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EVALUATING RISK IN THE INNOVATION PROJECTS OF SMALL FIRMS

A model developed for a risk assessment instrument to be used by entrepreneurs, their advisors and financial backers is presented. By modelling the entire lifecycle of an innovation project, and a variety of intrinsic and managerial risks of the project, we created an 'expert system' that serves both to evaluate and mitigate risk.

Many innovations are proposed and carried out by individual entrepreneurs and small firms. Many regions, including Montreal, Quebec and Ottawa owe them their economic rebirth. The success of entrepreneurial firms spurred an entire body of literature dealing with the inability of large firms to innovate (see Dougherty and Heller 1994; Christensen 1997; Leifer et al. 2001). Yet, entrepreneurs complain about the lack of adequate financing for innovation. On the one hand, banks rely heavily on personal guarantees, require physical assets as collateral, and have difficulty valuing intangible assets such as ideas, knowledge, competencies and even patents (Julien, St-Pierre & Beaudoin 1996). On the other hand, venture capitalists are accused of herding behavior, leading to waves of over-financing in certain areas leaving other areas hungry for funds (Robbins-Roth 2001), and of making trust in the entrepreneur and the management team the main criterion for the financing decision (Knight, 1994; Zopounidis 1994).

Most complaints center on the inability of financial institutions to assess the likelihood that an innovation project will be a successful. Banks and traditional financial institutions, used to deal with more mature or larger businesses, place entrepreneurial innovation projects outside the risk range with which they are comfortable (Levratto, 1994) and rely on collateral to prevent adverse selection by the entrepreneurs who seek funding. Venture capitalists and capital providers with higher risk tolerances have more technical competencies required to evaluate the innovation and reduce the information asymmetry. However, many dysfunctions have been revealed about the way they assess projects (Julien et al. 1996), including the paradoxical tendencies to make poorer predictions when they had more information (Zacharakis and Meyer 2000) and to give insufficient weight to technical issues as a source of project failure (Fries and Guild 2002).

Hence, a reliable tool for assessing the prospects of entrepreneurial innovation projects would be of significant value, particularly in the context of the Knowledge Economy. A team of researchers was commissioned by Canada Economic Development to produce a computerized tool for the assessment of risk in such projects. This paper details the model of risk that underlies the web-based tool, the measurement approach and the structure of the tool. The paper begins with a theoretical background on the evaluation of risk in entrepreneurial innovation projects. Then, we outline the methods used to develop and test the questionnaire. The following section introduces the model of risk and discusses how it was implemented in the tool. Next, we discuss the sections and sub-sections of the questionnaire. A conclusion section closes our argument.

Theoretical Background

Risk is a key element in the financial evaluation of investments. Financial theory regards risk as a one-dimensional construct, often measured using the past variability, both downward and upward, of financial results. Risk is related to uncertainty and is seen as exogenous, intrinsic to the given situation and context. Some theorists favor downside risk measures, either the potential variability below an aspiration level (Miller and Reuer 1996) or the potential for loss, a product of the probability and the magnitude of loss (MacCrimmon and Wehrung 1986). However, estimating probabilistic distributions with historical data is hardly applicable to small companies and innovation projects because of the lack of data. Moreover, studies of managerial risk perception (March and Shapira 1987; Shapira 1995) show that managers (i) see risk as multidimensional and refuse to reduce it to a single quantifiable construct and (ii) contrast risk taking, where skill, experience and information can improve the odds, with gambling, where odds are exogenously determined. By drawing upon the financial and managerial views, we argue that the ideal risk assessment instrument should (i) enable a multidimensional mapping of risk factors in innovation projects, which can inform subsequent mitigating actions, and yet (ii) produce a reliable unique indicator for comparison and decision.

