Visualising Intangibles: Measuring and Reporting in the Knowledge Economy

Edited by

Stefano Zambon

and

Giuseppe Marzo

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Chapter 2

Intangibles and Real Options Theory: A Real Measurement Alternative?

Giuseppe Marzo
University of Ferrara

Introduction

The possibility to employ Real Options Theory (ROT) for intangible assets' valuation seems to be very promising. Nevertheless, the ROT attitude for valuing "fluid" situations, where a pre-ordinate path to follow does not exist, can easily disguise the complexity of intangible assets' valuation.

This chapter addresses the problem of a balanced assessment of the usefulness of ROT for valuing IAs, analysing the pros and the cons of ROT. Firstly, it tries to underline the reasons that can justify a real options approach to the problem of IAs' valuation. Other papers (e.g., Bouteiller 2002; Bose and Oh 2003) have already proposed ROT for IAs' valuation, but they offer reasons too generalised for a ROT-based valuation. On the contrary, this chapter aims to demonstrate that a real options lens can be fruitfully employed for capturing the economic substance of IAs, so making ROT effective in their valuation.

Moreover, the chapter recognises that a ROT-based valuation of IAs cannot leave out neither the relationship between existing IAs and the one to be valued, nor the analysis of how such existing assets influence the ROT-based value of an on going IAs investment. To reach these points, the chapter presents the investment life-cycle model, where each single phase can be analysed in terms of real options that become available and the role of IAs in providing support to their value.

The second goal of the chapter is to present some criticisms to ROT, especially when applied for valuing IAs. As for this point, the chapter analyses the problems arising from the relationship between value and uncertainty[1] of a real option, and the techniques used for calculating the value of a real option.

Throughout the chapter, a distinction is made between existing IAs and investment creating (or able to create) new IAs. Such a distinction can be sometimes very clear, but other times it can be fuzzy. To better clarify it and in order to facilitate the reading of the chapter, it should be noted that an investment creating new IAs can sometimes consist in putting existing IAs at work but in new forms. The possibility

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1 Being conscious of the theoretical difference between risk and uncertainty, the two terms will be nevertheless used interchangeably along the chapter.

to employ a patented technology in other business and the opportunity to extend a firm's brand are example of such situations.

For avoiding any confusion, the chapter will deal with the example of a research project, giving so the possibility to unambiguously appreciate the different role of existing IAs with respect to the investment to be valued.

The points above presented correspond each one to a specific section of the chapter. After a short presentation of ROT, which next section is devoted to, section 3 will analyse how to use real options lens for re-interpreting IAs' features. Section 4 will present the investment life-cycle, also discussing the role of IAs in enhancing real options value. Section 5 is devoted to examine the criticisms of a ROT-based valuation. Section 6 concludes.

Some Basic Concepts on Real Options Theory

In 1977 Stewart Myers discovered the strong analogy between financial options and some of "real" projects and assets belonging to a firm, and he called real options such situations, so giving the start for the development of valuation models based on financial options theory.[2]

A real option is the right – and not the obligation – to make a potentially value–accretive decision if – and only if – the market conditions are or will become favourable. A very useful example is that of an R&D project. A firm valuing such a project knows that the uncertainty it must face with relates not only to the R&D in se, but to the market conditions also. At the moment of valuation, market conditions are usually very uncertain. Nevertheless such an uncertainty is not necessary detrimental for the value of the R&D project. Indeed, the firm will not be forced to undertake the investment for marketing the new product, if market conditions prevailing at the end of R&D will be unprofitable. On the contrary, the firm will have managerial flexibility consisting in the opportunity to avoid any further investment, so limiting its losses to the R&D's costs.

When an investment creates or embeds real options, it must be valuated comparing the cost for creating real options with their value. The R&D project presented above can be thought of as the cost of the created real option. At the light of ROT, this cost enables the firm to exercise an investment option in the case of a positive evolution of the market. Since striking an option requires a new investment, such a decision will be made only if the present value (PV) of the expected cash flows arising from this investment is likely to be greater than strike costs. Such a PV is equivalent to the underlying asset of a financial option. The valuation of the overall project (e.g. R&D project and the investment for building the plant) should be comprehensive enough to include the NPV of the R&D project and the value of the real options available to the firm. The sum of the two components is called the Expanded NPV.

