Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 07 May 2026
Revised 05 June 2026
Accepted 18 June 2026

Natural Resources for Human Health 2026, Vol. 6 (12s): 788–803

KEYWORDS:
Innovation management, Valley of Death, Role interdependence, Product commercialization, Knowledge integration, Resource dependence, Dynamic capabilities, Technological uncertainty

Surmounting the Valley of Death: A Theoretical Examination of Role Interdependence in Product Innovation

[1]Li Yuan Yu, [2]Tan Seng Teck

[1]INTI International University, Nilai, Malaysia i25032213@student.newinti.edu.my
[2]INTI International University, Nilai, Malaysia, sengteck.tan@newinti.edu.my

ABSTRACT: The passage from the technological invention to the development of a commercial product is a recurring problem in innovation management and often described as the "Valley of Death." Much emphasis has been placed in previous studies on constraints on resources, uncertainty regarding technology, commercialization challenges, and cross-functional integration, but theoretical focus on interdependence among the organizational roles that deal with this transition is relatively scarce. This paper conducts a theoretical analysis of role interdependence in product innovation and proposes that role interdependence is a relational process that brings together dispersed knowledge, resources, decision-making authority and capabilities in commercializing the innovation. The study uses integrative theoretical research based on literature-based analysis, conceptual synthesis and deductive proposition development, based on the Role Theory, Resource Dependence Perspective, Knowledge Integration Perspective and Dynamic Capability Perspective. These mechanisms are identified as the interdependency of knowledge, resources, and decisions, all of which play a part in the progression of innovation, accentuated by differentiated roles in innovation. It also shows how role clarity, technological uncertainty and market turbulence moderate the impact of these relationships, and how coordination overload, power imbalance, role uncertainty and excessive dependency are possible dysfunctional effects. The resulting Role-Interdependence-to-Commercialization Framework describes a process of commercialization as being dynamically configured, and as a recursive process instead of a linear technological process. Theoretically, the paper presents a framework of role interdependence as a key explanatory mechanism of how organizations deal with innovation discontinuities and provides the groundwork for future empirical studies.

1 INTRODUCTION

It is well established that product innovation is one of the most important ways that organisations can turn technology, science and market opportunities into new products and new competitive assets (Lee & Yoo, 2019). However, the process of developing a commercially viable product from an innovative idea or technological discovery is not always smooth. Often there is a significant gap between research and formal product development where good ideas are not realised because there are limited resources, commercialisation skills, market knowledge, organisational support and decision-making capability. (Edwards-Schachter, 2018). The "Valley of Death" in product innovation is referred to as this discontinuity (Kennedy et al., 2017; Klitsie et al., 2019). The Valley of Death as a separate front-end component between research and formal product development, and the involvement of several organizational actors, such as champions, sponsors, and gatekeepers (Yu et al., 2017). The significance of their findings lies in the fact that their actions are not independent but are interdependent with one another, such that an innovation project's transition relies on their roles to be performed in a dynamic fashion (Dean et al., 2022; Islam, 2017).

The Valley of death is thus not just a financial or technological development issue (Romme et al., 2023; Mittelmeijer et al., 2020). Innovation of products involves a simultaneous mobilization and integration of various types of knowledge, authority, expertise and organizational resources. Research and development staff can have high technical expertise and low knowledge of customers, commercialization, and strategic resource utilization (Helman, 2023). There may be marketing and commercial actors who know what the market wants but rely on technical specialists to decide the feasibility. Senior sponsors can leverage resources and organizational legitimacy, and gatekeepers assess if an innovation meets certain criteria for further development (Ellwood et al., 2022). The research on cross-functional integration also highlights the need for interaction, communication, information sharing, coordination, and joint involvement among organizational functions in the context of successful new product development, to transfer specialized knowledge into collective knowledge (Liu et al., 2025; Dean et al., 2022). Therefore, the movement between the nodes in the Valley is essentially relational, meaning that the dynamics of one role are often dependent on information, resources, decisions or actions by another role (In et al., 2020; Gbadegeshin et al., 2021).

Even with this recognition, the literature is still divided into various theories. The study of the Valley of Death has revealed resource constraints, uncertainty, difficult organizational structures and barriers to commercialization, and the study of new product development has extensively studied cross-functional integration, knowledge sharing, and cooperation between functions (Seyhan, 2019). These streams, however, need to be more informative about how the interdependent innovation roles collectively help overcome the discontinuity between technological invention and commercialisation (Al Natsheh et al., 2021). Specifically, previous studies have focused on integration as an organizational practice or organizational structure, rather than on interdependence between innovation roles as a key theoretical mechanism. This is significant because while high levels of integration can lead to positive innovation outcomes, it does not automatically mean the same. (Dean et al., 2022) Recent studies have shown that cross-functional integration has varying effects based on contextual and organizational factors and over-integration can create further coordination problems (Islam, 2017). The theoretical challenge is thus not only about the nature of the collaboration of different actors, but how they are dependent on each other, what complementary responsibilities they have, what boundaries of knowledge they share, what control over resources they have, and what authority they wield in the critical transition across the Valley of Death.

In the backdrop, the present paper develops a theory for role interdependence in product innovation. Drawing on the insights from role theory and knowledge integration, resource dependence, dynamic capabilities and new product development literatures, the paper conceptualises role interdependence as a coordination mechanism that enables distributed knowledge, resources and decision authority to be coordinated in the course of innovation progression (Fang & Qin, 2025). Successful crossing of the Valley is hinged on the productive interdependency between knowledge generation, championing, sponsoring, integration and commercialization roles (Kwun et al., 2024). The paper therefore focuses on the traditional question of why individual innovation projects fail, and on a more general question of how relationships between innovation roles facilitate or hinder commercialization (Pérez-Luño et al., 2019). This perspective will be developed in the study to continue the role-theoretical explanation of the Valley of the Death, deepen the innovation discontinuities explanation, and provide a conceptual basis for further empirical research on the role interdependence and commercialization of products.

1.2 Background: The Valley of Death in Product Innovation

The Valley of Death is the term used for a gap in the innovation process where ideas have the potential to become a product or service but are not able to make the leap from research and invention to a formal product or service development and commercialization. While the expression is also used when talking about entrepreneurship and finance or technology transfer, the particular entrepreneurial aspect of it is when technological knowledge is shared to the organizational action needed to turn the knowledge into a marketable product (Helman, 2023). The Valley of Death – a separate front-end stage of product innovation between research and formal product development. Projects at this stage may have significant technological potential but are not at a stage of development for market validation, organizational legitimacy, resource commitment and commercial feasibility (Ellwood et al, 2022). Therefore, an innovation failure at this stage does not necessarily mean that the technology itself is not valuable. Instead, it could be indicative of the inability to assemble the complementary resources and roles necessary to advance the innovation (Klitsie et al., 2019).

The Valley of Death is a state of significant uncertainty, as a decision needs to be made before the technical, commercial and strategic implications of the innovation become fully apparent (Assom et al., 2026). Generally, technical teams focus on scientific feasibility, technological performance, and problem solving, while commercial functions focus on customer requirements,

market opportunities, competitive positioning and financial return (Ardito et al., 2024). Meanwhile, senior managers and sponsors have an impact on resource allocation and organizational commitment, and gatekeeping actors are involved in decisions on further development of projects. These disparities result in gaps in understanding, goals, language, and decision criteria (Hadaya, 2026). The innovation project then relies on actors that have diverse types of expertise and different types of organizational resources. The Valley is thus better viewed as an organizational and relational issue, rather than just a technological or financial deficit.

