

# International Competitiveness and the Fourth Industrial Revolution

Chen Liu

## ABSTRACT

**Objective:** The objective of this article is to review the definitions, theories, and drivers of international competitiveness, examine how the Fourth Industrial Revolution (4IR) impacts the competitiveness framework, and build an ecosystematic model of competitiveness in the 4IR.

**Research Design & Methods:** The analytical work makes reference to the existing literature on international competitiveness, following a SALSA (Search, Appraisal, Synthesis, and Analysis) approach. The development of competitiveness theories and determinants are examined.

**Findings:** International competitiveness theories at country, industry, and firm levels, and its macroeconomic and microeconomic determinants are closely related, calling for a systematic approach in a competitiveness study. As a result, this article models competitiveness in the new era of the 4IR using an ecosystematic approach. Policy and managerial implications of the model are discussed following an integrated method.

**Implications & Recommendations:** Innovation, technological advancement, and relevant policies should be examined and understood in an ecosystematic approach. Future studies should theoretically model different components of the 4IR into the competitiveness framework and empirically examine the impact of 4IR to competitiveness from various aspects.

**Contribution & Value Added:** This article emphasizes the role of growing reliance on technology. It helps policymakers to re-evaluate national competitiveness by examining a nation's involvement and response to 4IR and how 4IR may potentially impact productivity and prosperity of a nation. It also deepens our understanding on firm level competitiveness in the age of 4IR and suggests future research direction.

**Article type:** conceptual paper

**Keywords:** competitiveness; fourth industrial revolution; innovation; diamond model; ecosystematic approach; firm strategy

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## INTRODUCTION

International competitiveness is a key topic of interest to policymakers, managers, and academics. Policymakers consider competitiveness to be essential to the success of a nation and therefore a central objective of national policies for the economic growth and prosperity of its citizens. Managers use the competitiveness framework to examine the business environment in order to develop and sustain their own firm level competitiveness. Academics in the disciplines of economics and management have extensively studied competitiveness but have yet come to an agreement on the definitions, theories, and drivers of competitiveness (Delgado, Ketels, Porter, & Stern, 2012). With the increased degree of globalisation which changes the role of nations in the competitiveness framework and business competition that has become fiercer both nationally and internationally (Chikan, 2008), we need to develop better understanding on international competitiveness at national, cluster, and firm levels.

Another reason that calls for the revision of the theories and determinants of competitiveness is the recent technological revolution (e.g. artificial intelligence, robotics) and the emergence of new business models (e.g. the Internet of things, the sharing economy) that significantly change ways of doing business and therefore our understanding of competitiveness. Schwab (2015) refers to these developments as the Fourth Industrial Revolution (4IR) and describes it as “a range of new technologies that are fusing the physical, digital and biological worlds, and impacting all disciplines, economies and industries” (Schwab, 2015). Based on Schwab (2015, 2016), the key drivers of the 4IR are the “emerging technology breakthroughs” in a number of fields, including artificial intelligence (AI), the Internet of Things, big data, robotics, autonomous vehicles, 3D printing, nanotechnology, biotechnology, and materials science. The U.S. Council on Competitiveness also calls for incorporating elements of the 4IR in the competitiveness framework by stating that “today’s competition is a race to see who will innovate and develop key technologies in artificial intelligence, The Internet of Things and 3D printing, to name a few”.

The goal of this article is to review the definitions, theories, and drivers of international competitiveness and to build a new competitiveness framework under the 4IR, with a focus on the role of innovation, adaptable factors of productions, shifting demand conditions, new business relationship, and proactive public policies and business strategies. To achieve the objective, the analytical work in this article makes reference to the existing literature on competitiveness and draws on recent studies on the 4IR. Then a new framework of competitiveness under the 4IR is recommended, using an ecosystematic approach.

This article contributes to our understanding of competitiveness at various levels (i.e., national, cluster, and firm levels), as it emphasizes the role of the growing reliance on technology. It will help policymakers to re-evaluate national competitiveness by examining a nation’s involvement and response to the 4IR and how the 4IR could potentially impact productivity and prosperity of a nation. It will also deepen managers’ understanding on how to sustain and proactively build firm level competitiveness by keeping up with and taking advantage of the new developments of the 4IR.

The rest of the article proceeds as following: the first section presents step-by-step methodology in selecting previous studies to be included in the review. The second section conducts an intensive review of literature on competitiveness and develops an ecosystematic model of competitiveness under the 4IR. The third section further discusses the model

by summarising how the 4IR impacts our understanding of the definitions and theories of international competitiveness and suggesting how governments, business, and societies should proactively respond to the 4IR in an ecosystematic approach. The fourth section discusses areas of future research, after which the article concludes.

## MATERIAL AND METHODS

The goal of this article is to understand and conceptualise competitiveness in the new era of the 4IR. In order to achieve this goal and to operationalise this project, a thorough literature study is conducted. Therefore, the main research method used is systematic literature review.