Literature on ROT (Amram and Kulatilaka 1999; Copeland and Antikarov 2003) points out that the value of a real option depends on the degree of managerial flexibility

2 The analogy with financial options is also responsible for some limits of ROT models (Lander and Pinches 1998; Marzo 2005).

available to the firm and on the risk of the project. For investment projects featuring high risk and high flexibility, the option value is at the maximum. The rationale for this is that managerial flexibility can protect the firm against negative evolution of market conditions without weakening the possibility to take advantage of the positive evolutions. In the ROT context, uncertainty is essential for a real option to have value. Indeed, in a certain world no option could have value: a decision-maker could be able to rightly plan the future since the beginning of a project. The combination of uncertainty with flexibility determines the asymmetry of a real options payoff. At the time the real option could be struck, the probability distribution of value is cut at the level of the exercise price. In fact, for values lower than the strike price (e.g. the cost for building the plant) the option will not be exercised. The faculty to exercise the option only if profitability limits the losses but not the gains, so translating into a hockey stick profile.

Even though literature on ROT focuses mainly on uncertainty and managerial flexibility, an additional two conditions are essential for a real option to have value: irreversibility and the arrival of new information at the time of option exercise.

Irreversibility is strongly correlated to sunk costs (Dixit and Pindyck 1994). Furthermore, the more an investment is firm-specific, the less it can be recovered. In fact, because its firm-specificity, it cannot be conveniently sold to another firm. Even if an investment is not firm-specific, the secondary market could price it non-correctly (Akerlof 1970). Irreversibility is important when coupled with the concept of path-dependency. Because of irreversibility, the future is dependent on present and (forward) path-dependency arises (Kogut and Kulatilaka 2001).

Irreversibility is also related to scarcity (Kogut and Kulatilaka 2001). If an asset can be replicated in the future, the problem of irreversibility is not important, and the firm can make a decision without consideration of future path-dependency. But if the asset cannot be replicated in the future – then the asset is scarce and irreversibility must be taken into account.

The fourth important condition for a real option to have value is that information must flow to the firm at a rate useful to make the right decision, that is to strike or not the real option. Coming back to the R&D example above proposed, it is possible to clarify this point. As said before, if the R&D project turns out successfully, the firm has the real option to make an investment for marketing the new product. At the moment the R&D project must be valued, nevertheless, the firm does not know if the market conditions will be profitable enough to compensate for the cost of the investment. The basic assumption of ROT is that during the R&D project, new information will flow to the firm, useful to enable the right decision.[3]

Giving the four conditions on the ground, the calculation of real options value can be performed through two different approaches: Contingent Claims Analysis (CCA) and Dynamic Programming (DP). The former is the same approach employed for valuing financial options, and it is based on the assumption that the real options payoffs can be replicated through a traded security (or a portfolio of securities) already existing. If such a security, called twin security, does not exist, a Marketed

3 For some critical considerations on the relation between value and risk of real options, see Coff and Laverty (2001), and Marzo (2005).

Asset Disclaimer approach (Teisberg 1995; Copeland and Antikarov 2003) can be followed, where the twin security is the project itself, valued by discounting its expected cash flow.[4]

Dynamic Programming calculates the value of a real option through the application of Bellman principle and the decision-maker's utility function. As Dixit and Pindyck (1994) point out, the two approaches collapse when DP is applied within the risk-neutral framework (DPRN). The risk-neutral framework is a way to put into DP the replication of real options payoffs. In fact, if the payoffs can be replicated by existing securities, the real option holder position can be perfectly hedged, so cancelling away any form of risk she/he bears.

A strong condition for applying CCA and DPRN is the market completeness[5], which make it possible to perfectly replicate the real options payoffs. Nevertheless, as Smith and Nau (1995) and Smith and McCardle, (1998 and 1999) have pointed out, the market completeness cannot be taken for granted. In this later case, the real option valuation should combine CCA and decision analysis. Anyway, if the market is not complete, the value coming out from CCA is only the upper limit of the real value of the option.

Even though the problem of valuation is undoubtedly the most investigated topic in the field of real options, in the last decade some interesting articles address the usefulness of the real options thinking or reasoning (Faulkner 1996; Morris, Teisberg and Kolbe 1991; McGrath 1997 and 1999; McGrath and MacMillan 2000; McGrath and Nerkar 2004). The conceptual framework of real options theory is applied in order to analyse and interpret economic phenomena, leaving on the ground the problem of valuation. This way, Bowman and Hurry (1993) have used the real options lens for discussing some interesting topics related to the strategy and the organisational processes of a firm.

Using Real Options Lens with Intangible Assets

A large part of literature on IAs (Dosi 1988; Lev 2000 and 2001; Wyatt 2002; Zambon 2003) highlights some characteristics that can be framed through the real options lens:

- Non-rivalry, since an intangible asset can be at the same time exploited in multiple activities, in contrast with tangible assets;
- Increasing returns, due to the fact that knowledge (and other intangibles) is cumulative, and its use enlarges its benefits;

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4 Authors proposing Market Disclaimer Approach assume that the project can be given the same value it would have if it was traded on financial market. Nevertheless, introducing a new asset in a non-complete market can modify the structure of equilibrium returns, so it is not possible to be sure that the calculated value corresponds to the market value of the project.

