A Framework for Accelerating Innovation through Innovation Webs

Oliver Schwabe*[1], Lynne Schneider[2], Nuno Marques de Almeida[3] and Ana Filipa Salvado[4]

[1] Cranfield University, School of Aerospace, Transport and Manufacturing, United Kingdom
[2] Entovation International, USA
[3] Instituto Superior Técnico, Civil Engineering Architecture and Georesources, Portugal
[4] Laboratório Nacional de Engenharia Civil, Portugal
*corresponding author: o.schwabe@cranfield.ac.uk

Abstract
Any efforts to accelerate innovation from ideation through market saturation depend on understanding the systemic behavior occurring within and throughout this process. "Systemic" is hereby understood to describe the holistic interactions of participants assuming roles and exchanging (in-) tangible deliverables from a living systems perspective based on the axiom that innovation is a social phenomenon which can only be served and not managed. Based upon previous research at individual, group, region, nation state, federation and global levels, this paper introduces a framework of systemic variables most critical for influencing the speed of value creation for ideas traveling across the diffusion of innovation curve. These variables are derived from a series of collaboration patterns portrayed as "innovation webs" that describe the dynamics found within the innovation stages of ideation, research, socialization, market validation and commercialization. The paper delivers actionable insights enabling the acceleration of innovation in industries such as construction and provides recommendations for future action-research to mature the dependency model suggested of variables affecting the speed of innovation.

Keywords: accelerated innovation, innovation webs, innovation metrics, construction industry, innovation policy.

1 Introduction

In practice the capability to innovate is stifled by industrial paradigms which suffer from stifling policies, a perma-frost of bureaucracy, an overemphasis of technical solutions and lack of trustful social collaboration (Edvinsson , 2002. Amidon, 2003. Sveiby, 2012. Formica, 2018). Furthermore the concept of innovation itself is often reduced to that of technical readiness levels only (Laursen and Salter, 2006. Héder, 2017) versus the extended diffusion to market saturation which characterizes the value an innovation can create and which is its purpose (Rogers, 1962. Mehmood et al., 2016). The authors present a framework for making the diffusion of innovation pro-

cess more transparent and the speed of its value creation measurable based on the concept of "innovation webs" that reflect the social living systems "inside" of the formal structures of innovation (Mercier-Laurent, 2015).

Section 2 introduces the research method and Section 3 discusses the results of an exemplary application to the context of the construction industry. Section 4 concludes the paper with a focus on how actionable insights might be derived to accelerate innovation in the construction industry and recommendations for future research.

2 Innovation Webs and Variables affecting their Speed

The concept of innovation relates to the rise of an idea, the research and early application of that idea in various forms, the socialization of the idea to a wider community which leads to a market validation phase followed by a commercialization phase which (ideally) ends with market saturation (Rogers, 1962). All of these stages exhibit archetypal patterns of exchanges of generic (in-) tangible deliverables between generic roles, the aggregation of which are termed "innovation webs". Innovation webs are specific forms of Value Networks (Allee and Schwabe, 2015). The archetypes of innovation webs an idea diffuses through are listed in Table 1.

Table 1. Innovation web archetypes

Innovation web archetypes	Description
Research	Focused on research and innovation exploration.
Socialization	Evolves out of the research web archetype as the innovation crystalizes and begins reaching early stage practitioners / evangelists in organizations. The research web archetype continues to "operate".
Market Validation	Evolves when the product or the result evolving from the socialization web is clear, and the goal of the network is to test and validate market or beneficiary readiness. The research web and the socialization archetypes continue to "operate".
Commercialization	Brings the product or result to the market and (ideally) market saturation through production and distribution. The research, socialization, and market validation web archetypes continue to "operate". The commercialization web archetype represents a nested system of innovation webs best understood as a living / complex adaptive system.