According to Babbie (2012), in order to obtain the most valuable cognitive effects of the research process, we need to identify a procedure following pre-determined steps. This article follows the SALSAs approach (Search, Appraisal, Synthesis, and Analysis) discussed in Booth, Sutton and Papaioannou (2016). Table 1 discusses the SALSAs approach and steps in detail.

**Table 1. Methodological process of this literature review following the SALSAs approach**

SALSAs approach & steps	Steps & details in this article
1. Search - finalise research topic, - identify key words, - preliminary literature searches, - full literature searches and reference management, - selection of articles, - obtain articles.	- topic: Competitiveness and the 4IR, - key words "competitiveness", "comparative advantage", "competitive advantage", "productivity", "diamond model", and "cluster", - preliminary and full literature searches conducted through EBSCO, ProQuest, Web of Science, Google Scholar, SSRN, - additional studies on the 4IR selected, - download and obtain all articles.
2. Appraisal - quality assessment.	- conduct citation analysis on all obtained articles, - review literature and further screen articles, - review full text, - compile a finalised pool of studies for this project.
3. Synthesis - integrating previous studies.	- categorize articles into definitions, theories, and determinants of competitiveness, - based on the above, categorise articles further into different strands of competitiveness literature, - identify connections, contradictions, and gaps in the competitiveness literature.
4. Analysis - analysis & conclusion.	- discuss the 4IR based on the reviewed literature, - formulate an ecosystematic model, discuss its applications and implications, and suggest future work.

Source: own study based on Booth *et al.* (2016).

With the goal of providing a comprehensive overview of competitiveness research, the article tries to identify all relevant studies on the subject in the first step of the SALSAs. The literature review started from peer-reviewed journal articles, books, and book chapters from EBSCO, ProQuest, Web of Science, and Google Scholar. The author also searched on SSRN for highly cited working articles. Primary key words included "competitiveness", "comparative advantage", "competitive advantage", "productivity",

“diamond model”, and “cluster”. This study also reviewed reports on national competitiveness rankings, such as the World Economic Forum’s *Global Competitiveness Report* and International Institute of Management Development’s *World Competitiveness Yearbook*. For the 4IR literature, this study reviewed Schwab’s (2016) book *The Fourth Industrial Revolution*, and white papers and journal articles on the 4IR and its applications such as the Internet of Things, artificial intelligence, and Financial Technology (FinTech, such as blockchains, cryptocurrencies, robo-advising, and crowdfunding).

This article then conducted a citation analysis of all articles obtained from step 1. Then it screened the abstract of the selected articles and compiled a pool of articles that were reviewed, validated, and, if applicable, used for this work. This is step 2 Appraisal from Booth *et al.* (2016).

Step 3 Synthesis is conducted through the next section of “literature review and theory development”. Specifically, the next section reviews the international competitiveness literature from three perspectives – its definitions, theories, and determinants, at country, industry, and firm levels – with a particular focus on tracking the development of competitiveness theories in various strands of literature and identifying competitiveness drivers. Step 4 Analysis is conducted in the theory development, discussion, and conclusion sections of this article, where a framework of competitiveness and the 4IR is developed and discussed, which also suggests future research.

## LITERATURE REVIEW AND THEORY DEVELOPMENT

### The Fourth Industrial Revolution

In order to better understand international competitiveness under the background of the Fourth Industrial Revolution (4IR), the literature review starts by briefly introducing and discussing the 4IR.

Looking back at the history, the First Industrial Revolution (1IR) utilised water and steam to mechanise production. The Second Industrial Revolution (2IR) used electric power to create mass production, assembly line, and the division of labour. The Third Industrial Revolution (3IR) witnessed the development of semiconductor, information technology, personal computer, the Internet, and automated production. The 4IR is based on the technologies and infrastructures developed in the 3IR but uses them in entirely new ways in which technology becomes embedded within businesses and societies. Klaus Schwab, the founder and executive chairman of the World Economic Forum (WEF) and the author of the book *“The Fourth Industrial Revolution”*, describes 4IR as a “technological revolution that will fundamentally alter the way we live, work, and relate to one another” (Schwab, 2015). The concept of the 4IR was recently made popular by the discussions in WEF’s 2016 annual meeting.

Schwab (2016) identifies three sets of deeply interrelated megatrends that drive the 4IR – physical, biological, and digital. Physical megatrends include advanced robotics, autonomous vehicles, 3D printing, and new materials. Biological megatrends include biotechnology, neuroethologies, and genome projects. Digital megatrends, probably the most important ones, refer to developments such as artificial intelligence (AI), the Internet of Things, Blockchain, cloud technology, big data, virtual and augmented reality. The digital revolution is creating radically new approaches to the way in which individuals, businesses, and governments engage and collaborate. For example, the Internet of Things facilitates

the connection between people and things (products, services, places, etc.). Blockchain, a secured ledger that records transactions in an efficient, verifiable and permanent way (Iansiti & Lakhani, 2017), creates a decentralised system in transactions. Table 2 lists ten most influential emerging 4IR technologies in the physical, biological, and digital megatrends, based on a study of PwC (2017) with brief explanation for each technology.

