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## **REAL OPTIONS APPROACH AS A NEW VIEW OF INVESTMENT**

***Abstract:** The article presents a survey of recent theoretical, as well as empirical, contributions concerning the business investments, which help to understand the investment decision-making of the companies better. As shown, they emphasize the relevance of idiosyncratic factors affecting investment decisions such as the degree of irreversibility and uncertainty, whose interaction may generate an opportunity cost equivalent to the exercise of an option, and so they add an important dimension to the neoclassical theory of investment (also called standard or orthodox theory of investment). This theory has not recognized the important qualitative and quantitative implications of this interaction, which can explain some of its failures. We investigate the irreversibility of investments and the impact this has on the nature of the relationship between investment and uncertainty in a way of empirical analysis. The empirical analysis uses firm-level data and is based on a survey of 53 automotive suppliers, which was carried out during the year 2011. We find supportive evidence for the fact that uncertainty is negatively associated with planned investments of the companies surveyed, which remains true also in the presence of irreversibility. Finally, we demonstrate the core of the real options approach in a form of a practical example.*

**Keywords:** investment, uncertainty, irreversibility

**JEL:** D 81, D 92

### **Introduction**

It is generally known that companies, as well as other economic entities, make capital investments in order to create and exploit profit opportunities. Understanding the investment decisions of companies is perhaps the most important for economic policymakers, since fluctuations in investment activity are not without the consequences for the rest of the national economy. Especially nowadays, in times of economic recession, this issue is getting back to the forefront due to its relationship with the overall performance of the national economy and hence with the employment and growth.

However, despite its importance, investment behaviour of firms, industries and countries is poorly understood and conventional structural models of business investment offer only fragile support for explanation and prediction of changes in capital expenditures of companies.

This may reflect the fact that available models have ignored potentially relevant features of investment behaviour, namely that investment expenditures are often irreversible and may be delayed due to the uncertainty surrounding the evolution of prices, costs and other market conditions relevant for investment decisions.

The turning point was at the end of the eighties in the twentieth century, when several authors stressed the importance of the possibility that investments are irreversible and that it affects the relationship between the investment and risk (for example [1] [2][3] [4], etc.).

The article offers a number of valuable insights into how managers can evaluate opportunities, and it highlights a basic weakness of the standard net present value rule. Moreover, we present the results of an empirical analysis, by which we investigate the irreversibility of investments and the impact this has on the nature of the relationship between investment and uncertainty. The article also shows how to include the value of the real options into the calculations of the effectiveness of the projects in a form of a practical example.

The remainder of the paper is organised as follows. Section 1 briefly summarizes the theoretical background and is divided into two parts to highlight the difference between Orthodox theory of investments and Real options approach. Section 2 is dedicated to the results of the empirical studies concerning the issue as well as to the results of our empirical analysis. Section 3 is an application of the theoretical knowledge in the form of a practical example.

## **1 Theoretical Contributions**

### **1.1 The Orthodox Theory**

Investment decisions of firms depend on a large number of factors, one of which may be the extent of uncertainty about future events. Uncertainty may well be an especially relevant factor in environments in which investors have difficulties in making predictions about the future, since the environment may be highly volatile and/or information to make predictions is difficult to obtain. It is true for the environment, in which companies operate nowadays, which is due to growing globalisation and more rapid technology-induced changes in the market place which are very volatile and unpredictable. In addition, uncertainty may be a particularly relevant factor determining investment in developing and transition economies. These economies are generally more volatile by nature and information problems in these economies are more prevalent due to deficient markets and institutions.

The nature of the relationship between investment and uncertainty has received a considerable attention in literature. As Jorgenson [5] noted in his survey “the most

important open question in the study of investment is the integration of uncertainty into the theory and econometrics of investment.” However, the theoretical literature on this issue is not conclusive on the sign of the relationship between investment and uncertainty.