Value network discovery and facilitation is based on principles of systemic and inductive inquiry which accepts the messiness of "living systems". The underlying philosophy has its roots in Exchange Theory (Homans, 1958). It is a social, psychological and sociological perspective that explains social change and stability as a process of negotiated exchanges between parties. This approach departs from mainstream ex-

change theory by linking the network to both financial and non-financial performance and asset generation for the overall network and at the level of individual roles and both tangible and intangible transactions. Research has continuously demonstrated that value networks can be effectively used to understand the true nature of collaboration (ERAnets , 2004. CESPRI, 2005. Allee et al., 2007. Allee and Schwabe, 2015. Yang and Li, 2019). Key roles in innovation web archetypes are listed in Table 2.

Table 2. Key roles in innovation web archetypes.

Innovation web roles	Description
Buyer(s)	Interested in achieving the value proposition expected by the Funder.
Commercializer(s)	Interested in putting the required commercial and legal agreements in place along with ensuring their compliant operation.
Funder(s)	Interested in defining the value proposition of the investment.
Innovator(s)	The originator of the "idea".
Marketeer(s)	Interested in creating a "coalition of the willing" with relevant self-organizational behavior along a shared purpose.
Product Packager(s)	Converts the "idea" into a product for the User.
User(s)	Applies the "idea" to a challenge in order to achieve the value proposition.
Web Weaver(s)	Serves the (overall) web in order to help achieve the shared purpose.

The research webs each form a unique pattern of roles and interactions. More detailed descriptions of each of the archetypes then reveal exact sequences of (in-) tangible deliverables being exchanged within and between the participants assuming the roles. Each transaction hereby generates a specific pattern of value in the form of structural, relational and competence assets plus financial capital. Typically each tangible transaction is enabled by parallel intangible transactions and triggers a response once a certain threshold value is created (which may result in times delays as value accrues towards relevant threshold levels).

Figure 1 illustrates a high level architecture of the innovation web archetypes and their interdependence. Key webs and roles are shown in the circular shapes and (in-) tangible value is transacted through deliverables between roles and webs across the open green & blue dotted boundaries of such. Important to note is that no single web on its own covers the complete diffusion of innovation process from ideation through market saturation – this is achieved by all acting in harmony. Ideation is an unmapped web-form giving rise to the research web which will transition to the socialization web upon achieving a specific set of threshold values, the socialization web transitions to the market validation web upon reaching its own specific set of threshold values, and the commercialization web is the aggregation of the three webs acting as nested complex adaptive systems in a harmonic balance. It is then the commercialization web that carries the idea through the diffusion of innovation curve.

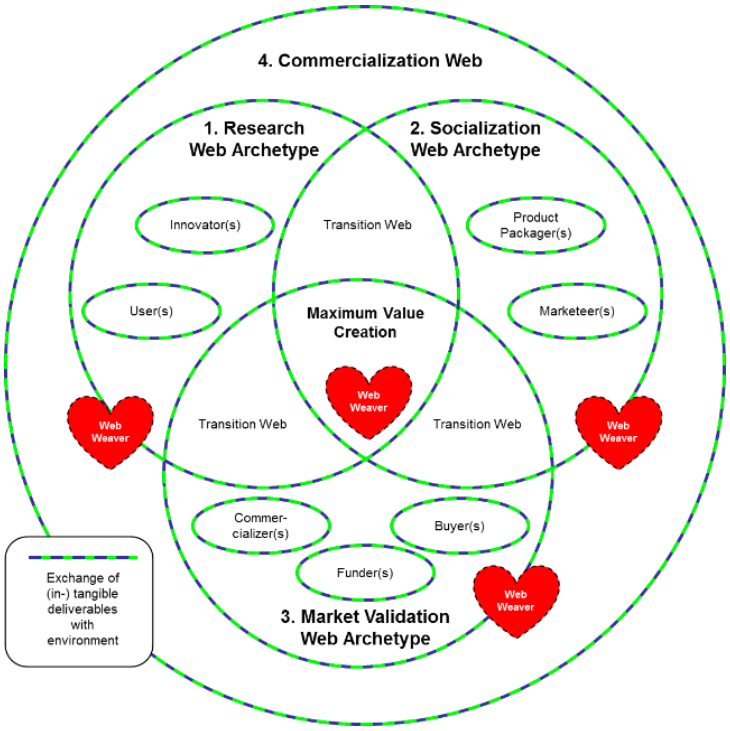

Fig. 1. Innovation web architecture (triggering ideation web not shown)