To assess the potential for success or the risk of their innovation projects, large companies often rely on 'questionnaires' or 'scorecards' (e.g. Cooper 1981; Hise and Groth 1995). Recent research shows that scorecards produce better innovation portfolios than financial methods such as the net present value (Cooper et al. 1998). A few scorecards have been proposed for evaluating the success or measure the risk of new ventures. For instance, the Bell-Mason Diagnostic (Bell and McNamara 1991) identifies four stages of an innovative venture and assesses the project on 12 dimensions against an ideal profile for each stage. This model provides managerial guidelines for each stage. However, it overemphasizes managerial readiness at the expense of the project's intrinsic risks. The Inventor's Assistance Programs at the Canadian Innovation Centre (CIC) in Waterloo, ON, assesses the projects proposed by independent inventors using a questionnaire with 37 criteria (Udell, 1989). Astebro (2002) reports that, using all criteria, CIC experts predict correctly no less than 79% of the venture outcomes (although the result is in part due to a self-fulfilling prophecy effect). Moreover, a linear regression model using CIC experts' ratings on only four criteria achieved a comparable predictive performance. Yet, in addition to requiring a lot of data gathering, the CIC model relies on experts' judgment in order to score the project on all criteria. The CIC evaluators are full-time in house experts who developed a unique expertise, difficult replicate by assessors with little prior experience. Furthermore, the model is applicable only for early stage assessment, as it does not evaluate at all organizational aspects of the venture. The ProGrid Venture methodology (Baker et al. 2002), also geared towards early-stage evaluation, uses 12 items and a "language ladders" approach, i.e. a gradation of statements that helps evaluate the score for each item. The items provide a balanced coverage of the aspects of a venture. However, with only 12 items there is not enough guidance for action.

Given our goals, we privileged an "expert system" approach, which relies on hundreds of simple YES/NO questions and sub-questions arranged in a logical sequence function of the answer to the main question. This approach, which has some distant similarities to the "language ladder", facilitates the assessment by inexperienced users and primes them to subsequent risk-reducing steps. The items are based on a review of the literature on innovation and on empirical research, for the identification of concrete risks that await the innovation projects of small firms. Like the Gordon-Mason model, our approach enables an assessment in different phases of the project lifecycle, from the early definition to commercialization. Our model relies on research regarding the evolution of risk in projects (2000; Floricel and Miller 2001); the nature of risk function of degree of technological and market novelty of the project (see for instance Hartmann and Myers 2001; Ulrich and Eppinger 2000); the patterns of uncertainty reduction function of research and development activities (Scherer 1999), including recent contributions that question the uniform decline of risk (Leifer et al. 2000); as well as environmental turbulence and its effects on innovation projects (Brown and Eisenhardt 1997; MacCormack, Verganti and Iansiti 2001).

Methods

In preparation for the research we performed group meetings with entrepreneurs and government employees to understand the kind of instrument that was needed and the typical projects to which it will be applied. The literature review enabled us to produce a basic framework regarding the evolution of risk and the phases of an innovation project and to identify the main categories of risk as well as some specific risks. Several brainstorming sessions led to a set of issues for discussion that covered all the aspects of a recently completed entrepreneurial innovation project as well as the more general experience of the interviewee with innovation projects. Using these issues we performed 11 case studies of innovation projects, based on individual semi-structured interviews with entrepreneurs, venture capitalists, bank employees and government officials. Interviews lasted about one hour and a half each, were recorded and subsequently transcribed. The content analysis of interviews helped us to identify a wide range of risks in entrepreneurial innovation projects. A semi-grounded (Corbin and Strauss 1990) model-building procedure enabled us to select risks of general relevance and produce individual items, arrange these in subsections, attribute weights to the subsections and a score to each item.

The resulting questionnaire was pre-tested both in paper form and as a functional web-based prototype. Twelve entrepreneurs, funding providers and government officials were asked to fill the questionnaire, having in mind a real project. This allowed us to assess the relevance of the questionnaire, the clarity of the items, the time required for completion as well as to perform a rough calibration, whether the total score corresponds to either the respondents' intuition of risk or the real outcome of the project. In the questionnaire calibration phase, now underway, entrepreneurs, financiers and officials will fill hundreds questionnaires using the final web-based version and having in mind a real project. This will allow us to gather data on the range and the distribution of risk scores and assess its correspondence to practitioners' experience with project outcomes and to the distribution predicted by the theory. We also hope to track the real outcome of some projects that will be entered into the database. All this will allow us to fine tune the section, sub-section and individual item weights and scores, hence increasing our confidence in the total score, and to clearly identify the most significant risks.

The Overall Model of Risk

We define *a risk* as a circumstance, situation, event or process that may preclude the innovation project from achieving its goals, for instance its profitability targets, and may even threaten the survival of the enterprise that carries out the project. Each risk identified as potentially having a significant impact on entrepreneurial innovation projects was represented by a question in our instrument. Risks are seen as separate sources of danger for the project; each of them was given a predetermined score corresponding to their likely impact. To simplify and accelerate the filling of the questionnaire we offered the respondent four answer choices for each question: Yes, No, Don't know/cannot answer, Does not apply. To better gauge each risk, some answers, particularly Yes and/or No, trigger additional questions referring to aggravating or mitigating circumstances. Depending on the answer to the additional question, a number of points are added to or deducted from the score for that risk or new questions may be asked. For example, in the market section, we ask: "Are there competitors offering similar product in the market?" If the answer is YES, we ask "Are these competitors large companies?" to better gauge the real risk. In some cases, we used up to four levels of sub-questions. This approach enables a rather precise evaluation of the likelihood and the potential impact of a risk, based on concrete questions. It spares respondents from agonizing over importance scales for general items, while keeping the overall number of questions low, because not all answers trigger additional questions. It also helps mitigate the information asymmetry problem, in case entrepreneurs are reluctant to share information, because they ignore its strategic value or are suspicious (St-Pierre, 1999).