One of the key elements of this phase is the dependency of roles around innovation. Normally, no one individual will have all the technical knowledge, market information, financial power, organizational influence and the know-how of commercialisation needed to advance a complex product innovation (Belz et al., 2019). The researchers/engineers can develop, mature, and refine the technological concept, though the progress of their research may be critically dependent on the market actors that can provide information derived from their customer needs and commercial requirements. Likewise, product champions can promote an innovation and generate organizational visibility, but they do so at the behest of sponsors with the authority to free up resources and to shield the project from the risk of being killed by the organization (Seyhan, 2019). Gatekeepers may assess whether the project is legitimate and fits the organizational strategy, but their verdict relies on information provided by actors of technical, marketing and financial and managerial actors. The role interdependence thus provides a view of innovation progression that does not assume the independent performance of individual roles but instead assumes a relationship between partially specialized actors.

This process has an important complementary understanding in cross functional integration. Knowledge distributed throughout research and development, manufacturing, marketing, finance, purchasing and other functions in the organization is often required when considering new product development (Al Natsheh et al., 2021). Some previous studies have focused on the mechanisms of interaction, communication, information sharing, coordination and collective involvement. But functional integration is not synonymous with success in innovation. Evaluation criteria and priorities in different functions can be conflicting and interaction may introduce additional coordination requirements (Gatto & Re, 2021). Effective integration will then rely in part on how organizational actors handle their dependencies and coordinate specialized responsibilities in innovative decision times.

In this context, the Valley of Death is a transition process that goes through resources, knowledge, power and organizational commitment. The project needs to gain technical credibility, market relevance, and financial justification, strategic legitimacy, and development support progressively (An & Zhang, 2021). These requirements are spread out in various actors and organizational units, and as such the transition is dependent upon coordinating between the actors and their roles (Stefanelli et al., 2020). This coordination can be analysed using the theoretical framework of role interdependence which focuses on the reciprocal interactions between actors where one actor's capacity to enact a role relies on the behaviours or resources of another actor. The idea therefore extends the analysis of the existence of individual barriers further to the mechanisms by which the participants of innovation overcome—or reinforce—the discontinuities in the Valley of Death (Dean et al., 2022).

The background literature therefore indicates that the Valley is not to be seen as a single barrier to cross or not to cross, but should be considered in terms of the innovation projects. It is more usefully seen as an ongoing organizational environment in which technological uncertainty and resource dependence, knowledge asymmetry, competing priorities and decisions making authority are interwoven (Assom et al., 2026). The theory of commercialization failure and success thus requires a more comprehensive description, and the understanding of the complementary role of actors, and how their dependencies change during the innovation process, therefore, is crucial. This perspective provides the groundwork for the next step in the review of the literature and the development of product innovation as a sensitising theoretical idea: role interdependence.

2. LITERATURE REVIEW

The advent of the 21st century has seen the biomedical diagnosis being increasingly altered by the use of artificial intelligence (AI), machine learning (ML) and deep learning (DL) that facilitates the automated extraction of clinically relevant patterns from complex medical data. Manual interpretation, subjective assessment, and reliance on specialist expertise are frequently used in traditional diagnostic approaches, potentially leading to inter-observer variability and scalability challenges. In this respect, deep learning models have shown great promise in image-, signal-, and lifestyle-based healthcare applications. For instance, Abbadi (2026) designed an image-based deep learning model (HuSHeM) that can automatically assess the morphology of human sperm

and compared this with a clinical approach supplemented with a Systemic Inflammation Response Index (SIRI), which is based on the World Health Organization. The results showed that image-based learning results in better discrimination, precision–recall performance, calibration, and decision-curve-based clinical utility, as compared to conventional rule-based assessment, thus offering more reproducible decision support by image-based learning. Likewise, Santos (2025) investigated the use of deep learning methods to predict Alzheimer's disease (AD) based on MRI images, pairing CNN networks like ResNet, DenseNet, and EfficientNet with LSTM, GRU, BiLSTM, and BiGRU networks for modelling the progression of the disease over time. Combining spatial MRI features with temporal clinical data showed the potential of hybrid CNN–RNN networks for the early identification and the prediction of progression. These studies in totality showcase a transition from the traditional diagnosis to biomedical intelligence through automation, data and multimodality.

The literature also shows that, in addition to predictive performance, the effectiveness of biomedical AI relies on the generalizability, interpretability, calibration, and robustness of the AI system. Ahammad (2026) analyzed voice-based PD detection and found that models that performed very well when tested on only one dataset showed significant drop in accuracy when tested on other datasets. The study thus highlighted the necessity of subject-aware validation, generalization across different datasets, explainable AI (XAI), and privacy-preserving federated learning for real-life clinical use. Korea et al. (2025) reported a similar generalization challenge for the classification of the severity of knee osteoarthritis via markerless motion capture and a long short-term memory fully convolutional network. The model's accuracy dropped from 0.91 for random splitting to 0.76 for subject based splitting, highlighting the impact of inter-subject variability on the performances and the need to test models on unseen subjects. Another key issue in medical AI that Hoq et al. (2025) tackled was the question of native-resolution 2D embeddings for lung cancer classification with a self-supervised RAD-DINO foundation model. Their findings indicated that calibration was a substantial improvement to probability reliability in realistic screening prevalence and embedding-based retrieval with SHAP analysis introduced interpretability. Together, these studies suggest that there is a need for more than just accuracy-based metrics as evaluation frameworks for robust biomedical AI, to incorporate class imbalance, calibration, subject independence, explainability and external or cross-dataset validation.

There has also been growing interest in (explanation and) multimodal representation learning in recent years in the field of biomedical AI. Sankoh et al. (2026) proposed a dual-attention CNN to automatically assess facial pain, which combines spatial attention and channel attention to learn pain-relevant features in the face. The proposed framework was supported by subject-wise stratified evaluation, ablation analysis, and Grad-CAM visualization, which enhanced the interpretability and repeatability of the proposed framework. Tokdar et al. (2026) also suggested CNN-Res-SE-BiLSTM-BiGRU for the detection of MCI using EEG signals. A framework of convolutional feature extraction, residual learning, bidirectional recurrent modelling and squeeze-and-excitation attention was employed, along with an explanation technique based on SHAP and LIME to explain learned spatiotemporal patterns. Reddy et al. (2026) showed the added value of using multiple CNN architectures and ensemble techniques for diabetic retinopathy detection and used Grad-CAM to highlight diagnostically relevant retinal regions. Muhammad et al. (2025) took this step further for brain tumour classification by adding Cross-Gated Multi-Path Attention Fusion on top of ResNet and Vision Transformer representations and using Grad-CAM and Integrated Gradients for revealing the visual evidence used by the model for making decisions. While these studies indicate that the use of attention mechanisms, hybrid architectures, ensemble learning, and XAI can enhance transparency and clinical relevance, a high predictive performance is not enough to guarantee the clinical generalizability of AI systems.