From the innovation web perspective the independent systemic variables influencing the speed of value creation from ideation to market saturation are derived from a blend of principles stemming from Value Network Analysis (Allee, 2008), Process Analysis (Quinlan et al., 2019), Social & Organizational Network Analysis (Cross and Parker, 2004) and Complex Adaptive Systems (Miller and Page, 2007).

These variables can then be used to assess the factors influencing the speed of innovation in a context such as the construction industry. It is argued that the future of the construction industry will be shaped by concepts such as those of servitisation (i.e. not only the short-term construction of long-lasting assets but also managing the different aspects of their entire life cycle) and the incorporation of technological developments from other industries (e.g. drones, 3D printing, smart devices, virtual reality). But the construction industry involves multiple stakeholders with different motivations and exchanges throughout the whole extended life cycle of its products. Introducing change into this complex multi-system context can create a ripple effect of secondary and tertiary impacts, which can be difficult to anticipate using current construction management theory and techniques (Slaughter, 2000). In the construction industry the traditional drivers for innovation include the augmented end-user requirements transposed through both regulatory and non-regulatory environments (Almeida et al., 2015). The five key variables affecting the speed with which these traditional drivers are transposed include: Safety, Serviceability, Durability, Energy

Consumption, and Sustainability (Almeida et al., 2015). These factors are however product focused and can thus only serve as a starting point for a deeper exploration.

The key variables influencing the speed of value creation are listed in Table 3.

Table 3. Variables influencing the speed of value creation.

Variable	Description
Resilience (Quantitative)	The ability to return to an archetype after an incident
Reciprocity (Quantitative)	The extent of "return" transactions between roles.
Agility (Quantitative)	The ability to adapt to changing external conditions.
Structural Integrity (Quantitative)	The number of alternate paths for value creation.
Structural Dependency (Quantitative)	The intensity / density of exchanges.
Complexity (Quantitative)	The number of relationships between roles.
Emergence (Quantitative)	The probability of unexpected self-organization.
Maturity (Quantitative)	The average length of relationships of participants.
Perceived Value (Qualitative)	The benefits participants attribute to deliverables.
Value Creation (Qualitative)	The intellectual and financial capital created by roles.
Value Consumption (Qualitative)	The intellectual / financial capital consumed by roles.
Cost Benefit (Qualitative)	The delta between value creation and consumption.
Sequence (Qualitative)	The speed of transfer for deliverables.

A high level assessment of the five key construction specific variables against the variables influencing the speed of value creation listed in Table 3 was conducted through a literature review, a small number of semi-structured interviews and a qualitative assessment of the degree to which the innovation web currently underlying the industry (de-) celerates the industry specific speed variable. For example the construction industry specific speed variable of "safety" (assuming "the safer the faster") is hindered by the low "resilience" of the industry innovation web in the case of a major safety incident since it takes a long time for new standards to emerge and diffuse that permit the innovation speed to return to normal.

The result of an initial assessment of these factors against the variables was visualized as a dependency model in the form of a radial polar force field (Schwabe, 2018). The radial polar force field is a probability field represented as a vector space where all vectors originate at the same point and are radially arranged with a constant degree of separation. All vectors are added head to tail in order to create an aggregated vector. If data from a specific time period is used then that time period is termed a "state space" in contrast to a "dynamic space" which could be considered to describe the change over time between two state spaces. Figure 2 visualizes the data in the above table using exemplary data from the construction industry (Almeida et al., 2015; Murphy et al., 2015; Hasan et al., 2018).