We also define the *total risk* of a project, the indicator of interest to both entrepreneurs and financial backers, as the likelihood that the project will *not* fulfill, partially or totally, its stated

goals. We decided to represent the total risk as a score ranging from 0, meaning a total likelihood of achieving the goals (in reality we expect that a score of 20 should be the minimum), to 100, virtually no chance that the project will achieve its goals. In our model, the total risk is the weighed sum of the various risks that the project faces. We grouped these risks in four categories and apply distinct weighs (shown in brackets) to the total score of each category: technical (30%), market (40%), other intrinsic risks (25%) and managerial/organizational (20%). The score for each category is generally obtained as a sum of the scores of different risks that respondents identify in that category. The total risk is the sum of these scores, multiplied by the category weigh. Calculating risk as a sum neglects the possibility of interaction between various risks. However, it simplifies the programming of the questionnaire and, although this led to some duplication, we used the gauging sub-questions to capture the most likely interactions.

The principle of risk assessment is that of an expert system; we present respondents with a large number of specific questions as opposed to asking them to assess large chunks of risk with a broad question such as “how high is the market risk for the project”. This approach helps respondents who have a technical background but very little managerial and business experience and need to be primed with respect to the factors that constitute a risk. It also serves the purpose of educating them with respect to situations that they may encounter and to the many aspects such as personnel, structure, resources, processes and practices to which they will have to attend. Even experienced users such as venture capitalists found that the questionnaire had an exhaustive and systematic coverage of the sources of risk and served them as a structured memory aid, while experienced entrepreneurs said that they would have liked to have such a tool when they were developing their first projects. Despite this didactic bent, in order to avoid “optimistic” and “socially desirable” responses as well as manipulation, we formulated many items in a way that does not foretell the “good” response (the one with a lower score) or even what exactly is risky in the given situation. A mitigation software capability is used to explain these to respondents.

The questionnaire covers in detail the “universe” of the possible risks facing entrepreneurial innovation projects. The larger is the part of this universe that corresponds to a given project the higher is the total risk of that project. To map this universe we used the literature review, studied concrete cases of projects, and drew upon the experience of interviewees, with an emphasis on completeness. We eliminated risks that were idiosyncratic to a given project or domain and retained those likely to be encountered in most projects. However, because entrepreneurial innovation projects are so diverse, it is impossible that all these risks be pertinent in all projects. Hence, our ‘universe’ and its risks do not constitute a partition in which the sum of all risks will be 100 points. Instead, the sum of the scores for the entire universe of risks is higher than 100. In reality, while total scores over 100 points are possible, a project will rarely be scored higher as many questions will receive a “Does not apply” answer. The calibration process described above will lead to a realistic distribution of results. In sum, despite the use of terms such as likelihood and distribution, the total risk score is not a Bayesian probability assessment in the strict sense of the word. Instead, we seek to provide to come as close as possible to an “objective” assessment of risk, based on the detailed study and modeling of innovation projects and entrepreneurial firms.

Modeling the Lifecycle of Risk

The review of literature as well as our own research on innovation projects show that the sources and the nature of risk vary during the lifecycle of the project. To be able to create a tool that will enable a risk assessment at various stages of the project we modeled the evolution of various risks during the project, particularly of technical and market risk, using the framework proposed by Floricel (2000, Floricel and Miller 2001). The lifecycle model is shown in Figure 1.

Early in the project lifecycle most of the risk comes from a lack of definition, as technical, market and organizational details of the innovation project are not clear. This ambiguity makes the investment risky and usually precludes investors from lending money to the project. As project definition activities, such as delimiting the scope and building a business case, continue the details become clearer and the risk due to ambiguity diminishes. We modeled this type of risk

by giving the answer “Don’t know/Cannot answer” to any question a score equal to the highest score among the “YES” or “NO” answers for the same question. (By contrast, an answer “Does not apply” will receive a score of zero points).

