Business Valuation Of Technology: An Experiential Model

By Mirjam Leloux and Aard Groen

Introduction

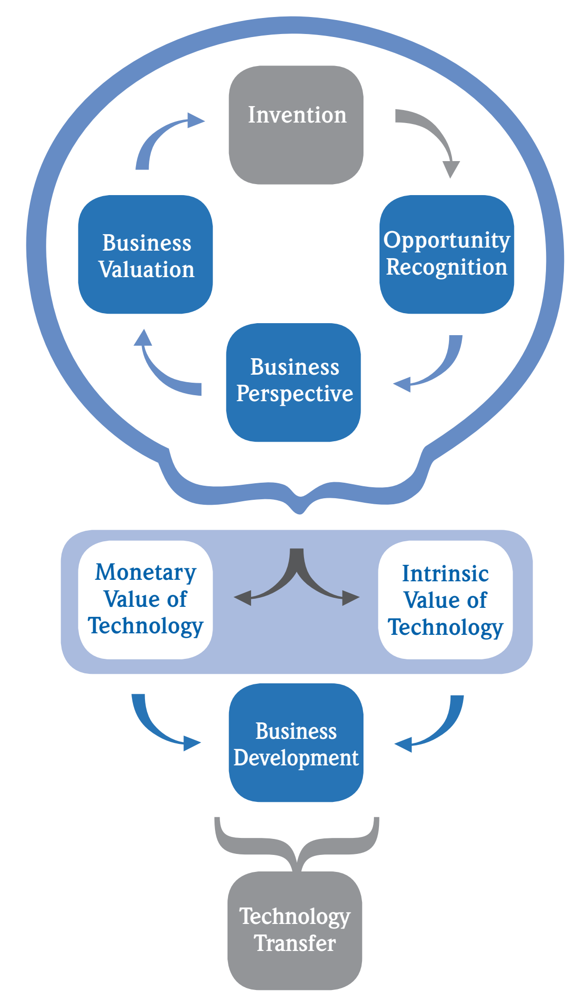
Nowadays, the valorization of research is a topic of enhanced interest at universities and public or private research institutes. Research organizations generally have a (considerable) portfolio of patents on their shelves, waiting for a sustainable exploitation strategy. However, the transfer of technologies from academia and other research institutes to commercial parties and/or the commercial exploitation of inventions is still in its infancy, as in-house business knowledge, experience and skills are often lacking. Moreover, financial valuation methods may be unknown, so the monetary value of technological inventions is generally difficult to obtain. Having experience in several technology transfer projects, we developed a novel technology business valuation model following a stepwise approach, starting at the invention, passing through a stage of business awareness creation and defining its business perspective, then entering the phase of business development and technology transfer after having elaborated on a process of business valuation, including both technological and financial points of view (Figure 1). In this paper we will discuss these phases in some detail.

The Invention

The process starts with technological invention, either a novel technological product or process, as a result from a research process or project. This invention may be a *discontinuous innovation*:[1] a novel technological product or process obtaining a substantial gain in one or more performance metrics with respect to its predecessor (e.g. a factor of 5-10 times in product performance or a significant (>30 percent) reduction in costs). It may alternatively be a *radical innovation*,[2] a totally new approach, offering a different package of performance attributes. A radical technology can be defined in terms of competence change (e.g. the technological distance to a preceding generation, the distance to a common scientific field, a substitution or complementation to the existing technology), as a physical product or process change (e.g. a new component, a new subsystem, complete redesign or a new product class) or changes in the price/performance level. The radicalness of innovations refers to the extent an innovation is based on a substantially new technology relative to existing practice.[3] The radicalness is thus a technology-based dimension of innovations.

A radical innovation will have a high degree of novelty and inventiveness, important terms with respect to patent policies. A patent may be described as an exclusive right of limited duration over a new, non-obvious invention capable of industrial application where the right to sue others for infringement is granted in return for publication of the invention.[4] Only technological invention meeting

Figure 1: Steps In The Business Valuation Process



requirements regarding to novelty (i.e. the technological distance between an invention and the prior art), inventiveness (i.e. the technological distance between the patented invention and existing technology in terms of obviousness) and industrial applicability may be patented.[5] A patentability awareness of a fundamental scientific invention (mainly focused at concept development and mechanism elucidation), may especially be related to a sense of radicalness of the innovation. Such an awareness may occur resulting from discussions within the scientific domain, e.g. between scientists involved in this research area, in the laboratory, at congresses, symposia or other scientific meetings, or—potentially—between a scientist and its patent attorney. For most academic scientists, however, patenting contributes less to their prestige and/or (scientific) reputation than scientific publications in refereed journals. If they decide to publish their invention, patenting will no longer be possible. So it may be before or at this point of patentability awareness and before the patent application process has started that their contribution to the innovation process stops.