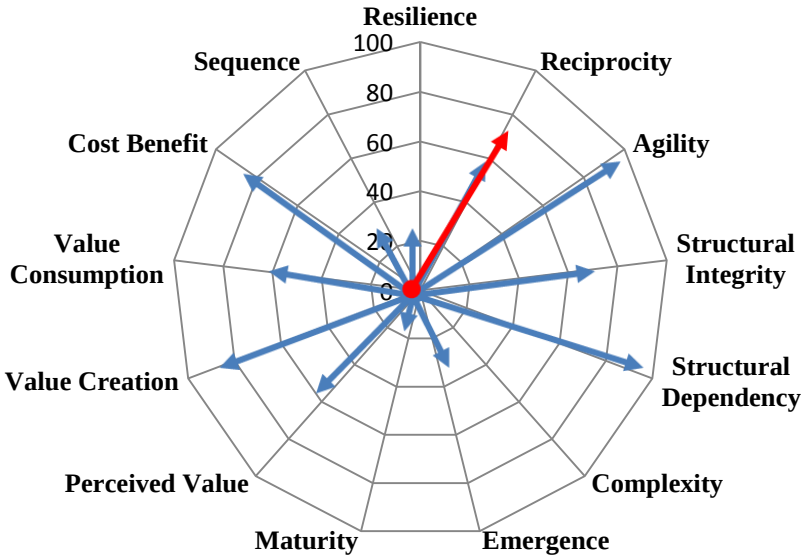

Fig. 2. Exemplary radial polar force field.

The key metrics for interpreting the radial polar force field are (a) overall symmetry as an indicator of speed of value creation (b) the aggregated vector magnitude as a pointer to the probability of emergence and (c) its radial angle suggesting the potential source of that emergence. The indicator of symmetry describes the degree to which a shape is invariant to being transformed across a reference point. The higher the symmetry score the closer the space enclosed by the perimeter of the vector space is to the maximum space it could enclose (therefore if all side lengths / vector magnitudes were the same). The larger that space, the greater the information entropy and the faster the diffusion of information can be assumed to be (Thims, 2012). The faster the diffusion of information the faster value creation can occur (Sveiby, 2001). The larger the magnitude of the aggregated vector magnitude the more likely the vector space will exhibit emergent behavior. The further along the innovation web evolution process an idea moves to the lower the impact of emergence is desired. The angle of the aggregated vector magnitude points to the variable which potentially has the highest sensitivity to emergent changes. Each metric has an uncertainty range associated with it based on the highest and lowest values generated when considering all permutations of the radial sequence for the variables.

3 Framework Application

Using an example from the construction industry the presented framework provides a high level assessment of the capability of an existing innovation web evolution pro-

cess to rapidly nurture an idea across the diffusion of innovation curve to market saturation. The framework then provides indications of relevant actions to increase that speed in that it is primarily the symmetry of the innovation web which should be increased in order to increase the probability of purposeful emergent behavior. Symmetry will increase as the value of the independent component variables becomes more equal while the underlying dependency model (which is currently the focus of research) will describe its propagation over time. Actions to balance out the scoring of the variables can be derived through the facilitation of relevant innovation web archetypes through the population of roles and the creation / hardening of their relevant (in-) tangible exchanges.

4 Concluding Remarks

This paper introduced a framework of systemic variables most critical for influencing the speed of value creation for ideas traveling across the diffusion of innovation curve. The concept of "innovation webs", their acceleration variables and a relevant dependency model were introduced and exemplified to describe the underlying collaboration patterns that describe the dynamics found within the innovation stages of ideation, research, socialization, market validation and commercialization.

The authors recommend continuing the ongoing action-research to mature the polar force field based dependency model presented. Especially the innate capability of the model to simulate and forecast future developments and scenarios with (-out) management interventions is considered to harbor the potential not only to accelerate the progress of individual ideas through the diffusion of innovation life cycle, but also to provide robust guidance to improving the ability of innovation policy to accelerate the value creation at individual, group, region, nation state, federation and global levels.

Acknowledgements

The authors wish to thank the members of the Open European Network for ENTerprise InnOVation in High Value Manufacturing (ENTOV-HVM) for its continued feedback and support.