A second area of research that is of great importance is the creation of user-friendly and non-invasive AI systems for scenarios where traditional diagnostic methods are cost, subjectively or logistically impractical. Ahmed et al. (2026) explored the feasibility of using lifestyle related variables for predicting dementia and evaluated multiple traditional ML and DL approaches. They employed SHAP to define the contribution of modifiable lifestyle risk factors and balancing and augmentation measures to handle class imbalance. Samieirad et al. (2026) explored the automated diagnosis of trigeminal neuralgia using multidomain EEG features extracted from EEG signals and CNN-attention architecture. They had integrated the temporal, spectral, complexity, statistical, and nonlinear aspects of their analysis to show the feasibility of multidomain physiological representations for automated neurological disorder detection. The authors also pointed out the restrictions stemming from the limited number of true controls and the resulting limitations for generalisability. The body of work highlights a gradual shift from traditional ML toward more complex combinations of DL techniques like attention, multi-modal information, explainability, calibration, and privacy-preserving learning. However, several methodological shortcomings, such as the subject leakage, small sample sizes, dataset dependency, class imbalance, lack of external validation, and high accuracy dependency

continue to be apparent in biomedical AI studies. Future studies should focus on validation and clinical interpretation of AI tools and systems, as well as generalization, and the replicability of these tools and systems, and not just the best performance on one data-set.

3 STATE OF RESEARCH

The flow from technological development to commercialization of products has been the object of increasing research interest, and has been shown to be affected by several organisational, managerial and relational factors. Several studies have explored the barriers to innovation from different points of view, including the availability of resources, technological uncertainty, knowledge of the market, organizational support, cross-functional coordination, and even commercialization skills. A common issue is the discontinuity where ideas are transferred from research-related to development and market-oriented activities. Innovation projects often need other types of knowledge and organisational engagement at this stage compared to other stages of the technological development. The value of communication and co-ordination between research, development, marketing, manufacturing, finance and managerial functions has been emphasized as a result of research. Much of this research, however, approaches these activities as organizational processes or integration mechanisms — it does not delve into the relationships between the people and groups who are doing the specialized roles for innovation.

Another is the lack of a comprehensive consideration of the actors who surmount innovation discontinuities. Product innovation research usually focuses on the identification of the champions, managers, technical specialists, commercial actors, sponsors and decision makers, but they are usually studied individually or in isolation. The method does not offer much insight into how the performance of one role is dependent upon the resources, knowledge, authority or decisions that are connected to another role. The literature thus offers rich knowledge of innovation activities, but much less theoretical insight into the interplay or role interdependence as a facilitator for crossing the Valley of Death. This mismatch implies a need for a conceptual framework that is integrated and that links role-relationships to resource mobilization, knowledge integration, organizational adaptation and commercialization. To fill this gap, the present study takes the role interdependence as the core of the theoretical explanation of the progression of product innovation.

4. SENSITIZING CONCEPT: ROLE INTERDEPENDENCE IN PRODUCT INNOVATION

Role Interdependence is a situation where the effectiveness of the execution of one role is greatly dependent on another role in respect to action, information, resources, decision or cooperation (Schmidt et al., 2022). This is relevant especially in the field of product innovation, as the innovation process is spread across people and organizational units with different types of expertise and authority. Technological solution may be developed by the technical specialists, customer requirements may be interpreted by the market oriented actors, resource allocation may be done by the managers, and mobilization of support may be done by the innovation champions (Sandberg et al., 2020). These contributions are supplemental and not independent. The success of an innovation is not only dependent on the actors' ability to execute their tasks, but also on the proper connection and supporting role of the actors during critical innovation phases (Talat & Riaz, 2020).

Role interdependence is a sensitizing concept that can serve as a conceptual tool to look at relations that are not captured in the normal model of innovation. It's not just about the abilities of actors or the set-up of organizations but about relationships between actors. There are several types of interdependence such as knowledge dependency, resource dependency, authority dependency, coordination dependency, and decision dependency (Jajja et al., 2017). Dependencies can be used to enable innovation, in scenarios where the involved actors share complementary resources and coordinate their roles, but can also cause delays and conflicts, when objectives, priorities or expectations differ (Raveendran et al., 2020). The idea is thus helpful in both identifying enabling and constraining mechanisms at the Valley of Death. The role interdependence perspective does not presume that collaboration automatically leads to successful innovation, but rather explores how roles are interdependent, when their interdependence becomes critical, and how these interdependencies affect the shift from being technologically possible to commercially viable product development (Es-Sajjade & Wilkins, 2017).

4.1 Role Theory

Role Theory offers a basis for understanding a persons behaviour in an organizational context related to expectations on roles and responsibilities. In the context of product innovations, actors in an organization have differentiated roles which include different responsibilities, authority, expertise and expectations. The image of research and engineering people as technological

problem solvers and developers and of marketing people as concerned with customer needs and market opportunities is common (Anglin et al., 2022). In addition to providing organizational authorization and resources, managers may also introduce innovative ideas and request continued support, while champions advocate for innovative ideas. The division of roles provides a separation of responsibilities that enables complex innovation activities to be shared between specialised participants (Caza et al., 2018).

When innovation is considered as a process, involving other processes, the relevance of Role Theory increases further. Conditions created by the performance of one role can enable or constrain the performance of another role. The technical actor might need commercial information before he/she can further develop the product idea, whereas the marketing actor might need technical information before he/she can provide realistic product benefits to customers (Schneider & Bos, 2019). Likewise, a champion might need managerial assistance if they are to secure resources, and managerial decisions to continue might rely on technical and market evaluations. The interdependence of roles then takes shape in the form of mutual expectations and dependencies of organizational actors. These relationships are especially important during the Valley of Death as uncertainty rises, leading to greater need for information, support, and coordinated decision making (Voegtlin et al., 2020). Role Theory therefore provides an understanding for why innovation outcomes can't be explained solely based on individual responsibilities and why relationships between roles are one of important mechanisms in the product development progression (Bullough et al., 2022).

4.2 Resource Dependence Perspective

The emphasis of the Dependence Perspective is that organizations and organizational actors rely on others' resources. They can be in the form of money, skills, data, organizational power, management input, access to markets, machinery, contacts or time. The resources necessary for product innovation generally are not centralized in a single person or functional unit (Coşkun & Öztürk, 2024). Finances and management frequently are needed along with technical knowledge, and sometimes marketing teams need to know what their customers want, but technical teams need to know about the feasibility of the products. Senior managers can make investment decisions, but rely on specialized actors for assessing technological and market uncertainty. These enable the innovation roles to be interdependent (Haveman & Wetts, 2019).

This dependency is compounded in the Valley of Death as innovation projects often need more resources in order to be commercially successful. Therefore, the actors have to bargain for resources as they are demonstrating the potential of the innovation. Role interdependence can serve as a mechanism of mobilizing and blending resources that are dispersed (Oh & Shin, 2026). A champion can bridge the gap between technical knowledge and managerial attention, a sponsor can bridge the gap between strategic priorities and financial resources, and commercial actors can bridge the gap between product development and market information. Resource dependence can also create power imbalances, conflicting priorities and delays when actors who control resources have divergent goals (Roundy & Bayer, 2019). This view suggests that, to cross the Valley successfully, a person or team must have enough resources and the right relationships between actors involved in the innovation process who control, provide, evaluate, and utilise these resources.

4.3 Knowledge Integration Perspective

The Knowledge Integration Perspective sees innovation in the process where specialized knowledge is spread across individual and organizational functions that needs to be integrated to produce useful output. The creation of innovative products typically requires multiple types of knowledge (Faccin et al., 2019). There are four specific types of technological knowledge to consider: feasibility, market, operational and financial and strategic knowledge. These knowledge domains are spread across a variety of actors, and innovation progression relies on enabling mechanisms that enable the transmission and interpretation of knowledge, as well as its combination and application (Swart et al., 2021).

