Leveraging academic knowledge in the innovation ecosystem

The Societal Impact Value Cycle as a toolbox

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Scientific advancement and advancements in information technology have increased our capability for sharing information, and spreading scientific discoveries throughout society. In the past decade the Dutch government has been trying to stimulate the knowledge economy through various means. Among them the stimulation of the founding of the Dutch Centres for Entrepreneurship, and the Valorisation programme. However, over the years, publication volume has become the main indicator for being a successful scientist. This focus on publications and research disincentivizes scientists from activities that generate more concrete value for society.

The Societal Impact Value Cycle seeks to offer scientists and others a toolbox for visualising and understanding the way innovation can be fostered, and how other processes can foster scientific research in return. It also maps the way by which an innovation ecosystem generates socio-economic value from academic activities. It should be noted that not all scientific research leads to innovations that generate value for society, and not all research is intended to change the course of events. Nonetheless, fostering cooperation between research institutes and societal stakeholders, and increasing awareness of how entrepreneurial skills and activities could not only lead to a return on investments necessary for scientific advancement, but also increase the societal impact from academic endeavours. This could benefit our society, and societies worldwide, both socially and economically.

This publication will offer valuable insight and an effective toolbox for people interested in socio-economic value creation from scientific research, or, in other words, valorisation. Therewith, it lays at the heart of Stichting Maatschappij en Onderneming's daily occupations and our close cooperation with the Erasmus University Rotterdam. I wish you an inspiring read!

Hendrik Halbe
Advisor Instituut SMO

1

INTRODUCTION

CHAPTER 1:
INTRODUCTION

While knowledge has always been a key factor in the functioning and development of any society, the last few decades in particular have marked the wide recognition of its importance as a driver of innovation, economic growth and societal progress. In this increasingly knowledge-based society, the university is an integral part of a larger system of innovation, and many world-changing innovations are based on publicly funded research. This research often takes on the riskiest aspects of innovation, after which the private sector can reap the benefits of public investment in research via the subsequent development and market introduction of innovative products and services (Block & Keller, 2008; Lazonick & Mazzucato, 2013). Therefore, although not all innovation involves academic research and not all academic research automatically leads to innovation, universities play a pivotal role in many innovation processes.

Despite the importance of universities in the innovation ecosystem, the creation of new knowledge in itself is not sufficient for achieving the intended socio-economic benefits (Audretsch & Keilbach, 2008; Pronker, 2013; Van den Nieuwboer, Van de Burgwal, & Claassen, 2015). In order to derive socio-economic benefits from academic knowledge, a process that transfers the knowledge to society and translates this knowledge into valuable products and services is necessary. This composite process has been studied by many scholars and a number of different terms have been used to conceptualise it, such as knowledge exploitation, knowledge or technology transfer, knowledge exploitation and academic entrepreneurship. Here we use the term *knowledge valorisation*, since it encapsulates the concept of *transferring* knowledge or technology to actors with an industrial or societal perspective and the concept of *commercialising* knowledge by adapting and developing the knowledge in order to yield socio-economic benefits. Knowledge valorisation can thus be seen as a process in which new knowledge is created and turned into value for society by making it suitable and available for societal or economic purposes, for instance in the form of innovative products, processes or services that are delivered to the market (Van den Nieuwboer et al., 2015; Van Geenhuizen, 2010).

As already indicated by the composite nature of the process, the many related concepts and the broad definition, knowledge valorisation is regarded as an extremely complex process that involves many steps and activities. Due to the many steps and activities involved in successful knowledge valorisation, making knowledge suitable and available for socio-economic purposes requires the competence and commitment of many different actors. These include (but are not limited to) university faculty members, university technology officers, firms and entrepreneurs, consumers and policymakers (Siegel & Wright, 2015). The actors involved transcend several domains, each of which has its own norms, values and practices (Mostert, Ellenbroek, Meijer, van Ark, & Klasen, 2010). Consequently, these actors might lack a reciprocal understanding and appreciation of each other's significance in optimising the societal impact of knowledge (Lazonick & Mazzucato, 2013). Many actors do not have a clear idea of the activities that constitute the complete process, which may contribute to failed innovations. In the case of the actors responsible for research and early development this may result in a failure to take the needs and constraints of manufacturers into account. Moreover, these actors might not even be aware of the need to make academic research results suitable for subsequent development and consequently the need to devote resources to these early development phases (Flagg, Lane, & Lockett, 2013; Stone & Lane, 2012). Arguably, even in the case of fundamental research or disruptive innovations, actors should be aware of constraints and requirements in adjacent phases of development in order to consciously choose the best allocation of resources or to effectively challenge the status quo. Conversely, although there is a tacit assumption that knowledge transfer processes are straightforward for knowledge receivers (Cusumano & Elenkov, 1994), research has shown that there are significant difficulties in identifying, planning and implementing these projects from an industry perspective as well (Ramanathan, 2008; Xie, Hall, McCarthy, Skitmore, & Shen, 2016).

Following from the above, knowledge valorisation is not a matter of course but a composite process involving many different subprocesses. A lack of adequate understanding of the complementary nature of these subprocesses by the actors involved further complicates the process of knowledge valorisation. As a result, industrial actors may underestimate the importance of academic research and academic actors may neglect the downstream activities necessary for development. A shared understanding of the process by different stakeholders is therefore crucial for enabling them to effectively direct their actions towards the development of innovations (Berkhout, Hartmann, & Trott, 2010). One way in which this can be achieved is through gaining practical experience with valorisation processes. Indeed, R&D centres with experience in further developing their research outcomes have a better understanding of the processes constituting this development and consequently are more successful in transferring and commercialising their research outcomes (Lane, 2010). Not all actors involved have such practical experience with knowledge valorisation processes, and when this experience is absent, conceptual models can play a mediating role in the mutual understanding of valorisation processes and innovation due to their ability to provide insight and foster communication among stakeholders (Nelson, Poels, Genero, & Piattini, 2012). Unfortunately, current models for knowledge valorisation processes deal with abstract theoretical concepts and do not combine theory with practical and operational aspects of knowledge valorisation (Flagg et al., 2013; Ranjan & Gera, 2012). This makes them difficult to understand and unlikely to be used by practitioners (Aken, 2004; Moody, 2005). Moreover, most of these models describe parts of the valorisation process but fail to provide an overarching perspective of the complete process for all stakeholders involved (Hussler, Picard, & Tang, 2010). The lack of a common, overarching perspective on knowledge valorisation is likely to result in many process inefficiencies and consequently there is a need for further insight and an improved understanding of valorisation processes (Leydesdorff, 2010; Van den Nieuwboer et al., 2015).

This publication will address this knowledge gap and provide further insight into the activities that constitute knowledge valorisation processes by introducing an overarching conceptual model that transcends individual actor and domain perspectives. This conceptual model, the *Societal Impact Value Cycle* or *SIVC*, is based on a synthesis of existing conceptual models and research findings on innovation through university-based knowledge valorisation. Chapter 2 covers the different perspectives of current conceptual models, and subsequently summarises some key findings that form the basis for the synthesised SIVC conceptual model. Chapter 3 then introduces and describes the complete SIVC, while Chapter 4 puts forth its implications and possible applications.

2

SYNTHESISING CURRENT LITERATURE INTO AN OVERARCHING CONCEPTUAL MODEL

CHAPTER 2:
SYNTHESISING CURRENT LITERATURE INTO AN OVERARCHING CONCEPTUAL MODEL

A systematic literature search revealed 32 papers discussing conceptual models related to innovation through university-based knowledge valorisation. We will highlight the different perspectives that these conceptual models take and subsequently summarise some of the key findings that serve as input for the SIVC. For 30 of the 32 conceptual models, graphic representations will be presented per section, 29 based upon original graphic representations and one drawn up based on the text of the paper. These models are redrafted in a uniform format for the purpose of clarity, while maintaining a resemblance to the original figures for the sake of recognition. Activity steps and phases are shown in different shades of orange. Gates are shown as dark blue diamond shapes or dark blue rounded rectangles, depending on the original format of the figures. Context, input and output elements are shown as light blue and white rounded rectangles. The remaining two conceptual models did not include a graphical representation.

Based upon the analysis of these models and the papers in which they were presented, a new model was synthesised. Activities that were described in the conceptual models or in the accompanying papers served as input for the model elements in the synthesised representation, while the channels and pathways described were used in shaping the target model's structural design. Activities were grouped into distinct overarching phases, and phases subsequently into overarching domains (Science, Business and Development, Market and Society & Policy). This resulted in a process model providing information on the activities and workflows that make up valorisation processes. A simplified model of the synthesised SIVC showing domains and phases is presented in Figure 1. For the sake of clarity, we will first describe the models and papers that were analysed in this chapter before elaborating on the SIVC and outlining the phases and activities that constitute the cycle in chapter 3.

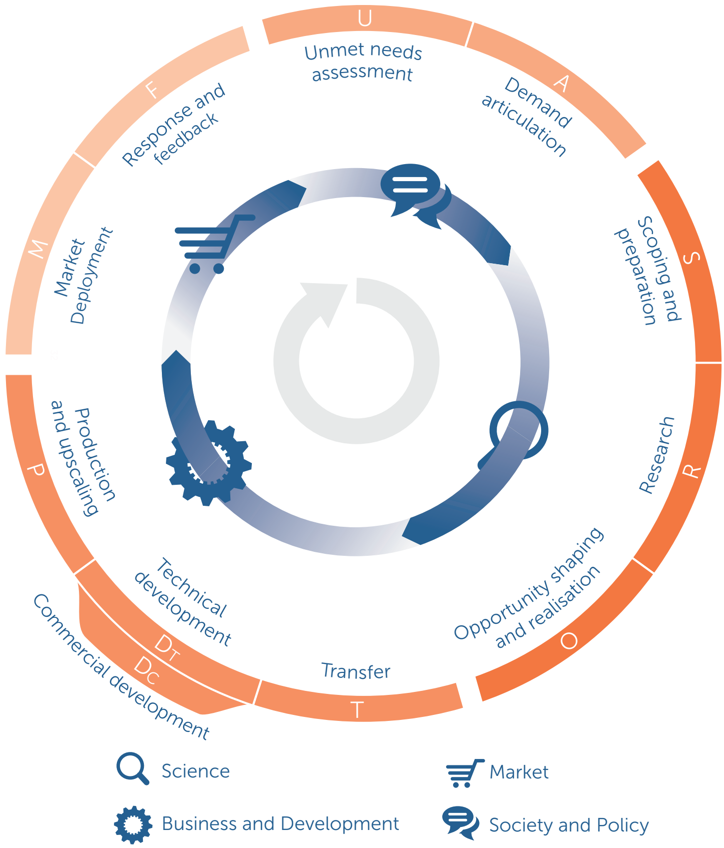


Figure 1. Simplified version of the Societal Impact Value Cycle.

2.1 Distinguishing between science, knowledge and innovation

Analysis of current literature

A number of conceptual models highlight the differences between science, knowledge and innovation processes. Some models explicitly distinguish science processes from a 'reservoir of knowledge' with science and innovation using and developing knowledge in this reservoir simultaneously (Kline, 1985; Oortwijn et al., 2008; Rothwell, 1994; see figures 2, 3 and 4). Other models leave out the concept of a knowledge reservoir and merely show science processes that contribute to this knowledge reservoir. The distinction between science and innovation is also debated. While two models conceptualise science as a separate process which can provide input for innovation processes but not a part of them per se (Graham et al., 2006; Kline, 1985; see figures 5 and 2), most other models consider science to be an integral part of innovation processes (Berkhout et al., 2010; Flagg et al., 2013; Oortwijn et al., 2008; Rothwell, 1994; Stone & Lane, 2012; see figures 6, 7, 3, 4 and 8).

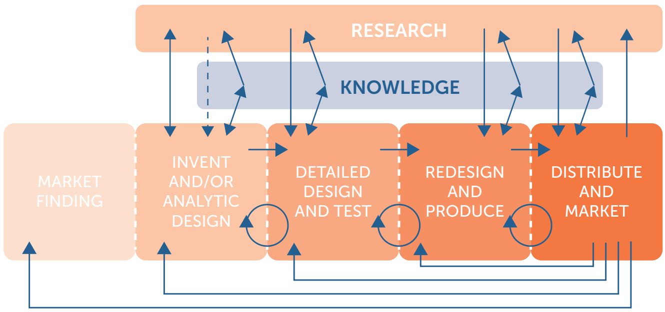


Figure 2. "The Chain-Linked Model". Adapted from Kline, 1985.

Kline (1985). *Innovation is not a linear process.*

Description: Describes pathways and stages in the process of innovation, proposing a Linked-Chain Model that involves feedback loops and therefore opposes the 'traditional' linear innovation models. Highlights the significance of the accumulated knowledge reservoir as a source for innovation.

Connection to SIVC: Activities concerning the evaluation of the existing knowledge reservoir and the need for new knowledge contribute to the U, A, and S stages. Feedback links are reflected in activities throughout the SIVC, including the F stage. Research and development activities are reflected in the R, O and D stages.