**Table 2. Ten most influential emerging 4IR technologies**

Technology	Description
<b>Most influential 4IR technologies in the physical megatrends</b>	
Advanced robotics	Electro-mechanical machines or virtual agents that automate, augment, or assist human activities, autonomously or through set instructions.
Autonomous vehicles and drones	Vehicles and drones that can operate and navigate with little or no human controls.
3D printing	Additive manufacturing techniques that create three dimensional objects based on “printing” successive layers of materials.
Advanced materials	Materials with significantly improved functionality, including lighter weight, stronger, more conductive materials, e.g. nano-materials.
<b>Most influential 4IR technologies in the biological megatrends</b>	
Synthetic biology	Inter-disciplinary branch of biology applying engineering principles to biological system.
<b>Most influential 4IR technologies in the digital megatrends</b>	
Artificial Intelligence (AI)	Software algorithms capable of performing tasks that normally require human intelligence, e.g. visual perception, speech recognition, and decision-making.
Internet of Things	Networks of objects embedded with sensors, software, network connectivity and computer capability, which can collect and exchange data over the Internet and enable smart solutions.
Blockchain	Distributed electronic ledger that uses software algorithms to record and confirm transactions with reliability and anonymity.
Cloud technology and big data	Enables the delivery of computer applications and services over the internet, reducing storage and computer power needs. Big data enabled by cloud form allow predictive relationships for optimisation.
Virtual & augmented reality (VR & AR)	Computer-generated simulation of a three-dimensional image overlaid to the physical world (AR) or a complete environment (VR).

Source: adapted from PwC, 2017, p. 9.

In a white paper, UBS (2016) argues that while all previous industrial revolutions are driven by advancement in automation and connectivity, the technology-driven 4IR is based on the forces of “extreme automation” and “extreme connectivity”. Extreme automation considers the growing importance of robotics and AI in business, government, and personal life. Extreme connectivity mitigates distance and time as obstacles to deeper and faster communication between and among humans and machines, and therefore gives rise to the increased reliance on Internet-enabled devices and social media. As a result of these developments, a growing number of new business models have emerged, such as the sharing economy (i.e. UBER & AirBnB) and crowdfunding (i.e. Kickstarter, Indiegogo, LendingClub).

As the concept of the 4IR was only recently brought into attention of policymakers and academics, studies that examined the impact of the 4IR on competitiveness are quite limited, although the effect of certain technologies on certain areas of business has been studied but still in the early stage. For instance, Yermack (2017) conceptually examines the potential use and impact of blockchain in corporate governance. Of the available studies, Schwab (2015, 2016) argues that the 4IR has the potential to dramatically improve efficiency and productivity, raise income, and improve the quality of life. However, it comes at a cost of employment, with automation and de-centralised system replacing human jobs, especially the low-skilled ones (Schwab, 2015, 2016; UBS, 2016). Through the literature review on various perspective of competitiveness in the next few subsections, this article discusses how we should understand international competitiveness under the 4IR.

### **Definitions of Competitiveness at Country, Industry, and Firm Levels**

National competitiveness is usually associated with high living standards and locational attributes which drive growth and prosperity over the long term (Delgado *et al.*, 2012). There are two competing views of competitiveness: the cost & market share-based view versus the productivity-based view. The discussion of competitiveness first started in the 1980s when the U.S. competitiveness was challenged by the rise in international competition from countries like Japan. Back then, competitiveness was associated with lower labour costs and home country policies that protected and helped companies gain market shares in both domestic and global markets (e.g. export subsidies in Brander & Spencer, 1985; strategic trade policies of Krugman, 1986), that is, the costs & market share-based view. Based on this view, low labour costs and favourable home country policies are considered as signs of competitiveness that lead to lower unemployment, higher exports, higher FDI, and sustainable balance of payments (Ketels, 2016).

The productivity-based view of competitiveness identifies productivity as the central driver of competitiveness and prosperity (e.g. Delgado *et al.*, 2012; Krugman, 1990, 1994; Porter, 1990). Both Krugman (1990, 1994) and Porter (1990), two authors that shape the fundamentals of contemporary competitiveness frameworks in economics and management literatures, respectively, directly link competitiveness to productivity. In addition, the Global Competitiveness Report (GCR) of WEF defines competitiveness as “the set of institutions, policies, and factors that determine the level of productivity of an economy, which in turn determines the level of prosperity a country can achieve” (GCR, 2017, p. 54). Compared to the costs & market share-based competitiveness that can be short-lived, productivity-based competitiveness focuses on a nation’s long-term growth with a future development perspective.