Relevant to this integration is the concept of role interdependence. The roles become interdependent because the one role has knowledge which the other roles need to carry out their roles. Technical experts can need customers' data to adapt the characteristics of products, whilst commercial actors need technical descriptions to build appropriate market propositions (Dean et al., 2022). Managers must have integrated information when determining whether a project should go forward and champions can convert technical possibilities into organizationally meaningful arguments. Knowledge integration is not just about the exchange of information, but also interpretation beyond professional and functional boundaries. Weak interdependence can lead to silo thinking, misunderstandings, knowledge duplication, and wrong choices; strong interdependence can enable the

different kinds of knowledge to be linked to form a more integrated innovation logic. When uncertainty or ambiguity is high, as it is in the Valley of Death, the ability to take the knowledge distributed across different institutions and combine it into a viable development-ready and commercialisable product becomes very important (Stefanelli et al., 2020).

4.4 Dynamic Capability Perspective

Dynamic Capability Perspective focuses on how organisations can adapt to their environment by identifying opportunities, deploying resources and altering capabilities. Product innovation often is done in the context of technology change, uncertainty about customer preferences, competition and changing market needs. Organizations must adapt their knowledge, resources, structures and routines as an innovation develops (Kodama, 2017). Going through the Valley of Death is especially difficult because the needs of an innovation shift as it progresses from the exploration of technology toward product development and commercialization (Nguyen & Le, 2025).

Role interdependence plays a part in this adaptational process by linking actors involved in sensing, mobilization, coordination and innovation resource transformation. Technological possibilities can be discovered by technical specialists, customer and competitive developments can be known by market actors and resources can be redirected by managerial actors following newly detected opportunities and risks (Salvato & Vassolo, 2018). Champions should ensure that the organization remains focused on the issue and sponsors should ensure that the organization is committed to strategically and mobilizes resources. The roles become dynamically interdependent when there are conditions changing and the innovation project needs adjustment in a timely manner (Schoemaker et al., 2018). Thus, crossing the Valley is not simply about maintaining a given set of organizational relationships, it is also about making the transition to a new set. Rather, relationships that will allow for innovation to develop in the face of shifting technological, market and organizational contexts are needed. Therefore, role interdependence can be viewed as a characteristic of the organizational ability to reconfigure knowledge, resources, responsibilities and decision authority as an innovation approaches commercialization (Franco et al., 2021).

5 METHODOLOGY

The present study is a theoretical research approach, exploring the role interdependence as a solution to the valley of death in product innovation. The study is not based on primary survey data, experiments, or simulated empirical data as the aim is to build up and refine a conceptual explanation. Rather, it draws on an integrative theoretical perspective that combines complementary theories of organizational roles, resource dependence, knowledge integration, dynamic capabilities, and product innovation.

The methodology is structured and includes theoretical framing, literature analysis, concept synthesis and proposition development. First, the main phenomenon to be explained, the Valley of Death, is established. Second, the theoretical frameworks are discussed based on their capacity to account for various aspects of the innovation-role relationship. Third, these views are combined to determine the relationships between the roles, resources, knowledge, the need to coordinate, and organizational adaptation. Lastly, theoretically derived propositions are stated to give a coherent explanation and set directions for future empirical studies. This method allows the study to transcend merely descriptive analysis of the barriers to innovation to a theoretical explanation of the way various roles are interdependent in the process of technological development and its transfer to commercialization.

5.1 Theoretical Research Design

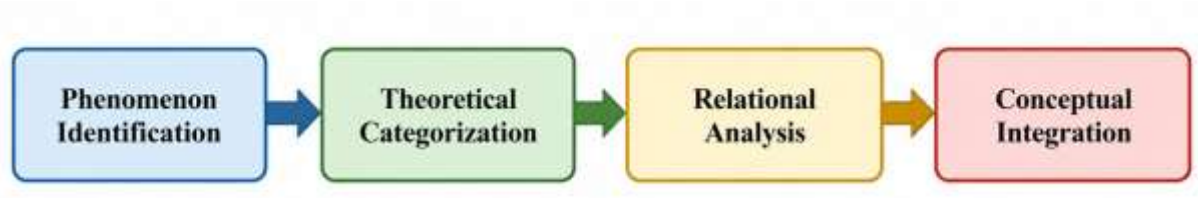
The research design is qualitative, theory-building, and is based on conceptual analysis. The relationship between organizational roles that participate in product innovation and the dependency of activities between them is the unit of theoretical analysis. The design of the innovation project is not a technical artefact, but a process in which actors with varying knowledge, resource, decision-making and responsibility. This allows the study to include the Valley of Death as a relational transition, where the innovation need in the transition from research to development and commercialization becomes different.

Four complementary perspectives (Role Theory, Resource Dependence Perspective, Knowledge Integration Perspective, and Dynamic Capability Perspective) are integrated in the theoretical design. The perspectives all focus on a different aspect of role interdependence. Expectations and mutual dependence between actors are covered by role theory, access and control over critical resources are covered by resource dependence theory, combination of dispersed knowledge is covered by knowledge integration theory, and adaptation and reconfiguration under changing circumstances is covered by dynamic capabilities theory.

The views are not considered as conflicting alternatives to an explanation. Rather, they are situated as complementary lenses of theory that provide complementary understandings of how roles of innovation interact. This design serves as the basis for the building up of a multidimensional conceptual explanation of how organizations cross the Valley of Death.

5.2 Literature Selection and Analytical Procedure

The literature analysis concentrates on scholarly literature in five interrelated themes: the Valley of Death in the product innovation process, the nature of the relationships between organizational roles, organizational resource dependence, integration of knowledge required for product innovation, and dynamic capabilities. Literature is conceptually chosen in terms of relevance to the central research problem, not in an effort to estimate the statistical frequency or effects of variables. Special focus is paid to work that provides explanations of innovation transitions, cross functional relationships, commercialization barriers, organizational resources, specialized knowledge, coordination and adaptive organizational behavior.



The analytical procedure consists of four steps. The literature is first explored to find recurring concepts linked with innovation discontinuities and commercialization. Secondly, these ideas are presented in the order of the theory that allows for their explanation. Third, relationships between concepts are explored, looking for places where concepts complement, overlap and are theoretically fragmented. Lastly, the relationships identified are combined around the main construct of role interdependence. It is thus a phenomenon identification → theoretical categorization → relational analysis → conceptual integration process. This analytical process assists in making sure that the proposition comes out of a clear theoretical rationale, not just from an assumption. It also provides the study with the opportunity to understand the mechanisms by which roles might be both a help and a hindrance to moving across the Valley of Death.

5.3 Conceptual Synthesis

The four theoretical perspectives are synthesized conceptually into a general explanation of role interdependence. The synthesis starts with the idea that product innovation needs the efforts of a number of different actors, who bring resources and capabilities that lie across organizational boundaries. These contributions are linked by the dependencies of knowledge, resources, authority, information, coordination and adaptation. As such, role interdependence is then analyzed as a multidimensional construct and not a mere indication of collaboration or communication between organizational functions.

The synthesis subsequently establishes relationships between the different theoretical dimensions. The roles dictate who does each innovation activity and how the roles are linked together. Resource dependence accounts for the need of actors for support and resources from others. That is why it's essential to share and fuse specialized expertise, which is what knowledge integration is. Dynamic capability theory provides an understanding of how such relationships need to change when the conditions of technology, markets, and organizations shift. All of these views imply that the Valley of Death is a result of some of these interrelated dimensions coming together at a point of discontinuity. Conceptual synthesis then establishes role interdependence as the linking mechanism that allows for the coordination and reconfiguration of distributed knowledge and resources as innovation moves forward. The model produced here offers a theoretical foundation to understanding the mechanisms by which innovation projects progress from technologic possibility to organizational commitment, product development and commercialization.