Generally, we can observe two main streams: standard and option ones. Standard investment theory states that the strategy of the firm is to invest in a project only if the present value of expected cash flows from the investment exceeds the total costs. The value of the total costs may be referred to as the threshold value of the investment. In principle, it can be shown that the threshold value increases with the degree of uncertainty with respect to the future growth rate of sales, which means that greater uncertainty leads to lower willingness to invest. Uncertainty may either raise or lower the investment. The exact nature of the relationship crucially depends on the model specification used and the underlying assumptions with respect to the risk behaviour of the investor, the extent of competition in his output markets, the characteristics of the production technologies used and the shape of the adjustment costs.<sup>1</sup>

The NPV rule, however, is based on some implicit assumptions that are often overlooked. Most important, it assumes that either the investment is reversible, i.e., it can be somehow undone and the expenditures recovered, should market conditions turn out to be worse than anticipated, or if the investment is irreversible, it is a now or never proposition, that is, if the firm does not undertake the investment now, it will not be able to in the future ([4]).

Although some investments meet these conditions, most do not. Irreversibility and the possibility of delay are very important characteristics of most investments in reality.

Since the late 1980s several authors have stressed the importance of the possibility that the investment is irreversible (i.e., taking into account the shape of the adjustment costs) and the impact of this on the investment – uncertainty relationship ([1] [2][3] [4], etc.). The fact that investment is (partly) irreversible increases the user cost of capital, thereby also leading to an increase in the threshold value of investment. This can be shown by applying the option pricing model of investment. When investment in capital stock is (partly) irreversible, this introduces a so-called option value to postpone investment until later, when more information about relevant future events is available. If uncertainty is higher the value of the option to wait also increases, thus leading to lower current investment outlays ([8] [9][10]). We dedicate more attention to this theoretical advances in the next part of the paper (part 1.2).

## 1.2 Recent Theoretical Advances: the real option approach

As stated above, irreversibility and the possibility of delay are very important characteristics of most investments in reality. Irreversibility usually arises because capital is industry or firm specific, i.e., it cannot be used productively in a different

<sup>1</sup> Broad surveys of the literature on the relationship between investment and uncertainty can be found in [6] and [7].

industry or by a different firm. A steel plant, for example, is industry specific. It can only be used to produce steel, so if the demand for steel falls, the market value of the plant will fall. Although the plant could be sold to another steel company, there is likely to be little gain from doing so, so the investment in the plant must be viewed as a sunk cost. As another example, most investments in marketing and advertising are firm specific, and so are likewise sunk costs. Partial irreversibility can also result from the „lemons“ problem. Office equipment, cars, trucks, and computers are not industry specific, but have resale value well below their purchase cost, even if new.

Irreversibility can also arise because of government regulations or institutional arrangements. For example, capital controls may make it impossible for foreign (or domestic) investors to sell assets and reallocate their funds. And investments in new workers may be partly irreversible because of high costs of hiring, training, and firing.

Firms do not always have an opportunity to delay investments. There can be occasions, for example, in which strategic considerations make it imperative for a firm to invest quickly and thereby preempt investment by existing or potential competitors. But in most cases, delay is at least feasible. There may be a cost to delay – the risk of entry by other firms, or simply foregone cash flows – but this cost must be weighed against the benefits of waiting for new information.

The ability to delay an irreversible investment expenditure can profoundly affect the decision to invest. It also undermines the simple NPV rule, and hence the theoretical foundation of standard neoclassical investment models. The reason is that a firm with an opportunity to invest is holding an „option“ analogous to a financial call option – it has the right but not the obligation to buy an asset at some future time of its choosing. As a consequence, option pricing theory can be used to “price” investment decisions and decide on optimal timing of exercise. This gave rise to a large body of new literature, and a new class of models usually referred to as “real options” models. Viewing the investment decision as exercising an investment option can be illustrated most simply by referring to the conventional NPV rule.<sup>2</sup> Like a financial option, the option itself has some (non – negative) value, denoted as  $F_0$  in the following, a.o. because of uncertainty over the future value of the investment project. The direct pay – off from investing is given by  $V - I$ , where  $V$  is the present value of the investment project and  $I$  the investment cost (the classical NPV criterion). When this pay – off is positive, it is worthwhile to invest. However, once the investment is made, the option is gone, so the value of the option today ( $F_0$ ) must be considered as an opportunity cost of investing, and hence must be added to the investment cost ( $I$ ). Hence the optimal investment criterion is modified into:

$V < I + F_0$  : wait to invest

$V \geq I + F_0$  : invest

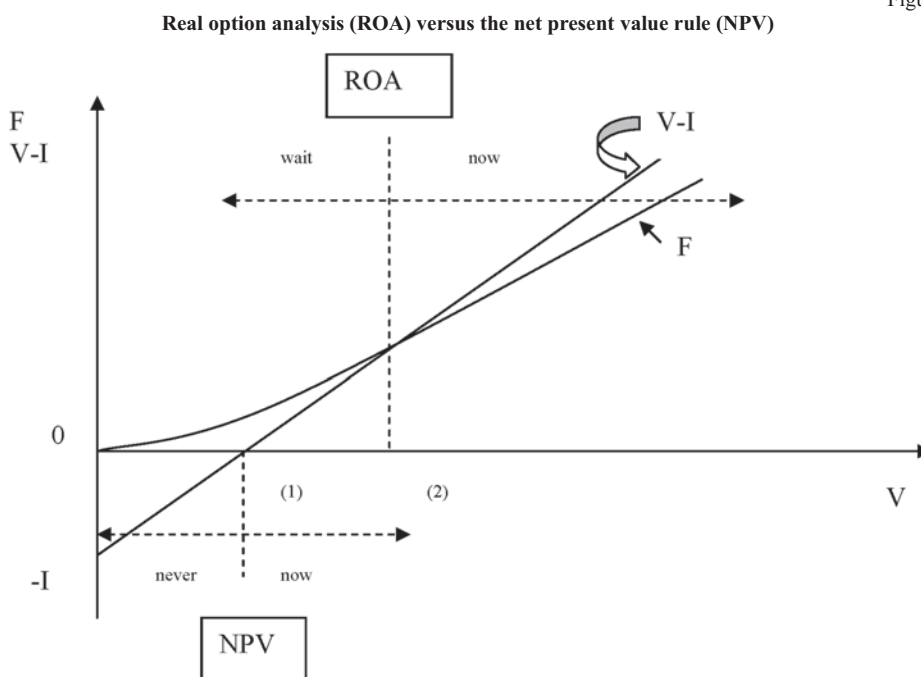
Another way of indicating the same criterion is stating that the value of the project,  $V$ , must exceed the investment cost,  $I$ , by at least the value of the option,  $F_0$ ,

<sup>2</sup> According to [11].

in order to decide to invest now. This minimum acceptable project value is generally called the “threshold value” of investment, in the following denoted as  $V^*$ .

In option pricing jargon, the option is said to be “out of money” in the first case (waiting) and „in the money“ when the underlying value of the investment ( $V$ ) exceeds the option value (price) plus the investment cost. The basic new insight is in fact that one should wait until the orthodox NPV is “very large”, with  $F$  putting an exact value to it. As such, the basic investment decision to take is not whether or not to invest (as indicated by the orthodox NPV – rule), but rather when to invest, i.e. determining the optimal moment of exercising the investment option.<sup>34</sup> This intuitive reasoning is graphically represented in Figure 1.

Figure 1



Source: [11].

From the viewpoint of the subject of this paper, the most important consequence resulting from this model solution is that uncertainty (and irreversibility) introduces a difference between the minimum-acceptable value of the project in order to invest ( $V^*$ ) and the cost of investment ( $I$ ). More important even, the greater the level of

<sup>3</sup> From the previous paragraphs, it is clear that the orthodox NPV criterion is no longer valid for “real option” investments. But whether this must be considered as a new theory of investment or a correction of the old paradigm remains open and is in fact less important, as indicated also by Dixit and Pindyck [4].