Definitions of competitiveness at the industry level and firm level are similar and therefore are examined together in this article. At both the industry and firm levels, competitiveness is defined as an industry or firm’s ability (1) to produce and sell products and services of superior quality, lower costs, and better innovation than its domestic and international competitors, and (2) to better satisfy the needs of various other stakeholders, such as providing superior returns to shareholders and providing a safe workplace for workers (e.g. Buckley, Pass, & Prescott, 1988; Chikan, 2008; Momaya, 1998).

### Theories of Competitiveness

Studies on international competitiveness date back to Adam Smith's "absolute advantage theory" and David Ricardo's "comparative advantage theory" (Bhawsar & Chattopadhyay, 2015; Cho & Moon, 2013). Subsequent studies focus on the determination of trade flows in terms of comparative advantage, with a particular focus on the opportunity costs of producing different goods domestically. For instance, the "Heckscher-Ohlin theory" (Heckscher, 1919; Ohlin, 1933) states that comparative advantage between countries is the result of their differences in the abundance of natural and factor endowments. The theory suggests that a nation should specialise in producing and exporting products which require more intensive use of locally abundant factors of production. Following this path, later studies separate capital into human capital (skilled labour) and physical capital, and examine them in greater depths (e.g. Baldwin, 1971; Kravis, 1956).

The seminal work of Posner (1961) shifts our focus away from intersectoral opportunity costs and argues that one of the main sources of advantage of a country is its relative technological position against its competitors. After Posner (1961), a strand of literature follows the technology-gap theory of international trade – that is, trade flows are primarily driven by widespread technological asymmetries between countries (e.g. Amable & Verspagen, 1995; Cimoli, 1988; Dosi, Grazzi, & Moschella, 2015; Dosi, Pavitt, & Soete, 1990; Krugman, 1979a). For instance, Amable and Verspagen (1995) indicate that technological capacities (patents and investments in technology) are major determinants in shaping the dynamics of exports. Vernon's (1966) "product life cycle theory" further contributes to the technology-gap literature, with the argument that comparative advantage could be shifted from developed nations to developing nations through the flow of technology over time. Audretsch and Feldman (1996) follow this path by focusing on R&D spillovers.

Contemporary competitiveness theories are built upon the works of Dixit and Stiglitz (1977) and Krugman (1979b, 1980) (see Olczyk, 2016 for a review). Dixit and Stiglitz (1977) model imperfect competition with highly differentiated products and downward-sloping demand curves. In the imperfect competitive market, Krugman argues that increasing returns to scale (Krugman, 1979b, 1980) – that is, productivity-determines trade advantages and the direction of export. Subsequent studies have connected competitiveness to production location (e.g. Krugman, 1991), productivity and trade growth (e.g. Melitz, 2003), and domestic environmental regulations (e.g. Copeland & Taylor, 2004).

In the management literature, international competitiveness theories are based on Porter's (1990) Diamond Model. The model illustrates four country-specific determinants of competitiveness – factor endowments, demand conditions, related and supporting industries (clusters), and firm strategy, structure, and rivalry-with two external factors – chance and government. This model explains factors which make a nation a successful home base for a particular industry and how firms could take advantage of the favourable conditions. Further development of the Diamond Model includes Moon, Rugman and Verbeke (1998), Moon and Cho (2000), and Cho, Moon and Kim (2009). Moon *et al.*'s (1998) "generalized double diamond model" incorporates both domestic and international diamond and emphasizes foreign direct investment (FDI) of a nation. Moon and Cho (2000) add to the Diamond Model four human resource related variables – workers, politicians

and bureaucrats, entrepreneurs, and professionals. Cho *et al.*'s (2009) "dual double diamond" model integrates the international context of the double diamond model and the human factors, and therefore covers four dimensions of domestic physical factors, domestic human factors, international physical factors, and international human factors.

At the industry and firm levels, companies need to take advantage of their home country competitiveness (Porter, 1990). Empirically, research shows that 36% of the variance in profitability could be attributed to the firms' characteristics and actions (McGahan, 1999). Extant literature mostly follows a resource-based view of competitiveness, that is, firm competitiveness is a combination of resources and a firm's capabilities to use these resources. The resource-based view can be considered as closely related to Porter's Diamond model, considering factor endowment, demand conditions, and clusters as resources, and firm's strategy, structure, rivalry, and interaction in its clusters as capabilities to use the resources.

