefore to determine the optimal investment. Also, the optimal investment time within the product lifecycle helps to maximize the NPV of the project, thus creating long-term value for the company. The diffusion is therefore directly related to the optimal investment behaviour of decision-makers of a company, because they affect the future development of cash flow and thus act directly on the capital value of the project and devel-

opment of the company.

6. Conclusion

The diffusion process represents an initial purchaser model and describes the adoption timing of a product by the purchaser, as Rogers (1983) showed. With the Bass diffusion model (1969) it is possible to determine the adoption curve and the diffusion curve. In addition, it can be determined from this situation then the product sales over time and the market saturation level. Overall, the life cycle model from Raymond Vernon (1966) can derive precise and the sales, which are determined over time.

The sales trend is for the value-based development of the project and the whole enterprise of great importance. It was determined that of the NPV of the future development of sales and consequently also of the cash flows is dependent. Thus, if an investment decision made on the basis of the NPV maximization, the cash flow development is a direct influence size of investment decision. In terms of future cash flow development there is a strong uncertainty. Dixit and Pindyck (1994) have shown how it is possible to reduce this uncertainty and nevertheless to calculate a meaningful forecast. This is caused primarily by the adoption timing, which will be described in the diffusion model by the acceptance of innovators and imitators. An innovative product enhances the market uncertainty by the buyer also.

The diffusion of products has a direct impact on the sales development of a company and thus directly affects the value-based development and the investment decision related to it. In the context of the diffusion theory and the NPV developing of a business, it would be interesting for future research, in which relation the Innovation expression stands on the diffusion rate of a product. With this knowledge, the planning period of the product life cycle might be ahead of the launch influenced by the company so as to adjust the capital performance of the project to the planning horizon of the company.

Therefore, the result of this paper was that the investment behaviour of a company at a capital value-maximizing decision basis most influenced by the adoption and the resulting diffusion process. The diffusion of products has a direct impact on the investment behaviour since they directly affect the future cash flow development of the company and thus substantially contribute to the future development of the project NPV. The first part of the underlying research question is whether the diffusion influence an investment decision, can thus be affirmed. This influence is to be regarded as positive, as the company thus attempting a more precise planning of cash flows. In connection with the real options theory, the calculations become even more precise, because the investment risk is involved.

With the help of the Real Option Theory an informed NPV-based decision-making basis arises, that takes into account with regard to the future development of

market uncertainty and also different investment timings. So it is possible to find a function of the future performance of the project an optimal time to invest, which provide the company with more flexibility and planning security.

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