

Industry 4.0 Virtual Value Chains and Collaborative Projects

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Keywords: virtual organization, value chain, virtual innovation communities, innovation ecosystem, collaborative strategies, program and project management

The fourth industrial revolution (Industry 4.0) – characterized by the increasing digitization and interconnection of products, value chains, and business models – has arrived in the industrial sector (Source: Price Waterhouse Coopers, 2014).

1. Drivers of Changes

The world is exiting the Industry 3.0 business environment where optimisation and automation of an organisation's resources were the main issues. The Industry 4.0 business ecosystem shown in Figure 1 does not depend solely on innovation, optimisation, and competitiveness of their resources. It depends on the inter-organisational value chain innovativeness, complementarity partner technologies, products, digitisation and supporting services systems as a whole. Together with partners, they are co-creating innovative inter-organisational value and supply chains operating in a global collaborative business ecosystem. Primary drivers and causes of these changes lie in the rapid development, availability and affordability of modern key enabling technologies (KETs). KETs are knowledge intensive and associated with high

research and development intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalise on their research efforts (Source: Study for the ITRE Committee, 2014). The KETs' bottom line is overall digitisation with the internet of things (IoT) and services, which enable opportunities for introduction of new products and



Figure 1: Industry 4.0 Business Ecosystem

business models endlessly. The PWC 2016 Global Industry 4.0 Survey provides a brief illustration of the Industry 4.0 framework and contributing digital technologies (see Figure 2). There is no doubt that strategic transformation and change of Industry 4.0 are driven by modern ICT artifacts that allow for the introduction and integration of new business models of vertical and horizontal supply- and value chains. Moreover, to prevent going backwards in the new economy this importantly compels organisations to adopt transformation and change initiatives as a priority strategy.

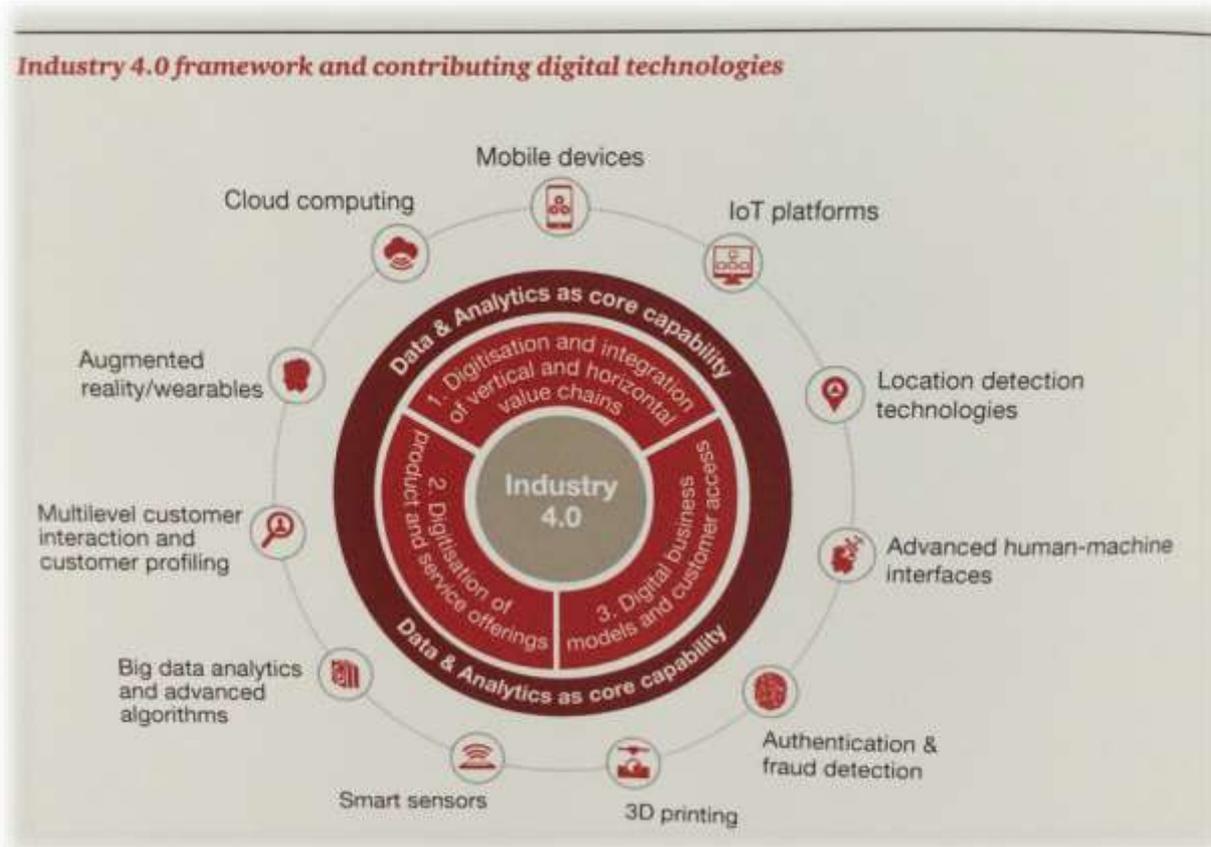


Figure 2: Industry 4.0 framework and contributing digital technologies
(Source: PWC's 2016 Global Industry 4.0 Survey)

KMPG (2016) assert that when it comes to manufacturing in Industry 4.0, there is a paradigm shift from "centralised" to "local" production, and this is provided through networking and transparency. Unlike globalisation where the focus was on taking advantage of lower labour rates and thereby building factories in these locations, in Industry 4.0 the focus is on strengthening local production (see also Steyn and Semolic 2017). According to Msengana (2017), Roblek, Meško, and Krapež (2016) argue that Industry 4.0 will have an important influence on the complete transformation of industry because it represents progress in three areas:

- Digitisation of production: information systems for management and production planning;

- Automation: systems for data acquisition from production lines and using machines;
- Linking manufacturing sites in a comprehensive supply chain: automatic data interchange (ADI).

Roblek *et al* (2016) aver that the distinguishing factor of Industry 4.0 is increased competitiveness through smart equipment, making use of information about high-wage locations, demographic changes, resources, energy efficiency, and urban production.

2. Virtual Value Chain Logistics

Modern logistics comprise engineering and management of logistics processes, systems and connected flow of material, information and other resources demanded by client(s). Logistics is an integral part of the service industry and as such must follow the needs of their clients and develop its services to customer requirements. Table 1 shows the historical development of industry logistics services. One can recognise the significant extent and importance of logistics activities in the emerging Industry 4.0 environment. Moreover, the phenomena of the next level of companies' specialisation that caused the increased need for more intensive collaboration between horizontal and vertical virtual value chain participants from different organisations of involved industries is clear (see Figure 3).