Even though literature agrees on the resource-based view, resources and capabilities are modelled in various ways (see Wach, 2014 for a review). For instance, Prahalad and Hamel (1990) propose that a firm's competitiveness, in the short run, is the outcome of price and performance attributes of its existing products; and in the long run, comes from the firm's ability to build products at lower cost and more speedily than competitors. Buckley, Pass and Prescott (1992) model three competitiveness dimensions: (1) competitive performance, (2) competitive potential (i.e. resources used to generate performance), and (3) competitive process (i.e. management of the company). Ajitabh and Momaya (2004) propose the asset-processes-performance (APP) framework. They argue that firms' competitiveness depends on the combination of tangible and intangible assets (e.g. materials, technology, reputation, trademarks, and human resources) and the process within the organisation (e.g. strategic management process, human resources process, operations management process, and technology management process). Assets and process contribute to the firm's competitive performance which is reflected in productivity, quality, costs, and financial, technological and international performance.

Within this resource-based view of competitiveness, one strand of research focuses in particular on innovation and entrepreneurship. Ma and Liao (2006) model three sources of firm competitiveness as (1) technological capability (R&D capability and manufacturing capability), (2) resource exploiting capability (technological learning, human resource), and (3) managerial capability (organisational and marketing). Man, Lau and Chan (2002) develop a competitiveness framework for small and medium-sized enterprises (SMEs). They propose that other than general factors applicable to all firms, entrepreneur attributes such as experience, knowledge, and skills are particularly important for SMEs. They suggest that SMEs need to focus on building entrepreneurial competencies in order to gain competitiveness. Subsequent work of Daszkiewicz and Wach (2012) model the competitiveness of SMEs as results of business innovativeness, internationalisation, and the formal and informal networks. Other studies which examine competitiveness of small business and entrepreneurs include Acs and Amorós (2008), Audretsch, Hülsbeck and Lehmann (2012), and González-Pernía, Peña-Legazkue and Vendrell-Herrero (2012).

Table 3 summarises theories of competitiveness and their developments.



**Table 3. Theories of competitiveness and their developments**

Theories	Description & development
<b>Panel A: Country level theories</b>	
Absolute Advantage Theory & Comparative Advantage Theory	<ul style="list-style-type: none"> <li>- Based on Smith (1776), Ricardo (1817), absolute or comparative advantage determines trade flow.</li> <li>- Subsequent studies include Baldwin (1971), Kravis (1956), Heckscher (1919), and Ohlin (1933), among others.</li> </ul>
Technology -Gap Theory of International Trade	<ul style="list-style-type: none"> <li>- Based on Posner (1961), trade flows are primarily driven by widespread technological asymmetries between countries.</li> <li>- Later developed by Vernon's (1966) "product life cycle theory" on the shift of technology from developed to developing nations.</li> <li>- Subsequent studies include Amable and Verspagen (1995), Audretsch and Feldman (1996), Cimoli (1988), Dosi <i>et al.</i>, (1990, 2015), and Krugman (1979a), among others.</li> </ul>
New Trade Theory	<ul style="list-style-type: none"> <li>- Based on Dixit and Stiglitz (1977) and Krugman (1979b, 1980), productivity growth is the main driver of competitiveness in the imperfect competitive market.</li> <li>- Subsequent studies include Copeland and Taylor (2004), Krugman (1991), and Melitz (2003), among others.</li> </ul>
Diamond Model	<ul style="list-style-type: none"> <li>- Based on Porter (1990), competitiveness depends on long run productivity. The four underlying conditions driving the competitiveness of a country's companies include: factor endowments, demand conditions, related and supporting industries (clusters), and firm's strategy, structure, and rivalry.</li> <li>- Further developments of the Diamond Model include Moon <i>et al.</i>'s (1998) "generalized double diamond model", Moon and Cho's (2000) addition of human factors, and Cho <i>et al.</i>'s (2009) "dual diamond model".</li> </ul>
<b>Panel B: Industry- &amp; firm – level theories</b>	
Resource-based Theory	<ul style="list-style-type: none"> <li>- Firm &amp; industry level competitiveness is a combination of resources and a firm's or industry's capabilities to use these resources.</li> <li>- Prahaland and Hamel (1990): price &amp; performance combination.</li> <li>- Buckley <i>et al.</i> (1992): performance, potential, and process.</li> <li>- Ajitabh and Momaya (2004): asset-processes-performance (APP).</li> </ul>
New development of Resource-based Theory: innovation & entrepreneurship	<ul style="list-style-type: none"> <li>- Ma and Liao (2006): technological capability, resource exploiting capability, managerial capability.</li> <li>- Man <i>et al.</i> (2002): entrepreneurs' characteristics.</li> <li>- Daszkiewicz and Wach (2012): business innovativeness, internationalisation, and formal and informal networks.</li> </ul>

Source: own study.