<sup>4</sup> We deal with the option to wait in this article. There are more kinds which can be taken into account. For more information, see for example Belanová [12].

uncertainty, the more the value of the investment opportunity must exceed its cost before investment is indeed taking place. As such, the individual investment decision is, in theory, very dependent on the level of uncertainty. The result is that changing economic conditions that affect the perceived riskiness of future cash flows can have a large impact on investment spending, larger than, say, a change in interest rates. This may help to explain why neoclassical investment theory has so far failed to provide good empirical models of investment behaviour, and has led to overly optimistic forecasts of effectiveness of interest rate and tax policies in stimulating investment.

The option insight also helps explain why the actual investment behaviour of firms differs from the received wisdom taught in business schools. Firms invest in projects that are expected to yield a return in excess of a required, or “hurdle”, rate. Observers of business practice find that such hurdle rates are typically three or four times the cost of capital.<sup>5</sup> In other words, firms do not invest until price rises substantially above long – run average cost. On the downside, firms stay in business for lengthy periods while absorbing operating losses, and price can fall substantially below average variable cost without inducing disinvestment or exit.

## 2 Empirical Studies

As we could see, the relationship between investment and uncertainty and the role of irreversibility is not clear from a theoretical point of view. On the other hand, empirical studies generally have found a negative effect of uncertainty on investment when taking into account the irreversibility of investment.<sup>6</sup> These studies take different approaches in analysing the relationship. In particular, they differ with respect to how they measure uncertainty and irreversibility and, related to these measurement issues, with respect to whether they use data at the industry or firm level. Moreover, the mostly focus on developed economies.

Concerning measuring of uncertainty, we can distinguish several groups of authors according to the selected measures. Several authors have used standard measures of risk – such as standard deviation, variance or coefficient of variation – of a variable that is considered to be crucial for investment decisions as their measure of uncertainty ([13] [14][15]). Other authors have taken GARCH estimates of conditional variances of such crucial variables as proxies for uncertainty ([16] [17]). Another group of authors have measured the volatility of a particular variable using AR model residuals [18]. Finally, some studies have used firms’ perceptions about future developments of a particular variable determining investment as their uncertainty measure ([19] [20][10][9]). Variables that have been considered as being

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<sup>5</sup> The hurdle rate appropriate for investments with systematic risk will exceed the riskless rate, but not by enough to justify the numbers used by many companies.

<sup>6</sup> The empirical literature on the relationship between investment and uncertainty is quite extensive. Many of these studies find a negative relationship and explain this by referring to the irreversibility hypothesis. This review of the empirical literature focuses on studies that analyse the relationship between investment and uncertainty and use irreversibility to explain their outcomes.

crucial in empirical studies are, among others, exchange rates, input prices, share returns, output demand and output prices [7].

Irreversibility has been measured, either directly by using information on the degree of Access to secondhand markets of used capital [19] or the ratio of the resale value to the replacement value of capital [20], or indirectly by defining different types of investment for which different degrees of irreversibility are assumed, such as greenfield investments versus capacity expansion (greenfield investment is considered to be less reversible [13]; material versus machinery industry (investment made by firms in the material industry is assumed to be less reversible [15]; and R & D investment versus non – R&D investment (R&D investment is assumed to be less reversible;) [21].

Empirical studies also differ with respect to whether they use an aggregate or disaggregate empirical analysis. Some authors make use of the data at the country level [21]. Other studies use aggregate data at the industrial sector level ([13][21]). Finally, several studies make use of firm-level data ([15][19][10][9][20][22][23]). As [22] stated in their study, a proper analysis of the relationship between investment and uncertainty should make use of firm-level data, since theoretical models indicate that the relationship between investment and uncertainty depends on firm-specific characteristics. At least part (if not most) of the uncertainty affecting a firm's investment decisions will be due to idiosyncratic events, which will disappear when uncertainty is considered at the aggregate level due to the canceling out of different shocks for different firms. Moreover, the analysis should make use of survey data containing information on the expectations of decision-makers about the future values of variables that influence their investment decision. Only with this kind of information can the subjective perception (i.e., conditional on firm's own information set) of uncertainty be measured (e.g., an ex ante measurement of uncertainty) and this is the relevant determinant of investment decisions. Yet, most studies use ex post measures of uncertainty, because it is difficult and time consuming to obtain survey data on decision-makers' perceptions of uncertainty.