References

1. Allee V., Innocenti, A., Koumpis, S., Mavridis, A., Molinari, F., Pasher, E., Shachar, S., Schwabe, O., Tektonidis, D., Tresman, M, Vontas, A. (2007) Effectiveness of ICT RTD Impacts on the EU Innovation System: Annex to the Final Report. Technical Report for the European Commission Information Society Directorate-General.
2. Allee, A., Schwabe, O. (2015) Value Networks and the true nature of collaboration. Meghan-Kiffer.
3. Allee, V. (2008) Value network analysis and value conversion of tangible and intangible assets. Journal of Intellectual Capital. 9(1):5-24.

4. Almeida, N.M., Sousa, V., Dias, L.A. and Branco, F. (2015) Engineering Risk Management in Performance-Based Building Environments. Journal of Civil Engineering and Management. 21(2):218–230.
5. Amidon, D.M. (2003) The Innovation SuperHighway. Taylor & Francis.
6. CESPRI (2005) Evaluation of progress towards a European Research Area for Information Society Technologies. Technical Report for the European Commission Information Society Directorate-General.
7. Cross, R., Parker, A. (2004) The Hidden Power of Social Networks. Understanding How Work Really Gets Done in Organizations. Harvard Business School Press.
8. Edvinsson, L. (2002) Corporate Longitude. Financial Times Prentice Hall.
9. ERAnets (2004) Evaluation of Networks of Collaboration between Participants in IST Research and their Evolution to Collaborations in the European Research Area (ERA). Technical Report for the European Commission Information Society Directorate-General.
10. Formica, Piero (2018) Exploring the Culture of Open Innovation: Towards an Altruistic Model of Economy. Emerald Publishing.
11. Hasan, A., Baroudi, B., Elmualim, A. and Rameezdeen, R. (2018) Factors affecting construction productivity: a 30 year systematic review". Engineering, Construction and Architectural Management.
12. Héder, Mihály (2017) From NASA to EU: The Evolution of the TRL Scale in Public Sector Innovation. The Public Sector Innovation Journal. 22(2).
13. Homans, George C. (1958). Social Behavior as Exchange. American Journal of Sociology. 63:597-606.
14. Laursen, K. , Salter, A. (2006) Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. Strategic Management Journal. 27(2):131-150.
15. Mehmood, Y., Barbieri, N., Bonchi, F. (2016) Modeling adoptions and the stages of the diffusion of innovations. Knowledge and Information Systems. 48(1):1-27.
16. Mercier-Laurent, Eunika (2015) The Innovation Biosphere - Planet and Brains in Digital Era. Wiley.
17. Miller, J.H., Page, S.E. (2007) Complex Adaptive Systems: An Introduction to Computational Models of Social Life. Princeton University Press.
18. Murphy, M.E., Perera, S. and Heaney, G. (2015) Innovation management model: a tool for sustained implementation of product innovation into construction projects. Construction Management and Economics. 33(3):209–232.
19. Quinlan, C., Babin, B., Carr, J., Griffin, M. (2019) Business Research Methods. 2nd Ed. Andover, UK: South Western Cengage
20. Rogers, E.M. (1962) Diffusion of Innovations. The Free Press A Division of Macmillan Publishing Co., Inc.
21. Schwabe, O. (2018) A Geometrical Framework for Forecasting Cost Uncertainty in Innovative High Value Manufacturing. PhD thesis. Cranfield University.
22. Slaughter, E.S. (2000) Implementation of construction innovations. Building Research & Information. 28(1):2–17.
23. Sveiby, K. (2001) A Knowledge Based Theory of the Firm to Guide Strategy Formulation. Journal of Intellectual Capital. 2(4).
24. Sveiby, K.A. (2012) Challenging the Innovation Paradigm. Routledge.
25. Thims, L. (2012) Thermodynamics ≠ Information Theory: Science's Greatest Sokal Affair. Journal of Human Thermodynamics. 8(1):1-120.
26. Yang, Q., Li, C. (2019) User Roles and Contributions in User Innovation Communities. American Journal of Industrial and Business Management. 9:1318-1331.