### Determinants of Competitiveness: Macroeconomic Factors

Literature has identified two broad categories of the determinants of international competitiveness: macroeconomic conditions and microeconomic strategies. Macroeconomic conditions set a context which creates opportunities for competitiveness at national, regional, and cluster levels and sets the stage for the firm level competitiveness. Macroeconomic determinants include factors such as institutions (e.g. rules and regulations), economic and

financial policies and developments, physical infrastructure and geographic factors. Microeconomic strategies have a direct impact on a firm's competitiveness and include factors such as the sophistication of a firm's strategies and operation, and its interaction with other firms (i.e. clusters). Within the Diamond framework, macroeconomic conditions set the factor endowment, demand conditions, and structure of the clusters and rivalry, whereas microeconomic drivers are mostly related to a firm's strategy, structure, its response to rivalry and interaction within clusters. This subsection reviews literature on macroeconomic conditions and the next subsection on microeconomic drivers.

Examining the macroeconomic factors of competitiveness, the first driver is institutions, mostly rules and regulations that governments impose on markets and companies. Institutions define a broader context in which regulations and policies are made and industry- and firm-level productive activities take place, and therefore have long been a focus of competitiveness analysis (Delgado *et al.*, 2012). A number of studies have found a significant long-term relationship between the nature of institutions and the competitiveness at country, industry, and firm levels (e.g. Hall & Jones, 1999). Particular aspects of institutional quality that have been carefully examined include the rule of law (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1998), the quality of government (Kaufmann, Kraay, & Mastruzzi, 2008), corruption (Shleifer & Vishny, 1993), colonial origins (Acemoglu, Johnson, & Robinson, 2001), and the overall regulatory quality (Brunet, 2012).

Macroeconomic policy, including monetary and fiscal policy, as well as the stage and development of a nation's economy and market are also the focus of competitiveness research. Factors found to be important to long-term competitiveness of a nation and companies within the nation include monetary policy and interest rate (e.g. Sinn, 2014), exchange rate and related policy (e.g. Cooper, 2014; Gulati, Knif, & Kolari, 2013), access to capital (e.g. Ragan & Zingales, 1998), restrictions on capital flows (e.g. Delgado *et al.*, 2012), government spending and taxation (e.g. Vietor & Weinzierl, 2012), innovation policy (e.g. Furman, Porter, & Stern, 2002), environmental policy (e.g. Esty & Porter, 2005), and the quality of administrative practices, such as low costs and fast process of starting a business (e.g. Branstetter, Lima, Lowell, & Venancio, 2014). As a result of various policies, developments of physical infrastructure (e.g. Garcia-Milà, McGuire, & Porter, 1996) and human capital, including quantity and quality of workforce training, higher education, managerial education and research (e.g. Krueger & Lindahl, 2001), have also been found to be important drivers for competitiveness at the macroeconomic level. A country's policy and the degree of openness also have a significant impact on competitiveness (e.g. Dollar & Kraay, 2003). Specifically, openness impacts international knowledge transfer (e.g. MacGarvie, 2006). In addition, sophisticated and demanding domestic buyers are also considered as important macro-level drivers, as they allow firms to anticipate future changes and opportunities in other markets and thereby encourage domestic firms to innovate and build profitable international position that are difficult for foreign firms to match (Porter, 1990).

Prior studies have also found that competitiveness is related to a country's endowments, such as geographic location (e.g. climate, time zone, and coastlines) (e.g. Gallup, Sachs, & Mellinger, 1999) and natural resource (e.g. Van der Ploeg, 2011). In this review, the author considers endowments as important macro-level drivers for national and firm competitiveness. Table 4 summarises the macroeconomic factors discussed above, along with selected studies of each factor.

**Table 4. Macroeconomic determinants of competitiveness based on selected previous studies**

Factors	Discussion
Institutions: rules and regulations	<ul style="list-style-type: none"> <li>- overall impact (Hall &amp; Jones, 1999),</li> <li>- rule of law (La Porta <i>et al.</i>, 1998),</li> <li>- quality of government (Kaufmann <i>et al.</i>, 2008),</li> <li>- corruption (Mauro, 1995; Shleifer &amp; Vishny, 1993),</li> <li>- colonial origins (Acemoglu <i>et al.</i>, 2001),</li> <li>- regulatory quality (Brunet, 2012).</li> </ul>
Economic and market policies and developments	<ul style="list-style-type: none"> <li>- monetary policy and interest rate (Andr�n &amp; Oxelheim, 2002; Sinn, 2014),</li> <li>- exchange rate policy (Andr�n &amp; Oxelheim, 2002; Cooper, 2014; Gulati <i>et al.</i>, 2013),</li> <li>- access to capital (Aghion, Howitt, &amp; Mayer-Foulkes, 2007; Ang, 2008; King &amp; Levine, 1993; Rajan &amp; Zingales, 1998),</li> <li>- restrictions on capital flows (Delgado <i>et al.</i>, 2012),</li> <li>- government spending and taxation (Viator &amp; Weinzierl, 2012),</li> <li>- innovation policy (Fagerberg, 1988; Furman <i>et al.</i>, 2002; Jaffe, 1995),</li> <li>- environmental policy (Esty &amp; Porter, 2005; Porter &amp; Van der Linde, 1995),</li> <li>- costs of starting a business (Branstetter <i>et al.</i>, 2014),</li> <li>- workforce training, higher education, managerial education and research (Genaioli, La Porta, Lopez-de-Silanes, &amp; Shleifer, 2013; Krueger &amp; Lindahl, 2001),</li> <li>- physical infrastructure (Aschauer, 1989; Garcia-Mil� <i>et al.</i>, 1996; Gramlich, 1994),</li> <li>- nation-wide human capital (Krueger &amp; Lindahl, 2001)</li> <li>- openness and international knowledge transfer (Baldwin, 2004; Bernard &amp; Jensen, 1999; Bernard, Jensen, Redding, &amp; Schott, 2007; Branstetter, 2006; Coe &amp; Helpman, 1995; Dollar &amp; Kraay, 2003; Frankel &amp; Romer, 1999; MacGarvie, 2006),</li> <li>- sophisticated and demanding local buyers (Porter, 1990).</li> </ul>
Endowment	<ul style="list-style-type: none"> <li>- geographic location (e.g. Gallup <i>et al.</i>, 1999),</li> <li>- natural resource (e.g. Van der Ploeg, 2011).</li> </ul>