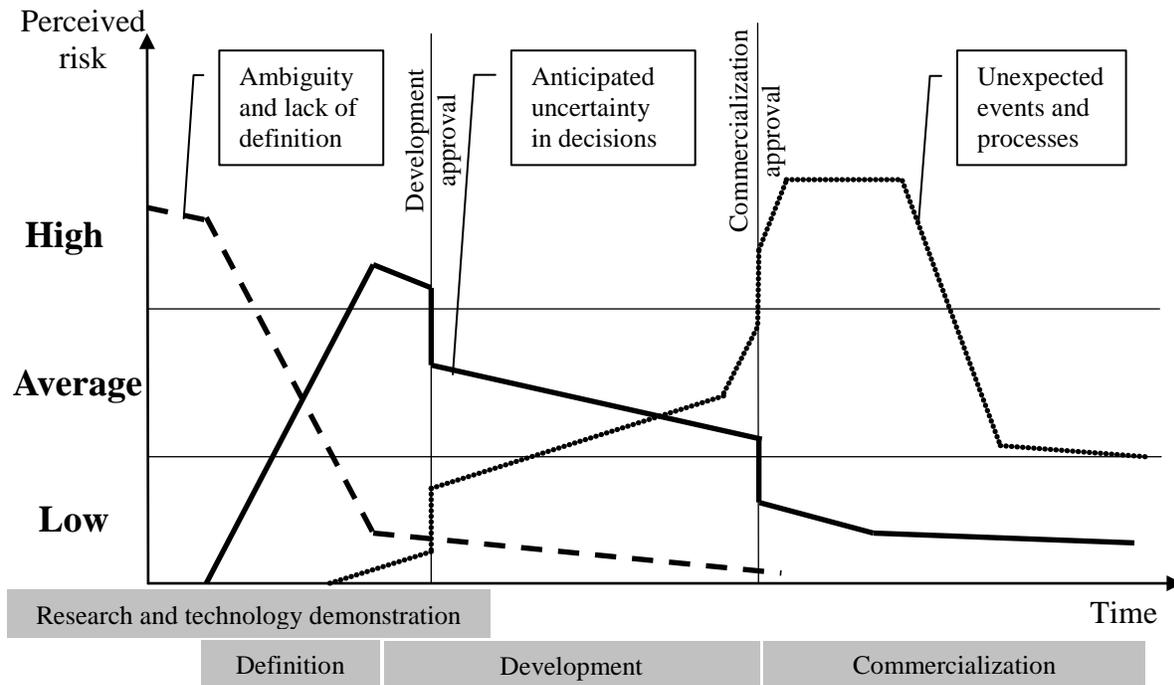


Figure 1 The model of risk lifecycle for an entrepreneurial innovation project

The risk due to ambiguity diminishes during the project definition phase, but we see a concurrent increase in the risk caused by the uncertainty regarding various aspects of the project, such as technical performance, costs, sales potential etc. For instance, managers may not know whether technology will enable them to achieve an adequate level of performance, whether the markets will respond favorably or whether a law will be passed or not. In this case, the risk stems from the possibility that the unknown reality will be unfavorable for the project, although it may also turn out more favorable than expected. We surmise that, in the initial development stage, uncertainty is highest because, while the main elements of the project are already defined, there is little market research, concept testing, design or prototyping (Scherer 1999). At that point, risk is caused mainly by the lack or insufficiency of knowledge and information that would allow managers to resolve the technical, market and other uncertainties of the project. Theorists and practitioners argue that this kind of uncertainty increases with the degree of novelty of the project and the lack of relevant experience on the part of the firm. Hence, from a technical point of view, a project is more risky if it is an advanced R&D effort rather than a marginal improvement based on existing technology (Hartman & Myers 2001; Ulrich and Eppinger 2000 etc.). Regarding its market potential, a project is deemed more risky if the entrepreneur has to create a new market, as opposed to selling into an existing market, particularly one in which the firm is already present with other products. We used semantic ladders to assess the level of initial technical and market uncertainty; the score for each statement corresponds to the degree of technical or market novelty.

The advancement of development activities, such as technical and market feasibility but also of contracting and regulatory processes, is generally thought to reduce uncertainty (e.g. Scherer 1999). For instance, technical uncertainty is reduced successively by a literature review, analytical modeling, physical modeling etc. Market uncertainty is reduced through market research, simulated market tests, and limited product launches. Hence, a series of questions that ask whether these actions were already completed allows us to measure objectively the advancement of the uncertainty reduction activities. The total score for this battery of questions is

deducted from 100 percent and the resulting percentage multiplies the 'degree of novelty' score, which is therefore reduced as more of these activities are completed.