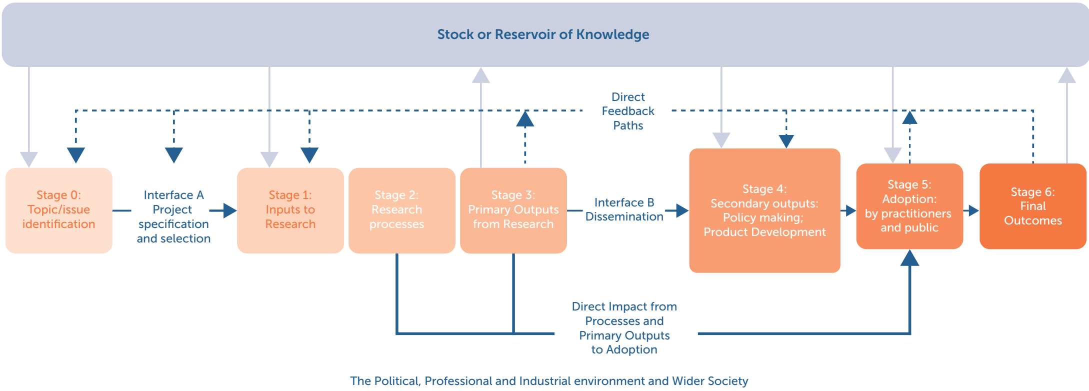


Figure 3. "The Payback Model". Adapted from Oortwijn et al., 2008.

***Oortwijn et al. (2008)**. Assessing the impact of health technology assessment in the Netherlands.*

Description: Provides an evaluation framework that serves to indicate a series of stages that helps to organise payback assessments for health research. This model consists of two components: a logic model of the research process, and evaluation criteria for its outputs and outcomes.

Connection to SIVC: Evaluative activities contribute to stages throughout the cycle.

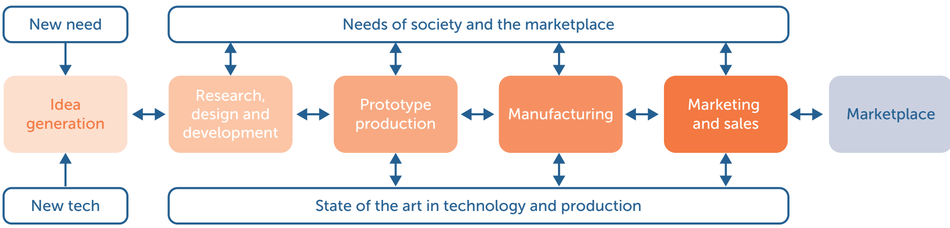


Figure 4. "The 'Coupling' Model of Innovation (Third Generation)." Adapted from Rothwell, 1994.

***Rothwell (1994)**. Towards the fifth-generation innovation process.*

Description: Describes four 'generations' in innovation process modelling throughout history. Based on the fourth, characteristics and success, drivers for a proposed fifth-generation innovation model are discussed.

Connection to SIVC: Conceptualisation of innovation process is reflected in feedback and iteration during research and technical development.

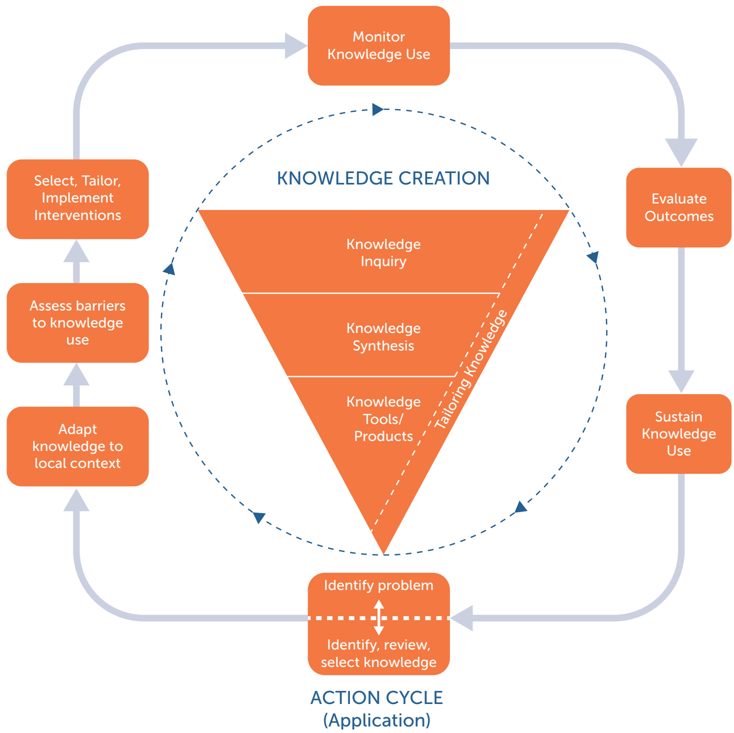


Figure 5. "Knowledge to Action process." Adapted from Graham et al., 2006.

Graham et al. (2006). *Lost in knowledge translation: Time for a map?*

Description: From a health policy perspective, the process of implementing knowledge for action to address an identified problem is described. The paper offers a conceptual framework that distinguishes between knowledge creation and knowledge application, and integrates both into the knowledge to action process.

Connection to SIVC: Identifying external knowledge and translating, appropriating and maintaining useful knowledge contributes to the T stage. The knowledge creation cycle is reflected in the R stage.

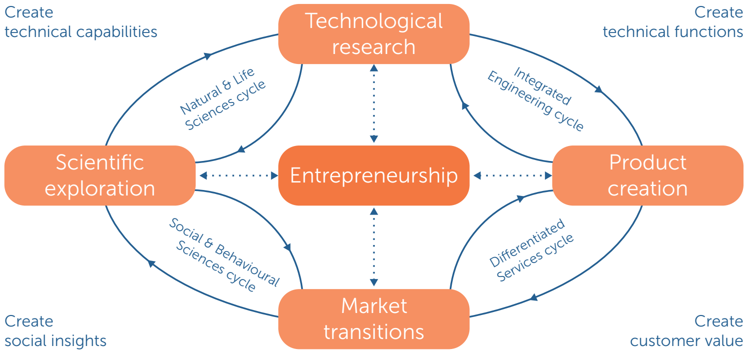


Figure 6. "The Cyclic Innovation Model (CIM)." Adapted from Berkhout, Hartmann & Trott, 2010.

Berkhout et al. (2010). *Connecting technological capabilities with market needs using a cyclic innovation model.*

Description: Identifies limitations of existing models and schools of thought in innovation. Introduces a cyclic conceptual model that attempts to capture the iterative nature of network processes in innovation. The endless innovation cycle with interconnected cycles bridges hard and soft sciences, research and development, and market communities.

Connection to SIVC: Cyclic, reinforcing nature of innovation and iterative character of process activities are reflected in the SIVC structure and content.

"Academia and industry add to the available reservoir of knowledge. In turn, this reservoir is a resource used in innovative processes."

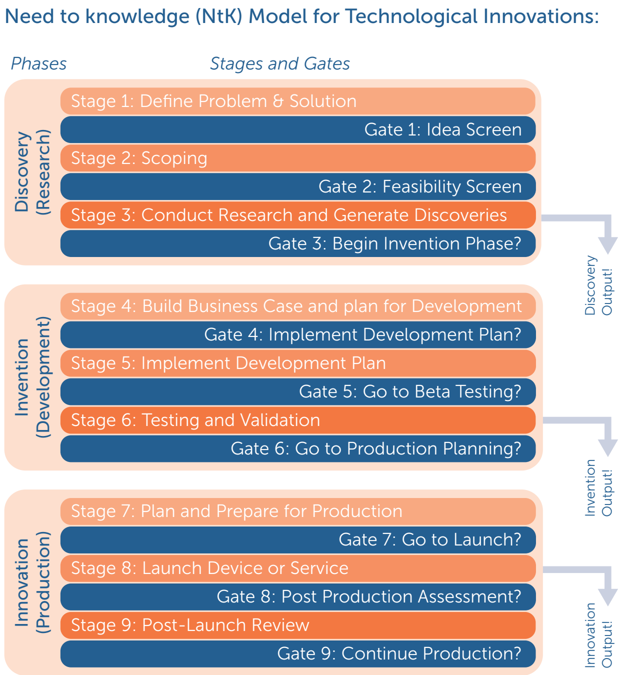


Figure 7. "Need to Knowledge (NtK Model) for Technological Innovations." Adapted from Flagg, 2013.

Flagg (2013). *Need to Knowledge (NtK) Model: an evidence-based framework for generating technological innovations with socio-economic impacts.*

Description: Provides an operational-level 'Need-to-Knowledge' process model of technological innovation that is grounded in evidence from academic analyses and industry best practices. The process model displays phases, stages, gates, and outputs, and is a means of realising returns on public investments in R&D programmes intended to generate beneficial socio-economic impacts.

Connection to SIVC: Paper is reflected in market-oriented activities throughout the Society, Science, Business & Development and Market domains that aim to increase the beneficial socio-economic impact of public R&D programmes.

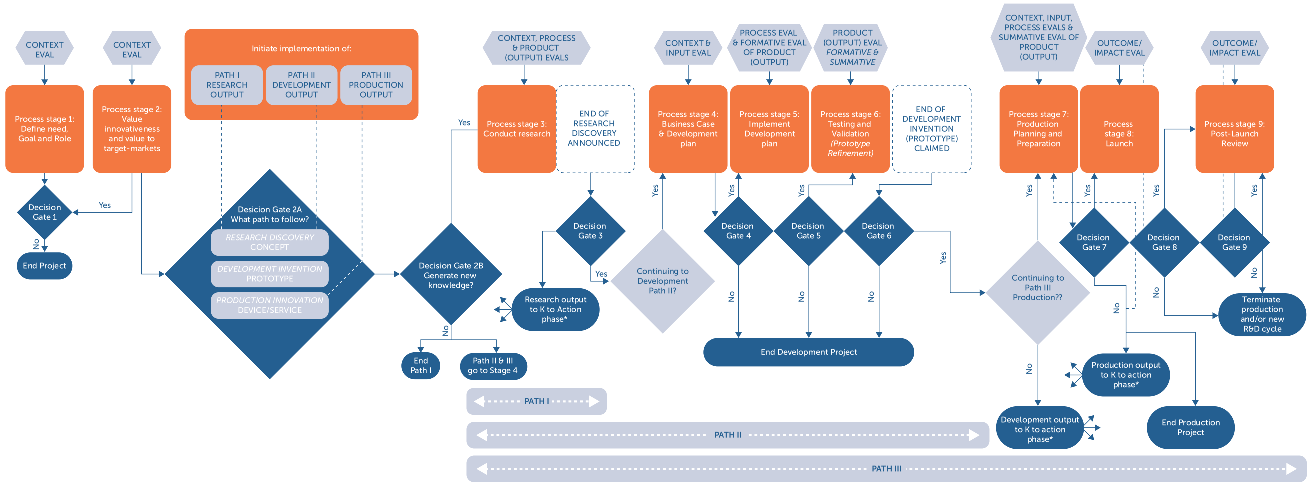


Figure 8. "Evaluation and the R-D-P process." Adapted from Stone and Lane, 2012.

***Stone and Lane (2012).** Modelling technology innovation: How science, engineering, and industry methods can combine to generate beneficial socio-economic impacts.*

Description: Proposes a logic model framework that integrates knowledge generation with evaluation, to be used for planning technology-based R&D and for evaluating the resulting impact of the implementation of its outputs in practice.

Connection to SIVC: Context evaluation prior to the conducting of research contributes to the U, A, and S stages. Research discovery (Path I), development of the invention (Path II), and production of the innovation (Path III) contribute to the R and O stage and throughout the stages of the Business & Development and Market domains.

Implications for the synthesised model

The reciprocal use of knowledge between industry and academia is well-demonstrated in practice and the phenomenon of knowledge spillover leads to cumulative knowledge creation and innovation (Lehmann & Menter, 2015). Research is conducted in both domains and consequently both industry and academia can contribute to the development of new knowledge. Innovations can subsequently be based on new combinations made with the available reservoir of knowledge (Schumpeter, 1934) that is the result of these research processes. This reservoir of knowledge—the 'Academic Response Repertoire' (Van den Nieuwboer et al., 2015)—serves three purposes. First of all it is the basis for continuous knowledge development, either by academia or industry, resulting in peer-reviewed publications or patents that are accessible for other researchers. Secondly, it forms the basis for new innovations or applications of knowledge. Thirdly, the Academic Response Repertoire can be seen as the capabilities developed within academia and industry to respond to future demands by conducting research or developing new knowledge (Hanney, Grant, Wooding, & Buxton, 2004; Hussler et al., 2010; Stone & Lane, 2012). What then constitutes innovation are the activities conducted either with newly developed knowledge or with new combinations of the knowledge that is already available in the Academic Response Repertoire. In this sense, the Academic Response Repertoire can be seen as a resource that can be used throughout valorisation processes. Since the model aims to shed light on the activities and processes that constitute knowledge valorisation, rather than on the resources that are needed for this process, the synthesised model does not explicitly depict a knowledge reservoir, but the use of knowledge from the Academic Response Reservoir is implicitly present in every step of the SIVC. Furthermore, since the current model aims to elucidate the link between activities executed in domains, the science domain is shown as being integral to the subsequent development of the created knowledge.