Business Awareness

It can be assumed that patent attorneys play a pivotal role during the patent application process of a fundamental scientific invention, as they are supposed to elaborate on the strengths and potential benefits of the invention, its technological radicalness, its breadth of industrial application, its technical and economic feasibility, its quality, etc., and consequently secure these as legal rights in patent claims. Although business-related information on the commercial opportunities of an invention is marginally addressed in patent applications, the patent attorney will try to maximize the potential profit of the patent by finding the balance between patenting in an active market with a small inventive step and high risk of infringement or extending the breadth to its maximum for patents showing a high inventive step.[6] It therefore seems that a patent attorney is able to play an important role in creating *business awareness, i.e. having or showing realization, perception or knowledge of a commercial perspective* in the case of an invention in the field of fundamental research. At this stage, the application area of the invention may also be elaborated on, e.g. by systematically identifying the "fundamental scientific concept behind the invention" and extrapolate it to an exhaustive list of potential technology applications.

In the field of applied research, business awareness in the inventor's realm may result from a different origin. Applied research is commonly being advocated or initiated by a clear business need and/or demanded by a sponsor (usually a company and/or a (governmental) grant) financially contributing to a co-development or contract research project. Sponsors often set up research collaborations with specialized scientists to reduce the developmental risks of radical technologies (besides for other reasons such as a lack of research-capacity in-house). Any intellectual property rights of any novel intellectual property created during the sponsored research project will be owned by the sponsor, as common sponsoring contracts dictate. However, the sponsor is assumed to be mainly interested in novel intellectual property related to its own business needs, with generally a proper fit to either its own technology base or market area.

In this case, business awareness with the scientist is created by the interaction with a third party: "the market" (*in casu* the commercial sponsor). Moreover, a *"savant and entrepreneurial inventor"* will probably envisage an additional business application of his inventions being outside the business scope of its particular sponsor. Those inventions, e.g. the so-called *disruptive technologies*, offering a very different package of attributes and at a far worse performance along one or two dimensions being particularly important to the sponsor,[7] may still have a novel and challenging *business perspective* as a novel product/market combination.

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The Business Perspective

For the inventor having become aware of a challenging *business perspective* related to his/her invention, a definition of a business need per application related to the invention in various market segments is needed and worked out in an initial business plan (i.e. *Business Scan*). To enable this initial *Business Scan*, the non-skilled inventor needs to interact with a person or organization familiar to this new business development process, e.g. a business manager or consultant. At universities or public research institutes, technology transfer or liaison offices exist, which may traditionally have been focused more on governmental grant application rather than on active commercial exploitation of inventions or early entrepreneurship related to such inventions. At private contract research institutes, generally focusing more on applied research, the interaction with "the business" is more embedded in daily practice and occurs more smoothly.

The first step in this stage is to link different product applications as obtained in the former patent application process to an industry and/or market segment based on technology factors (e.g. radicalness, developmental risks, technology fit, price/performance ratio) and market-related factors (e.g. disruptiveness, market risks, competitiveness, demand). Market demand for the novel invention may be different in several market segments, based on the relationship between the functional preferences of the different market segments, the critical performance trajectory per market segment and the common technological base within this market segment.[8] The forecasting of the market diffusion of discontinuous and disruptive technology is different from forecasting most innovations, due to the relative novelty of the innovation. Also, discontinuous and disruptive technologies generally serve multiple market segments being either unidentified or having non-similar diffusion drivers, such as relative advantage, compatibility, complexity, trialability and observability, or variable rates of diffusion. It seems that the business fit for the invention will be optimal within market segments, e.g. industries with a similar technology fit and with as low degree of disruptiveness as possible.