5.4 Proposition Development

The propositions are deductively derived from the conceptual relationships that have been synthesized in the theory. Every proposition is a theoretically meaningful relationship between role interdependence and some mechanism that relates to crossing the Valley of Death. The development process starts with the identification of conditions in which various roles connected with innovation become interdependent. It then examines the impact of these dependencies on the exchange of

knowledge, mobilisation of resources, coordination, decision making and adaptation of the organization. The propositions are conceptual and they are meant to be followed by empirical investigation, rather than being statistically tested hypotheses.

The proposition-development logic is: role dependency of proposition → exchange of resources and knowledge between the propositions → coordinate the innovation activity of the propositions → reconfiguration and adaptation of the propositions' activity → progression to commercialization of the propositions. In this sequence, the framework will not only help explain why there is interdependence, but how it can affect innovation outcomes. The propositions differentiate productive interdependence from those cases where dependencies lead to coordination problems, conflicting priorities, or delays. As such, role interdependence is viewed as a potentially facilitating mechanism whose influence in turn hinges on the quality and the fit of the relations between the actors of innovation. The resulting propositions are a bridge between the theoretical views presented in the previous sections and the conceptual model in the next analysis. They also draw specific theoretical links that can then be explored in qualitative case studies, surveys, network analysis or longitudinal studies.

6 ANALYSIS

The analysis sees the Valley of Death, not as a single moment in time, but rather as a multidimensional organisational disconnection, created by the misalignment of knowledge, resources, authority, roles and environmental demands. The core analytical principle is that the actors who are responsible for technological innovations become increasingly dependent on actors whose expertise, organizational position and control of resources are different from that of those who are responsible for the initial technological development. Thus, commercialization is a gradual shift in the nature of dependence, and not just the transfer of an innovation between stages of the organizational process. The mechanism for analysing the dependencies is provided through role interdependence.

The effectiveness of interdependence is in the configuration, quality, timing and adaptability of it from this perspective. Interdependence can enable innovation through a sharing of knowledge, a pooling of resources, a coordination of decisions, and an adaptation to uncertainty between complementary roles. But when such interdependence becomes too great or unregulated, it can create power imbalances, role conflict and decision delays, or coordination costs. The analysis then separates out the presence of interdependence from the organizational implications. This distinction is important on a theoretical level, as it would be wrong to assume that better collaboration means better commercialization results.

6.1 Role Interdependence and the Valley of Death

Theoretically, role interdependence is the basic model that explains the Valley of Death. An innovation project which is first initiated within a technical field slowly starts to face requirements that are beyond the scope of knowledge and power of the actors. Commercialization and commercial feasibility, financial justification, strategic fit, regulatory compliance, and organizational legitimacy grow in importance. Every requirement brings into play specific roles that produce complementary, but not identical, contributions. The project thus enters a phase of structural dependency, in which it is necessary for several actors to move together for the project to advance.

The theoretical importance of role interdependence rests on its ability to help understand the reasons why, despite the existence of technically promising ideas, innovation discontinuities remain. Market appeal and technological viability can exist in separate entities for a project. The Valley as a whole is thus an imbalance between the resources needed at a given phase of innovation and the resources held by the actors who currently manage the project. Role interdependence offers the link to enable these mismatches to be addressed. What is important here is not that roles are interdependent, but that the interdependence is complementary, apparent, and controllable enough to allow for transiting through successive innovation thresholds.

6.2 Knowledge Interdependence and Innovation Translation

Knowledge interdependence is an essential element of role interdependence, as knowledge that is relevant to innovation is always distributed. The knowledge of technical specialists includes knowledge about possibilities and limitations of technology, while knowledge of market facing actors includes knowledge about customers, competitors and demand conditions. Manufacturing workers know about the constraints of the process, and managerial actors interpret the strategic, financial and organizational implications. As a result, the knowledge architecture is partial epistemic ownership, meaning that no one has the full knowledge to commercialize.

The mechanism that is critical is thus not knowledge sharing, but knowledge translation. Translation is where the knowledge created within one professional or functional area is transformed into information that can be comprehended and used by another professional or functional area. Technical specifications can have to be translated into value propositions for the customer; customer requirements can have to be translated into engineering specifications; experimental results can have to be translated into investment decisions. The translation is effective if its output is an input into another role's decision process, thus creating a cumulative informational value. In contrast, when translation fails, epistemic fragmentation occurs, i.e., technically correct knowledge is not economically exploitable, or economically relevant knowledge has no impact on technological development. Knowledge interdependence, therefore, serves as a mechanism that connects technological possibility with organizational and market meaning.

6.3 Resource Interdependence and Commercialization

Resource interdependence occurs because the resources required for commercialization are spread out between organizational actors and units. They encompass financial capital, specialized workforce, technological facilities, managerial interest, production capacity, market access, organizational authority, and outside connections. This resource recombination process across the Valley, however, must be a process that brings together resources being controlled by different actors around an emerging innovation opportunity. The innovation project is not just tied into the availability of resources; it relies on the willing and able of resource-controlling actors to make resources available.

This dependency gives rise to an important temporal dimension. Small-scale innovations typically need investment before they can be proven for returns in the end. Champions and technical teams, therefore, need the support of sponsors and senior decision makers, whilst resource providers need technical and commercial evidence that is credible. This yields a mutual dependence instead of a unidirectional resource supply. A positive cycle can occur if there is a commitment to resources, followed by experimentation, followed by evidence, followed by more legitimacy, followed by more resource commitment. But it's possible to have an opposite cycle when using withholding of resources. Nothing helps development when resources are limited, less development leads to less evidence and less evidence leads to a higher commercial risk. Resource dependence is thus a process which can either constrict or expand the Valley.

6.4 Decision Interdependence and Innovation Governance

Decision interdependence is where the results and information needs of an innovation decision are not limited to one person's role. Product innovation is a package of interrelated decisions regarding product technical characteristics, investment, positioning the product in the market, product development priorities, manufacturing arrangements, risk acceptance, and product commercialization timing. Not all of these decisions are independent to optimize because changes in one domain can have repercussions in another. A technological change may change the cost, and a commercial change, may take a significant technological modification.

Distributed decision coordination, rather than universal participation, is thus needed to govern innovation. The theoretical question is who has the responsibility to decide, who must supply information and who must be responsible for implementation. Good governance links decision making to appropriate expertise and has adequate organizational velocity. In the case of inadequate decision interdependence, escalation delays, repeated approvals, responsibility diffusion, and functional objective conflicts can occur. Interdependent decision making and collective decision making are the key analytical differences. Interdependence does not mean that there is equal decision authority for all actors. Rather, it calls for the linkage of differentiated authority via proper information and accountability mechanisms.

6.5 Role Clarity and Coordination

Clarity of the role is a contributing factor in the transformation of interdependence to coordinated action. The more an actor knows about their responsibilities, boundaries, authority, and what to expect from the other roles and their dependence on these actors, the more predictable interdependence is. Ambiguity over responsibility, on the other hand, can turn required interdependence into a coordination problem. Actors can duplicate activities, shirk responsibility, fight for authority and believe someone else will solve a developing problem. In the Valley of Death where the odds are already low, this uncertainty can further complicate the prospects of a project getting started.