However, accumulating knowledge does not automatically reduce the project risk. Recent innovation literature (see for instance Leifer et al., 2000) shows that definition and feasibility activities, while reducing uncertainty, also reveal many concrete and often unexpected 'problems' 'adverse circumstances' and 'difficulties' that sometimes become 'showstoppers.' Although their ultimate effect on the project may still be uncertain, detection increases risk because they reduce the chances of success, complexify the task, put additional pressure on firm's resources, or reduce the control over the underlying processes. For example, understanding that the product requires a complex purchasing process in the client's organization, the approval of multiple stakeholders, departments and organizational levels, lengthens and complexifies the sales process and requires additional human and financial resources. The literature review and empirical research identified a number of adverse circumstances, which commonly increase project risk, and we added corresponding items to the questionnaire. Examples include technical challenges, certain types of market structure, certain firm ownership and financial structures, even some psychological traits of the owner. Positive answers to these items add to the total risk score. However, entrepreneurs can mitigate at least in part these concrete risks using various strategies, with a corresponding reduction in the risk score. For instance, leasing the product or pricing it under the thresholds that trigger lengthy approval processes may reduce the risk stemming from complex purchasing processes. The software has a «mitigating actions» capability that recommends steps to reduce the specific risk and allows for a reduction of the risk score if these actions are undertaken.

Florice (2000) argues that late in the lifecycle of a project most risk comes from unexpected problems and events, because decisions taken earlier, such as technical choices, market strategies and contractual commitments, reduce the flexibility managers have in responding to surprises. Changing project elements requires significant additional resources, which puts a significant strain on small companies. Because anticipatory analytical approaches have many limitations there is a high probability of unexpected problems occurring as the project confronts the reality directly, e.g. when as full-scale prototypes are built or when market tests and commercialization begins. Adverse circumstances (see above) are more difficult to tackle if uncovered late in the project lifecycle. Moreover, projects become particularly vulnerable to surprising developments in the market, technological, regulatory and other environments. The more turbulent is an environment the more likely the project is to encounter surprises (Emery and Trist, 1965; Bettis & Hitt, 1995). To assess the potential for unexpected events stemming from environmental turbulence, we included questions regarding the frequency with which unpredictable changes in market, technical and other environments occur. Our research shows that surprises are common in innovation projects and require significant additional financial and human resources and well as time reserves, which will surely strain the bearing capacity of a small firm. In order to assess the ability of the project to deal with such surprises we included many questions regarding the availability of reserves or the easy access to significant additional resources on the part of project.

The Subsections of the Questionnaire

Table 1 presents a summary of the sections and subsections of the questionnaire. We divided the project risk in two large categories: (a) intrinsic risks, which reflect the failure potential independently of the entrepreneur or of the firm that will implement the project and of the practices that are being used; and (b) managerial risks, which are related to the potential of the entrepreneur, the organization and its practices to implement the project adequately.

Intrinsic Risks

We divided them in (a) technical risks, reflecting the potential for failure to achieve the technical goals of the product or project (the product does not work; it does not achieve the targeted level of performance, reliability and durability; it is too costly to develop, manufacture or

operate; it is not ready in time; it is technically inferior to other products that reach the market at the same time etc.); (b) market risks, reflecting the potential for failure to achieve the sales or revenue goals of the project (dissatisfied clients, disappointing revenues or a longer than expected time lapse until sales begin to ramp up, distribution difficulties, inability to sustain the competitive advantage in the marketplace etc.); and (c) other risks, which group additional circumstances that can stop the project, increase costs or diminish potential profitability.

Table 1: Summary of the sections and subsections of the questionnaire

Intrinsic risks	Technical risk	Technological novelty of the product
		Resolution of the technical uncertainty concerning the product
		Technical uncertainty regarding the production process
		Nature of the problems and technical issues that remain to be solved
		Technical turbulence
	Market risk	Novelty of the market
		Resolution of market uncertainty
		Product-market characteristics
	Other intrinsic risks	Regulatory, social and intellectual property
Managerial risks	Organizational potential	The competencies of the entrepreneur and the management team
		The ability to finance the project
		Management systems
		Growth capacity
	R&D potential	Research and technology demonstration
		Development, design and engineering
	Commercialization potential	Production and input acquisition
		Marketing and sales