Source: own study.

### Determinants of Competitiveness: Microeconomic Factors

While the macroeconomic drivers discussed above create an environment in which businesses can gain competitiveness, it depends on the firm itself to grab the opportunities. Microeconomic factors are those which have a direct influence on the firm's productivity. This article categorises microeconomic factors into two groups: (1) firm strategy and structure which refer to the sophistication of various strategies and operations of a firm, and (2) cluster and rivalry which examine how a firm interacts with other firms in its clusters and deals with rivalry.

First, previous studies that examine the impact of firm strategy on competitiveness have found a significant role of strategic management (e.g. Porter, 1990), financial management (e.g. Salazar, Sot, & Mosqueda, 2012), human resource management (e.g. Oishi, 2013), operation and manufacturing management (e.g. Russell & Taylor, 2006), marketing management (e.g. Shang *et al.*, 2009), innovation strategy (e.g. Forsman, Temel, & Uotila, 2013), information technology (IT) management (e.g. Ross, Beath, & Goodhue, 1996), internationalisation strategy (e.g. Delgado *et al.*, 2012), sustainability (e.g. Rao & Holt, 2005) and corporate social responsibility (CSR) (e.g. Zhang, 2013), among others. Studies have also found the above factors to be important for small business, with the additional entrepreneur attributes, such as experience, knowledge, and skills (e.g. Man *et al.*, 2002). With

respect to firm structure, studies have documented that ownership structures of companies (i.e. private vs. state-owned, conglomerate vs. single-business) are important for efficiency and competitiveness (Megginson & Netter, 2001).

Second, clusters of related and supporting industries are geographic agglomerations of companies, suppliers, service providers, and associated institutions in a particular location (Porter, 1990, 1998). Porter (1998) argues that firms in a cluster are often better able to perceive new buyer needs, actions of other firms, and new technological and operational opportunities. The interconnections among firms and industries within a cluster facilitate knowledge spillovers and thereby increase firms' capacity for innovation and stimulating new business formation. Empirical evidence shows that the presence of strong clusters enables companies to achieve high productivity and raises regional performance (Feldman & Audretsch, 1999; Glaeser & Kerr, 2009; Delgado *et al.*, 2010, 2014). Studies have also examined strategies of cluster management (e.g. Ketels *et al.*, 2012).

For domestic rivalry, studies have found high levels of competition on local markets to be crucial for performance (e.g. Porter & Sakakibara, 2004). Specifically, from an industry perspective, competition affects industry dynamics including the entry of new firms, the exit of underperforming old firms, and the performance patterns across existing firms (e.g. Bloom, Sadun, & Van Reenen, 2012). Table 5 summarises the microeconomic factors and strategies discussed above.