5 In general terms, a market can be defined complete if linear combination of traded securities can replicate any new investment opportunity.

- Firm specificity, since IAs' value is dependent on the specific characteristics of the firm;
- Path dependency, since IAs are grounded on the history and on decisions the firm made in the past;
- Scarcity, in the sense that because of specificity of IAs, they are hardly replicable by other companies
- High level of risk, particularly if compared to tangible assets.

Giving the remarks on real options' value and what just introduced about IAs' features, it is now possible to use real options lens for giving an interpretation of IAs' characteristics.

Non-rivalry, increasing returns and the portfolio of real options The possibly to employ IAs in multiple activities is tightly relating to flexible decision-making. The Hamel and Prahalad's concept of portfolio of technologies (1990) is a good example of this point. Flexibility means that a firm is not obliged to employ IAs in many different contexts, but it has the opportunity to do it. In particular, the non-rivalry of IAs translates into the creation of a portfolio of real options, the strike of which depends on the market conditions (Kogut and Kulatilaka 2001). The real options lens can account for such a situation.

Path-dependency and the real options value Literature on capabilities, core competencies and IAs shows that the firm's future actions are conditioned by its past decisions. Capabilities, core-competencies and IAs in general, accumulate during the firm's history (Abernethy and Wyatt 2003). IAs feature path-dependency, which in turn creates irreversibility, a condition of paramount importance for the value of a real option.

Path-dependency, irreversibility, specialisation and competitive positioning Since future decisions are influenced by past decisions, a firm cannot easily modify its strategy to react to competitors. The higher the specialisation, the higher will be the inertia of a firm. Specialisation is a way to make stronger the weight of the history, e.g. irreversibility and path-dependency. In the perspective of ROT, specialisation is the result of a stream of struck real options, each one being the possibility to expand or to contract the modules of knowledge and the capabilities of the firm. Indeed, an available real option confers to the firm the opportunity to postpone a decision in the future. Until decision is not made, the future paths are not pre-determined, and the flexibility a firm has is very high. When an option is struck, the firm decide for a specified course of action, so reducing availability of other different paths. This is a way to say that specialisation can be framed in term of strike decisions: the larger is the number of real options a firm decides to strike, the less is flexibility it is saving for the future. From a rational perspective, real options lens can account for the intentional strategy of limiting future path-dependency, through the creation of (a large number of) real options giving the firm the opportunity to postpone irreversible decisions.

Furthermore, the great the specialisation, the high the possibility of phenomena of escalation of commitment (Coff and Laverty 2001; Marzo 2005), with the possibility of producing effects detrimental of the value of the firm.

Value and firm-specificity Real options on one hand and IAs on the other hand are anchored to firm-specificity. Indeed, firm-specificity contributes to determine the value of IAs and, on the other hand, generates irreversibility in decision-making, therefore influencing the value of a real option. For example, a lower degree of specificity increases the value of the exit option; while on the contrary a higher degree of specificity can produce inertia (Dixit 1992; Dixit and Pindyck 1994) by raising barriers to exit.

Value and uncertainty As known, the value of an option increases, ceteris paribus, with uncertainty, but only if managerial flexibility is available to the firm. IAs' investments can be carried on in order to reduce the firm's business risk (Abernethy and Wyatt 2003). Event though there are several ways to obtain this effect, the creation of managerial flexibility (e.g. real options) seems to be of interest. Upton (2001) notes that this could really justify the adoption of ROT for IAs' valuation.

IAs, real options and risk Berk, Green and Naik (1998 and 1999) show that R&D projects and new ventures display high level of systematic risk, and Ho, Xu and Yap (2004) empirically demonstrate that R&D investment increase a firm's systematic risk. Wyatt (2002) remarks that the risk associated to IAs is higher than risk associated to tangible assets, since generally IAs precede investment in tangible assets. So, IAs pay for a greater uncertainty. As pointed out by Lev (2001), the risk progressively reduces during the investment, since it is at its maximum at the moment of the research project, while it reaches a lower level at the moment of the marketing phase. The rationale for the higher uncertainty of IAs can be analysed in the ROT perspective. An R&D project, for example, is riskier than the following tangible investment because of the technical risk and the uncertainty about the market evolution. Investment in tangible asset (the building of the plant, for example) is not more subject to the same relevant technical uncertainty, and the market risk is also lower. Indeed such an investment will be carried on only if market conditions are positive enough to make the investment profitable. Thus, it is the arrival of new information and knowledge that make it possible the reduction of the risk during the life of the investment. Such a phenomenon can be also interpreted at the light of real options lens reminding that the arrival of new information and knowledge is one of the four conditions giving economic value to a real option.[6]

Following the analogy with financial options, it can be shown that the systematic risk of an option is greater than the risk of the underlying asset (Gemmil 1993). Chung and Charoenwong (1991) decompose a firm's systematic risk into the risk

6 See section 2 for a discussion on this point.

associated with asset in place and the risk arising from future growth opportunities, demonstrating that the latter is higher than the former.