Industry Generation	Technology Characteristics	Business Characteristics	Needs for External Logistics Services
Industry 1.0	Water and steam power	<ul style="list-style-type: none"> - Craft production, - Unique products or small series 	Transport of material and products
Industry 2.0	Electric power	<ul style="list-style-type: none"> - Standardization and mass production, - Distribution, - Suppliers, - Regional markets 	<ul style="list-style-type: none"> - Transport services, - Warehousing services
Industry 3.0	Electronics and automatization	<ul style="list-style-type: none"> - Specialization, - Different levels of product customization, - Developers-integrators, - Networks of suppliers, - Global markets 	<ul style="list-style-type: none"> - Transport services, - Warehousing services, - Logistic centers, - Distribution services
Industry 4.0	Cyber physical systems	<ul style="list-style-type: none"> - Products are enriched with a range of customized services, - Flexible multi-organizational businesses with supporting services, - Business as portfolio of different collaboration platforms, - Virtual organization and concurrent enterprising, - Open innovation in reality, - Supporting services to the global and regional business ecosystems 	<ul style="list-style-type: none"> - Transport services, - Warehousing services, - Production location services, - Logistic center services, - Logistic platform services, - Distribution services, - Value chain office services, - Supply chain office services

Table 1: Development of the requirements of external logistics services

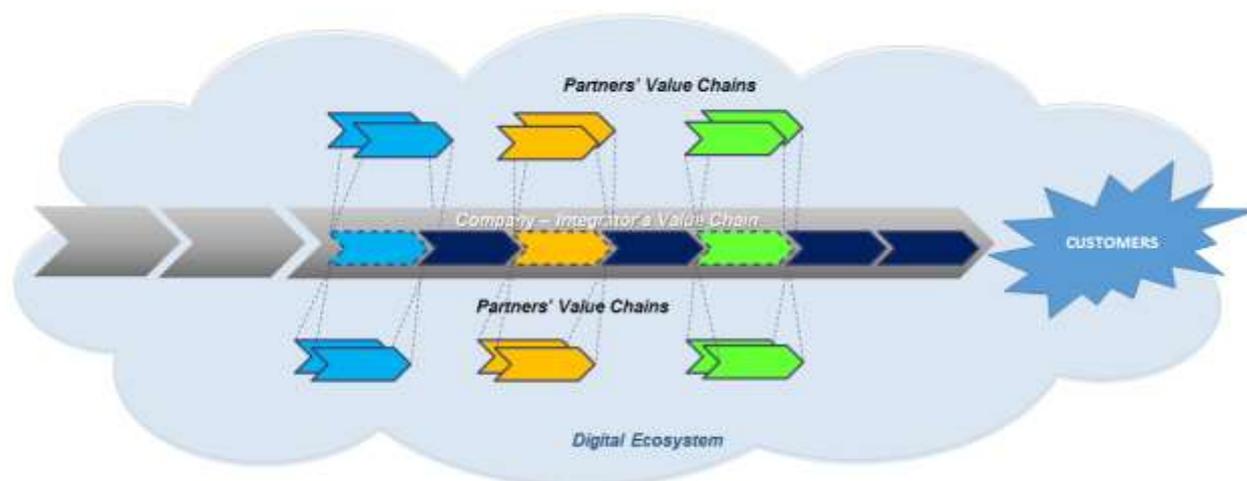


Figure 3: Virtual value chain

Concurrent collaborative businesses, inter-organisational and interpersonal productivity are the main elements of new business models. The virtual value chain dissects a virtual organisation into its strategically relevant collaborative value driven activities. These activities are performed by involved partners in order to best understand their behaviours, value chain competitive advantages and benefits. Involved entities and other supporting organisations gain a competitive edge by collaboratively performing these strategic activities more efficiently and effectively than their competitors.

Specialisation, development of organisational key competencies based on the utilisation of flexible, adaptive, innovative business models supported by the utilisation of modern technology solutions, is one of the key success factors of a modern establishment. The organisational borders between modern entities are fading. As shown in Figure 5 they are superseded by different collaboration modalities and connections with their business partners, customers and other stakeholders. The efficient digitalised organisational and inter-organisational business processes are critical components of these new corporate setups. Innovativeness and competitiveness of individual partnering organisation are critical elements of an inter-organisational value chain.

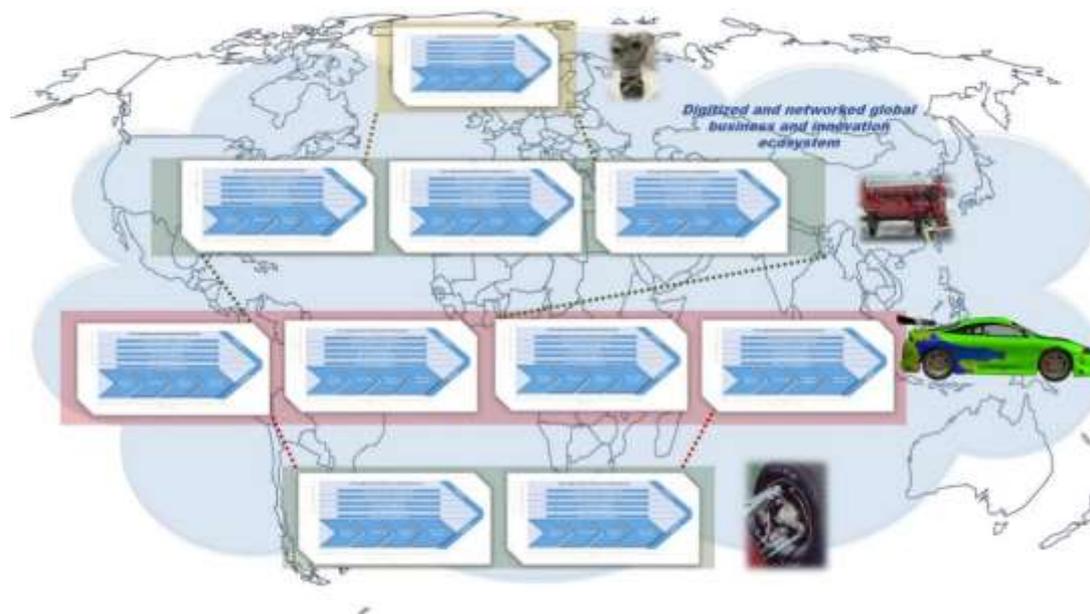


Figure 5: Illustration of the virtual value chain of partnering-collaborative and inter-organisational business ecosystem

According to Branch (2009), Harvard's Michael Porter is of opinion that competitive advantage cannot be understood by looking at a firm as a whole. It stems from the many discrete activities a firm performs in designing, producing, marketing, delivering, and supporting its product. Each of these activities can contribute to an organisation's relative cost position and create a basis for differentiation. The value chain disaggregates a firm into its strategically relevant activities to understand the influence of costs and the existing and potential sources of differentiation. An organisation gains competitive advantage by performing these strategic activities more cheaply or better than its competitors.