Clarity of role, however, does not mean a "specialization". Responsibility has to be shared between actors in an innovation environment, which is changing due to technological and market developments. Over-constrained roles can result in boundary rigidity and which inhibits the re-combination of knowledge needed by new challenges. The construct of interest in theory is adaptive role clarity, which requires a sufficiently clear understanding of role expectations to create accountability, while also allowing for role adjustment. Role clarity that is adaptive can help eliminate some of the costs of coordinating while empowering actors who are interdependent to react to shifting innovation needs. This indicates that coordination is the result of an interdependence between differentiation and integration, not of full specialization or complete synergy.

6.6 Technological Uncertainty and Role Interdependence

Technological uncertainty affects the content and form of role interdependence. In situations where the performance, scalability, reliability or feasibility of an innovation is not known, actors have to make decisions under conditions of uncertainty. Technical specialists need more contact with commercial and managerial actors due to financial and market implications of technological alternatives. Meanwhile, managers and commercial actors rely increasingly on technical interpretations to determine the feasibility of an innovation to meet market needs. Thus, uncertainty raises the informational interdependence of roles.

However, there's also a paradox when it comes to uncertainty. The more uncertain, the more needed and the more difficult the integration. There may be multiple interpretations of incomplete evidence by actors and disagreements may be escalated as some functions utilize one set of criteria for evaluation and other functions utilize another. The uncertainty- role interdependence linkage can therefore not be interpreted as a simple link of a positive nature. But rather than uncertainty altering the coordination needs of innovation, coordination needs are altered.Rather, coordination needs are altered by uncertainty. Under uncertainty, communication, feedback, experimentation and the ability to change assumptions in an iterative manner are necessary for effective interdependence. Technological uncertainty, then, is a contingency condition that affects greatly the progression of innovation, in terms of when, how and how much role interdependence plays.

6.7 Market Turbulence and Commercialization

The changes in the markets add even more external variability to the already complex and interdependent innovation system. A number of things can happen in the process of developing an innovation before it reaches the market: customer preferences, competitor strategies, technology options, regulatory requirements, and market structures may change. Therefore, the initial product concept set up may no longer be applicable when the product goes to market. This can generate a need for on-going communication between external market sensing and internal product development. Market-facing roles, in particular, need to be able to convey emerging signals, whereas technical and operational roles need to figure out if and how such signals can be factored in.

The main theoretical question is thus: adaptive translation. Market information that is not translated into product design, positioning, resource allocation, or commercialization strategy is of little value. But this may cause instability too if it is constantly responsive. Too much modification can result in scope bloat, distributed resources, development delays, and lack of strategic direction. This role interdependence must therefore allow for selective responsiveness and not be unlimited. This implies that the impact of the quality of inter-role coordination is significant when conditions are particularly turbulent in the market. Commercialization calls for an organizational structure that can take in the necessary environmental inputs and have enough stability to carry out development.

6.8 The Dark Side of Role Interdependence

Role interdependence has an inherent duality in itself. The very same factors that allow companies to pool specialized expertise and resources can also lead to vulnerabilities. If a few individuals are critical to the success of a project, then if one of them is delayed, absent, disagrees or withdraws, then many additional activities down the project may be impacted. While interdependence can lead to coordination overload, actors may also find themselves running into it as they try to keep in touch as the networks become more complex. In addition, the actors controlling critical resources or pieces of information might also gain excessive control over innovation decisions, giving rise to power imbalance in the process of innovation.

The other facet of the dark side is over-integration. Too many actors can slow down decision-making, make consensus-seeking more likely and lead to multiple, competing functional priorities. These issues can be exacerbated by role ambiguity in the case of actors who are very involved and have no clear accountability. The theoretical implication is that role interdependence may not be considered as per se beneficial. It is dependent on the continuation of complementary and reciprocal interdependencies, boundedness, and governability. Productive interdependence is an interdependence relationship between actors that does not remove role differentiation, while dysfunctional interdependence relationship gives rise to dependency but not to effective coordination. This distinction reinforces the theoretical model because it acknowledges that the goal is not to achieve maximal interdependence, but rather to have the appropriate level of interdependence as it pertains to innovation needs.

6.9 The Role-Interdependence-to-Commercialization Framework

The above analysis allows a role-interdependence-to-commercialization framework to be developed, which sees commercialisation as a consequence of the combination of differentiated roles, interdependent resources, distributed knowledge, coordinated decisions and adaptive responses. The framework starts with the role differentiation and moves on through a series of interconnected elements, including knowledge interdependence, resource interdependence, and decision interdependence. Adaptive role clarity is the mechanisms that supports these, and it sets accountability parameters while allowing for flexibility. The intensity and configuration of these relationships change in response to technological uncertainty and market turbulence as contextual conditions.

The framework can therefore be represented conceptually as:

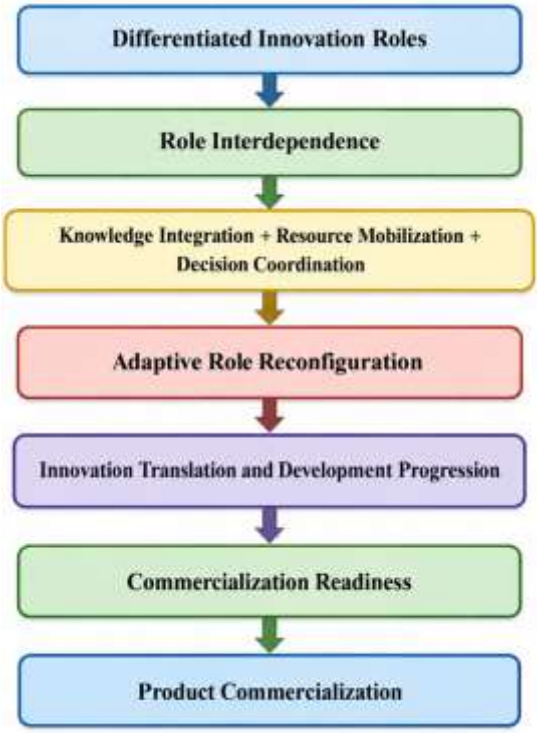


Figure 1. Role-Interdependence-to-Commercialization Framework for Surmounting the Valley of Death in Product Innovation

This is a recursive (non-linear) relationship. Technological needs can change due to commercial feedback, resource needs can change as a result of technological developments, role responsibilities can change as a result of resources, and market changes can cause new decision dependencies. The framework also highlights the potential for interdependence to be dysfunctional, with ambiguity, power imbalance, coordination overload and dependency preventing progress. The theoretical contribution is thus not to define commercialization as a necessary result of a technological quality or just a matter of resources, but to make commercialization a possible result of the role relationships which are dynamically configured. This creates a foundation for developing the propositions and subsequent empirical testing of conditions for role interdependence to ease or impede the crossing of the Valley of Death.