The two effects just discussed can jointly explain the riskiness of IAs. Section 5 will come back to this point.

Intangible Asset and Real Options Along an Investment Life-Cycle

This section deepens the analysis of the relationships between IAs and real options highlighting the mutual influence along a generic Investment Life-Cycle (ILC).[7] Following such a conceptual model, one can understand how IAs' and real options value influence each other.

Figure 2.1 and the following analysis present the main phases of the ILC, the real options available in each phase and the relationships with IAs.

The ILC approach developed in this section requires a distinction between existing IAs and on going IAs investments. Such a distinction makes it possible to analyse the impact of existing IAs on the new investment value, identified as the prerequisite investment.

1. **Prerequisite investment**. Prerequisite investment is the condition enabling the portfolio of real options along the ILC. Following the analogy with financial options, such an investment can be though as the premium to be paid in order to obtain the right to strike (if convenient) the option(s) in the future. For the carrying on of a prerequisite investment, IAs a firm holds are of paramount importance. An R&D project is a typical prerequisite investment, since it gives to the firm the opportunity to market the new product without obligation to do it. The success of an R&D project is mainly dependent on the available skills, capabilities and competencies. In some circumstances, the property of patents of such similar rights can contribute to carry on the R&D project in a faster way or with more profitable results. From the ROT standpoint, the IAs role is twofold. They influence both on the technical success R&D project and on the time and the costs of the project.
2. **Recognition of the investment opportunity**. With the success of the research project, the new product can be marketed. Obviously, this is a faculty for the firm, and in fact it will go ahead with the building of the plant only if profit is expected. This is the first real option available: the faculty to continue by building the plant or to stop in case of negative scenarios.

   Another type of real option can be available during this phase: a deferring option. A firm indeed can decide not only about the possibility to invest or to stop its activity, but also about the possibility to defer the investment in tangible assets. Traditional DCF-based capital budgeting systems are not able to value correctly such a situation, while ROT can do it (Dixit and Pindyck 1994; Amram and Kulatilaka 1999). In particular, investment in tangible asset can be deferred

7 The ILC is adapted from Benaroch (2001).

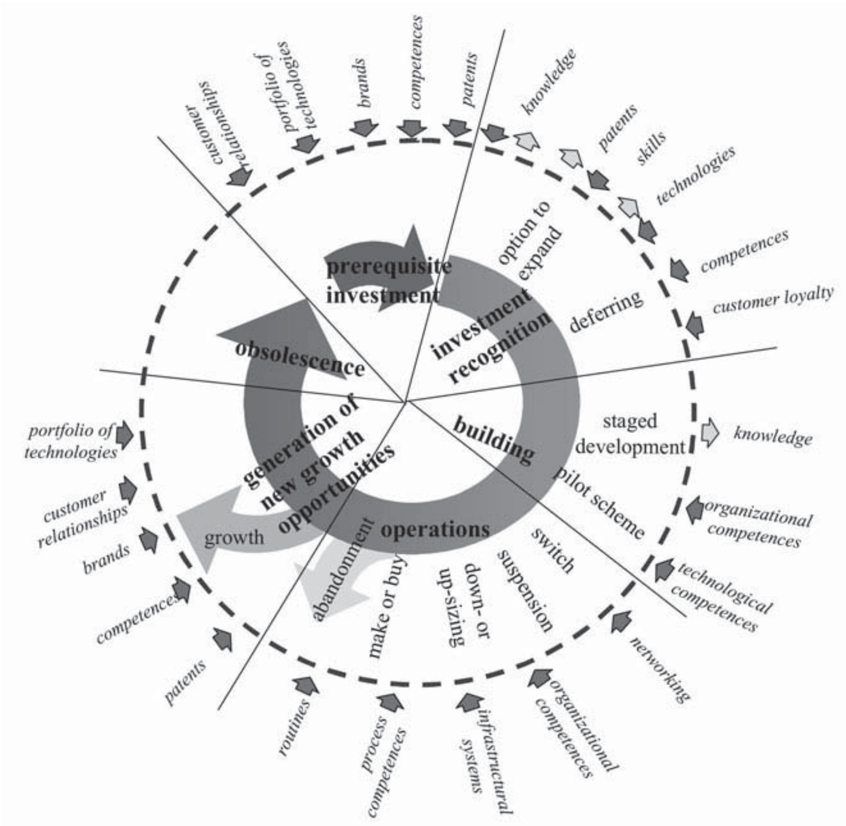

Figure 2.1 Investment life cycle, real options and intangible assets

even if the immediate investment seems to be profitable but the expected growth of the future price can generate a higher profit for a wait-and-see strategy.