The concept of the modified Porter value chain is illustrated in Figure 6. It is adjusted in accordance with the current authors' understanding of the needs of emerging partnering collaborative value chains in the Industry 4.0 environment.

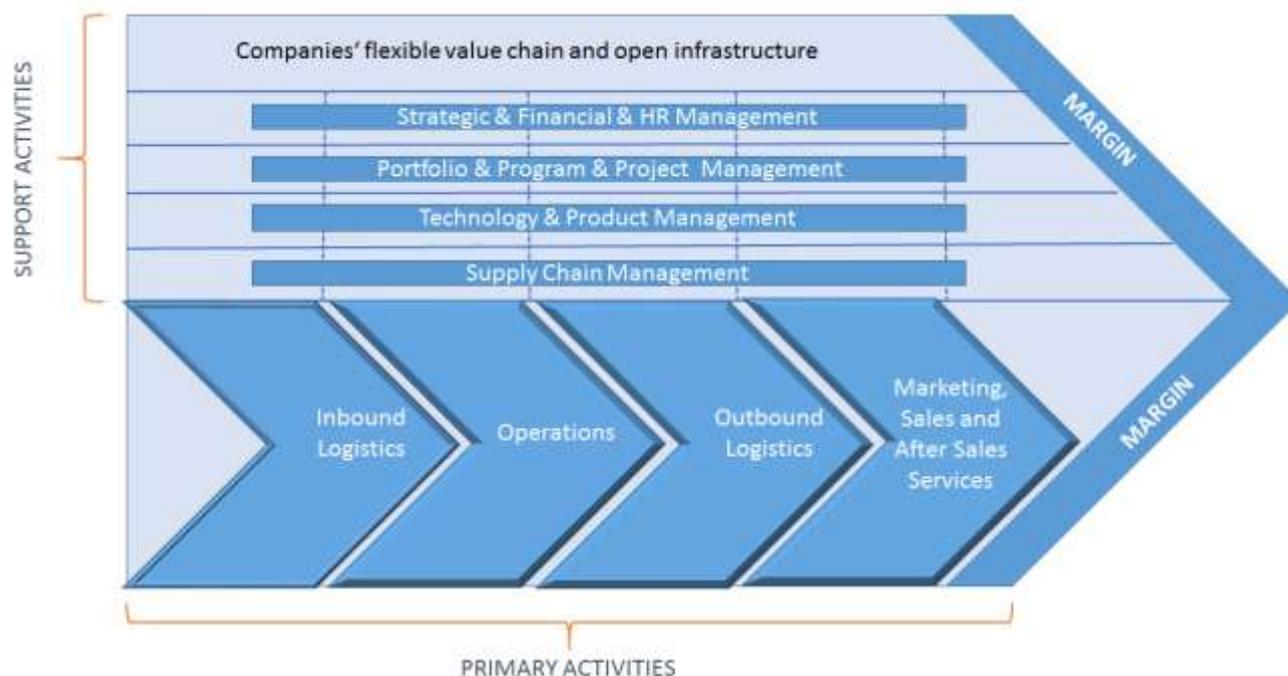


Figure 6: Modified Porter Value Chain

According to Semolic (2016) the modified Porter value chain is seen as a component of the harmonised inter-organisational value chain where well-coordinated and aligned value chain supporting activities play critical roles with respect to success. Supporting inter-organisational related activities embedded in the governance of an organisation are as follows:

- Harmonised strategic management activities where each organisation recognises, envisions and utilises its own key competencies, internal-regional knowledge capacities, and development funding opportunities.
- Adequate administration of the commercial, capex and innovative research project, programme and portfolio implementation.
- Identification and management of critical core, supporting and enabling technologies, together with products that are relevant for the competitiveness of the organisation and other inter-organisational value chain partners involved.
- Management of the portfolio of harmonised supply chains of required resources and information.

All business activities and processes must be supported by well-designed and performed digitalised communication technologies and systems. Modern organisations are progressively more embedded in regional and global virtual value chains. It is a question of survival for all involved players to be aligned, or lead the industry development and demand innovation investment cycles.

This phenomenon is present in all areas and levels of interconnected societies. Internet of things and services supported by global digital business ecosystems are not

sufficient. Only enabling technologies and systems that generate opportunities for improvement of existing products, the introduction of new products, markets and the transformation of the organisation as a whole are provided. The above must be enhanced by utilising innovative robust and competitive business models. The need for strategic shifts and modifications are not addressed exclusively to the industry participants. The new situation requires improvements in the existing global trade, technical and business standards. Moreover, these holistic changes present a solid foundation for the successful development and utilisation of new corporate business models based on the effective use of the internet of things, services and digital ecosystems. Figure 7 is an illustration of the globalised Industry 4.0 environment and its components in need of coordination and collaboration.