Technical risks section has a weight of 0.3. As the total score for this section will be calibrated so as to rarely be larger than 100 points, the section can contribute a maximum of 30 points to the total risk. Technical risk is estimated using the risk lifecycle model described above. First, the respondent chooses between five degrees of technical novelty of the product. The lowest has a score of 20 points and the highest a score of 70 points. Then, the respondent is asked to identify whether a series of technical uncertainty resolution activities regarding the product have been completed. These activities follow the typical sequence of methods for concept feasibility and testing, with progressive uncertainty reduction and cost increase: literature and patent search, analytical modeling and simulation, laboratory experiments, internal tests of prototypes, external tests of prototypes and exploitation in commercial regime. Positive answers for each question produce a percentage reduction in technical uncertainty. The highest reduction occurs if physical prototypes are tested internally and externally, 20 percents each. The sum of the percentages for each of these activities, which has a maximum of 90%, is deducted from 100 percent to obtain the residual percentage of technical uncertainty. This percentage is multiplied by the score obtained for technical novelty to obtain the overall score for the risk from technical uncertainty. Moreover, we ask whether manufacturing the product requires a novel high-volume dedicated process. If the answer is positive, we add 30 points to the technical risk. Then, we ask whether the feasibility of the process was demonstrated on an industrial scale. A positive answer reduces the risk.

To assess the concrete anticipated technical risks that have surfaced as a result of the uncertainty reduction activities, we ask a series of questions regarding the technical issues *that have yet to be solved*, e.g. whether there is a need to develop new technology, to use external technologies that are not mastered by the firm, to deal with levels of complexity that are unusual for the firm etc. Any positive answer increases the risk score because either the literature or our empirical research suggests higher chances of failure. To reduce the number of questions, we use only a few categories of circumstances but we prime respondents using specific examples. For

instance, unusual complexity may stem from a situation in which an information system product has to be combined with heritage information and production systems of the client.

Finally, we ask questions that assess the turbulence in the technical environment, such as whether new technologies, materials and components are frequently proposed. Such events increase the risk because they may enable a competitor to offer a superior product and because components and materials currently used could no longer be available, calling for a redesign of the product. Other sources of turbulence are changes in infrastructure technologies (e.g. operating systems) and in the tools and methods for technical research and product development. Positive answers increase the technical risk. The risks from all the above batteries of questions are added up to produce the technical score risk that will subsequently be multiplied by the section weigh.

Market risk has a weigh of 0.4. The higher weigh than for the technical risk reflects the fact that even excellent technical concepts often fail to find buyers or match the requirements of marketplace (Christensen, 1997). In answering the market risk section, the respondent will follow two distinct paths, function of whether the innovation is developed for a client that supports all project costs (including R&D) or not. In the former case, the market risk is much lower and the questionnaire is shorter and regards the possibility of conflict with the clients, stemming from the unrealistic or ambiguous contractual elements, or from change requests. In the latter case, including cases in which there is no firm contract or the clients support the costs only partially, the respondent has to answer a larger series of questions with respect to the presence of certain market characteristics that are risky, particularly for small enterprises.

The market risk section follows the same lifecycle structure as the technical risk. We first ask questions in order to assess the level of uncertainty. The highest uncertainty score results if the market has to be developed, because the firm may have to generate consumer awareness for the new class of products, change consumption and purchasing behaviors, develop distribution circuits, and so on, all with limited knowledge about the relation between effort and success. The score is lower if the market exists but is new for the firm, because some of the above elements are already in place but the firms' knowledge and assumptions may not be appropriate for the new market. Finally, the uncertainty score is lowest if the market exists and the firm is already present with other products in that market. Then, a series of questions address the uncertainty reduction. For instance, we ask whether the entrepreneurs have previous experience with the market as consultants, employees, service providers etc.; whether a formal needs analysis (interviews, visits, observations etc.) and an estimation of the market size have been performed; whether potential clients have been given the opportunity to use-test a prototype; whether the product was launched in a test market; and, finally, whether formal agreements have been concluded for the sale or distribution of the product. A positive answer to any question reduces uncertainty by a certain percentage. The total for this battery of questions is deducted from 100% and the result multiplies the uncertainty score corresponding to the market novelty (known, existing, to be developed).

Then, we ask whether the knowledge gained so far revealed risky circumstances, identified in the literature on marketing, strategy, industrial organization and the adoption and diffusion of innovation (see for instance Rogers, 1995 etc.) as well as through interviews. The latter were useful in defining conditions that are especially difficult for small companies, given their resource limitations. These questions are grouped in three subsections dealing respectively with the nature of the market (demand), competition (offer) and product. In general, a positive answer to the corresponding question increases the risk score. For instance, regarding demand, we ask whether the potential customers are represented by one or a few large firms. The risk is increased by the potential that such firms would impose their conditions on the small firm. Moreover, a fragmented market in which customer needs are not homogeneous and no distribution partner can reach a sizable part of the market will also pose problems to a small firm. Regarding competition, the presence on the market, or the intention to enter it, on the part of a large company increases the risk of the project. The risk increases further if the competitor can influence distribution channels or if it offers a complete family of products (which could prove for a small firm to achieve in the short term). A market prone to price and promotion wars will also reduce the

window of opportunity for a small firm to consolidate itself in the market. Product-related risks increase when the success is conditioned by the adoption of a standard, the provision of complementary products, and the compatibility with existing infrastructure, systems or practices.