The value of a deferring option is influenced by several conditions. First of all, if the firm decides to defer the investment, it will lose, at least, a part of value of the cash flows that will be generated during the waiting period.[8] Indeed, the possibility to defer the investment determines a reduction in the value of cash flows since they must be discounted for a longer period. Secondly, the waiting period can reduce the value of the project because the firm cannot completely exploit the advantages related to the legal protection of a patent or a similar right.[9] In such a situation, the value reduction is not only related to the discounting problems, but also to the loss of some of those cash flows. Finally,

8 The cash flow lost during the waiting period is embedded in the ROT model by the same way than the dividend in financial options models.

9 A simple model proposed by Damodaran (s.d.) models such a situation assuming that the value of underlying asset reduces 1/N per year, where N is the n umber of the year of validity of patent or similar right.

the waiting period can permita new competitor to enter the market, so acquiring the advantages of the first mover.[10]

Relationships of IAs with real options are, in this case, of two types. Deferring option is a learning option (Dimpfel and Algesheimer 2002) because it gives the firm the opportunity to acquire or to develop its knowledge about the market conditions. It originates a knowledge-based intangible asset.

On the other hand, IAs affect the value of the real option, through the influence on the condition characterising its life and its exercise. For example, the existent IAs can protect the firm from the entrance of a new competitor. Patents and other legal rights, customer relationships and the firm's core competencies can represent effective protection of the value of the project.[11]

3. **Building.** The investment decision is generally implemented through the building of a tangible asset. Such a decision can be structured as a staged investment decision: the plant can be built according to a modular approach or following a path of increasing commitment. The staged development is a learning option, since it confers to the firm, the opportunity to acquire new knowledge. Despite the case of the deferring option, the staged development option can strongly contribute to offer to the firm new information not only on the external conditions, but also on the internal conditions. After each stage, the firm can indeed verify the way its plans are carrying on, and in case of necessity can assume appropriate correcting actions. This option can permit a reduction of some type of endogenous[12] uncertainty relating, for example, to the capabilities of building the plant.

   Often, the staged development requires organisational competencies. For example, the decision to enter foreign markets (Pellicelli 1992; Hurry 1993) is developed through subsequent stages, where each stage represents an option to carry on the internationalisation, and features a higher commitment than the previous one.

   Also technological competencies can be of paramount importance. The competencies relating to scaling up in the downstream investments influence the way a firm can develop a full-size plant starting from a prototype plant.
4. **Operations.** During this phase various options can became available. One of these is the suspend option, consisting in the possibility to temporarily suspend the project in the case the prices of the product are not sufficient to recover the production costs.[13] Another type of option is that of switch: a firm can change the mix of either the inputs or the outputs of its production. In more general terms, the switching between different knowledge modules is also possible (Levinthal

10 Such situations can be modelled by means of a Poisson process which accounts for the probability of the entering of a new competitor or technology. More complex models can be based on Game Theory (Grenadier 2000a, 2000b e 2000c; Smit and Trigeorgis 1999).

11 Patents, legal right, trademarks and others, can influence the cost competitors must support for copying an invention (Levin, Klevorick, Nelson and Winter 1987). So, they can be accounted for by correcting both the useful life of a real option and the exercise costs.

12 A definition of endogenous uncertainty is provided in the next section.

13 In order to value a suspend option, costs arising from such a decision must be carefully estimated. Examples of such costs are those relating to mothballing of the plant or to its restart.

and March 1993; Kogut and Kulatilaka 2001). In the latter case, the role of IAs is twofold: they can enable the switching between different modules of knowledge; or, if firm features high specialisation, they can increase the cost of switching. Then the cost of switching reflects the degree of operational flexibility of a firm.

5. **Abandonment**. When the market conditions become structurally unfavourable, the firm has the opportunity to completely abandon the investment. Such an option is very similar to a financial put option, if the firm receives some amounts from the divestment. As said in section 3, the more specific is the asset to be sold, the higher the exit barriers and the lower the real option's value.
6. **Growth opportunities**. The firm can expand by entering new businesses. This is the essence of the growth option. Such options are rooted, for example, in technological capabilities and competencies. Prahalad and Hamel (1990) showed that Canon founded on the imaging technologies the diversification of its product: scanners, printers, cameras, all share the same portfolio of technological competencies, and this is the basis for exploiting such growth options.