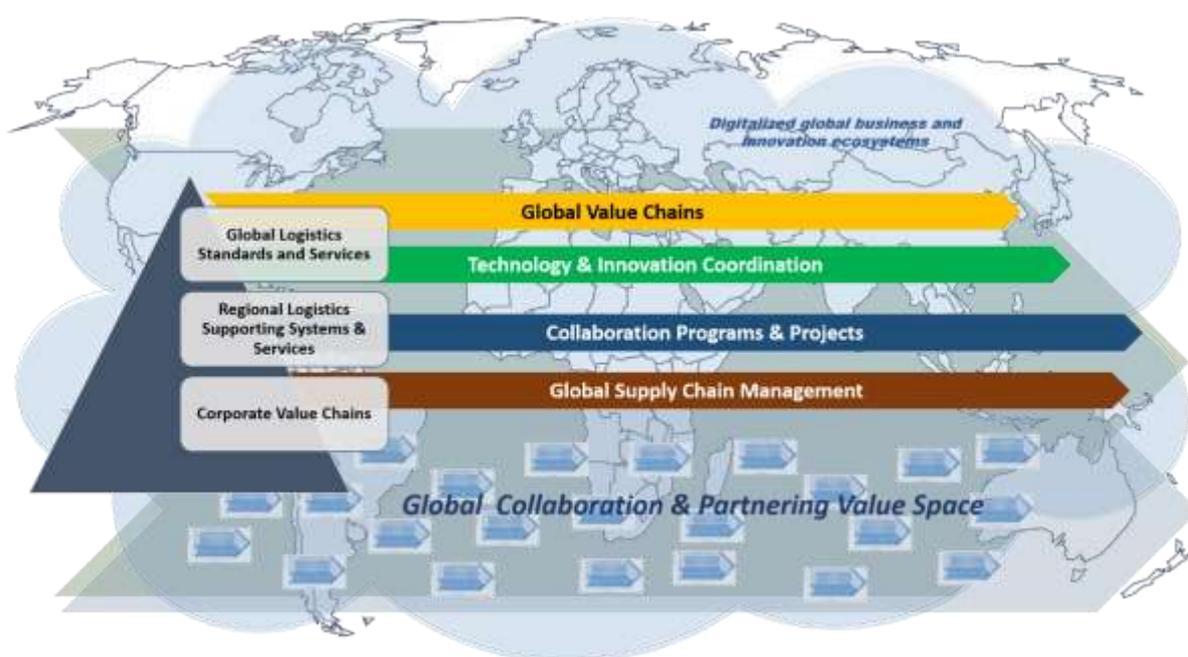


Figure 7: Digitalised global business and innovation ecosystems

3. Collaborative Projects and Concomitant Project and Programme Management as Value Chain Integrators

Collaborative projects and concomitant project and programme management are critical enabling competencies of Industry 4.0 organisations. They present “*organisational Integrators*” of modern organisations and their flexible inter-organisational value chains. Figure 8 shows characteristics of global megatrends, their influence on industries, organisations, corporate culture and the project management profession, and how it is envisioned for the year 2030. This vision is based on trends observed by the current authors in industries where they are currently engaged (*inter alia* ICT, logistics, industrial engineering, automotive, industry toolmaking, aerospace), and research outputs from different authors.

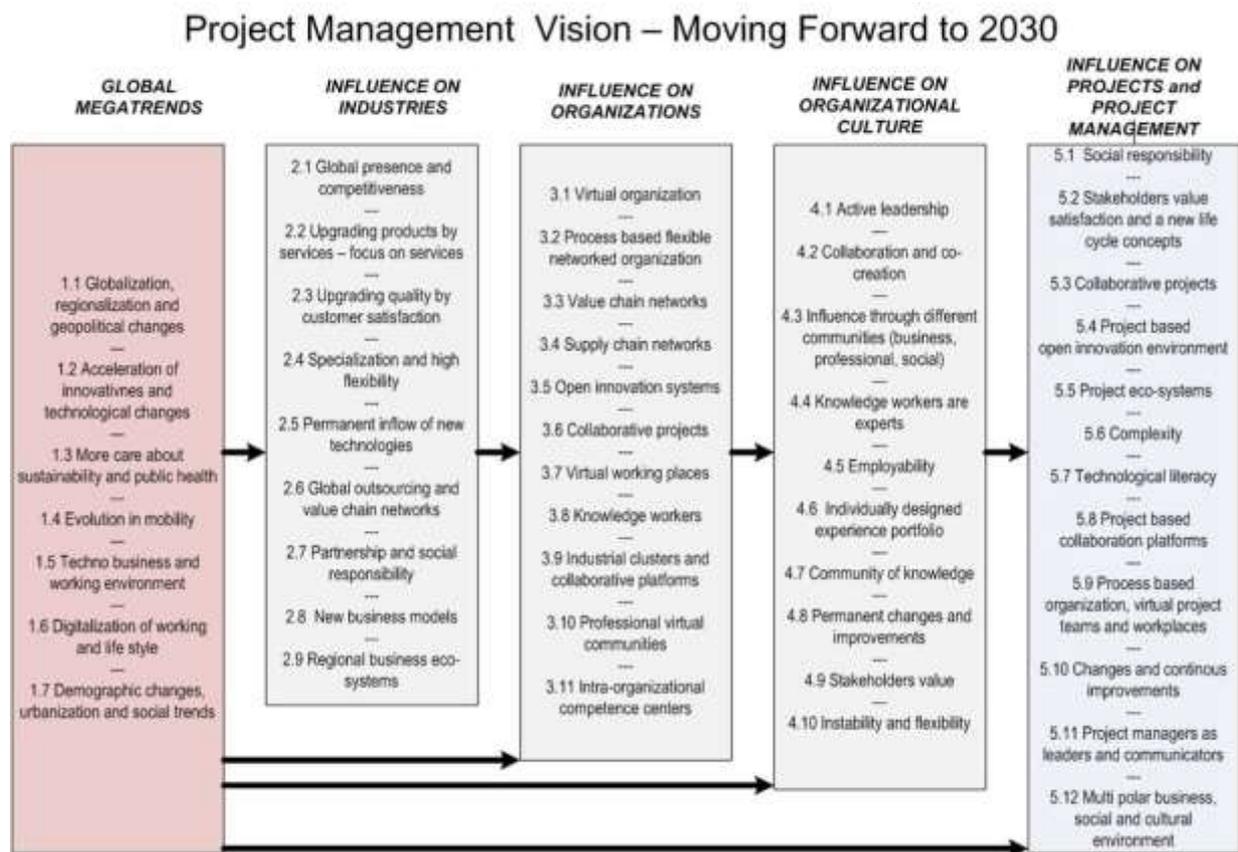


Figure 8: Envisioning of the characteristics of the emerging business environment and the role of project management

4. Transformational Leadership, Management and Governance of Virtual Value Chain Projects, Programmes and Portfolios

The fourth industrial revolution (Industry 4.0 economy), characterised by the increasing digitisation and interconnection of products, value chains, and business models has arrived in the commercial and industrial sectors. According to Semolic and Steyn (2017) the world economy is moving forward from globalisation and the Industry 3.0 economy business environment where optimisation and automation of an organisation’s resources were the main issues. Overall competitiveness in the Industry 4.0 enterprise does not depend solely on innovation, optimisation, and competitiveness of its resources, but the total inter-organisational value chain innovativeness and supportive partner technologies, products, services, and systems.

With the aid of partners, organisations are co-creating innovative inter-organisational value and supply chains that operate in a local, regional and sometimes international collaborative business ecosystem. Organisational design and development has entered a brand new phase. The strategic transformation and change of Industry 4.0 organisations are driven by modern information, communication and technology principles and practices that allow for the introduction and integration of new horizontal

supply and value chain business models. Virtual value chains shape the organisation into strategically relevant collaborative value driven activities, some performed by carefully selected partner organisations. A competitive edge is gained via collaboratively performing the strategic activities more effectively and efficiently. This approach calls for carefully planned and executed governance principles supported by leadership excellence and a clear understanding of programme management principles by all partner organisations in the virtual network. As discussed below, the seeds for industry 4.0 were planted as early as the 1950s, 1960s and 1970s.

Forrester (1958) displayed profound vision when he argued that: “Management is on the verge of a major breakthrough in understanding how industrial company success depends on the interactions between the flows of information, materials, money, manpower, and capital equipment. The way these five flow-systems interlock to amplify one another and to cause change and fluctuation will form the basis for anticipating the effects of decisions, policies, organisational forms, and investment choices.” Forrester introduced the theory of distribution and had the foresight to recognise the integrated nature of organisations. These interrelationships also included integration between the entity and its markets, its industry, other organisations and the national economy. Hence, Forrester identified key management issues illustrating the dynamics of factors associated with the phenomenon referred to in the contemporary management literature as Supply Chain Management (SCM).