Formulae for forecasting the market diffusion of discontinuous and disruptive innovation, based on the work of Bass, have been created. All of the diffusion models currently in use require the determination of some set of parameters, e.g. market size, coefficient of imitation and coefficient of innovation. The size of the market (or market penetration) may be determined through the use of industry surveys that consider variables such as economic factors and a detailed analysis of potential substitutes. Database analysis, "Google" and company annual reports are important tools to gather market data on the macro-level (market structure, market segmentation, and market size/ growth) as well as identify market trends in particular markets. Market data on the micro-level are more difficult to obtain and must be extrapolated by a skilled business analyst or obtained by interviewing market leaders and prospective users of the novel invented technology per segment (pre-launch surveys). Note that such micro-segmentation data are preferential inputs for the business valuation model that follows. A conventional SWOT-analysis contributes to recognizing the current status and the implying difficulties of the novel invention which is helpful to further determine its competitive position within each market segment. Preferably, the SWOT is created in a workshop with participants from both the scientific as well as business-oriented areas. The SWOT-analysis may be based on the technical specification (strengths, weaknesses) which has already (partly) been compiled during the patent application process and the market data (business opportunity, threads) that have been gathered in the business scan so far. The riskiness of the business opportunity, which is industry-dependent and relates also to the maturity of the invention, its patent protection, legal and regulatory issues, its radicalness/disruptiveness as well as its distance to industrial applicability, is also addressed.

Business Valuation: the Intrinsic Value of Technology

Having conducted a Business Scan providing a detailed and dedicated market analysis on the micro segment level, the business valuation process starts aiming at deriving a monetary value of the invention, based on both intrinsic technology/ intellectual property value and market data.

According to Gibbs,[10] three primary determinants are interactive indicators of technology value: legal factors, commercial factors and technological factors. Patent attorneys will put more value on the patent legal factors, such as claim scope, invalidity risk and so forth. The technologist will more narrowly value a patent on its technical attributes, while the business professional will more broadly correlate patent value to the commercial opportunities that the patent helps create. Integrated models for business valuation are however scarce, so we will first focus on either technology/ intellectual property valuation or monetary valuation models, respectively.

The *intrinsic value of technology* is often expressed as the result of a common technology scoring model, which is a relatively popular tool within companies to investigate the technological and business potential of a novel technology. Generally, an expert committee with various professional expertises (e.g. scientists, patent attorneys, business managers) assess the total score of a technology in several aspects, such as level of technology, marketability of technology, technology potential and profitability. For each factor, an evaluator subjectivity rate score is included. The results of the scoring process comprise a score index which is a qualitative indication for the value of the technology within its industrial context. Scoring models are robust and simple in use. Negative drawbacks also exist. First, the score index indicates the relative preference among alternatives thus having only a limited relation with the value of the technology. Second, the ignorance of the relationship between the technological and business variables may cause misleading results.[11] The *intrinsic value of intellectual property* is even more complicated, as uncertainties occur about both the technological and commercial success in competitive markets of underlying technology, as well as about the legal challenges which can occur both during application and subsequent enforcement. This complex series of possibilities involves costs that increase along the lifetime of the patent.[4] A patent value should relate to observable as well as counterfactual information on prices, costs and quantities sold of patent-protected products. From the literature, *qualitative value-determining parameters of patents* include the lifetime of a patent, the patent-breadth, the number of backwards citations, portfolio position, and the difficulty of "inventing around." Various authors elaborate on this topic of the qualitative patent value, defining various patent value indicators, such as the state-of-the-art of existing technology, the inventive step, the breadth of the patent;[6] the country of the inventor, the technological field, local and international cooperation in the invention process, ownership of the patent by a foreign multinational firm, the administrative path followed by the patent (strategy of the patentee) and the number of designated states (countries where the invention is protected;[12] citations received from subsequent patents, backward citations, family size, and observed outcomes from opposition cases.[13] Knowledge of technical importance, the position of a patent in a portfolio, its learning value for competitors through its disclosure and its difficulty to invent around may contribute to the value of a patent; whereas the disclosure, the difficulty of the invention and the position a patent holds within a portfolio play a minor role. Another important value-determinant is the importance of the patent-protected invention for current or future technical developments.[5] In science-oriented fields such as pharmaceuticals and chemicals, references to the non-patent literature carry explanatory power; in other technical fields studied no such evidence exists.