2.2 Unmet needs and cyclic processes

Analysis of current literature

Once knowledge has been developed in the academic domain it needs to be translated to stakeholders in other domains. In an abstract sense, three phases of knowledge translation can be identified: the transfer of research into development, the transition from development into market introduction and the shift from market to integration into policies (Lal, Schulte In den Baumen, Morre, & Brand, 2011; see figure 9). Hussler and colleagues add to this conceptualisation by highlighting the awareness of market needs by scientists as a pivotal aspect of knowledge valorisation alongside academic research and absorptive capacity within industry (Hussler et al., 2010; see figure 10). These societal and market needs can be seen as input into the scientific process but also as a result of the implementation of new innovations, thereby emphasising the circular nature of knowledge valorisation (Oortwijn et al., 2008; Rothwell, 1994; as shown before in figures 3 and 4). To capture these needs, a needs assessment can be carried out as a separate activity that provides input into the research process and increases scientists' awareness of market needs (Punter et al., 2009; see figure 11). The link between societal needs and research is elaborated on in more detail by Braun & Guston (2003; no graphical presentation) in their description of the dynamics of demand articulation within the context of principals (i.e. policymakers assigning research tasks) and agents (i.e. scientists executing these tasks and also acting as autonomous researchers).

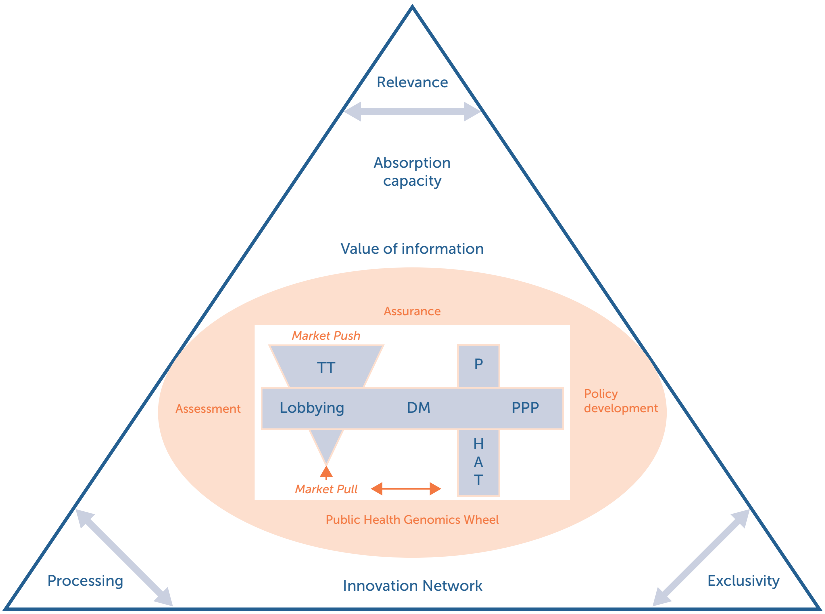


Figure 9. "The LAL Model: Learning Adapting Levelling." Adapted from Lal, Morré & Brand, 2011.

Lal et al. (2011)*. Public health and valorisation of genome-based technologies: a new model.*

Description: Discusses the three phases of translating genome-based technologies to commercially feasible products with practical applicability. States the presence of two separate institutional entities (university-industry infrastructure, governmental bodies) during these phases, and provides a model that integrates both entities in order to increase the efficiency of technology transfer and policy integration. *The paper does not display a process model, but was still included on the basis of its textual relevance.*

Connection to SIVC: Paper is reflected in the connection of the policy discourse with the scientific and industry discourses within the F, U, A, and S stages. The LAL model also describes activities in the O and D stages.

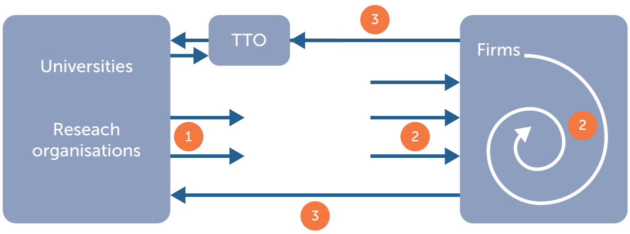


Figure 10. "Making academic research useful: a three-dimensional process." Adapted from Hussler, Picard, & Tang, 2013.

Hussler et al. (2010)*. Taking the ivory from the tower to coat the economic world: Regional strategies to make science useful.*

Description: Provides a conceptual model of the system to provide academic research with more economic value, involving three value-driving dimensions: dissemination of scientific knowledge, strengthening of regional absorptive capabilities, aligning of research with existing regional needs.

Connection to SIVC: Paper is reflected in the dissemination of research results and appropriation of scientific knowledge by industrial actors (T stage), and the alignment of research ideas with unmet needs (U, A, and S stages).

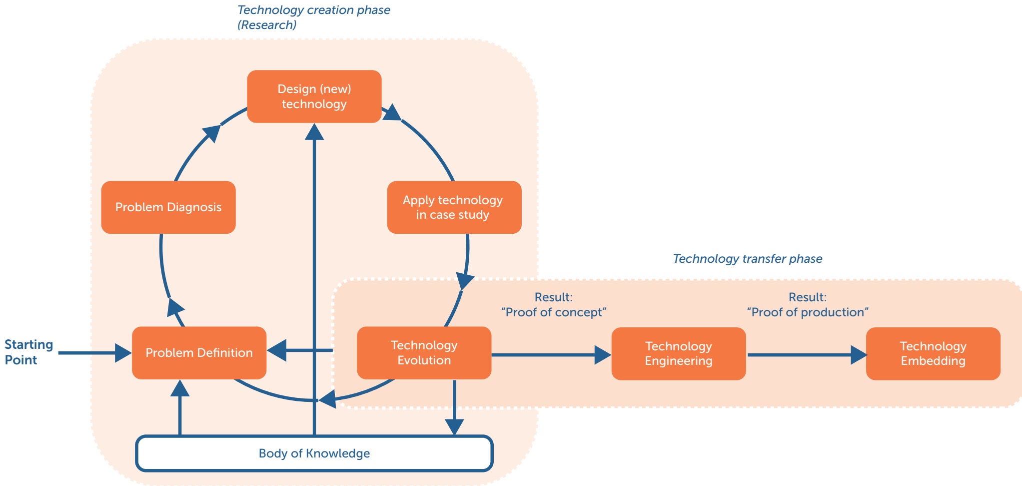


Figure 11. "Technology innovation: creation and transfer." Adapted from Punter, Krikhaar & Bril, 2009.

Punter et al. (2009). *Software engineering technology innovation – Turning research results into industrial success.*

Description: Provides a process model that integrates a technology creation phase and a technology transfer phase to achieve technological innovation in the area of software engineering. Addresses phases and activities, stakeholders and roles.

Connection to SIVC: Paper is reflected throughout the cycle, particularly in evaluative activities at the gate between the Science and Business & Development domains.

Braun and Guston (2003). *Principal-agent theory and research policy: an introduction.*

Description: Addresses the applicability of 'Principal-Agent' theory in research policy by describing the linkages between policymakers and funding agencies on the one hand, and funding agencies and scientists on the other, as two Principal-Agent relationships. In the triangular relationship between these three stakeholders, funding agencies are ascribed a mediating role.
The paper does not provide a graphic representation of a conceptual model, but was included on the basis of its textual relevance.

Connection to SIVC: Activities connecting policy actors with academic actors contribute to the A stage in the SIVC, and therefore to the link from the Society & Policy domain back to the Science domain.

Implications for the synthesised model

The current analysis demonstrates that it is not just university-to-industry knowledge transfer and industrial development that constitute the valorisation of academic research, but also a variety of other processes taking place in wider society, including technology assessment, societal needs assessment and research agenda-setting. The recognition of the role of the society at large in valorisation processes builds upon an emerging perspective of knowledge transfer which is increasingly appreciative of the essential societal connections of knowledge valorisation (Siegel & Wright, 2015).

The societal relevance of academic research may be optimised by synchronisation with unmet societal needs (Johnson, 2011). As an example, a recent study on the unmet needs for Ebola found that different stakeholders from different geographical regions had different articulations of medical, societal and technical unmet needs (Van de Burgwal et al., 2016). These discrepancies were likely to result in mismatches in development stages and adequate response to the 2014 Ebola outbreaks, highlighting the need for an understanding and concordance of unmet needs to inform the actors involved in innovation. Importantly, the synchronisation with societal unmet needs should not be interpreted as merely acknowledging applied research and incremental (demand-pull) innovation, and it is important to emphasise that innovation processes are not linear but rather parallel processes that take place in different domains with multiple feedback and feed-forward connections (Berkhout et al., 2010; Rothwell, 1994).

The linear model of innovation (Bush, 1945) has received much criticism due to its simplified and unrealistic assumption that academic research is the starting point of innovation and will subsequently lead to marketed innovations (Godin, 2006). One way in which this criticism is addressed in the synthesised model is by the lack of a clear starting point in the cycle; innovations can start anywhere in the cycle and from there continue their way through the cycle (Berkhout et al., 2010). Although in some cases university-based research forms the starting point for developments and industry innovations, in other cases innovations by industry form the starting point for fundamental research by academia. New industrial innovations are an important source of inspiration for scientific research (Rosenberg, 1994) and there are numerous examples of fundamental research resulting from new innovations or their impact on society (Sarewitz &

Pielke, 2007), thereby instigating successive cycles of university-based innovation. New knowledge and new innovation can thus originate from different points in innovation ecosystems.

Research motivated by articulated demands is not necessarily less fundamental and does not necessarily sort effects on the much shorter term than what is considered pure or basic research. This notion is supported by the finding that a significant proportion of the most important advances in science have arisen from very practical, societal problems, a phenomenon that Stokes has called use-inspired research (Stokes, 1997). Furthermore, curiosity-driven science may form the starting point for a new series of valorisation cycles. In this sense, curiosity-driven research is essential for advancing our understanding and for the emergence of radical (technology-push) innovations (Strandburg, 2005). Thus, curiosity-driven research can be seen to reflect an unmet societal need in itself (Claassen, 2014). Ultimately it is irrelevant to delineate cause and effect since science and industry constantly build upon each other's knowledge. The distinction between technology-push and demand-pull essentially loses all meaning, as, once captured in the valorisation cycle, every effect becomes in due time a cause and every cause becomes in due time an effect.

2.3 Shedding light on transfer processes

Analysis of current literature

In order to move through the cycle, knowledge and projects have to be transferred from one domain to another. In the literature, most emphasis has been placed on the transfer of knowledge from the science to the business development domain. To execute this transfer process, it needs to be clear who owns the knowledge that is transferred and which different regimes on the ownership of intellectual property exist. Two such regimes are the professor's privilege regime (the researcher owns the IP and is responsible for its societal impact) and the open science regime (new knowledge is directly transferred to industry without IP protection), but the dominant one is the Bayh-Dole regime. In this latter regime, the university owns the IP and the researcher is entitled to 'fair compensation' when this IP is transferred and revenue is received by the university (Swamidass & Vulasa, 2008; see figure 12). Different studies have looked into the specifics of transfer processes within this regime. An abstract conceptualisation sees the transfer of knowledge from the academic to the industrial domain as the linkage between the stage of research innovation and value creation (Ho, Liu, Lu, & Huang, 2013; see figure 13). Value creation can lead to market or more specifically social, economic and cultural benefits (Matsumoto, Yokota, Naito, & Itoh, 2010; OECD, 2013; see figures 14 and 15). These benefits can be achieved indirectly via formal IP protection, transfer and subsequently marketed technologies but also directly via informal transfer such as consultancy, networking and teaching (OECD, 2013; see figure 15). Heterogeneities between sectors and regions influence the choice between formal or informal transfer and although some research has been done on the distinction between these channels (Shohet & Prevezer, 1996; see figure 16), most scholars have focused on formal transfer.

An intuitive process flow of formal transfer starts with scientific discovery and invention disclosure and ends with the licensing of IP to a firm (Siegel, Waldman, Atwater, & Link, 2003; see figure 17). Other stages that are part of formal transfer processes include identifying relevant new knowledge; searching for solutions and bringing a market focus to research results; searching for users; creating awareness or marketing of research results; brokering between academia and industry; securing industry partnerships; selection of commercialisation mechanisms and commercialisation itself (Berbegal-Mirabent, Sabaté, & Cañabate, 2012; Geuna & Muscio, 2009; Wood, 2011; see figure 18 and figure 19; no figure presented for Geuna & Muscio). Different stages of formal transfer can also be identified from an industry perspective, such as identifying technologies that could lead to customer value, searching for technologies, negotiations, preparing and implementing a transfer plan and a final audit on the impact of the transfer (Ramanathan, 2008; see figure 20). Technology or Knowledge Transfer Organisations (TTOs or KTOs) can play a mediating role in the transfer process (Berbegal-Mirabent et al., 2012, figure 18). Another mediating role in knowledge transfer is played by public-private partnerships (PPPs) that execute support activities which can lead to increased knowledge utilisation performance (Garbade, Omta, Fortuin, Hall, & Leone, 2013; see figure 21).