Burns and Stalker (1961) distinguish between mechanistic and organic organisations. They describe mechanistic organisations as rigid bureaucracies with strict rules, narrowly defined tasks, and top-down communication with a tendency towards centralised decision-making. Organic organisations they described as flexible networks of multi-talented individuals who perform a variety of tasks, with a tendency towards decentralised decision-making. Where organisations operate in environments that are more stable they tend to exhibit a more mechanistic organisational structure. However, where organisations operate in more dynamic and uncertain environments (as in today’s Industry 4.0) they tend to show a more organic organisational structure. Leaders should look at the contingencies of the environment, and determine whether or not the organisation is capable of handling the uncertainties of the environment, and whether or not the organisation is able to process the required information load.

Lawrence and Lorsch (1967) researched successful and unsuccessful organisations in three industries. They hypothesised as follows:

- Overall performance was dependent on the degree of differentiation in subsystems consistent with environmental requirement AND the degree of integration between subsystems consistent with the environment.
- When the environment requires high differentiation and integration, integrative devices (task-groups, planning departments, cross-functional teams, etc.) will emerge.

They concluded that as environmental complexity increased, successful organisations exhibited higher degrees of both differentiation and integration. This means that these organisations maintained an effective balance. In contrast, unsuccessful organisations

suffered from an imbalance of too much differentiation and not enough off-setting integration. The lesson learnt was that managers need to maintain focus on the balance between growing and increasingly differentiated organisations on the one hand, and on the other hand the evolution of ever better means of integration and coordination. Moreover, they discovered that the more differentiated an organisation becomes, the more difficult it is to achieve integration.

In Industry 4.0 terms this means that the situation becomes more complex. Hence, it can be concluded that managers of modern day complex organisations need to strive constantly and creatively to achieve greater integration through programme management principles, structures and paradigms. This demands creative organisational design, transformation and change. Lawrence and Lorsch (1967) also concluded that as environmental complexity increased, successful organisations exhibited higher degrees of both integration and differentiation. Hence, and importantly, in the profoundly complex Industry 4.0 situation more differentiation is required than before, compelling them to look for outside partner organisations to provide supportive resources in their quest to mitigate risk and be competitive.

Lawrence and Lorsch (1967) as early as the mid-1960s interestingly concluded that it is patently clear that as complexity and risk increase in organisations, the more they will revert to cross-functional teams. Similarly, Ibraguim Kenguerli (2013) in a Master's dissertation at Cranfield College concluded that high complexity and risk situations demand transformation from bureaucracy to a knowledge-based learning organisation. These should be shaped cross-functionally in portfolio and programme structures embedding paradigms known and proven to provide high degrees of integration as differentiation increases in the organisation. Moreover, Lawrence and Lorsch (1967) propose several integrating mechanisms in addition to cross-functional teams such as a formal hierarchy; standardising the organisation's policies, rules and procedures; and departmentalisation. Although the research was done during the 1960s, it never dated. As stressed earlier, their conclusion regarding environmental complexity and the need for higher degrees of differentiation and integration under those circumstances is even more important in today's Industry 4.0 situation.

It was during the mid-1960s that the first ever articles on 'program management' by Dr Russ Archibald appeared, followed by the publication of his trail blazing textbook on the subject in 1976. By then the principles and ideas related to matrix management were known, hence the mention of cross-functional teams as integrating mechanisms by Lawrence and Lorsch (1967). The above-mentioned elements were the forerunners of cross-functional project, programme, portfolio, supply chain, and value chain structures utilised in modern day knowledge-based learning organisations. These elements have an influence on how Industry 4.0 organisation are designed and developed. A contingency approach to design can be put into practice by first assessing the degree of environmental uncertainty. The contingency model next calls for the utilisation of various organisation design configurations to achieve an effective organisational environment fit. Figure 9 illustrates three new organisational patterns that emerged from the contingency approach, including the virtual networks of partners organisations.

New Organisational Patterns

- **Hourglass Organisations** (thanks to modern info-tech, a relatively **small executive team** can co-ordinate the efforts of numerous operating personnel).
- **Horizontal Organisations** (**programme managed cross-functional** Supply Chain Portfolio and Project Portfolios aimed at satisfying external and internal customers . These are **team-based integrating structures** built around **core business processes, coordination and collaboration**).
- **Virtual Networks of Partners Organisations** (**programme-managed networks of partners organisations** operating integrative despite **geographical dispersion**; situation **complex and high risk** demanding efficient coordination and collaboration; applies to the Supply Chain Portfolio and Project Portfolios).

Figure 9: New Trends in Organisational Design

In the Industry 4.0 economy era of today it is well-known that closed-system bureaucracies are the epitome of inefficiency. Conversely, organic organisations are seen to have a new open-system perspective. The open-system perspective sees organisations as ecosystem participants, where organisational ecologists seek to explain how social, economic, and political conditions impact the diversity of organisations, and thus attempt to account for the changing composition. Steyn and Semolic (2016) argue that organisations can no longer rely on prescriptive strategies such as profit maximisation alone. Organisations require more emergent approaches to strategy development and implementation. The speed of change has an impact on every organisation, and the operational environment is dissolved into a series of events, which potentially orchestrates chaos and confusion. More risk means more complexity and chaos, and in turn, more chaos and complexity means more risk. Wysocki (2011) warns that complexity is here to stay and is only going to increase. Organisations must be appropriately shaped and learn to handle complexity while capitalising on these to remain competitive and add value.

The programme-managed portfolio of virtual networks of external partners is a relatively new concept in organisational design and development and an ideal vehicle for coping with complexity and mitigating risk. Moreover, its characteristics are profoundly suitable for integration and coordination of activities and collaboration between stakeholders. In the new economy era the world is currently experiencing, an increasing number of organisations realise that networking with partners can lead to innovation and be highly beneficial to all stakeholders. By utilising the capability of partner organisational resources while optimising their own potential, leads to local, regional and transnational research, development and production networks being formed. In this way temporary association of

specific resources from an initiating organisation combined with those of its partners is formed to attain the objectives of innovation, competitive advantage and value add.

Virtual networks of partners are innovative forms of organisational design and development requiring specialised governance. Governance of virtual organisations start with goal definition and the structuring of a virtual network of organisations for a specific purpose. It is profoundly different from designing and developing a conventional organisation. The following are specific questions that should be asked when creating a virtual organisation of any kind:

- What are the primary strategy, goals, and objectives of such initiative?
- What are involved benefits, risks and overall business value?
- Where is motivation and the proposed role of virtual organization initiator?
- What kind other alternatives do we have?
- Who should be partners in the proposed virtual organization?

The last question is probably the most important. If an error is made in the selection of a partner or partners, it could lead to dire consequences for the initiating partner and other stakeholders. Harmony in the organisational cultures of the participating partner organisations is a profound necessity.