The direct *quantitative (financial) value of a patent* or patent application per se, must be the value of the potential extra profits obtainable from fully exploiting the invention defined by the patent's claims in the patent's presence compared with those obtainable without patent protection.[4] In an empirical study information on the value of patents was obtained by multiplying annual sales and profit data by a correction factor accounting for the contribution of the patent to these data.[13]

Business Valuation: The Monetary Value of Technology

Current monetary (financial) valuation methods for technology include cost-based methods, income-based methods and market-based methods.[14,15, 4]

Cost-based methods are based on the costs to create and develop or to replace the assets under consideration, may additionally incorporate the benefit of introducing the product to the marketplace sooner, and typically results as a lump sum value of the subject technology. This approach might be useful for valuing embryonic basic technology for which market applications cannot yet be defined and for narrow-scopes technology which is easy to replicate or "design around." Their most serious drawback is that they make no allowance for the future income and/or profits streams, market conditions, buyer/seller motivations, useful life and the risk associated with receiving future economic benefits which might accrue from the patent. In addition, the approach necessitates accurate cost data and depreciation, which in practice, may often be difficult to obtain.

Market based methods are accounting for market conditions. A useful guide to the value of a patent may be the price paid for a similar intellectual property asset in a very recent commercial transaction. Market based valuation methods may also be based on comparable royalty rates which are generally applied in specific industry segments. Other approaches include the calculation of P/E ratios. Factors to consider include the nature of assets transferred, the industry and products involved, agreement terms and other factors, which may affect the agreed-upon compensation. Although this rationale is reasonable, public information on price and comparability is usually not readily available. Additionally, unusual intellectual property or disruptive technology portfolios do not have comparables that can be used as guidelines and require much more investigation.

Income based methods are accounting for future value using conventional Discounted Cash Flow methods (DCF). Income-based calculations generate a present value based on an estimation of future cash flows (through licensing or through direct exploitation) and their timing, expectations about variations in the amount or timing of those cash flows, the time value of money as well as the costs of uncertainty and risk. The duration and timing of the cash flow is determined by forecasting, e.g. using common market diffusion tools, the useful lifetime of the asset, either as its physical or service life, its statutory or legal life (e.g. as patents), its economic life (the period of time during which the property is producing an adequate return) or its functional or technological life (the period after which the technology becomes commercialized but before which the technology becomes obsolete). The business risk associated with the realization of the stream of expected cash flow may be captured through the use of appropriate discount rates, which are industry-specific and/or linked to the development stage of a novel technology. This method is often used for new technologies when comparables are not available and the enabled market is sizeable. Its major drawback is the chance of error due to subjective estimation. The DCF-approach also doesn't account for the different risks and uncertainties associated with a multi-stage cash flow and variable discount rates over the lifetime of a patent. So the valuation of the patent would have to be split into several distinct phases. Therefore, several risk-adjusted DCF-methods have been developed, such as *Monte Carlo methods* (sensitivity analysis), the end-result being a frequency distribution of Net Present Values (NPV). The real role of such simulations is to understand the way in which the values vary with the parameters of the model constructed. *Decision Tree Analysis (DTA)* accounts for more flexibility as in each branch an underlying DCF analysis is done, starting with the final ones and working backwards in time to give a present value. *Option Pricing Theory (OPT) methods*, such as the continuous time Black Scholes (B-S) Option Pricing Models are accounting for changing risk of future cash flows. The present value of returns the company will receive from the investment is likened to the value of the share subject to the call option. Option pricing methods have some advantages. First, they circumvent the relatively arbitrary matter of the appropriate discount rate by employing the measurable volatility of an asset's index value as an indicator of risk. In addition, such pricing models can circumvent the uncertainties of future cash flows by employing index values based on the present value of assets in the same class.

Several authors advocate the application of option-based valuation methods in strategic investments rather than DCF models only and have developed multiple scenario integrated models complementing DCF and option pricing techniques.[16-20] In practice, such multiple scenario valuation methods are applied by various multinationals in pharmaceutical, chemical industries and energy as well as consulting companies.

Business Valuation: Integrated Models

In the literature we have identified two different integrated models for business valuation of patents that are, however, not easily accessible for general applicability. Gibbs[10] offers an integrated model for business valuation of patents based on a market adoption/diffusion model, including technology factors, such as the level of technological advancement and technical sophistication as well as market-related factors, such as combinatorial accession (tied to diffusion—market penetration) and cogency. He demonstrates the capability to chart adoption/diffusion S-curve data, characterizing the technological importance of the present patent against the generational time line of the technology as defined by the most closely related patents. S-curves analyze the speed at which the technology is adopted not only within the field that spawned the technology, but also across unrelated sectors of society, industry and commerce. Important technologies "diffuse" more quickly than technologies of lesser importance. Higher value is attributed to the more highly diffused technologies. Park and Park[21] developed a module-based, holistic framework for technology valuation, taking into account both technology factors and market factors. The framework of the new valuation method encompasses two separate factors which are interrelated:

- *Value of Technology (VOT)*, which means the potential value that is embedded in the subject technology itself. It includes some intrinsic factors (proprietary position, level of technology, life of technology, degree of standardization) and an application factor (type of technology, contribution ratio, scope of application, degree of completeness).
- *Value of Market (VOM)*, which means the practical value of subject technology that is material-

ized in market or in business process. It includes some value-typing factors (profit generating, cost-saving) and some value-size factors (amount of income, duration of income and risk of income).

Due to the interrelationship between VOT and VOM, the proposed method is designed to evaluate VOT factors first and determine VOM factors based on the values of VOT factors. This model was worked out in considerable detail and applied to some cases, but a proper theoretical background is lacking, which may limit a widespread use of their approach.

Business Development Process

Having elaborated on the business valuation of technology, the next stage in our model is about the business development process. A successful commercialization of the invention is our ultimate goal. For universities and (public) research institutes, the main route for intellectual property commercialization is out licensing to a private partner that will be able to further develop, manufacture and market the patented technological product/process. Another form of intellectual property commercialization is co-development, enhancing partnership formation with business partners. In these commercialization processes, information on technology, marketing, competition, laws and regulations on patents are essential.[22] The first step in technology transfer is finding a partner willing and able to commercialize the technology.[15] Approaches to identifying an appropriate licensee are many and diverse and include usually a combination of generating awareness through broad or focused publicity, market analysis of industry trends and segmentation, analysis of corporations' focus based on patent and citation concentrations, presenting technical papers at society symposia and relevant conferences, and seeking leads from technical staff who are active in the field. Product-based licensees may be identified using marketing surveillance, databases, etc., by finding commercial products similar to the patented products. In some cases, producers of upstream and downstream products may be potential licensees, too. Publications are also important sources of information for identifying potential licensees, using either citation or direct content analysis.[22]

In general, the business development process starts with a qualification of (a) potential business partner(s) for the invention derived from the business scan. Rogers[23] introduces a segmentation of innovation adopters, ranging from early market innovators (technology enthusiasts), early adopters (visionaries), mainstream markets-early majority (pragmatists), late majority (conservatives), and laggards (skeptics). It seems to be clear that a potential business partner for the invention will certainly be from one of the first two groups. In the literature, the capability to successfully develop and commercialize a disruptive technology is based on the interaction between a firm's strategic orientation (Prospector, Analyzer, Defender) and (a) its selection of target market, and (b) the way it implements its market orientation, either responsively or proactively (Slater and Mohr, 2006). A technology choice tool for a market-pull case developed by Meyhack was cited,[1] defining seven meta-criteria for the potential business partner, such as potential of acquisition, implementation, use, market diffusion, securing, future developments, and technological impact. In our experience, we select comparable qualification criteria for the potential (licensing and/or co-development) partner including strategic considerations (buying-in behavior), skills (technology fit, e.g. the partner's technology base distance to the disruptiveness of the technology, its intellectual property portfolio relevance), company innovativeness (e.g. culture), company size (e.g. R&D and Marketing & Sales budgets) and company structure (e.g. degree of vertical integration) as well as its competitive position (e.g. market leadership). Based on such criteria, within each market (micro-) segment a business partner (company) is selected. Next, the decision making unit within this company is identified (usually a licensing department professional, business unit manager or R&D director) and contacted. A product information bulletin, i.e. confidential technical written and/or oral information on the invention, will be exchanged after a secrecy agreement has been signed. If both parties are interested to pursue further discussions, negotiations on terms and conditions for a further collaboration or licensing scenario will follow and contracts can be drafted.

Licensing

The essence of technology licensing is the asymmetrical information on the value of the technology between licensor and licensee and the uncertainty concerning the output. The value of a patent will only be effectuated at the time of licensing the technological know-how, as value is only created by marketplace success. The determination of a fair transaction price is not straightforward, given the developmental and marketing risks and returns on investments associated with the outcome of the technology to be expected. During the negotiations, all information gathered on market potential and business valuation of the invention may serve as input to optimize deal making. The license itself should be structured to support the business objectives of both parties, such as the alignment with a licensee's strategic goal and important strategic factors such as exclusivity, periods of restraint and fields of use.[15] These factors ensure that multiple market applications are considered so value may be maximized, e.g. by awarding multiple licenses, which may be non-exclusive or exclusive for different fields of use.