Within the transfer phase, different subprocesses take place. It is not enough to simply transfer knowledge or technology; the knowledge must also be appropriated by the receiver. One group of scholars conceptualises this phenomenon as consisting of two subprocesses: communication (transferring knowledge from one party to another) and translation or transformation (making the knowledge useful for the receiver) (Liyanage, Elhag, Ballal, & Li, 2009; see figure 22). Different activities have been identified to describe the phases of this phenomenon including activities relating to the identification of new knowledge (search, expose or identify); activities that relate to selecting relevant knowledge (assess or select); activities related to adapting it to the new context (adopt, tailor, learn or adapt) and activities related to using the new knowledge (use, implement or practice) (Goldhor & Lund, 1983; Graham et al., 2006; Simpson, 2002; see Figures 23, 5 and 24).

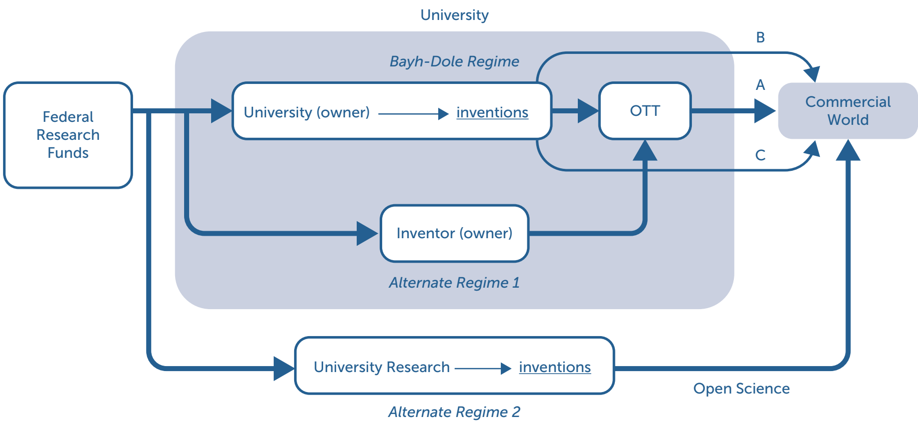


Figure 12. "Bayh-Dole Regime and Two Alternate Regimes." Adapted from Swamidass & Vulasa, 2009.

***Swamidass and Vulasa (2009).** Why university inventions rarely produce income? Bottlenecks in university technology transfer.*

Description: Addresses the efficiency (or lack thereof) of Technology Transfer Offices (TTOs) in the light of the American 'Bayh-Dole' IP ownership legislation. Represents the three-dimensional process of technology transfer graphically in a conceptual model.

Connection to SIVC: Paper contributes to activities concerning evaluation, protection, and transfer of research output to the commercial sphere. The paper also highlights activities for the subsequent development of these research outputs.

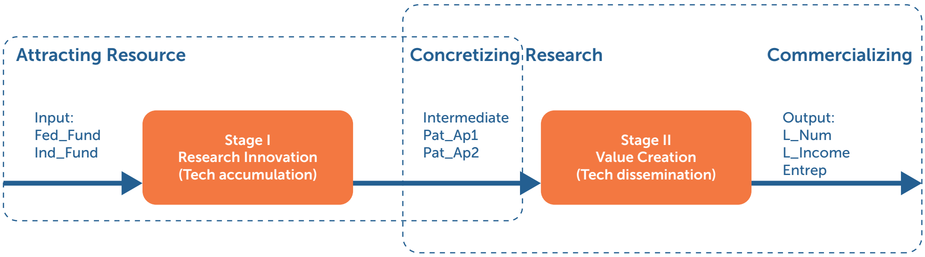


Figure 13. "The two-stage DEA framework." Adapted from Ho et al., 2014.

Ho et al. (2014). *A new perspective to explore the technology transfer efficiencies in US universities.*

Description: Explores the required capabilities in different stages of technology transfer. Displays a two-stage process model of technology transfer that considers several variables to quantitatively assess the transfer efficiency of universities.

Connection to SIVC: Activities increasing transfer efficiency contribute to the R, O, and T stages.

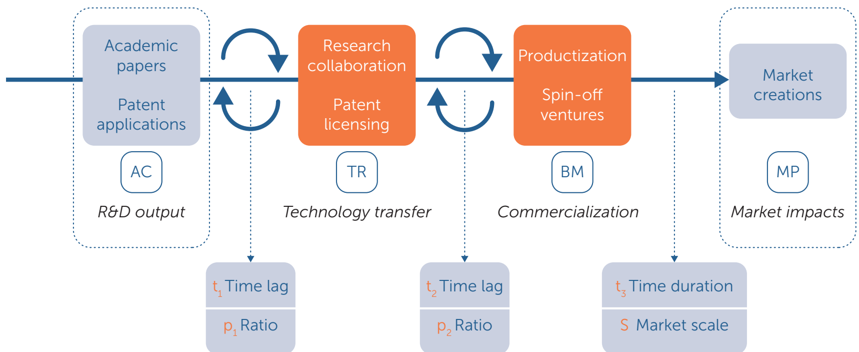


Figure 14. "Process model on R&D output generating market impacts". Adapted from Matsumoto et al., 2010.

Matsumoto et al. (2010). *Development of a model to estimate the economic impacts of R&D output of public research institutes.*

Description: Provides a process model to guide the assessment of economic impact of public R&D at the public research institutional level.

Connection to SIVC: Activities concerning the transfer and commercialisation of R&D output contribute to the O stage and to the stages of the Business & Development domain. Market impacts are reflected in the F stage.

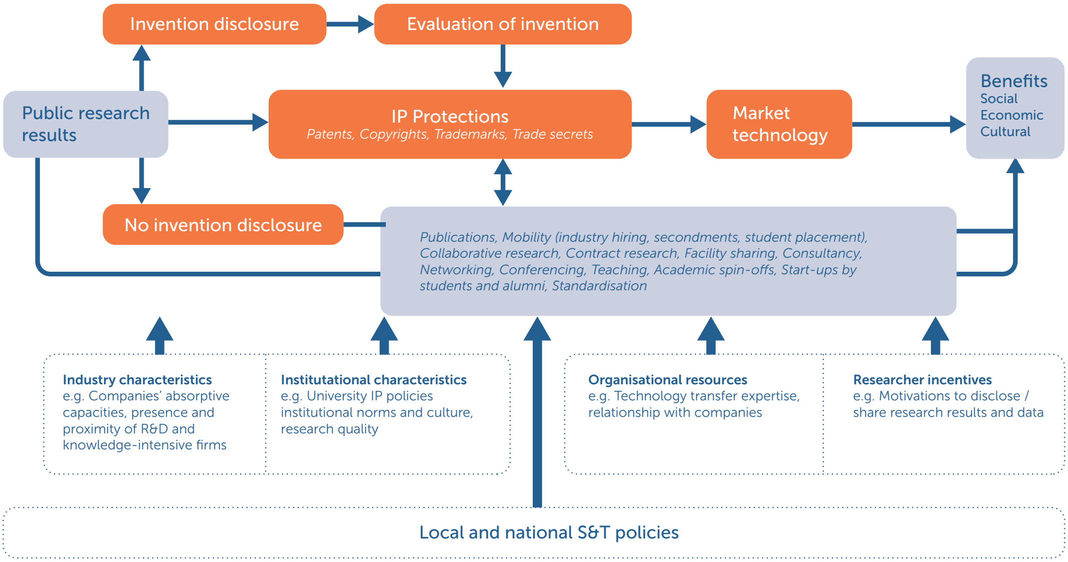


Figure 15. "Simplified knowledge transfer and commercialisation system". Adapted from OECD, 2013.

OECD (2013). *Commercialising public research: New trends and strategies.*

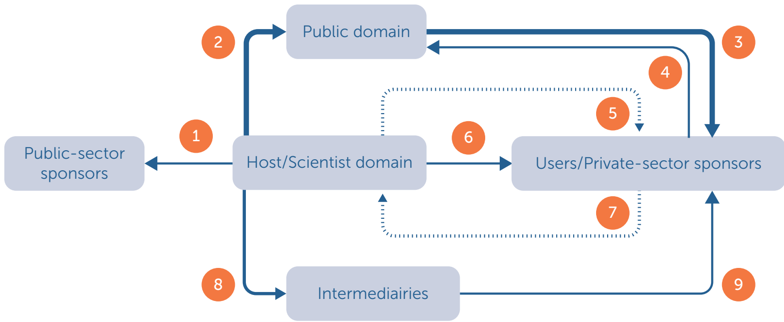
Description: Displays a model of the knowledge transfer process and commercialisation system, including activities, actors, a variety of channels, and influencing factors.

Connection to SIVC: Disclosure, invention, evaluation, and IP protection contribute to the O stage, channel selection and technology marketing to the T stage.

Geuna and Muscio (2009). *The governance of university knowledge transfer: A critical review of the literature.*

Description: Discusses the mechanisms of knowledge transfer (KT) from academia to the business world, and the governance of the university-industry interactions involved. Highlights the importance of individual characteristics in addition to institutionalised KT infrastructures. *The paper does not provide a graphic representation of a conceptual model, but was included on the basis of its textual relevance.*

Connection to SIVC: Paper contributes to activities that connect the Science and Business & Development domains, e.g. commercial shaping and channelling of the invention, and partnering between academic and industrial actors.



1. Progress reports, preliminary research findings.
2. Codified knowledge in the form of papers and 'shareware' cells, seeds, genes, etc. Published patent applications.
3. Papers, conference proceedings, reports and published patent applications
4. Joint publications into the public domain.
5. Tacit knowledge sharing and trading-techniques, skills, recruitment, consultancy and secondment.
6. Formal information conveyed to sponsors e.g. progress reports, research results.
7. Instruments, informal information and expertise.
8. Pre-patents publications, technology audit information.
9. Filed patents, industry club reports.

Figure 16. "Summary of knowledge flows by institutions." Adapted from Shohet and Prevezer, 1996.

Shohet and Prevezer (1996). *UK biotechnology: institutional linkages, technology transfer and the role of intermediaries.*

Description: Examines the institutional linkages and interactions in the UK technology transfer system, using the example of the biotechnology sector. Provides several models, including a process model displaying inter-institutional knowledge flows and the activities involved..

Connection to SIVC: Paper contributes to activities succeeding scientific research that concern knowledge dissemination and inter-institutional transfer.

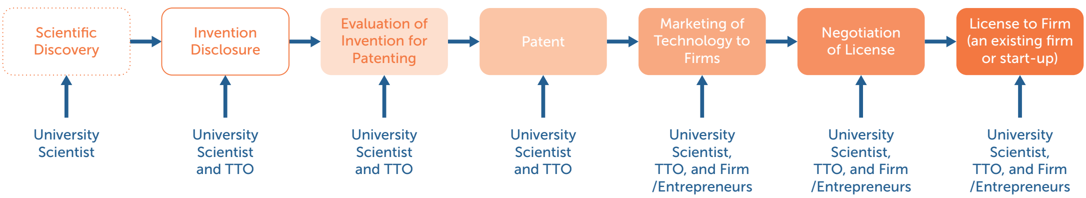


Figure 17. "General Flow Model of University-Industry Technology Transfer (UITT)". Adapted from Siegel et al., 2003.

Siegel et al. (2003). *Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration.*

Description: Addresses stages, key stakeholders, roles, motives, differences, and critical barriers in the process of technology transfer. Displays a general process model of technology transfer to clarify the study's focus.

Connection to SIVC: Paper contributes to activities succeeding scientific research that concern the transfer of research output to high tech industry. The authors also describe the creation of a production-proof version of the technology in the P phase.

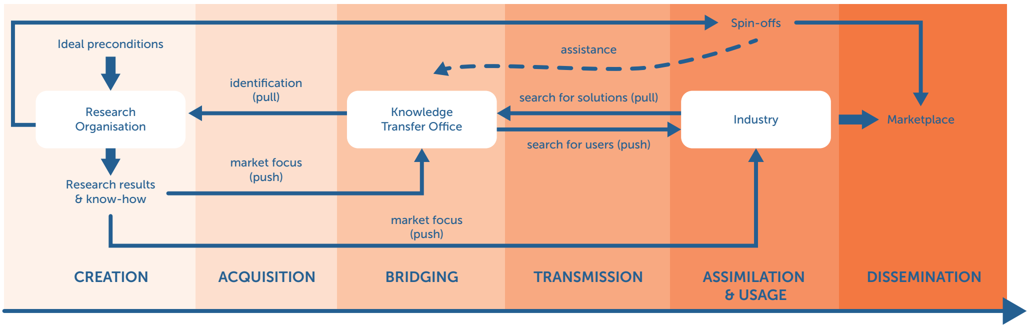
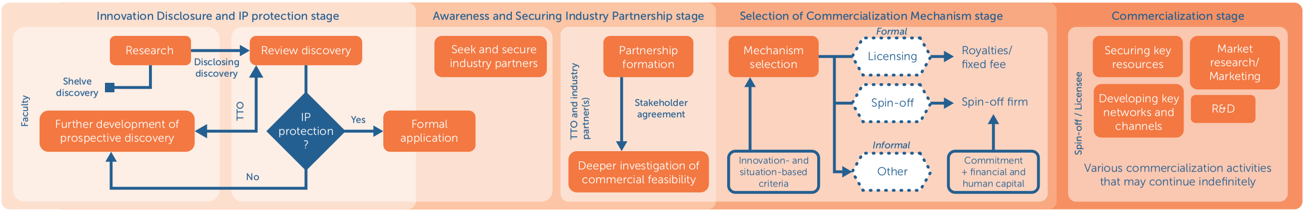


Figure 18. "Conceptual framework on the role of Knowledge Transfer Offices (KTOs) as knowledge brokers" Adapted from Berbegal-Mirabent, Sabaté, & Cañabate, 2012.