In governance of virtual networks of partners, leadership and management are of paramount importance. Excellent leadership abilities are required all round. Knowledge of and experience in differentiation, integration, coordination and collaboration of networking activities are management skills that lead to success. The same can be said for the ability to gain appropriate resources for operating the virtual network from the initiating partner and the participating organisations. All participants in the virtual network must possess a high level of project management maturity and be exceptionally proficient, skilled and experienced in the essential programme management skills required for the task.

Of utmost importance is that harmony should exist and prevail in the organisational cultures of all the participating organisations in the virtual network. This requires that the value systems of the participating organisations jointly dictate a preferred culture and paradigm conducive to cooperation and collaboration. It must deliver a clear understanding of the abilities of the partner organisations' cultures and attitudes, similar to what is required in customer relationship management. This needs to be complemented by leadership role modelling that clearly supports the expected behaviours and attitudes demanded by the preferred common culture. It also means that all participating organisations must adopt the guiding principles of the value system pertaining to the four pillars of total quality management philosophy, i.e., having a customer focus, doing continuous improvement, involving and empowering team members, and practicing systems thinking where process outputs are measured, appraised and, if necessary, also reviewed.

The management system of the virtual network of partners must exist for the entire time that the network is operational. It must be clearly understood that the management jurisdiction differs entirely from that of a classical organisation. Major integration and coordination activities remain the responsibility and are generally performed by the

initiating partner. The other partners in the virtual network are responsible for the integration and coordination of the specific tasks that they perform internally in their organisation, but must participate actively in the coordination and integration activities carried out by the initiating partner. Collaboration among the partners in the virtual network is of paramount importance for the success of the initiative as a whole, and is the responsibility of all the participating organisations in the network. Combined with appropriate programme-managed structures this will advance simplification of complexity and mitigation of risk in the virtual operations.

The primary business functions performed in a virtual network of partners range from research, development and production of the product or service, to its sale and delivery in the market. The research, development and production of a product or service is generally referred to as the technical process. The supporting business functions include business planning, organising, financing, managing, and supervising the activities in the virtual network of partners. Combined the primary and secondary business functions constitute the entrepreneurial process.

Van den Berg (2017) avers that all projects, programmes, portfolios, strategy design and strategy implementation are subject to the proposals and demands of governance. Moreover, virtual networks of partners are likewise subject to organisational governance (Steyn and Semolic, 2016) and the governance of partners should follow the same values across each partner organisation. All parties, in particular, collaborative parties, should adopt a similar governance system and not develop a culture where they operate completely outside this governance system.

Müller (2017) argues that the body of knowledge on governance involves a multitude of definitions. Among them is “Governance as Relationships” stressing the role of governance in delineating the relationships among the various internal or external stakeholders; and the rights, responsibilities and relationships of the different members of the organisation. He defines governance as “providing the value system, structures, processes, and policies that foster transparency, accountability, responsibility, and fairness to allow projects to achieve organisational objectives and foster implementation that is in the best interest of all stakeholders, internal and external, and the corporation itself”. Due to the pivotal role played by collaboration and coordination in achieving success in Industry 4.0 virtual networks of partner organisations, the current authors opine that “governance as relationships” is of paramount importance.

Van den Berg (2017) purports that the Governance, Risk and Compliance Framework (GRC) proposed by Tadewald (2014) is emerging as a critical and challenging innovation (see Figure 10). It introduces the requirements for new or adapted business approaches for compliance and service modelling. Moreover, it introduces the requirements for the extension of business processes and execution frameworks for risk management and compliance, as well as discovery of policy violations. In addition, it presents questions specifically related to the deployment of technology to support compliance management.

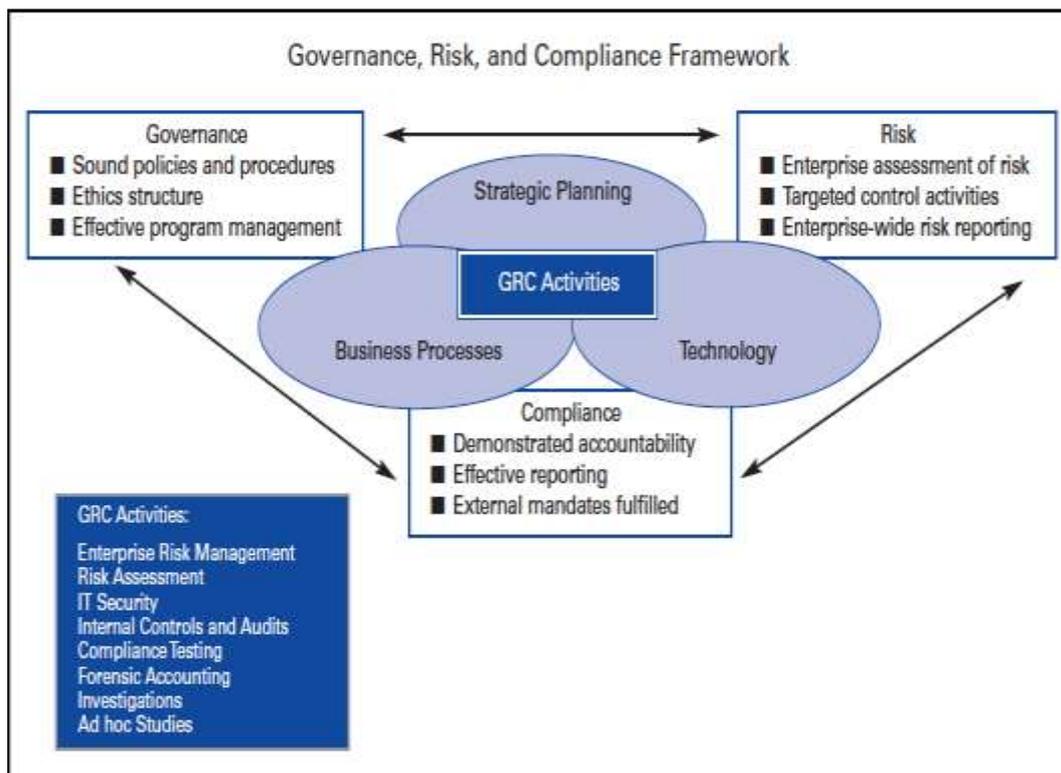


Figure 10: The GRC Framework. (Source: Tadewald, 2014).

According to Tadewald (2014) employing effective technology to integrate GRC frameworks across multiple industries and sectors provides uniformity and continuity. Importantly, these efforts need to be integrated strategically. In support of Van den Berg (2017) the current authors aver that Industry 4.0 virtual networks of partner organisations need to adopt the GRC framework with the objective of establishing an effective GRC programme to ensure sound governance, overall compliance and mitigate risk. Moreover, it will support the adoption of appropriate business models.