Among the studies that have investigated the investment – uncertainty nexus and have focused on irreversibility, only some of them use survey data to construct uncertainty measures based on subjective perceptions of agents. [19] use data based on a survey among Italian manufacturing firms. They measure uncertainty based on the perception of firms about future product demand. They find a negative relationship between investment and uncertainty and show that the degree of irreversibility influences this relationship: the negative relationship is stronger for firms for which the degree of irreversibility is higher. [10] test the effects of real options induced by risk and irreversibility of fixed capital on a sample of Italian firms. They make use of the expectations of the companies about future investments. Different from [19], their measure of risk allows them to determine the long-term impact of risk on capital accumulation, and so to examine the dynamics of investment. They demonstrate slower response of investment to demand shocks at a higher risk level. [9] came to similar conclusions by the investigation of the British companies. They find

a convex effect of demand shocks on investment decisions. [20] uses firm-level data from a panel of manufacturing firms in Ghana and focuses on the role played by the irreversibility of investment in determining the relationship between investment and uncertainty. She also finds evidence for the fact that the irreversibility of investment leads to lower investment under uncertain conditions. [22] use in their empirical analysis, which is based on a survey of 210 rice-milling firms in Vietnam, firm-level data. They show that uncertainty reduces investment of rice millers in the presence of irreversibility, as is predicted by the real options approach to investment. They do not find evidence that the negative association between uncertainty and investment is influenced by the degree of irreversibility.

## 2.1 Results of the Empirical Study in Slovakia

As mentioned, there are only few studies using the information from transition or developing economies. Yet, investigating the investment – uncertainty relationship seems to be particularly relevant in the context of these economies. That is why we investigated whether the irreversibility of investment has an impact on the nature of the relationship between investment and uncertainty for automotive suppliers in the SR. We used the following specification of investment behavior:<sup>7</sup>

$$I_i = \alpha_1 + \alpha_2 SAL_{i,2010} + \alpha_3 PRO_{i,2010} + \alpha_4 VKS_i + \alpha_5 NEZ_i + \varepsilon_i$$

where:

- $I_i$  – is total planned (gross) investment divided by total fixed assets in 2010;
- $SAL_{2010}$  – is total sales in 2010 divided by total fixed assets in 2010 and reflects the accelerator model of investment, since past sales may reflect future investment opportunities; therefore we expect  $\alpha_2$  to be positive;
- $PRO_{2010}$  – is total profit in 2010 divided by total fixed assets in 2010 and measures the existence of financial constraints with which automotive suppliers may be confronted; we expect  $\alpha_3$  to be positive reflecting the importance of the availability of internal funds in determining investment decisions, which is taken as evidence for the existence of financial constraints for automotive suppliers when deciding on future investment;
- $VKS$  – is the uncertainty variable; based on the theoretical literature as discussed in Section 1 of this paper,  $\alpha_4$  may be either positive or negative;
- $NEZ$  – is our measure of irreversibility; we expect  $\alpha_5$  to be positive: the higher  $NEZ$ , the lower the irreversibility of investment, which according to the real options approach to investment decisions would suggest higher levels of planned investment.

The empirical model was estimated using the simple OLS technique based upon information about 53 automotive suppliers that we obtained from the survey.

<sup>7</sup> According to [22]



We find supportive evidence for the fact that uncertainty is negatively associated with planned investments of the companies surveyed, which remains true also in the presence of irreversibility.