   Another example relating to such types of real options can be that of strategies of brand extension, by which a firm enter new (related) businesses. In the fashion sector, for example, the total-look strategy is based on such an approach.
7. **Obsolescence**. This phase represents the end of the project.

Figure 2.1 shows the phases of a generic ILC and the real options available along each phase. Outside the broken circle, the figure also shows the relationships between IAs and real options. The arrows highlight the influence of IAs on real options (arrows externally-oriented) and the fact that learning options can create knowledge assets (arrows internally-oriented).

Intangible Assets and Real Options Theory: Some Criticisms

The two previous sections have used the real options lens to analyse the economic characteristics of IAs. Real options lens is a very fruitful tool for that purpose. Nevertheless, in order to appreciate the usefulness of adopting ROT for IAs valuation, a deeper analysis should be carried out in order to identify pros and cons. The advantages of using ROT for analysing IAs have been already discussed in the previous sections. This section is devoted to highlight some criticisms to the use of ROT for valuing IAs. The first criticism comes out from the way ROT is usually implemented. Here the problem is the assumption that a greater uncertainty is always positive for the value of a real option. Nevertheless, existing IAs can reduce the risk of the new IAs. Thus, the effect of IAs on the risk of the firm should be carefully appreciated.

The second criticism relates to the methodologies employed for calculating the real options value. In particular, the assumption that the real options payoffs can be perfectly replicated by existing securities or through the MAD approach. This section will discuss these two issues.

A good point for starting with the analysis is the relationship between the value and the risk of a project embedding real options.

Below a fruitful, even if not exhaustive, classification of different types of risk is provided:

- Diversifiable and systematic risk;
- Endogenous and exogenous risk;
- Technical, market and economic risk;
- Replicating and private risk.

Figure 2.2 shows the four different classifications and their relationships. The oblique borders demarcating the classes testify the fact that the distinctions are not usually completely dichotomous but fuzzy, then some overlapping areas emerge. For example, market risk can be in part diversifiable when it refers to industry risk, but it is in part systematic.

The classification based on the distinction between diversifiable and systematic risk is at the core of traditional financial theory. On financial markets, only systematic

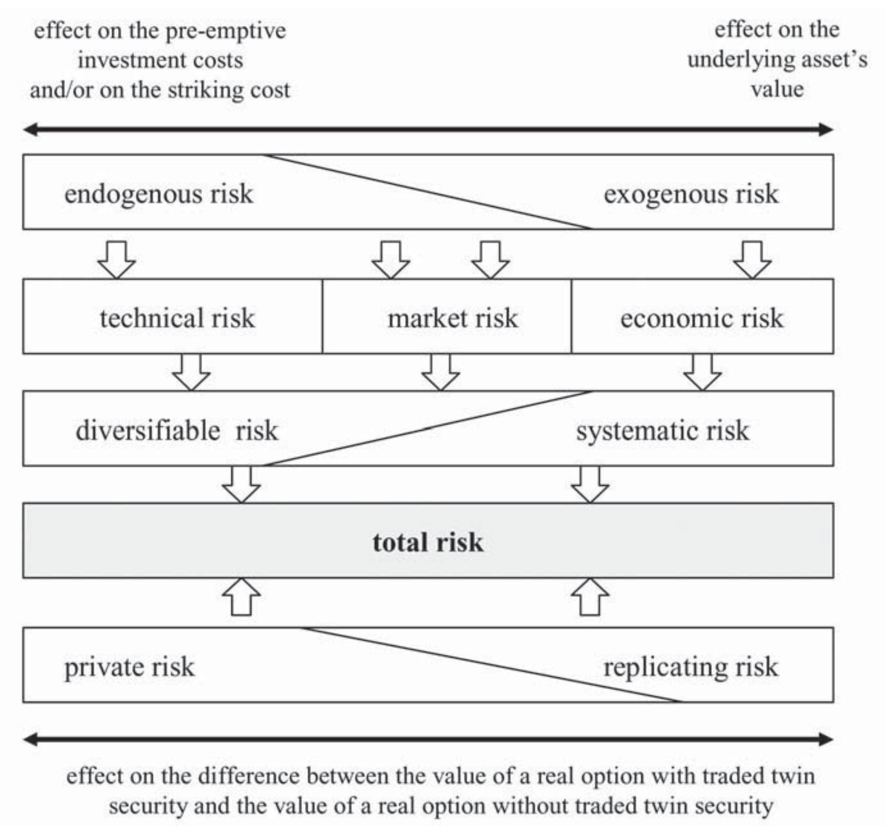

Figure 2.2 Some classifications of risk and their overlapping areas

risk requires for an excess return with respect to risk-free investments. Models such CAPM are based on such a distinction. Cash flows featuring systematic risk should be discounted using a risk-adjusted interest rate, while cash flows with no systematic risk should be discounted using the risk-free interest rate. Examples of the first types are cash flows coming from revenues, while cash outflow relating to R&D investment, tangible investment and fixed costs are generally characterised by diversifiable risk.