Berbegal-Mirabent et al. (2012). *Brokering knowledge from universities to the marketplace: the role of knowledge transfer offices.*

Description: The paper displays a framework for the knowledge transfer process that depicts knowledge transfer offices (KTOs) as central brokers between academia and industry and identifies success drivers for the performance of KTOs.

Connection to SIVC: Activities that are associated with the successful performance of KTOs, and therefore university-industry knowledge transfer, contribute to the R, O, T, D and M stages of the SIVC.

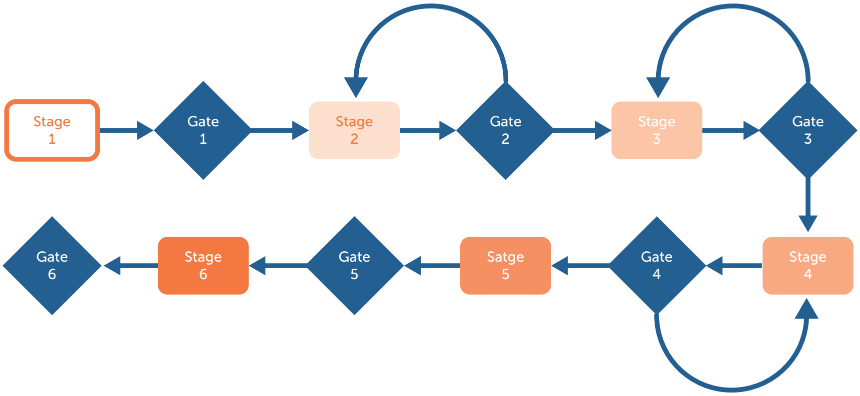


Wood (2011). *A process model of academic entrepreneurship.*

Description: Describes a multi-stage process model of academic entrepreneurship that includes activities, actors, and success drivers for each separate stage. The paper does not give a graphic representation of the process model described. One was therefore drawn up by the authors.

Connection to SIVC: Paper reflects the activities between research output (S, R and O phase) and commercialisation (T, D and M phase).

Figure 19. "Process Model of Academic Entrepreneurship." Drawn by current authors based on the description provided by Wood, 2011.



Stage 1: Identifying CVD enhancing technologies
Stage 2: Focused technology search
Stage 3: Negotiation
Stage 4: Preparing a TT project implementation plan
Stage 5: Implementing technology transfer
Stage 6: Technology transfer impact assessment

Gate 1: Confirming identified technologies
Gate 2: Technology and supplier selection
Gate 3: Finalising and approving the TT agreement
Gate 4: Approving the implementation plan
Gate 5: Implementation audit
Gate 6: Developing guidelines for a new project

Figure 20. "The Life Cycle Approach for Planning and Implementing Technology Transfer." Adapted from Ramanathan, 2011.

Ramanathan (2008). An overview of technology transfer and technology transfer models.

Description: Provides an overview of models that address the adoption and implementation of externally received technology and the issues involved in these processes, from the perspective of the SME receiving the technology. Offers a concluding stage-gate process model for planning and implementing technology transfer.

Connection to SIVC: Activities concerning the preparation and execution of technology transfer projects contribute to the T stage.

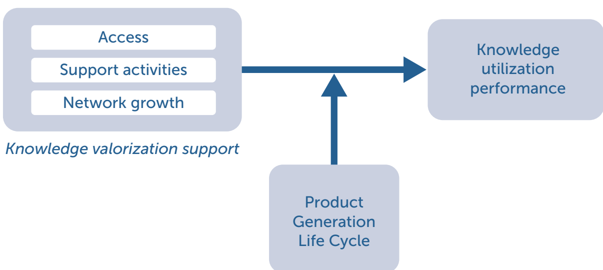


Figure 21. Conceptual model on knowledge valorisation in a public private partnership." Adapted from Garbade et al., 2013.

Garbade (2013). *The impact of the product generation life cycle on knowledge valorisation at the public private research partnership, the Centre for BioSystems Genomics.*

Description: Discusses the knowledge valorisation process in public-private research partnerships, addressing the impact of the intended output's 'Product Generation Life Cycle' on the process. Displays a conceptual model of the variables under study.

Connection to SIVC: Preparatory activities preceding research programmes, aiming to increase the likeliness of successful valorisation, contribute to the S stage. PPRPs furthermore play a role in the R and T stages.

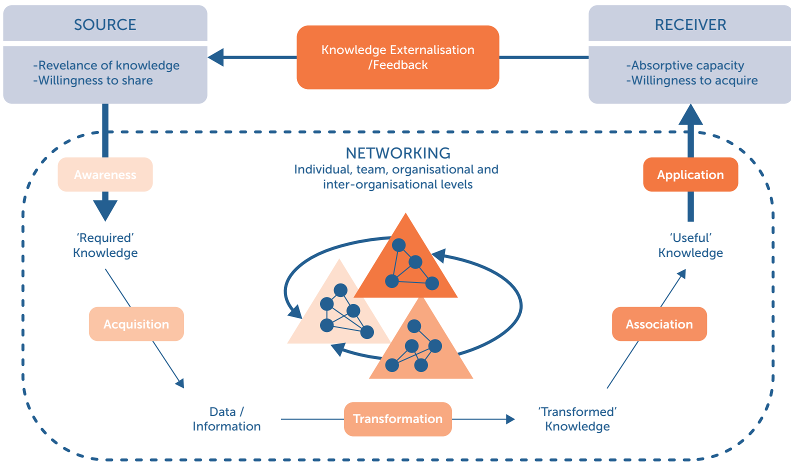


Figure 22. "Process model on knowledge transfer." Adapted from Liyanage et al., 2009.

Liyanage et al. (2009). *Knowledge communication and translation – a knowledge transfer model.*

Description: Provides a five-stage model of the process of knowledge transfer between a source and receiving party, which is grounded in theories of translation and communication.

Connection to SIVC: Provides a five-stage model of the process of knowledge transfer between a source and receiving party, which is grounded in theories of translation and communication.

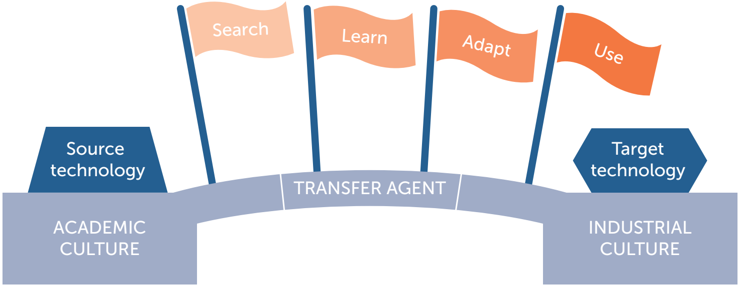


Figure 23. "Technology Transfer Model." Adapted from Goldhor & Lund, 1983.

Goldhor and Lund (1983). *University-to-industry advanced technology transfer: a case study.*

Description: Describes the sequential steps of adaptation and utilisation during the process of technology transfer, based on a case study of the transfer of an advanced technology from a university group to an industrial firm. Integrates its case findings into a process model that seems particularly appropriate for the university to high tech industry situation.

Connection to SIVC: Partnering activities and interactions between actors of the Science and Business & Development domains contribute to the T stage. The authors also describe activities related to acquiring resources in the D stage.

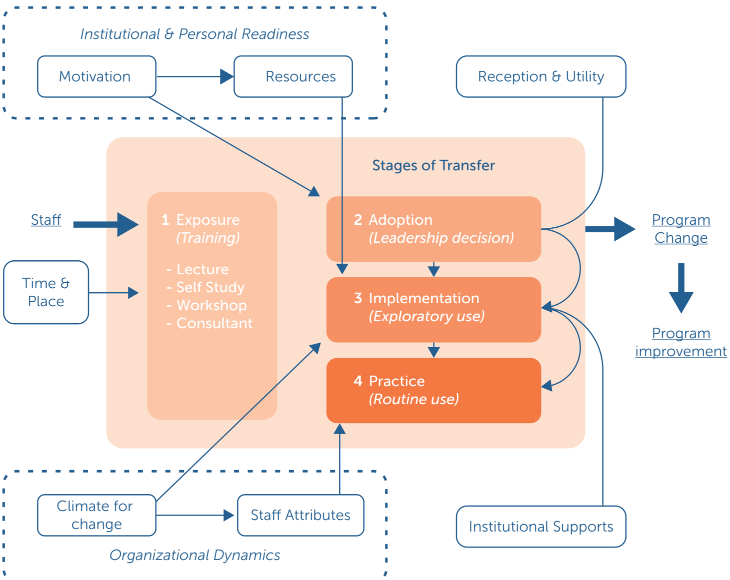


Figure 24. "Program change model for transferring research to practice." Adapted from Simpson, 2002.

Simpson (2002). *A conceptual framework for transferring research to practice.*

Description: Describes the transfer of research-based interventions to practice by means of programme change implementation. Proposes a four-stage programme change process model that also addresses key influencing factors.

Connection to SIVC: Paper is reflected in activities ranging from transfer via technical development to market adoption and policy implementation of research outcomes.

Implications for the synthesised model

Although the SIVC is presented as a simplified, circular process, the process of university knowledge valorisation is not to be seen as a one-way pipeline with a fixed sequence of steps. Rather, the steps within the cycle are iterative, can be executed in parallel and include many feedback and feed-forward loops (Berkhout et al., 2010; Kline, 1985; Rothwell, 1994). Considering that a higher degree of connections and a higher density are related to a lower comprehensibility of conceptual models, these looping processes are left out of the graphic representation (Mendling, Reijers, & Cardoso, 2007). The graphic representation therefore should be regarded as one of pseudo-linearity, and as being in line with many recent authors on innovation-related matters that reject the traditional linear way of thinking (see, for example, Godin, 2006).

2.4 A special role for university spin-offs

Analysis of current literature

A specific form of transfer is achieved via the creation of university spin-offs. Spin-offs can be seen to play a role in transformation processes, such as bringing research results to the market; mediating between knowledge and market needs to increase the absorption of knowledge; and exploitation of industry-oriented knowledge (Fontes, 2005; see figure 25). As with other types of transfer, spin-offs are dependent on their context and are influenced by environmental, cultural and structural factors (Elpida, Galanakis, Bakouros, & Platias, 2010; O'Shea, Chugh, & Allen, 2008; see figures 26 and 27). A broad perspective on spin-off formation is taken by Rasmussen, who looks at these macro-level and historical influences but also at the initial phases of opportunity recognition, conflicts that arise when the spin-off project is launched and business development aspects (Rasmussen, 2011; see figure 28).

Different scholars have analysed the process, emphasising the main stages of spin-off formation, such as the idea, business concept or venture project, financial resources, spin-off firms and value creation (Elpida et al., 2010; Ndonzuau, Pirnay, & Surlemont, 2002; see figures 26 and 29), some even by designing a main process flow with possible side avenues (Roberts & Malone, 1996, see figure 30). A seminal article on the development of spin-offs elaborates on the steps between the subsequent phases, which can be seen as the critical junctures that reflect resources and capabilities that spin-off ventures need to establish before they are able to proceed to the next phase (Vohora, Wright, & Lockett, 2004, see figure 31).

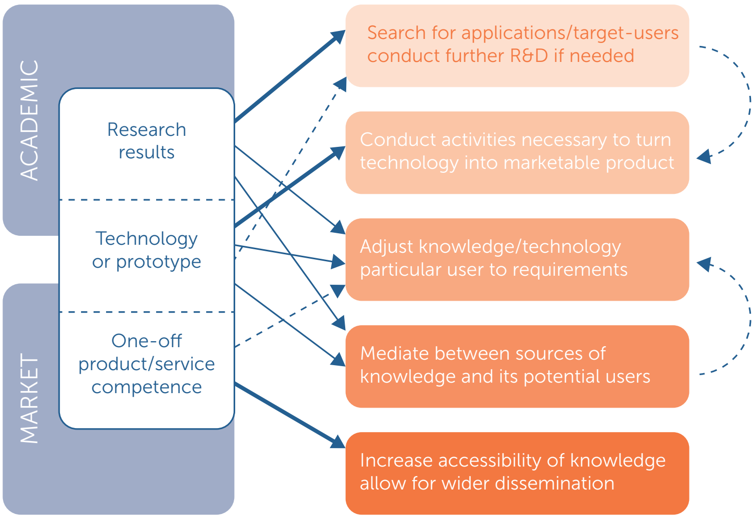


Figure 25. "The transformation process." Adapted from Fontes, 2005.