Steyn and Semolic (2017) aver that governance in virtual networks of partner organisations should be effectively and efficiently integrated and co-ordinated by the initiating organisation applying state-of-the-art programme management. Moreover, governance of the portfolios of programmes, including the virtual networks, should be directed and managed by a Chief Portfolio Officer (CPO) at the executive level as proposed by Steyn (July, 2010) and strongly supported by Russ Archibald (Aug, 2010). In the Industry 4.0 situation, *inter alia*, the CPO, project driven and non-project driven business models are of profound importance.

In summary, Steyn and Semolic (2016, 2017) aver that organisations are progressively adopting strategies that focus on their core business in order to be competitive. They consequently build their internal capacities based on core competencies, while partnering with other organisations for non-core components that constitute their final products and/or services. In this way virtual networks of partner organisations are formed with the purpose of timeously providing high quality products and/or services at

the lowest possible cost. This approach is regardless of whether an organisation utilises a project driven, non-project driven, or hybrid (a combination of the two) business model, and calls for high levels of coordination, integration, and collaboration in the networks of partners to achieve synergy. The system is characterised by an initiating organisation acting as the principal partner in the virtual network of participating organisations, and founded on project-, programme-, and portfolio management principles. Furthermore, the approach demands and leads to a paradigm shift in modern day organisational development and design.

Figure 11 depicts the value chain schematic illustrating four project portfolios proposed by Murray-Webster & Thiry (2001) and Semolic (2010), and the supply chain portfolio proposed by Steyn (2001, 2003 and 2010). The project portfolio in the centre indicates the position of the virtual partner network project portfolio for developing special products proposed by Semolic (2010). The supply chain portfolio proposed by Steyn (2001, 2003 and 2010), is shown at the bottom of the figure. The supply chain process grouping for projects done for external customers (when a project driven business model is utilised) is illustrated. Appropriately governed virtual networks of partners structures are created as the needs arise.

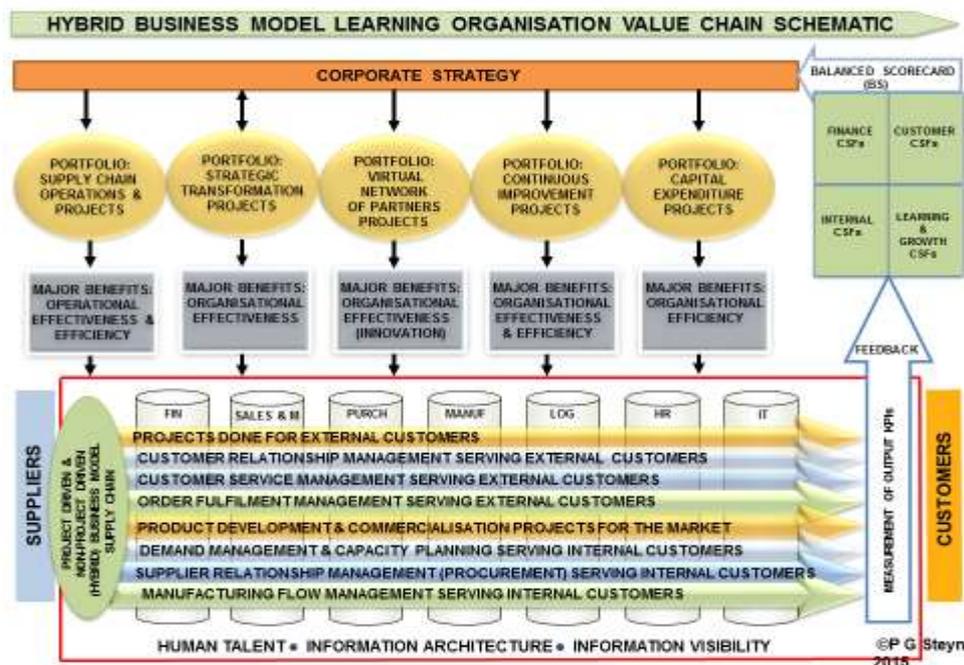


Figure 11: Programme-managed Portfolios in the Learning Organisational Value Chain Schematic.

Figure 12 illustrates the cross-functional links between the initiating partner's programme-management portfolio structures, and partner organisations' teams in virtual networks.

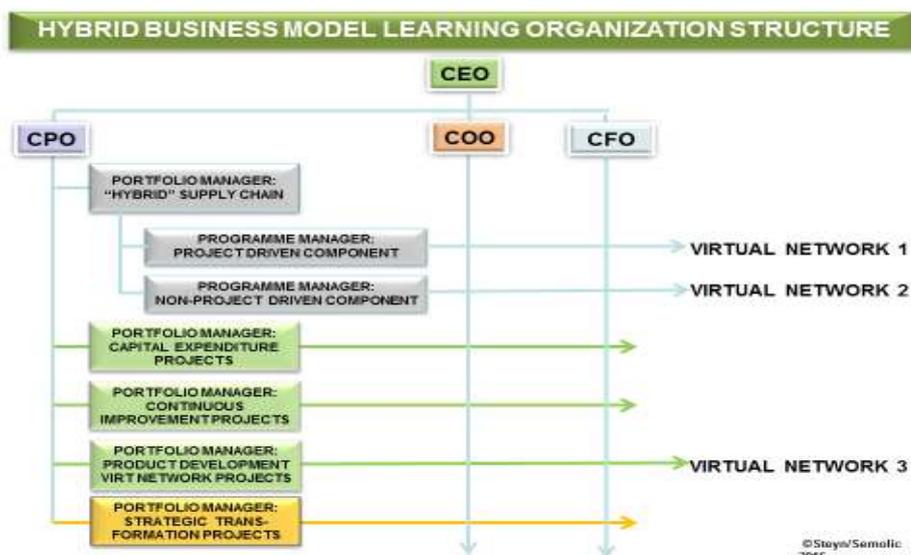


Figure 12: The Initiating Partner Organisation’s Programme-management Portfolio Structures Linked to the Virtual Networks of Partner Organisations’ Teams.

Virtual networks of partner organisations are created depending on the needs of the initiating partner and the business model employed. These are:

- supply chain project operations of the initiating partner for external customer projects;
- manufacturing operations of the initiating partner;
- specialised product development project work of the initiating partner.

The above figure illustrates the “hybrid” business model portfolio/programme management structures, reflecting the project driven and non-project driven components of the supply chain proposed by Steyn (2012 and 2013).

5. Conclusions

Today’s complexity of technologies, emerging businesses, and business environments call for specialisation and sustainable collaboration. Vibrant, flexible, high performing virtual organisations of innovative specialised partners are the critical success factors of the emerging business environment. Critical for the success of Industry 4.0 organisations is the enhancement of its operational resources and innovation potential through the involvement of local, regional and international virtual networks of partners with adequate logistical support. Its cross-functional programme-managed structures and culture combined with effective and efficient transformational leadership, management and governance is the ideal vehicle for delivering the integration, coordination, collaboration and synergy required for mitigating complexity and risk, while achieving essential organisational performance, strategic benefits and value add in the Industry 4.0 environment.