The most common arrangement for technology transfer is a royalty-bearing license, based on the performance (usefulness) of the technology. The performance can be measured by the volume of sales or profits generated by the technology, and royalties can come in different forms reflecting the various distributions of risks between licensor and licensee. Royalty schemes may include lump sum payments, minimum payments and different payment schemes including ceilings on the payments. A royalty arrangement can be viewed thus as a risk-sharing rule between the parties. Four valuation models for royalty schemes were proposed[24] which can be used

Table 1: Stepwise Model For Business Valuation Of Technology

Business Valuation Stage	Description Of The Process	Actor	Output
I. Invention	Research Process	Scientist	Laboratory journals, Research reports, Scientific papers & publications
Intrinsic valuation of technology	Technology Assessment	Scientist, peer review (consultant)	Technology scoring models, Intellectual property (patent) scoring models resulting in an intrinsic technology value of the invention
II. Business Awareness	Patent Application	Scientist, patent attorney (sponsor)	Patent application, Product aplication areas
III. Business Perspective	Market Research	Business manager, consultant (scientists)	Business Scan, e.g. • business need, • market drivers, • value chain, • macro/micro-segmentation, • market size, • market growth, • competitors SWOT analysis
Monetary valuation of technology	Financial Scenario Modeling	Business manager, consultant	Cost-based, market-based, income-based (DCF), option-based and multiple integrated scenarios models resulting in a market-based monetary value of the invention
IV. Business Valuation	Business Valuation Process	Business manager, consultant, scientist	Integration of the technological and monetary value models resulting in an integrated business value of the invention
V. Business Development	Business Development Process, Licensing	Business manager, consultant, lawyer, customer/applicant	Product/Process information bulletin, Secrecy agreements, License agreement, Co-development contract
VI. Technology Transfer	Technology Implementation Process	Scientist, customer/applicant	Detailed product/ process technical information

by decision makers to determine the cost of alternative royalty combinations. Each of the four developed combinations entails varying degrees of incentive and "moral hazard" with regard to inventive activity.

Linking the license to other activities, such as a co-development can add significant value to both the research organization (the licensor) and the customer/company as the licensee. Typically, this form of commercialization is applied when (a) the technology is disruptive and may require years to mature and a substantial investment to reach commercial viability, (b) when a technology may be important to a business but not a core, or (c) when the hurdle rate is below a company's threshold for profit or sales contribution.

In the technology transfer process, the knowledge of the inventor of the technical potential of the invention can greatly improve the chances for success. This tacit knowledge can be transferred by transferring the researcher along with the technology. Alternatively, an additional consulting agreement can be signed between licensor and licensee to allow key people to support the technology transfer process.

Conclusion

The business valuation process of a novel invention is not easy as many different types of risks (e.g. developmental risks, market-related risks, uncertainties regarding intellectual property-protection) are involved. Ultimately, the value of the invention is established between the licensor and licensee across the table! Substantial financial returns of intellectual property will only be achieved if the licensee/assignee is successful in the marketplace. Objective business valuation methods encounter two problems, i.e. lack of any commonly accepted objective valuation method with which to process this information, and secondly, the fact that the decision processes involved in valuation are subject to a number of potential biases.[4] As all methods of patent valuation involve some elements of forecasting ranging from forecasting depreciation rates to forecasting future cash flows, market conditions, effects of competition and distributions, and volatilities of returns to patents, some speculation is unavoidable.

However, prior to entering into licensing negotiations with (a) potential business partner(s), the licensor is in need of an objective business valuation model as a starting point or merely as a help in more rational and better decision making (Table 1).

The use of integrated valuation methods, combining technological, market diffusion and monetary factors, is certainly to be preferred as the uncertainties associated with forecasting might be diminished as well as possible. The availability of such integrated valuated methods is however limited and are still lacking in completeness. Furthermore, their practical applicability has only been tested to a limited extent. Therefore, we present a stepwise model for the business valuation of technology being a context for an optimized integrated technology and monetary valuation model that can be used for practical applications. Within this context, we are currently developing and evaluating a selection of business valuation methods in several case studies. The results of this evaluation will be the subject of a next paper. ■

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