Fontes (2005). *The process of transformation of scientific and technological knowledge into economic value conducted by biotechnology spin-offs.*

Description: Addresses the various roles that can be fulfilled by academic (in this case. biotechnology) spin-offs in the complex process of transforming academic knowledge into industrially exploitable knowledge products. Depicts its findings in a summarised process model.

Connection to SIVC: Activities to transform research output into marketable products or services contribute to activities throughout the O, T, D, and M stages.

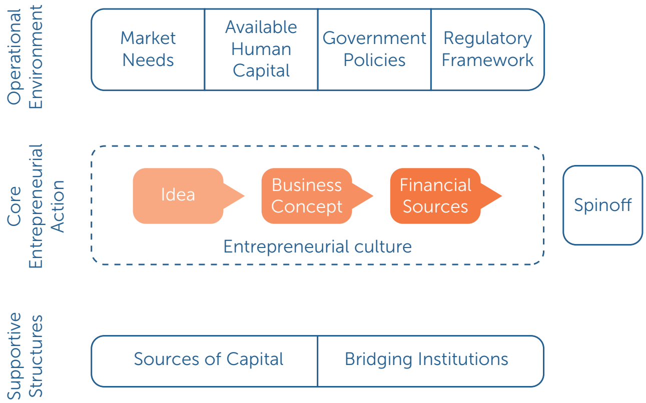


Figure 26. "The spin-off chain". Adapted from Elpida et al., 2010.

Elpida et al. (2010). *The spin-off chain.*

Description: Provides a conceptual 'Spin-off Chain' framework on the basis of existing models of the spin-off process. The framework includes a four-stage process core, supportive factors, and environmental factors, and is to be used to guide an undeveloped region throughout the spin-off process.

Connection to SIVC: Activities concerning the evaluation of inventions, shaping of commercial opportunities and development of science-based firms contribute to the O, T and D stages.

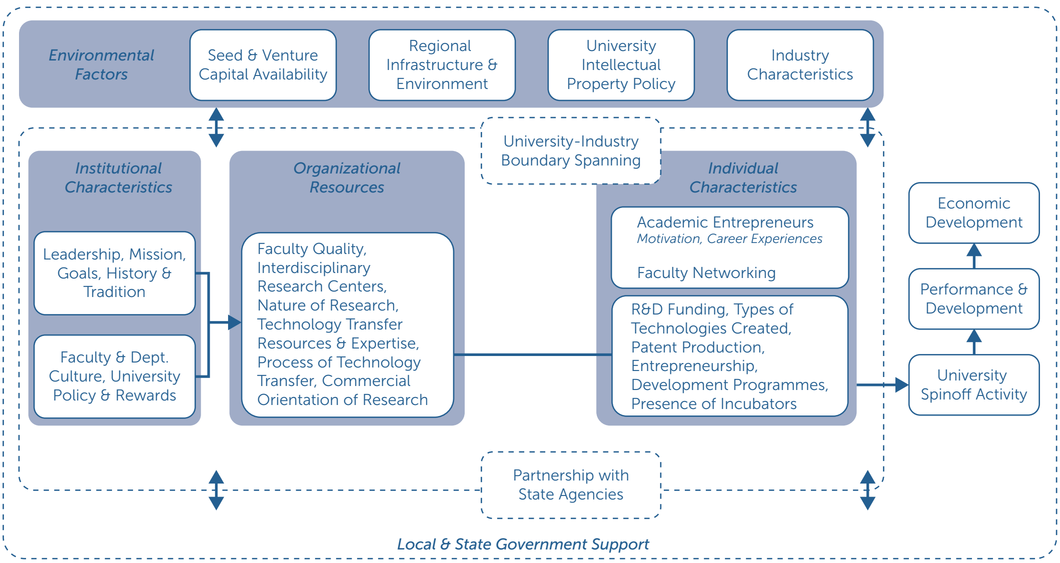


Figure 27. "University spinoff framework." Adapted from O'Shea, Chugh & Allen, 2008.

O'Shea et al. (2008). *Determinants and consequences of university spinoff activity: a conceptual framework.*

Description: Proposes a university spin-off framework that involves four categories of socio-psychological factors that may influence university spin-off activity. *The paper does not display a process model, but was included on the basis of its textual relevance.*

Connection to SIVC: Activities concerning the establishment and development of firms out of university research contribute to the O, T, and D stages.

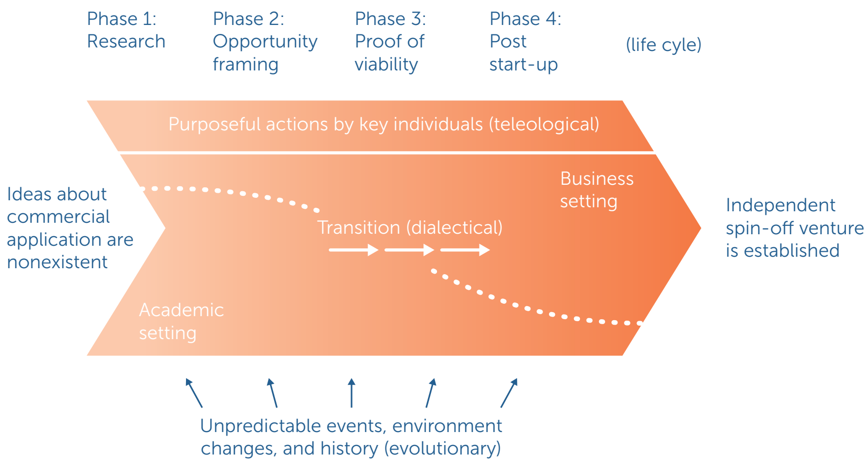


Figure 28. "Conceptual framework of the university spin-off venturing process." Adapted from Rasmussen, 2011.

Rasmussen (2011). *Understanding academic entrepreneurship: Exploring the emergence of university spin-off ventures using process theories.*

Description: Aims to provide a better understanding of the university spin-off phenomenon by invoking together four basic theories that relate to organisational change and innovation. A conceptual framework of the university spin-off venturing process is provided.

Connection to SIVC: Activities concerning the establishment and development of firms out of university research contribute to the R, D and M stages.

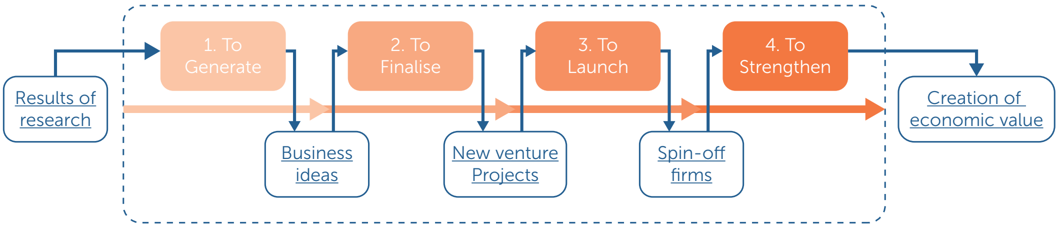


Figure 29. "The global process of valorisation by spin-off." Adapted from Ndonzuau, Pirnay & Surlemont, 2002.

Ndonzuau et al. (2002). *A stage-model of academic spin-off creation.*

Description: Examines the 'black box' that is the process of academic spin-off creation. Provides a four-stage model of the spin-off process and addresses major issues involved, from the perspective of public and academic authorities.

Connection to SIVC: Activities concerning the establishment and development of firms out of university research contribute to the O, T, and D stages.

"A specific form of transfer is achieved via the creation of university spin-offs."

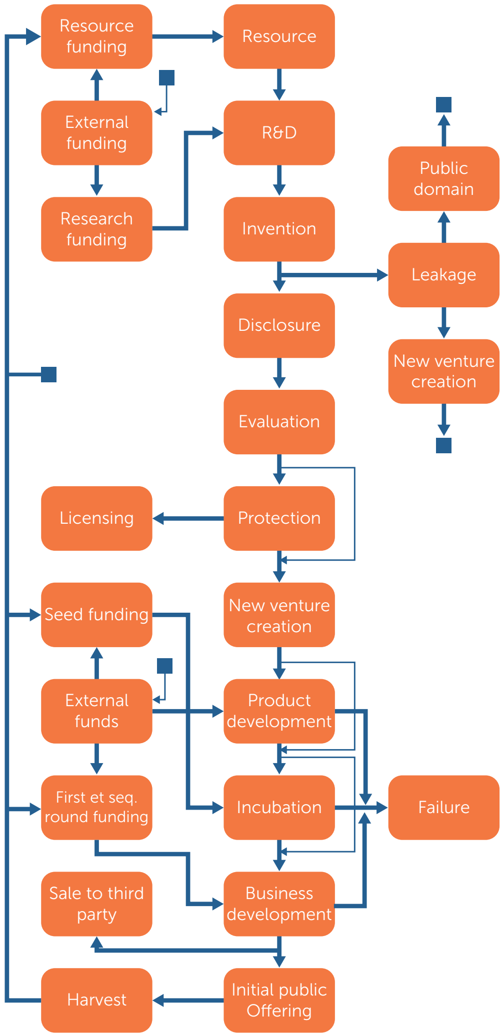


Figure 30. "Spin-off stages model." Adapted from Roberts and Malone, 1996.

Roberts and Malone (1996). *Policy and structures for spinning off new companies from research and development organisations.*

Description: Describes the process of academic spin-off creation from R&D organisations, focusing on process stages, actor roles and actor interactions. Provides a stage model of the spin-off process.

Connection to SIVC: Activities concerning the establishment and development of firms out of university research contribute to the S, R, O, T, and D stages.

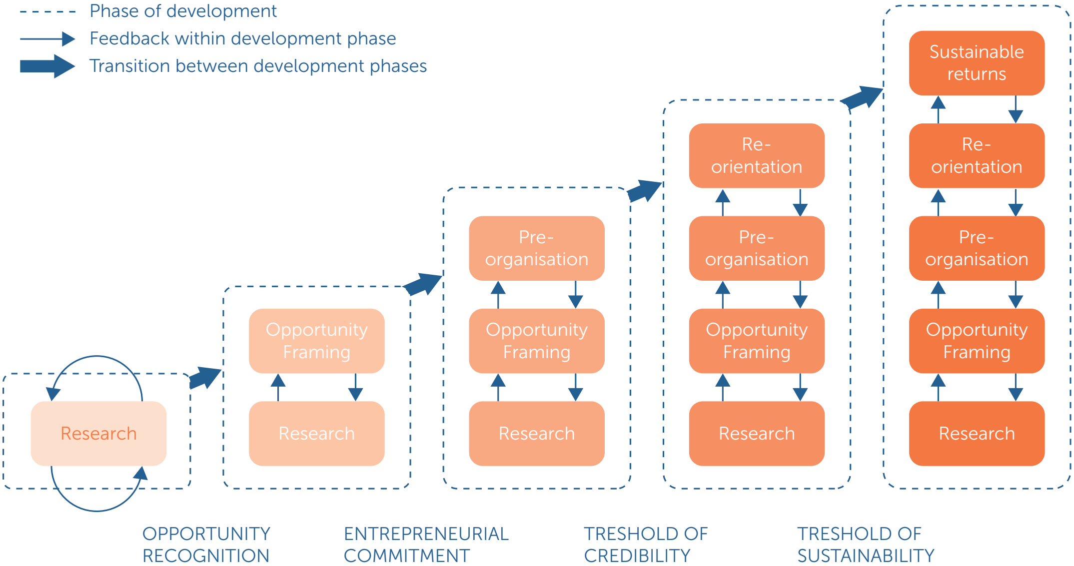


Figure 31. "The critical junctures in the development of university spinout companies." Adapted from Vohora, Wright and Lockett, 2004.

Vohora et al. (2004). *Critical junctures in the development of university high-tech spinout companies.*

Description: Drawing on literature both on stage-gate models of new firm development and on the resource-based view, the development of academic spin-offs is investigated. A stage-gate model of the spin-off process including critical junctures is provided.

Connection to SIVC: Paper is reflected in preparatory and evaluative activities in the development of firms to exploit research output, which includes the R, O and D stages.

Implications for the synthesised model

While some conceptual models referred to tasks typically being conducted by specific actors, many others indicated that different actor roles can be occupied by the same person, such as a faculty member who also becomes an entrepreneur, or an industry representative who is also involved in basic research (Chrisman, Hynes, & Fraser, 1995; Matsumoto et al., 2010). These specific tasks seem to be allocated based on personal and contextual factors rather than purely on the corresponding domain (Boehm & Hogan, 2012). This even applies to different organisations, since both spin-offs and incumbent companies can appropriate new knowledge or technologies and develop them into marketable products. An overarching synthesised model should therefore be actor-transcending, referring to the notion that although phases and activities occur in a specific domain—with domain-specific dominant norms, values and practices—they are not necessarily attributed to specific actors.