Endogenous and exogenous risks qualify for the origins of the risk. In particular, endogenous risk is relating to the time for carrying on the project, (Bräutigam, Esche and Mehler-Bicher 2003), its complexity and its costs. Exogenous risk arises from the market and the whole economy.

The distinction between technical, market (Dixit and Pindyck 1994; Amran and Kulatilaka 1999; Copeland and Antikarov 2003) and economic risk (Miller and Park 2003) breaks down the previously analysed category. Technical risk relates to time, cost and success of an investment activity, while market risk is firmly relating to the dynamics of demand and competition, and economic risk is shaped by forces influencing the whole market. Then technical risk is mainly diversifiable, while systematic and economic risks are more systematic. The latter is prevalently systematic. Market risk, in fact, can be reduced by mean of an inter-sectors diversification.

Figure 2.2 also shows that the different types of risk affect different components of the value of a real option. In fact, endogenous, technical, and diversifiable risk affect the cost of the prerequisite investment and/or the cost of striking the real option. On the contrary, exogenous, market, economic and systematic risk affect the present value of the project underlying the real option.

The latter classification, e.g. replicating and private risk, is proper to ROT, and will be explored in detail further. Here it suffices to say that, according to remarks in Section 2.2, the major proportion of private risk with respect to public risk, affect the usability of CCA (or DPRN).

Once the categories of risk has been presented, it is possible to note that the assumed positive influence of the risk on the value of a real option should be better investigated, also at the light of existing IAs and of their effect on the risk. In particular at least two effect can be found:

1. A reduction of technical/diversifiable risk relating to the cost, time and probability of success of project. For example, a firm's competencies can permit to increase the probability of a research project's success;
2. A reduction in market/systematic risk. For example, a high quality of IAs can protect firm against competition or demand weakness. A deeper understanding of the effect of exiting IAs on the systematic risk can be obtained by decomposing the overall systematic risk (identified by the beta index) into a three-factor model. Such a mode, for example, (Chung Charoenwrong 1991; Hamada 1972; Rubinstein 1973; Lev 1974; Mandelker — Rhee 1984; Miles 1986; Hawawini — Viallet 1999; Griffin — Dugan 2003), could relate the systematic risk to: a) the expected revenues; b) the variable/fixed costs structure (the so called operating leverage); c) the financial leverage. As for

the first point, it could be though of that IAs can reduce the revenues volatility and/or increase the expected average revenues. As for the operating leverage, the IAs have a dual effect, since they can increase the level of fixed cost, due to the amount of their investment cost, while at the same time reducing the variable unit cost, because of the improvement of the firm efficiency. As for the financial leverage, Ho, Xu and Yap (2004) found that firms with more growth opportunity have a lower debt/equity ratio. Recalling that such growth options can arise from IAs, it could be thought of that company with more IAs have a lower financial leverage degree.

The first effect determines, ceteris paribus, an increase in the project's Expanded NPV, and this for two reasons. Firstly, it can improve the probability of success of the prerequisite investment. For example if the IAs level of a firm can increase the probability of success from 50% to 60%, the Expanded NPV will increase proportionally. Secondly, the reduction of technical risk can become evident during the investment in tangible asset, so reducing the cost for exercising the available real options. It should be noted that the analogy with financial options has often led to mis-consider the problems associated to the cost for striking a real options. A large number of ROT models, indeed, do not consider explicitly the possibility that the strike costs can increase so reducing the value of the option. Such an approach has also led to neglect the importance of the ability of a firm to strictly control time and cost of striking investment.[14]

The effect of the reduction of systematic risk is more difficult to analyse. On one hand, it reduces the risk-premium required by investors, so increasing the present value of the underlying asset. This effect translates into a greater value of the real option. On the other hand, if the reduction of systematic risk implies a reduction of the overall risk of the project, a reduction of the value of the real option can also be possible:; indeed, ceteris paribus, the value of the real option is positively correlated to the overall risk (variance) of the underlying asset value.

Figure 2.3 shows a qualitative model embedding the remarks just presented. The signs "+" and "-" near to the arrowhead mean that the two linked variables change in the same or, respectively, in the opposite direction. The Figure shows how the existing IAs impacts on the value of available real options and on the Expanded NPV of the project, through their influence on the risk of the project. The Figure also shows that existing IAs can enhance expected cash flows from new investment, so increasing the value of underlying asset. Effects of a variation in economic risk are intended to be completely exogenous so they are not affected by IAs.