Contrary to the technical section, we included some circumstances that can actually reduce the market risk. For instance, we see the presence of a high potential for demand growth in the short term or having a product that offers a unique value to the customers (i.e. no competing or substitute product) as reducing the overall market risk. The possibility to demonstrate the product in use also reduces the market risk. Finally, we included a subsection on market turbulence, in which we ask whether user needs are constantly changing, competitors introduce frequently new products and there is a constant flow of new entrants with products based on the different business models and technical principles. The sum of the uncertainty risk, anticipated risks and turbulence potential is the market risk of the project, calibrated to rarely exceed 100 points.

The other intrinsic risks section has a weigh of 0.25. It groups circumstances related to the protection of intellectual property, the necessity to obtain a regulatory approval or certification for the product or the manufacturing process, the possibility of social or political resistance with respect to the product or the underlying technology. This section is shorter than the previous two and has only a few questions about the remaining anticipated risks and the possible mitigating measures (i.e. does not follow the entire lifecycle of risk). Its total sum rarely exceeds 40 points and hence this section can contribute a maximum of 10 points to the total risk score.

Managerial Risks

The second large category of our instrument refers to firm-specific factors that can preclude the project from attaining its goals. The literature and the case studies suggest that the abilities of the entrepreneur and the management team, the capacity of the firm to access resources, its management processes, and its R&D and commercialization practices may pose additional risks (Harris & Jackson 1999; Heunks, 1998; Karlsson & Olsson, 1998). Then again, interviewees showed a preference to finance “an average project proposed by an excellent team, rather than an excellent project proposed by a weak team”. Moreover, firms able to take on risky projects may be more profitable, because the field of contenders is less crowded and the competitive advantage is more sustainable (Lessard and Miller, 2001). As a result, we allowed the overall score for managerial risks to have negative values. However, the literature in entrepreneurship also underscores that those who evaluate innovation projects proposed by small companies tend to give too much importance to human factors related to the entrepreneur. Hence, the weigh for the managerial risk is 0.2 and the score for the section is allowed to vary between –10 points and +20 points (the potential positive effect on risk is discounted compared to the potential for additional risk stemming from managerial factors). The managerial risk section has three subsections (i) organizational potential to manage innovation projects and acquire resources, without regard to the project and its various stages; (ii) the practices that will be used for the remaining R&D activities; and (iii) the practices that will be used in the commercialization phase of the project.

Organizational potential. This section regards four aspects: the managerial capabilities of the entrepreneur and the top management team; the capacity to secure funds and other resources; the managerial processes put in place in the firm; and the capacity to sustain rapid growth. While often exaggerated, the personal traits of the entrepreneurs are among the most important risk as well as success factors for innovation projects (Heunks, 1998). Among the risky traits are the lack of experience in the management of innovation projects, the tendency to hide problems and inability to seek help and advice from others, the lack of a network of contracts, the tendency to control everything and the inability to delegate etc. The main risks plaguing the team as a whole are the dominance of one type of expertise (particularly technical), as well as the possibility of conflicts between two co-owners that don't know or trust each other. Regarding the capacity to finance the project, the main risks stem from the lack of understanding of the resource requirements and, consequently the lack of a long term financial vision or plan and so on. Among the key management processes whose inadequacy or total absence could endanger the project

were strategic planning, particularly the ability to integrate the project with the existing firms' mission and activities; a system of periodic reevaluation and reorientation (gating) of the project; systems for the operational and financial control; recruiting, motivation and team building processes; risk management; systems for documenting and preserving technical information (e.g. source codes; justification for key decisions). Finally, the growth potential of the company can be hampered, among others, by the inability to secure funding to support a cash flow deficit and by the entrepreneur's reluctance to share the control of the enterprise.