3

THE SOCIETAL IMPACT VALUE CYCLE: A SYNTHESISED CONCEPTUAL MODEL

CHAPTER 3:
THE SOCIETAL IMPACT VALUE CYCLE: A SYNTHESISED CONCEPTUAL MODEL

The papers describing theoretical and empirical insights contained a great diversity of conceptual models in terms of modelled domains, model perspectives, and model purposes. This diversity in models demonstrates that knowledge valorisation, and specifically university-based innovation, is hard to delineate, comprising multiple heterogeneous subprocesses and associated activities that may all play a contributing role in the composite overarching process of realising societal impact. Furthermore, heterogeneities between regions and sectors need to be taken into account (Lester, 2005). Simultaneously, the conceptual models underline that even in the case of non-linear, iterative and heterogeneous processes, a certain sequence of phases can often be distinguished (Matsumoto et al., 2010) and an overarching model could serve a heuristic purpose (Kaplinsky & Morris, 2001).

Figure 32. Societal Impact Value Cycle.

3.1 Illustrating the Cycle's Rationale: a hypothetical valorisation project

In the *Society and Policy* domain, unmet needs (socio-economic, health or academic curiosity-based) are identified and subsequently evaluated in order to prioritise those needs that are most urgent or most feasible to tackle (*Unmet Needs Assessment* or *U* phase). Prioritisation as such doesn't mean that the needs with the highest priority will be articulated as a demand to the academic domain since demand articulation is dependent on dynamics in the policy or industrial domain. Identified demands are translated into directions for solutions and objectives for research and innovation projects. These solutions and objectives are based, among other things, upon the feasibility of knowledge-based solutions and the necessity of new knowledge development versus the availability of already developed knowledge. Alignment of the Society and Policy domain with the Science domain occurs via research agenda-setting, and the management of stakeholder expectations (*Demand Articulation* or *A* phase).

In the science domain, ideas for research projects can be based upon articulated demands or interactions with societal actors. These ideas are evaluated and project preparation activities are conducted, such as establishing joint R&D partnerships and developing solid research proposals. After successful (peer) review of these proposals, financial and human resources are allocated to the research project (*Scoping and Preparation* or *S* stage). Subsequent research activities may involve collaboration with societal stakeholders, and should result in the realisation of tangible (e.g. a proof of principle invention) or intangible (e.g. a conceptual discovery) research output (*Research* or *R* stage). Not all academic researchers are aware of the possibilities for further development of their research output and therefore the promotion of disclosure opportunities and the identification of inventions are vital steps in the progress of the value cycle. Once interesting research output is identified, it may be subjected to an iterative process of evaluation and development, to assess and shape an opportunity for further valorisation. This may include the development of a business case, protection of IP, selection of a channel via which the invention is transferred to society, the management of IP and the development of a business plan (*Opportunity Shaping and Realisation* or *O* stage).

The result of a positive *O* stage is typically an IP-protected, realised invention (i.e. an invention with established proof of principle), for which a technical and commercial development plan is in place. Alternatively, the output may be disseminated without planned technical and commercial development via the publication of academic papers or dissemination to other societal stakeholders. In the case of further development, the process makes a transition into the industrial, profit-seeking sphere of the *Business and Development* domain, which involves private companies and related stakeholders. Often, this domain transition either involves the transfer of IP exploitation rights from the university to an external organisation—for which the cycle includes various partnering activities—or the launch of a start-up venture that spins off from the parent university to further develop and exploit the invention. In either case, the invention has to be translated and transferred from the academic to the industrial domain where the knowledge subsequently needs to be appropriated (*Transfer* or *T* stage).

The invention may then become part of company processes or be further developed into marketable products and services. The *Business and Development* domain deals with the latter case and consists of iterative development processes for both invention (e.g. prototype / pilot development, testing, and evaluation activities; *Technical Development* or D_T stage) and business (e.g. strengthening entrepreneurial culture, iterative commercial planning, recurrent resourcing activities; *Commercial Development* or D_C stage), ultimately yielding a marketable version of the invention or created knowledge.

This version then proceeds to the production phase, which may require the upscaling of production capacities to meet company and future market demands (*Production and Upscaling* or *P* stage). The transition from the *Business and Development* domain to the subsequent *Market* domain, while already taken into account at several earlier points in the cycle (e.g. consultation of target users during the *S*, *O*, and D_T stages), also becomes apparent: various activities to prepare for the market introduction of the innovation take place during the *P* stage (e.g. conducting marketing research, the creation of an action plan for introducing the new product/service and the development of key networks and distribution channels).

The cycle then enters the *Market* domain with the 'introgression' of the product or service in the marketplace, transforming the invention into an innovation (*Market Deployment* or *M* stage). This is where societal return on public investment for the university-based innovation is realised, via innovation diffusion to users, sales revenue to the innovation developers, and tax revenue to the government—which is then redistributed throughout society in the form of grants, contracts, entitlements, programmes and services. A special note should be made of the adoption of publicly disclosed knowledge (e.g. research findings) that is yet to be developed into commercially viable products or services. Governmental bodies may decide to implement these findings in policy documents or guidelines. Research implementation thus shortcuts the commercial business and development domain, but does not exclude it: conceptual discoveries that are properly protected under IP law may still be used for the development of commercial products and services.

Market deployment of the innovation instigates market responses that can be assessed to evaluate the innovation's performance and ensure production output quality (*Response and Feedback* or *F* stage). In addition, the availability of the university-based innovation for the target population changes the existing dynamics of the market landscape. Continuous evaluation of these changing dynamics may yield valuable information that feeds into the perception of current unmet needs (*U* stage). These articulated demands then feed back into the *Science* domain, giving direction to successive cycles of innovation, for instance through research agenda-setting by governmental bodies and funding agencies.

3.2 Illustrating the Cycle's Rationale: its application to different innovations

The first application of the SIVC to a specific field of innovations was to gain insight into the innovation paradox in the medical food (Weenen, Pronker, Commandeur, & Claassen, 2013) and especially in the vaccine industry (E. S. Pronker, 2013). In the latter, many efforts are dedicated to research and development, while the introduction of new vaccines remains lagging behind. In some cases this is due to a knowledge paradox, where opportunity shaping and realization is limited to the academic domain and high quality knowledge is not made available for further development in the business domain (Claassen, 2014). In other cases the cause lies in an innovation paradox, where increased resources being dedicated to the development process do not result in the introduction of new vaccines to the market because market authorization demands are not met (E. Pronker, Weenen, Commandeur, Claassen, & Osterhaus, 2014). Even if vaccines successfully address the requirements for market introduction, progression through the SIVC is not self-evident. With rising health care costs and a negative public perception of the safety of vaccines, there has been a reduction in vaccination coverage rates, chances of reimbursement and uptake in vaccination programs. The effect of these phenomena on innovation can only be understood when taking the full scope of activities into consideration. The SIVC shows that all steps within the cycle are important and reinforce each other and moreover that skipping certain steps might lead to disintegration of the cycle and the arrest of the vaccine candidate in earlier stages of development. Rather than focusing on the single next step, the application of the societal impact value cycle in the vaccine industry has shown that it is essential to appreciate all the activities and stakeholders in the societal impact value cycle to fully reach an impact of academic knowledge and address unmet societal and medical needs (cf. also Van de Burgwal et al., 2016).

Another insightful application of the SIVC was made in the field of probiotics. In this field the interrelation of the different domains and the disintegration of the cycle when certain steps are skipped was highlighted even further (Van den Nieuwboer, Van de Burgwal, & Claassen, 2015). After early scoping and preparation, research and realization stages, specific strains of bacteria are selected for further development into probiotics, primarily based upon their potential for scalability. In some cases this comes at the expense of selection based upon their potential effects or insight into the way they work, the so-called mode of action. In subsequent technical development stages this leads to difficulties in gathering evidence. Some products therefore do not continue beyond this phase while numerous studies are conducted to gather insight into why they might work, a phenomenon called "pilotitis". Without a solid evidence base, probiotic products cannot be marketed with what is called a 'health claim', a claim stating their beneficial effects on the health of people who use the product. However, they can be marketed as food or dietary supplements without specific health claims. This results in the introduction of 'pirate' probiotics that might be highly beneficial but for which no evidence base is available. In turn, this has two negative consequences. First of all, there is a lack of incentives to properly evaluate and prove the mode of action of new probiotics, since they can be introduced on the market without this investment in technical development as well. Second, companies with products already on the market are disincentivized to continue studies into their products because negative results can lead to steep reductions in turnover. As a result, both effective and ineffective probiotic products are available on the market and the two types are not readily distinguishable. This leads to skepticism among physicians and consumers and a lack of demand for new, effective products. Without sufficient demand, research funds to develop effective tools and select proper strains of bacteria will remain limited and the innovation in this field is threatened to come to a halt.

A third example of the use of the SIVC has been in the industry of Integrated Photonics (Splinter, Roos, Claassen, & Van de Burgwal, 2017). This technology uses light to transmit information and in the future may serve as a replacement for conventional integrated circuitry to meet ever increasing demands of data transport. A first step in this innovative industry has been the societal unmet need for increased data velocity and more energy efficient solutions which have been articulated into demands by the leading relevant industry and governmental agencies. This has led to financial, political and regulatory support for new research initiatives in the field Photonic Integrated Circuits (PICs). Research activities subsequently consisted of fundamental research by scientists and applied research by engineers. After sufficient verification of results a public-private partnership was able to align the requirements of the visionary end goal of the technology. Opportunity shaping in this stage involved the selection of a limited number of technological building blocks from many possibilities to ensure interoperability. In turn this resulted in roadmaps for the creation of building blocks and their integration on a platform. Next steps involved pilot production of PICs in a semi-commercial fashion to gather market feedback. Ultimately, this will lead to a design-freeze after which production can start. The SIVC for this development is still developing, but it is clear that this new technology cannot exist without addressing the societal unmet needs. Moreover, market introduction will require disruption of the current infrastructure for integrated circuits, providing a very specific challenge for this new innovation. To facilitate successful introduction, customer feedback already proves essential for improvement of the PIC technology and the production of PICs. The wide range of required specifications, both technological and functional, warrants intense collaboration between the developers, manufacturers and customers in early stages of development to assure the PIC innovation will ultimately continue through the SIVC, similar as to what we have shown for e-health apps (Dehzad, Hilhorst, de Bie, & Claassen, 2014).

4

THE SIVC: IMPLICATIONS AND POSSIBLE APPLICATIONS

CHAPTER 4:
THE SIVC: IMPLICATIONS AND POSSIBLE APPLICATIONS

The SIVC synthesises current insights on activities and processes contributing to university-based innovation into an actor- and domain-transcending circular model of value-adding phases. In this sense, the synthesised model primarily serves a heuristic purpose.
To provide a single process model that accurately represents all potential situations of university knowledge valorisation is almost impossible. This is due to the wide variety of possible contextual heterogeneities (for example, in terms of national innovation systems or sector-specific regulations), but also because of the rigid character of stage models, which inevitably oversimplify complex real-world processes. As a consequence of these contextual heterogeneities, the valorisation practice may require deviation from the proposed model's sequence, in terms of skipping specific steps and executing steps in parallel or in a different order.

The actor- and domain-transcending perspective of the SIVC enables stakeholders to appreciate the full scope of university-based innovation and the full extent of its possible societal impact. This perspective complements models that offer a more isolated and in-depth focus on subprocesses (e.g. transfer of knowledge), specific domains (e.g. the science and industry domains), or certain actors (e.g. university administrators). The synthesised model may therefore serve a boundary-spanning purpose by increasing reciprocal insight, and thus appreciation, among stakeholders across domains.

Furthermore, the SIVC enables stakeholders to more consciously consider the relevance of steps for their specific cases and thereby more responsibly skip, combine or rearrange steps. Rigorous contextualisation of heuristic models allows for the generation of a tick-the-box process model, providing a true user-friendly toolbox as previously shown in a much simpler form for the probiotics industry (Van den Nieuwboer et al., 2015). Since the process involves a cycle of chained elements, obstacles anywhere in the cycle may affect any other place in the cycle. Inefficiencies can therefore only be fully comprehended once the entire valorisation cycle has been considered. The SIVC presented here may enable a better understanding of valorisation inefficiencies and thus contribute to reducing inefficient knowledge valorisation practices.

More importantly, the synthesised model can serve as a toolbox for the organisation and improvement of knowledge valorisation tools, ultimately improving the beneficial societal impact of knowledge.

"If you don't know where you are going, you will end up someplace else" - Yogi Berra

Aken, J. E. v. (2004). Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. *Journal of management studies, 41*(2), 219-246.

Audretsch, D. B., & Keilbach, M. (2008). Resolving the knowledge paradox: Knowledge-spillover entrepreneurship and economic growth. *Research Policy, 37*(10), 1697-1705.

Berbegal-Mirabent, J., Sabaté, F., & Cañabate, A. (2012). Brokering knowledge from universities to the marketplace. *Management Decision, 50*(7), 1285-1307. doi:10.1108/00251741211247012

Berkhout, G., Hartmann, D., & Trott, P. (2010). Connecting technological capabilities with market needs using a cyclic innovation model *R&D Management, 40*(5), 474-490.