The model just presented is a first attempt to discuss the relations between risk and the value of a real option. A simple simulation model (Marzo 2005) can be run in order to demonstrate that in some circumstances, an increase in the uncertainty of cash flow expected from entering a new business can be make a growth option more valuable for a firm with IAs of less quality with respect to another firm whose IAs are characterised by a higher quality level.

14 See Marzo (2005) for a critical analysis on this point.

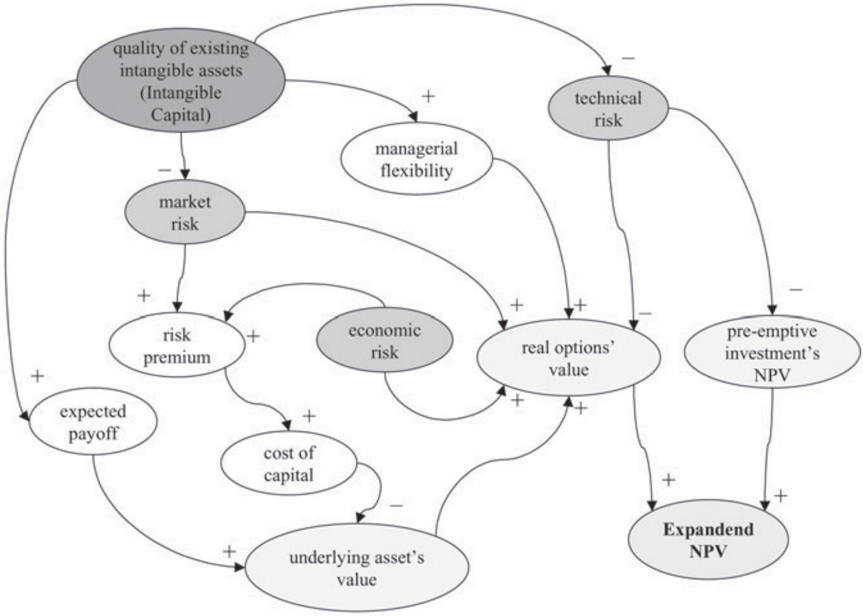

Figure 2.3 How existing IAs influence on an ROA-based valuation of a new IA investment

As for the second criticism, related to the replicability of the real option's payoffs, the distinction between private and public risk is important. As said before, Contingent Claims Analysis, or alternatively DPRN, is usually employed for valuing the real options.[15] The existence of a twin security is of paramount importance for applying both CCA and DPRN.

Referring to the distinction between public and private risk, the more the project features public risk, the more easy is the applying the CCA. A problem arises, however, from the fact that the importance of IAs derives from their specificity for a firm. IAs are specific in the sense that they are difficultly replicable by other firms. Moreover, their specificity is of paramount importance for generating economic value through the strategy they permit to implement.

Due to the specificity of IAs, it could be thought the they display mainly private risk, so making ineffective the use of CCA for their valuation.

The consideration just exposed is also supported by the fact that assuming the completeness of the markets indirectly means that any new venture can be perfectly replicated by existing securities. This way, there is no justification for any process of economic innovation.

15 Dynamic Programming (DP) can also be employed for valuing real options. When DP is employed jointly with the risk-neutral approach the results are consistent with those coming from CCA. The risk-neutral approach can be though of as a way for considering the fact that, if twin security exists, investors are fully diversified and do not ask for risk premium.

Since the existence of private risk, the value of IAs calculated by applying CCA (or the DPRN) can be thought of at least as the upper limit of their value. Without introducing the utility function of the decision-maker, the value of IAs is therefore indeterminate.

Conclusions

This chapter has proposed a balanced valuation of the usefulness of ROT for valuing IAs. In doing this, the chapter has presented the pros and the cons of such an approach.

The advantages with using ROT for valuing IAs are related to the opportunity to interpret some characteristics of IAs through the real options lens. This way, it is possible to appreciate, in a qualitative form, the value of an IA. Moreover, the real options lens can be used to identify different real options along a generic investment cycle in IAs. Such a portfolio of real options and its relationships with existing IAs is potentially a useful tool for appreciating the role of IAs in the value-creation process.

On the other side, ROT is also characterised by techniques for performing the calculation of the value of a real options. In particular CCA and DPRN are the two major techniques employed in literature. Such techniques, however, are based on assumptions that do not match with the reality especially for the case of IAs. This represents the major criticism to the ROT-based valuation of IAs. Due to the unrealism of the assumptions, the value of IAs calculated through ROT does not seem to be reliable.

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