Research and development section is divided into (i) research and technology demonstration activities and (ii) product development, design, engineering and testing activities. Each subsection starts with a question whether there still are respective activities to be performed. A negative answer leads to a zero risk score for the respective subsection and the respondent is not presented the other questions in the subsection. Hence, this section follows a lifecycle logic, in the sense that, as activities are performed, the managerial risk related to the ability to perform them diminishes. If the answers to both subsections are negative, the respondent is only asked questions regarding commercialization activities (see below). In the research and technology demonstration subsection, questions deal primarily with the availability of, or access to the required resources: financial, human (scientific and technical expertise and skills) as well as specialized facilities and equipment. It is well known that talented specialists are difficult to find. Moreover, in certain periods, there are shortages of given skills, as was the case for programmers during the Internet boom and Y2K bug years. The firms also has to take measures to retain them in the long term, for instance by giving them shares and options. The high cost of research activities requires a knowledge of, and an ability to use, government financing, support programs and facilities. Given the high level of uncertainty with regard to this type of activities, the firm must be able to bear a 50% budget overrun. Other issues regard the access to technologies that are the property of other entities (e.g. through licensing) as well as whether the firm secures an adequate guidance for research activities (e.g. thorough the creation of an advisory committee). In the development, design and engineering section, similar questions regard the availability or access to resources and the capacity to bear budget and schedule overruns. In addition, we ask questions regarding the use of product development processes and practices that reduce the risk of producing ineffective products and of cost overruns: development or learning plans that give high priority to solving critical issues; the involvement of clients and suppliers in the development process; systematic analysis of used needs and definition of target specifications; early consideration of manufacturing, operability and quality issues; setting clear criteria for knowing when the development goals are attained and the product can be commercialized (to avoid what respondents called the "never good enough syndrome"). In addition, we included items referring to practices for turbulent environments (such as getting rapid client feedback or using flexible technical solutions), for the development of the manufacturing process and to the use of alliances.

Commercialization. Most small innovative firms have to live with the precarious situation of their firms and projects (Julien, St-Pierre & Beaudoin, 1996). An interviewee argued that it is almost useless to think beyond the next six months (or the current financing round). In other words, small firms have a rolling span of attention that includes only the nearest set of activities, for which it has resources, and which, in the early stages, does not include commercialization. However, this does not diminish, and may in fact increase, the risk that projects and firms will fail in the commercialization stage because of their inability to organize and manage activities. Hence, it is useful to assess the firms' commercialization abilities and intended approach even in early stages. Moreover, for projects in the later stages of development, the remaining risks are mostly linked to commercialization. Therefore we included a detailed commercialization section, divided in two subsections: production and marketing. In the production section, we propose two distinct paths: (i) the firm manufactures the product, and (ii) the firm subcontracts manufacturing. In the former case, items refer to the current manufacturing capacities and to the firm's ability invest in equipment acquisition, facility upgrading or construction etc. Some small companies we interviewed had difficulties in competing for skilled labor with large organizations in their area, which offered more stability, higher salaries and more attractive benefits. Therefore, we included items referring to the availability human resources or the ability to train existing workforce. Other

items refer to securing on-time delivery of specialized equipment and making sure that inputs (materials, components) will be available in the long term. For cases in which manufacturing is subcontracted, which is very frequent in for small firms, items refer to the availability of subcontractors as well as to the ability of the firm to retain control over the quality of the product. In the marketing section we also have two paths: (i) commercialization by the company, and (ii) commercialization by or with a partner. In the latter case, the items regard whether such a partner has been found and, if yes, whether it has the required competencies and financial strength. In the case of commercialization by the firm, one the main issues is resource endowment. Our case studies revealed that small companies as well as some of their backers do not seem to understand the difficulties and the amount of effort and resources required to market a new product. While the costs of manufacturing may be more evident, marketing costs are often neglected, because of the inexperience of entrepreneurs or of the “better mousetrap” fallacy. In some cases, particularly in Quebec, institutional pressures lead to a tendency to dilute risk capital investment among several companies, none of which gets enough funding. Several respondents conveyed to us a rule of thumb that commercialization costs are 5 to 10 times higher than development costs. While these costs may be lower for some products and market contexts, we decided to create an item based on this rule of thumb in order to assess the readiness of the enterprise to undertake commercialization. The other questions ask whether the standard items of a marketing strategy have been addressed, including product positioning, features, guarantees, pricing strategy, sales force and distribution. A point that has often afflicted small companies in our sample, and hence has a higher risk score, was recruiting, retaining and motivating sales executives and a sales force.

Conclusion

The research underlying this questionnaire can contribute to the theories of innovative entrepreneurship, and to a better definition of the risk lifecycle in innovation projects. We hope that, after further research and careful validation, the theoretical insights and practical tools can help the development of better financing institutions, programs and practices, as well as provide guidance to entrepreneurs and their advisors.

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