### 3 Application

#### 3.1 Description of the Problem and Entry Data

A company considers whether it should buy the licence for a production of a new line of luxury face creams. It is quite cheap nowadays according to the fact that it is possible to get one of the ingredients only in an area with civil unrest. The improvement of the situation is expected within 3 years. Capital outlay is 1 mil. f.u. and it is expected to generate yearly cash flow of 300,000 f.u. for 4 years by the discount rate 12% and non-risk rate 5%. Volatility in the sector is characterized by a 50% standard deviation.

#### 3.2 Aim of the Application

The aim of the application is to determine:

- NPV in a case of standard theory (i.e. without real option)
- The value of the real option and so the NPV with this value (strategic NPV).

#### 3.3 Solution

##### 3.3.1 Evaluation of the Project in the Case of Standard NPV

In this case we adjust the value of the project for the planned investment outlays, i.e., if the project is implemented immediately, NPV is -88,796 f.u.

##### 3.3.2 Evaluation of the Project Incorporating the Value of Real Options

In this case we evaluate the licence as a call option for the realization of the future cash flows.

We use the formula for the calculation of the value of call option:

$$C = \sum \frac{CF}{(1+i)^t} \cdot N(d_1) - C_0 \cdot e^{-rt} \cdot N(d_2)$$

while

$$d_1 = \frac{\ln\left(\sum \frac{CF}{(1+i)^t} / C_0\right) + (r + \sigma^2 / 2)t}{\sigma \cdot \sqrt{t}}$$

$$d_2 = d_1 - \sigma \cdot \sqrt{t}$$

where

CF – cash flow in each year

i – discount rate

$C_0$  – capital outlay

r – non – risk rate

$\sigma$  – standard deviation.

When we insert the required data, we get  $d_1 = 0,498$  and  $d_2 = -0,367$ . The values  $N(d_1)$  and  $N(d_2)$  can be found in the statistical tables for normal distribution function. In our example we have:  $N(d_1) = 0,691$  and  $N(d_2) = 0,365$ .

We get the value of the licence incorporating the possibility of flexibility in decision making according to the changes in the environment characterised by the certain volatility by putting the data to the formula for the value of the call option.

$$C = 911,205 \cdot 0.691 - 1,000,000 \cdot 0.356 \cdot e^{-0.05 \cdot 3} = 323,230.6 \text{ f.u.}$$

So the strategic NPV is 234,434.6 f.u.

### 3.4 Interpretation of the Results

It is obvious, that when we evaluate the project with the standard NPV rule, it is not acceptable. When we incorporate also the value of the real option, then the strategic NPV is positive. This value does not exclude the purchase of the licence if its price was lower than the calculated estimation of the strategic NPV. Anyway, the project should be carefully considered and evaluated by the sensitivity analysis as well.

### Conclusion

In this paper we have surveyed recent developments in the literature on business investment that have shed light on important aspects of firms' investment behaviour. A common feature of the theoretical contributions is to emphasize the relevance of idiosyncratic factors affecting investment decisions. Some of these factors relate to specific features of an investment project, such as its degree of irreversibility and uncertainty, whose interaction may generate an opportunity cost equivalent to the exercise of a (real) option. Overall, these new contributions add an important dimension to the traditional neoclassical theory of investment in so far as they emphasize cross-sectional differences in optimal investment behaviour.

We presented the results of an empirical analysis, which makes a contribution to the existing empirical literature. There are only a few other studies which have

used information from transition or developing economy, although investigating the investment – uncertainty relationship seem to be particularly relevant in the context of these economies, since they are generally more volatile by nature. We find supportive evidence for the fact that uncertainty is negatively associated with planned investment of automotive suppliers in the SR. Moreover, we show that this remains true given the presence of irreversibility.

At the end of the paper we demonstrate that when we incorporate the value of the real option into evaluation of effectiveness of investment, the conclusion according to the standard NPV rule can be changed. The value of the real option increases the value of the project.

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