CONCLUSION

In this paper, the Valley of Death in the process of product innovation has been explored from the perspective of the theory of role interdependence, which suggests that the transition from technology invention to commercialisation is essentially a relational and organizational process. Innovation failure is not simply a product of technological failure or lack of resources and is not solely due to the failure of individual actors to possess the right knowledge, resources, authority and responsibility; instead, the analysis demonstrates that commercialization is a process that relies on the coordinated action of actors who have different knowledge, resources, authority and responsibility. These relationships can be explained in a multidimensional manner using the four perspectives: Role Theory, the Resource Dependence Perspective, the Knowledge Integration Perspective and the Dynamic Capability Perspective. The analysis reveals three major mechanisms mentioned, namely knowledge interdependence, resource interdependence and decision interdependence, that link differentiated innovation roles to commercialization progression. The level of role clarity helps to facilitate coordination, and technological uncertainty and market turbulence help determine the intensity and structure of the interdependencies. The study is also cognizant of the negative aspects of interdependence, such as coordination overload, role ambiguity, power asymmetry, dependency concentration, and delays in decision making. It is not necessary to have the highest level of interdependence in order to be successful in innovation, in fact, the level of interdependence depends on how the pattern is configured, how it adapts, and how it is governed. The proposed "Role-Interdependence-to-Commercialization" Framework provides a theoretical account of how organizations cope with innovation discontinuities. It frames the commercialization process as a recursive one of transferring knowledge, reconfiguring resources, coordinating decision-making, and reconfiguring roles; it offers a platform for further empirical investigation in different organizational and technological environments.

REFERENCE

[1] Abbadi, M. (2026). Comparative Evaluation of Deep Learning-Based and WHO-Informed Approaches for Sperm Morphology Assessment. *arXiv preprint arXiv:2601.10070*.

[2] Ahammad, I. (2026). Generalization over accuracy: A cross-dataset, explainable, and federated learning framework for Parkinson's disease detection. *Digital Health*, *12*, 20552076261467837.

[3] Ahmed, M. K., Rahman, A., Kundu, D., Alam, M. A. A., Ovi, M. U. S., Mahir, S. H., ... & Mansor, S. (2026). An explainable framework for dementia risk prediction based on lifestyle data using machine learning and deep learning. *Discover Artificial Intelligence*, *6*(1), 581.

[4] Al Natsheh, A., Gbadegeshin, S. A., Ghafel, K., Mohammed, O., Koskela, A., Rimpiläinen, A., ... & Kuoppala, A. (2021). The causes of valley of death: a literature review. *INTED2021 Proceedings*, 9289-9298.

[5] An, Y., & Zhang, Y. (2021). Crossing the valley of death for SMEs: Management practices from China. *Sage Open*, *11*(3), 21582440211047581.

[6] Anglin, A. H., Kincaid, P. A., Short, J. C., & Allen, D. G. (2022). Role theory perspectives: Past, present, and future applications of role theories in management research. *Journal of management*, *48*(6), 1469-1502.

[7] Ardito, L., Natalicchio, A., Messeni Petruzzelli, A., & Del Giudice, M. (2024). Converting inventions into innovations to address cancer grand challenges: The role of scientific and digital search intensity. *Journal of Product Innovation Management*, *41*(2), 267-292.

[8] Assom, L., Larsson, A., & Chiolerio, A. (2026). Tracing Innovation Pathways. *Inventions*, *11*(1), 19.

[9] Belz, A., Terrile, R. J., Zapatero, F., Kawas, M., & Giga, A. (2019). Mapping the "valley of death": Managing selection and technology advancement in NASA's Small Business Innovation Research program. *IEEE Transactions on Engineering Management*, *68*(5), 1476-1485.

[10] Bullough, A., Guelich, U., Manolova, T. S., & Schjoedt, L. (2022). Women's entrepreneurship and culture: gender role expectations and identities, societal culture, and the entrepreneurial environment: A. Bullough et al. *Small business economics*, *58*(2), 985-996.
[11] Caza, B. B., Vough, H., & Puranik, H. (2018). Identity work in organizations and occupations: Definitions, theories, and pathways forward. *Journal of organizational behavior*, *39*(7), 889-910.
[12] Chen, S. H., & Lin, W. T. (2017). The dynamic role of universities in developing an emerging sector: a case study of the biotechnology sector. *Technological forecasting and social change*, *123*, 283-297.
[13] Coşkun, R., & Öztürk, O. (2024). Dependence as strategy: extending resource dependence theory and clarifying its understanding of the strategic options of dependent firms. *International Journal of Organizational Analysis*, *32*(9), 1982-2009.
[14] Dean, T., Zhang, H., & Xiao, Y. (2022). The role of complexity in the Valley of Death and radical innovation performance. *Technovation*, *109*, 102160.
[15] Edwards-Schachter, M. (2018). The nature and variety of innovation. *International Journal of Innovation Studies*, *2*(2), 65-79.
[16] Ellwood, P., Williams, C., & Egan, J. (2022). Crossing the valley of death: Five underlying innovation processes. *Technovation*, *109*, 102162.
[17] Es-Sajjade, A., & Wilkins, T. (2017). Design, perception and behavior in the innovation era: Revisiting the concept of interdependence. *Journal of Organization Design*, *6*(1), 12.
[18] Faccin, K., Balestrin, A., Volkmer Martins, B., & Bitencourt, C. C. (2019). Knowledge-based dynamic capabilities: a joint R&D project in the French semiconductor industry. *Journal of Knowledge Management*, *23*(3), 439-465.
[19] Fang, S., & Qin, Y. (2025). Social identification in open innovation projects: Role of knowledge collaboration and resource interdependence. *Systems*, *13*(2), 129.
[20] Franco, M., Minatogawa, V., Durán, O., Batocchio, A., & Quadros, R. (2021). Opening the dynamic capability black box: An approach to business model innovation management in the digital era. *Ieee access*, *9*, 69189-69209.
[21] Gatto, F., & Re, I. (2021). Circular bioeconomy business models to overcome the valley of death. A systematic statistical analysis of studies and projects in emerging bio-based technologies and trends linked to the SME instrument support. *Sustainability*, *13*(4), 1899.
[22] Gbadegeshin, S. A., Al Natsheh, A., Ghafel, K., Mohammed, O., Koskela, A., Rimpiläinen, A., ... & Kuoppala, A. (2021). Collated Summary of Articles on the Valley of Death. *Published on*, *9*, 2-2.
[23] Hadaya, B. (2026). From research to business: Addressing commercialisation bottlenecks in Espoo's deep tech ecosystem.
[24] Haveman, H. A., & Wetts, R. (2019). Contemporary organizational theory: The demographic, relational, and cultural perspectives. *Sociology Compass*, *13*(3), e12664.
[25] Helman, L. (2023). Innovation funding and the valley of death. *SMU L. Rev.*, *76*, 263.
[26] Hoq, M. E., Tarbox, L., Johann Jr, D., Larson-Prior, L., & Prior, F. (2025). Harnessing native-resolution 2D embeddings for lung cancer classification: A feasibility study with the RAD-DINO self-supervised foundation model. *Journal of Imaging Informatics in Medicine*, 1-23.
[27] In, S. Y., Monk, A. H., & Knox-Hayes, J. (2020). Financing energy innovation: The need for new intermediaries in clean energy. *Sustainability*, *12*(24), 10440.
[28] Islam, N. (2017). Crossing the valley of death—An integrated framework and a value chain for emerging technologies. *IEEE Transactions on Engineering Management*, *64*(3), 389-399.
[29] Jajja, M. S. S., Kannan, V. R., Brah, S. A., & Hassan, S. Z. (2017). Linkages between firm innovation strategy, suppliers, product innovation, and business performance: Insights from resource dependence theory. *International Journal of Operations & Production Management*, *37*(8), 1054-1075.
[30] Kaya, E., Şirzai, H., Yavuzer, G., & Argunsah, H. (2025). Classification of knee osteoarthritis severity using markerless motion capture and long short-term memory fully convolutional network. *Computers in Biology and Medicine*, *195*, 110647.
[31] Kennedy, S., Whiteman, G., & van den Ende, J. (2017). Radical innovation for sustainability: The power of strategy and open innovation. *Long range planning*, *50*(6), 712-725.
[32] Klitsie, J. B., Price, R. A., & De Lille, C. S. H. (2019). Overcoming the valley of death: A design innovation perspective. *Design Management Journal*, *14*(1), 28-41.
[33] Koch, M. (2017). *Crossing the Valley of Death: exploring commercialization of food startups in Switzerland* (Doctoral dissertation, ZURICH UNIVERSITY OF APPLIED SCIENCE).