Block, F., & Keller, M. (2008). Where Do Innovations Come From? Transformations in the US National Innovation System 1970-2006.

Boehm, D. N., & Hogan, T. (2012). 'A jack of all trades': the role of PIs in the establishment and management of collaborative networks in scientific knowledge commercialisation. *The Journal of Technology Transfer, 39*(1), 134-149. doi:10.1007/s10961-012-9273-8

Braun, D., & Guston, D. H. (2003). Principal-agent theory and research policy: an introduction. *Science and Public Policy, 30*(5), 302-308.

Bush, V. (1945). Science: The endless frontier. *Transactions of the Kansas Academy of Science (1903-), 48*(3), 231-264.

Chrisman, J. J., Hynes, T., & Fraser, S. (1995). Faculty entrepreneurship and economic development: The case of the University of Calgary. *Journal of Business Venturing, 10*(4), 267-281.

Claassen, E. (2014). Valorisation at the EUR. In P. A. G. v. Bergeijk & L. Johnson (Eds.), *Social impact @ sciences: The end of the ivory tower?* (pp. 30-39). Den Haag: ISS.

Cusumano, M. A., & Elenkov, D. (1994). Linking international technology transfer with strategy and management: a literature commentary. *Research Policy, 23*(2), 195-215.

Dehzad, F., Hilhorst, C., de Bie, C., & Claassen, E. (2014). Adopting Health Apps, What's Hindering Doctors and Patients? *Health, 06*(16), 2204-2217. doi:10.4236/health.2014.616256

Elpida, S., Galanakis, K., Bakouros, I., & Platias, S. (2010). The spin-off chain. *Journal of technology management & innovation, 5*(3), 51-68.

Flagg, J. L., Lane, J. P., & Lockett, M. M. (2013). Need to Knowledge (NtK) Model: an evidence-based framework for generating technological innovations with socio-economic impacts. *Implementation Science 8.1 (2013): 21., 8*(21).

Fontes, M. (2005). The process of transformation of scientific and technological knowledge into economic value conducted by biotechnology spin-offs. *Technovation, 25*(4), 339-347. doi:10.1016/j.technovation.2003.08.004

Garbade, P. J. P., Omta, S. W. F., Fortuin, F. T. J. M., Hall, R., & Leone, G. (2013). The Impact of the Product Generation Life Cycle on Knowledge Valorization at the Public Private Research Partnership, the Centre for BioSystems Genomics. *NJAS - Wageningen Journal of Life Sciences, 67*, 1-10. doi:10.1016/j.njas.2013.07.002

Geuna, A., & Muscio, A. (2009). The Governance of University Knowledge Transfer: A Critical Review of the Literature. *Minerva, 47*(1), 93-114. doi:10.1007/s11024-009-9118-2

Godin, B. (2006). The Linear model of innovation the historical construction of an analytical framework. *Science, Technology & Human Values, 31*(6), 639-667.

Goldhor, R. S., & Lund, R. T. (1983). University-to-industry advanced technology transfer: a case study. *Research Policy, 12*(3), 121-152.

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions, 26*(1), 13-24. doi:10.1002/chp.47

Hanney, S. R., Grant, J., Wooding, S., & Buxton, M. J. (2004). Proposed methods for reviewing the outcomes of health research: the impact of funding by the UK's 'Arthritis Research Campaign'. *Health Res Policy Syst, 2*(1), 4. doi:10.1186/1478-4505-2-4

Ho, M. H.-C., Liu, J. S., Lu, W.-M., & Huang, C.-C. (2013). A new perspective to explore the technology transfer efficiencies in US universities. *The Journal of Technology Transfer, 39*(2), 247-275. doi:10.1007/s10961-013-9298-7

Hussler, C., Picard, F., & Tang, M. F. (2010). Taking the ivory from the tower to coat the economic world: Regional strategies to make science useful. *Technovation, 30*(9-10), 508-518. doi:10.1016/j.technovation.2010.06.003

Johnson, W. H. (2011). Managing university technology development using organizational control theory. *Research Policy, 40*(6), 842-852.

Kaplinsky, R., & Morris, M. (2001). *A handbook for value chain research* (Vol. 113): IDRC Ottawa.

Kline, S. J. (1985). Innovation is not a linear process. *Research Management, 28*(4), 36-45.

Lal, J. A., Schulte In den Baumen, T., Morre, S. A., & Brand, A. (2011). Public health and valorization of genome-based technologies: a new model. *J Transl Med, 9*, 207. doi:10.1186/1479-5876-9-207

Lane, J. P. (2010). At the Confluence of Academic Research and Business Development-Merging Technology Transfer with Knowledge Translation to Deliver Value. *Assistive Technology Outcomes & Benefits (ATOB), 6*(1).

Lazonick, W., & Mazzucato, M. (2013). The risk-reward nexus in the innovation-inequality relationship: who takes the risks? Who gets the rewards? *Industrial and Corporate Change, 22*(4), 1093-1128. doi:10.1093/icc/dtt019

Lehmann, E. E., & Menter, M. (2015). University–industry collaboration and regional wealth. *The Journal of Technology Transfer*. doi:10.1007/s10961-015-9445-4

Lester, R. (2005). *Universities, innovation, and the competitiveness of local economies. A summary Report from the Local Innovation Systems Project: Phase I.* . Retrieved from

Leydesdorff, L. (2010). The knowledge-based economy and the triple helix model. *Annual Review of Information Science and Technology, 44*(1), 365-417.

Liyanage, C., Elhag, T., Ballal, T., & Li, Q. (2009). Knowledge communication and translation – a knowledge transfer model. *Journal of Knowledge Management, 13*(3), 118-131. doi:10.1108/13673270910962914

Matsumoto, M., Yokota, S., Naito, K., & Itoh, J. (2010). Development of a model to estimate the economic impacts of R&D output of public research institutes. *R&D Management, 40*(1), 91-100.

Mendling, J., Reijers, H. A., & Cardoso, J. (2007). What makes process models understandable? *Business Process Management* (pp. 48-63): Springer.

Moody, D. L. (2005). Theoretical and practical issues in evaluating the quality of conceptual models: current state and future directions. *Data & Knowledge Engineering, 55*(3), 243-276. doi:10.1016/j.datak.2004.12.005

Mostert, S. P., Ellenbroek, S. P., Meijer, I., van Ark, G., & Klasen, E. C. (2010). Societal output and use of research performed by health research groups. *Health Res Policy Syst, 8*, 30. doi:10.1186/1478-4505-8-30

Ndonzuau, F. N., Pirnay, F., & Surlemont, B. (2002). A stage model of academic spin-off creation. *Technovation, 22*(5), 281-289.

Nelson, H. J., Poels, G., Genero, M., & Piattini, M. (2012). A conceptual modeling quality framework. *Software Quality Journal, 20*(1), 201-228.

O'Shea, R. P., Chugh, H., & Allen, T. J. (2008). Determinants and consequences of university spinoff activity: a conceptual framework. *The Journal of Technology Transfer, 33*(6), 653-666. doi:10.1007/s10961-007-9060-0

OECD. (2013). *Commercialising Public Research: New Trends and Strategies*. Retrieved from http://www.oecd-ilibrary.org/science-and-technology/commercialising-public-research-new-trends-and-strategies_9789264193321-en

Oortwijn, W. J., Hanney, S. R., Ligtvoet, A., Hoorens, S., Wooding, S., Grant, J., . . . Bouter, L. M. (2008). Assessing the impact of health technology assessment in The Netherlands. *Int J Technol Assess Health Care, 24*(3), 259-269. doi:10.1017/S0266462308080355

Pronker, E. S. (2013). *Innovation Paradox in Vaccine Target Selection* (Vol. 282). Rotterdam: ERIM - Research in Management.

Pronker, E., Weenen, T., Commandeur, H., Claassen, E., & Osterhaus, A. D. M. E. (2014). Scratching the surface: Exploratory analysis of key opinion leaders on rate limiting factors in novel adjuvanted-vaccine development. *Technological Forecasting and Social Change*. doi:10.1016/j.techfore.2014.04.017

Punter, T., Krikhaar, R. L., & Bril, R. J. (2009). Software engineering technology innovation – Turning research results into industrial success. *Journal of Systems and Software, 82*(6), 993-1003. doi:10.1016/j.jss.2008.12.035

Ramanathan, K. (2008). *An overview of technology transfer and technology transfer models*. Paper presented at the International Conference on South-South Cooperation for Technology Transfer and Development of Small and Medium Enterprises.

Ranjan, J., & Gera, R. (2012). Bridging the gap in knowledge transfer between academia and practitioners. *International Journal of Educational Management, 26*(3), 252-273. doi:10.1108/09513541211213336

Rasmussen, E. (2011). Understanding academic entrepreneurship: Exploring the emergence of university spin-off ventures using process theories. *International Small Business Journal, 29*(5), 448-471.

Roberts, E. B., & Malone, D. E. (1996). Policies and structures for spinning off new companies from research and development organizations. *R&D Management, 26*(1), 17-48.

Rosenberg, N. (1994). *Exploring the black box: Technology, economics, and history*: Cambridge University Press.

Rothwell, R. (1994). Towards the Fifth-generation Innovation Process. *International Marketing Review, 11*(1), 7-31. doi:10.1108/02651339410057491

Sarewitz, D., & Pielke, R. A. (2007). The neglected heart of science policy: reconciling supply of and demand for science. *Environmental Science & Policy, 10*(1), 5-16. doi:10.1016/j.envsci.2006.10.001

Schumpeter, J. A. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle* (Vol. 55): Transaction publishers.

Shohet, S., & Prevezer, M. (1996). UK biotechnology: institutional linkages, technology transfer and the role of intermediaries. *R&D Management, 26*(3), 283-298.

Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university–industry collaboration. *The Journal of High Technology Management Research, 14*(1), 111-133. doi:10.1016/s1047-8310(03)00007-5

Siegel, D. S., & Wright, M. (2015). Academic Entrepreneurship: Time for a Rethink? *British Journal of Management, 26*(4), 582-595. doi:10.1111/1467-8551.12116

Simpson, D. D. (2002). A conceptual framework for transferring research to practice *Journal of Substance Abuse Treatment, 22*(4), 171-182.

Splinter, M., Roos, E., Claassen, E., & Van de Burgwal, L. H. (2017). Stage-gates and barries in the integrated photonics innovation process. Submitted.

Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation*: Brookings Institution Press.

Stone, V. I., & Lane, J. P. (2012). Modeling technology innovation: How science, engineering, and industry methods can combine to generate beneficial socioeconomic impacts. *Implementation Science, 7*(1), 44.

Strandburg, K. J. (2005). Curiosity-driven research and university technology transfer. *University entrepreneurship and technology transfer: Process, design, and intellectual property*, 93-123.

Swamidass, P. M., & Vulasa, V. (2008). Why university inventions rarely produce income? Bottlenecks in university technology transfer. *The Journal of Technology Transfer, 34*(4), 343-363. doi:10.1007/s10961-008-9097-8

Van de Burgwal, L. H., Reperant, L. A., Osterhaus, A. D., Iancu, S. C., Pronker, E. S., & Claassen, E. (2016). Self-Centric and Altruistic Unmet Needs for Ebola: Barriers to International Preparedness. *Disaster Med Public Health Prep, 10*(4), 644-648. doi:10.1017/dmp.2016.64

Van den Nieuwboer, M., Van de Burgwal, L. H. M., & Claassen, E. (2015). A quantitative key-opinion-leader analysis of innovation barriers in probiotic research and development: valorisation and improving the tech transfer cycle. *PharmaNutrition, 10.1016/j.phanu.2015.09.003*. doi:10.1016/j.phanu.2015.09.003

Van Geenhuizen, M. (2010). Valorisation of knowledge: preliminary results on valorisation paths and obstacles in bringing university knowledge to market.

Vohora, A., Wright, M., & Lockett, A. (2004). Critical junctures in the development of university high-tech spinout companies. *Research Policy, 33*(1), 147-175. doi:10.1016/s0048-7333(03)00107-0

Weenen, T. C., Pronker, E. S., Commandeur, H. R., & Claassen, E. (2013). Barriers to innovation in the medical nutrition industry: A quantitative key opinion leader analysis. *PharmaNutrition, 1*(3), 79-85. doi:10.1016/j.phanu.2013.04.001

Weenen, T. C., Pronker, E. S., Commandeur, H. R., Claassen, E. (2013). Barriers to innovation in the medical nutrition industry, a quantitative key opinion leader analysis. PharmaNutrition. 1(3). 79-85.

Wood, M. S. (2011). A process model of academic entrepreneurship. *Business Horizons, 54*(2), 153-161. doi:10.1016/j.bushor.2010.11.004

Xie, Z., Hall, J., McCarthy, I. P., Skitmore, M., & Shen, L. (2016). Standardization efforts: The relationship between knowledge dimensions, search processes and innovation outcomes. *Technovation, 48–49*, 69-78. doi:http://dx.doi.org/10.1016/j.technovation.2015.12.002

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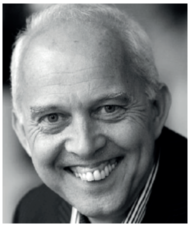

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