6. Bibliography

Archibald, Russ. 1976. *Managing High Technology Programs and Projects*, Wiley and sons, New York.

Archibald, R. 2003. *Managing Project Portfolios, Programs and Multiple Projects: Proceedings of the IPMA 17th World Congress on Project Management*, held in Moscow, Russia, on 6-8 June 2003.

Archibald, Russ. 2010. "Letter to the Editor", *PM World Today*, August Vol XIII, Issue VIII, Dallas, USA.

Becker, B., Huselid, M. & Ulrich, D. 2001. "The HR Scorecard. Linking People, Strategy, and Performance", Harvard Business School Press, Boston, Massachusetts.

Beer, Michael. 1996. *The Organisation Change Imperative*. In: *The Relevance of a Decade*, Harvard Business School Press. Boston, Massachusetts.

Branch, E. Alan. 2009. *Global Supply Chain Management and Industrial Logistics*, Routledge, New York, USA.

Burns, T. and Stalker, G. 1961. *The Management of Innovation*, Tavistock, London.

J.W. Forrester. 1958. *Industrial dynamics. A major breakthrough for decision makers*. *Harvard Bus Rev* 36, 37–66.

EU-Directorate General for Internal Policies. 2014. *Horizon 2020: Key Enabling Technologies (KETs), Booster for European Leadership in the Manufacturing Sector*, Brussels.

Geissbauer, R., Schrauf, S. 2014. *and All: Industry 4.0 – Opportunities and Challenges of the Industrial Internet*, PwC,

Kenguerli, I. 2013. *Organisational Dynamics in Complex Environments*, unpublished Master's dissertation, Cranefield College, Pretoria, South Africa.

KPMG, 2016. *The Factory of the Future, Industry 4.0 – The challenges of tomorrow*.

Lawrence, Paul and Lorsch, Jay. 1967. *Differentiation and Integration in Complex Organizations*, *Administrative Science Quarterly* 12, Cornell University, Johnson Graduate School of Management.

Geissbauer, R., Vedso, J. and Schrauf, S. 2016. *Global Industry 4.0 Survey, Industry 4.0: Building the digital enterprise*, PWC.

Msengana, Lunga. 2017. "The Role of Behavioural Strategic Dimensions as a Project, Programme and Portfolio Management Success Factor in a National Utility Organisation", unpublished PhD thesis, Cranefield College, Pretoria, South Africa.

Müller, R. 2017. *Governance and Governmentality for Projects: Enablers, Practices, and Consequences*. New York, NY: Routledge.

Murray-Webster, R. & Thiry, M. 2000. Gower Handbook of Project Management, 3rd Edition, Chapter 3, "Managing Programme of Projects", Gower Publishing, England, Ed, Rodney Turner.

Roblek, V., Meško, M., and Krapež, A. 2016. A Complex View of Industry 4.0, *SAGE Open Journal*, April-June.

Semolic, Brane. 2010. "Virtual Networks of Partners", Proceedings of the IPMA Research Expert Seminar, March, Cape Town, South Africa.

Semolic, Brane. 2016. Logistics of Virtual Value Chains – Technology Collaboration Platform (LogDyn) Platform Charter, Version 2016-1.0, LENS Living Lab, EU.

Steyn, Pieter. 2001. "Managing Organisations through Projects and Programmes: The Modern General Management Approach", *Management Today*, Vol 17, No 3 April, Johannesburg, South Africa.

Steyn, Pieter. 2003. The Balanced Scorecard Programme Management System, Proceedings of the 17th IPMA Global Congress on Project Management, Berlin, Germany.

Steyn, Pieter. 2010. "The Need for a Chief Portfolio Officer (CPO) in Organisations", *PM World Today*, July Vol XII, Issue VII, Dallas, USA.

Steyn, Pieter. 2012. Sustainable Strategic Supply Chain Leadership and Management. *PM World Journal*, December Vol I, Issue 3, Dallas, USA.

Steyn, Pieter. 2013. A Business Model for Programme Managing the Supply Chain Portfolio. *PM World Today*, March Vol 2, Issue 3, Dallas, USA

Steyn, Pieter and Semolic, Brane. 2016. The Critical Role of Chief Portfolio Officer in the Emerging 'Collaboratist Economy', *PM World Journal*, Feb Vol V, Issue 2, Dallas, USA.

Steyn, Pieter and Semolic, Brane. 2017. Collaboratism: A Solution to Declining Globalisation and Rising Protectionism, *PM World Journal*, March VI, Issue 3, Dallas, USA.

Tadewald, J. 2014. GRC Integration: A Conceptual Foundation Model for Success. *Management Accounting Quarterly*, 15(3): 10-18, Spring.

Van den Berg, Julian. 2017. The Emergent Role of Chief Portfolio Officer: An Introduction to the Agent of Change within the Supply Chain, unpublished PhD thesis, Cranefield College, Pretoria, South Africa.

Wysocki R. 2014. *Effective Project Management*, 7th Ed, Wiley, USA.

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Brane Semolic studied mechanical engineering, engineering economics, and informatics; he holds a scientific master degree and doctorate in business informatics. His focus of professional interest is industrial and system engineering, innovation and technology management, virtual organizations and systems, project and knowledge management. He has 40 years of working experiences in different industries (industrial engineering, IT, chemicals, household appliances, government, and education), as an expert, researcher, manager, entrepreneur, counselor to the Slovenian government and professor. He operates as head of the open research and innovation organization LENS Living Lab. LENS Living Lab is an international industry-driven virtual living laboratory. He is acting as initiator and coordinator of various research and innovation collaboration platforms, programs and projects for the needs of different industries (ICT, robotics, laser additive manufacturing, logistics, education). He was co-founder and the first director of the TCS - Toolmakers Cluster of Slovenia (EU automotive industry suppliers). Since 2004 he is serving as the president of the TCS council of experts. Besides this, he is operating as a part-time professor at the Cranefield College.

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He was the co-founder and president of the Project Management Association of Slovenia (ZPM), vice president of IPMA (International Project Management Association), chairman of the IPMA Research Management Board (2005-2012), and technical vice-chairman of ICEC (International Cost Engineering Council). Now he is serving as a director of the IPMA & ICEC strategic alliance. He actively participated in the development of the IPMA 4-level project managers' certification program. He introduced and was the first director of the IPMA certification program in Slovenia. He has been serving as the assessor in this certification program since 1997. He performed as assessor in the IPMA International PM Excellence Award Program in China, India, and Slovenia.

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He was a Member of Strategic Advisory Board of European Competitiveness and Innovation, as well as the president of the Slovenian Chamber of Business Services.

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