[34] Kodama, M. (2017). Developing strategic innovation in large corporations—The dynamic capability view of the firm. *Knowledge and Process Management*, *24*(4), 221-246.
[35] Kwun, S., Sohn, Y., & Park, J. (2024). Study on the Role of Innovation Intermediaries in Open Innovation: From the Perspective of Resource Dependence Theory and Core Competency Theory. *Asian Journal of Innovation & Policy*, *13*(3), 277.
[36] Lee, K., & Yoo, J. (2019). How does open innovation lead competitive advantage? A dynamic capability view perspective. *PloS one*, *14*(11), e0223405.
[37] Liu, J., Wang, S., & Zhang, F. (2025). From Innovation to Application: The Role of Government Venture Capital in Technology Commercialization.
[38] Mittelmeijer, H. G., Romme, A. G. L., Dolmans, S. A. M., Bell, J. H. J., & Frericks, G. (2020). *Vertical: an innovative financial mechanism to bridge the Valley of Death* (Doctoral dissertation, MSc thesis, Eindhoven University of Technology. https://pure. tue. nl/admin/files/16342 9722/Master_ Thesis_ Hessel_ Mitte lmeij er. pdf).
[39] Muhammad, A., Jin, Q., Musaddiq, M. H., Mir, M. S., Alkanan, M., & Gulzar, Y. (2025). Explainable AI for brain tumor classification using cross-gated multi-path attention fusion and gate-consistency loss. *IEEE Access*, *13*, 192731-192746.
[40] Nguyen, T. N. L., & Le, S. T. (2025). Factors leading to the digital transformation dead zone in shipping SMEs: A dynamic capability theory perspective. *Sustainability*, *17*(12), 5553.
[41] Oh, C. H., & Shin, J. (2026). Clash of the titans: conflict intensity, community dependence on environmental resources, and stakeholder multiplicity. *Journal of Management Studies*, *63*(6), 3249-3277.
[42] Pérez-Luño, A., Bojica, A. M., & Golapakrishnan, S. (2019). When more is less: The role of cross-functional integration, knowledge complexity and product innovation in firm performance. *International Journal of Operations & Production Management*, *39*(1), 94-115.
[43] Raveendran, M., Silvestri, L., & Gulati, R. (2020). The role of interdependence in the micro-foundations of organization design: task, goal, and knowledge interdependence. *Academy of Management Annals*, *14*(2), 828-868.
[44] Reddy, G. P., Javali, P. D., Raghavendra, S., Chandrakala, C. B., & Venugopala, P. S. (2026). A Hybrid Deep Learning Approach with Explainable AI for Diabetic Retinopathy Classification. *IEEE Access*.
[45] Romme, A. G. L., Bell, J., & Frericks, G. (2023). Designing a deep-tech venture builder to address grand challenges and overcome the valley of death. *Journal of Organization Design*, *12*(4), 217-237.
[46] Roundy, P. T., & Bayer, M. A. (2019). To bridge or buffer? A resource dependence theory of nascent entrepreneurial ecosystems. *Journal of Entrepreneurship in Emerging Economies*, *11*(4), 550-575.
[47] Salvato, C., & Vassolo, R. (2018). The sources of dynamism in dynamic capabilities. *Strategic management journal*, *39*(6), 1728-1752.
[48] Samieirad, S., Boroujeni, S. R., Rokhva, S., Behtaji, S., Anousheh, M., Amiri, S. R., & Najafzadeh, H. (2026). Automated detection of trigeminal neuralgia using multi-domain EEG feature analysis and CNN-attention architecture: a comparative machine learning study. *Scientific Reports*.
[49] Sandberg, J., Holmström, J., & Lyytinen, K. (2020). Digitization and phase transitions in platform organizing logics: Evidence from the process automation industry. *MIS quarterly*, *44*(1), 129-154.
[50] Sankoh, A. P., Raza, A., Parwez, K., Shishah, W., Alharbi, A., Javed, M., & Bilal, M. (2026). Automated Facial Pain Assessment Using Dual-Attention CNN with Clinically Calibrated High-Reliability and Reproducibility Framework. *Biomimetics*, *11*(1), 51.
[51] Santos, A. D. C. P. (2025). *Predictive Modeling of Alzheimer's Disease Using Combined MRI Data* (Master's thesis, Universidade NOVA de Lisboa (Portugal)).
[52] Schmidt, C. G., Yan, T., Wagner, S. M., & Lucianetti, L. (2022). Performance implications of knowledge inputs in inter-organisational new product development projects: the moderating roles of technology interdependence. *International Journal of Production Research*, *60*(20), 6048-6071.
[53] Schneider, M. C., & Bos, A. L. (2019). The application of social role theory to the study of gender in politics. *Political psychology*, *40*, 173-213.
[54] Schoemaker, P. J., Heaton, S., & Teece, D. (2018). Innovation, dynamic capabilities, and leadership. *California management review*, *61*(1), 15-42.
[55] Seyhan, A. A. (2019). Lost in translation: the valley of death across preclinical and clinical divide–identification of problems and overcoming obstacles. *Translational Medicine Communications*, *4*(1), 18.

[56] Seyhan, A. A. (2019). Lost in translation: the valley of death across preclinical and clinical divide–identification of problems and overcoming obstacles. *Translational Medicine Communications*, *4*(1), 18.
[57] Stefanelli, V., Boscia, V., & Toma, P. (2020). Does knowledge translation drive spin-offs away from the "valley of death"? A nonparametric analysis to support a banking perspective. *Management Decision*, *58*(9), 1985-2009.
[58] Swart, R., Celliers, L., Collard, M., Prats, A. G., Huang-Lachmann, J. T., Sempere, F. L., ... & Timmermans, W. (2021). Reframing climate services to support municipal and regional planning. *Climate Services*, *22*, 100227.
[59] Talat, A., & Riaz, Z. (2020). An integrated model of team resilience: exploring the roles of team sensemaking, team bricolage and task interdependence. *Personnel Review*, *49*(9), 2007-2033.
[60] Tokdar, A., Agarwal, L., Chatterjee, S., & Sukriti. (2026). A deep hybrid CNN-BiLSTM-BiGRU architecture with explainability for mild cognitive impairment detection using EEG. *Brain Informatics*.
[61] Voegtlin, C., Frisch, C., Walther, A., & Schwab, P. (2020). Theoretical Development and Empirical Examination of a Three-Roles Model of Responsible Leadership: C. Voegtlin et al. *Journal of Business Ethics*, *167*(3), 411-431.
[62] Yu, C., Zhang, Z., Lin, C., & Wu, Y. J. (2017). Knowledge creation process and sustainable competitive advantage: The role of technological innovation capabilities. *Sustainability*, *9*(12), 2280.