**Table 5. Microeconomic determinants of competitiveness based on selected previous studies**

Factors	Discussion
Firm strategy and structure	<ul style="list-style-type: none"> <li>- strategic management (Grupp, 1997; Loch, Chick, &amp; Huchzermeier, 2008; Porter, 1990),</li> <li>- financial management (Randøy, Oxelheim, &amp; Stonehill, 2001; Salazar <i>et al.</i>, 2012),</li> <li>- human resource management (Delgado <i>et al.</i>, 2012; Oishi, 2013; Smith, 1995; Wright, Ferris, Hiller, &amp; Kroll, 1995),</li> <li>- operation and manufacturing management (Corbett &amp; Van Massenhove, 1993; Mehra, 1998; Rao &amp; Holt, 2005; Russell &amp; Taylor, 2006),</li> <li>- marketing management (Shang <i>et al.</i>, 2009),</li> <li>- innovation (Bosma, Stam, &amp; Schutjens, 2011; Dangelico &amp; Pujari, 2010; Forsman <i>et al.</i>, 2013; Grupp, 1997; Reeve &amp; Deimler, 2011),</li> <li>- IT management (Ollo-López &amp; Aramendía-Muneta, 2012; Ross <i>et al.</i>, 1996),</li> <li>- internationalisation strategy (Altomonte &amp; Ottaviano, 2011; Delgado <i>et al.</i>, 2012),</li> <li>- sustainability and CSR (Dangelico &amp; Pujari, 2010; Rao &amp; Holt, 2005; Zhang, 2013),</li> <li>- small business strategies &amp; management (Acs &amp; Amorós, 2008; Audretsch <i>et al.</i>, 2012; Daszkiewicz &amp; Wach, 2012; González-Pernía Peña-Legazkue, &amp; Vendrell-Herrero, 2012; Horne, Lloyd Pay, &amp; Roe, 1992; Man <i>et al.</i>, 2002),</li> <li>- ownership structures (Megginson &amp; Netter, 2001).</li> </ul>
Firm rivalry and interaction in clusters	<ul style="list-style-type: none"> <li>- benefits of clusters (Delgado <i>et al.</i>, 2010, 2014; Feldman &amp; Audretsch, 1999; Glaeser &amp; Kerr, 2009; Porter, 1998),</li> <li>- cluster management (e.g. Ketels <i>et al.</i>, 2012),</li> <li>- benefits of rivalry and industry dynamics (Bloom &amp; van Reenen, 2007; Bloom <i>et al.</i>, 2012; Nickell, 1996; Porter &amp; Sakakibara, 2004).</li> </ul>

Source: own study.

As a result of understanding the macro- and micro- level factors, measures of competitiveness usually take a multi-dimensional approach that captures all recognized factors. Two most used measures, the *Global Competitiveness Report* (GCR) published by

WEF and the IMD’s *World Competitiveness yearbook* (WCY), both consider drivers of competitiveness by including factors such as institutions, macroeconomic environment, education, financial market development, innovation, among others. The measurements of the factors are then aggregated to calculate an overall ranking.

### Competitiveness in the Era of the 4IR

While previous studies in competitiveness literature have extensively examined the role of technology and innovation (see Dosi *et al.*, 2015 for a review), this article models competitiveness in the era of the 4IR through an ecosystematic approach. The 4IR could impact competitiveness at country-, industry-, and firm- levels, and through both the macroeconomic and microeconomic drivers. As a result, all relevant parties, including governments, businesses, and individuals should react in a systematically consistent way. This subsection synthesises the discussions above and presents a competitiveness model in the era of the 4IR (Figure 1). More discussions on policy implication and managerial actions of the model are included in the “Discussion” section.

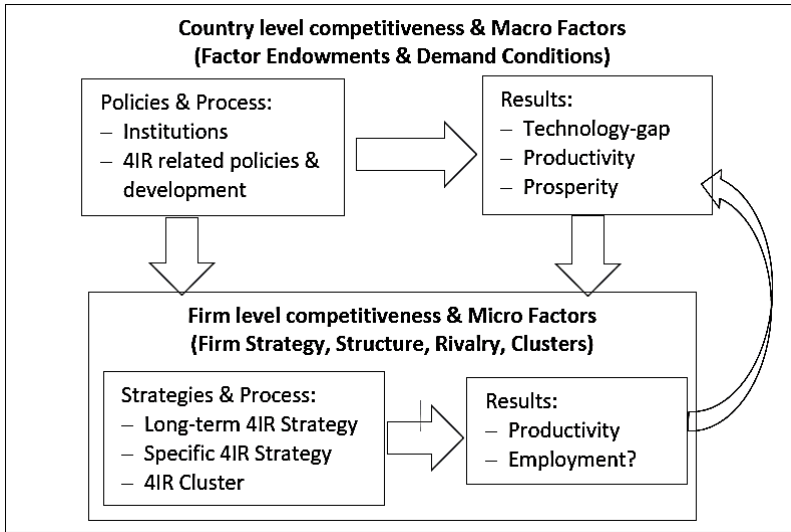


Figure 1. An ecosystematic approach to competitiveness in the era of the 4IR

Source: own elaboration.

First, macroeconomic factors and their cross-border differences determine national competitiveness, which also set the context for the industry- and firm- level competitiveness. Specifically, institutions and 4IR-related policies and developments (such as development of innovation and IT infrastructure) could potentially increase a country’s technology advantage compared to other countries, therefore improving the country’s competitiveness. This is consistent with the technology-gap theory of international trade literature. Technological advancements from the 4IR would also improve productivity and potentially prosperity of a nation.

At the micro level, a firm’s long-term strategy and its specific operations in various areas such as finance and marketing towards 4IR-related advancement could improve its productivity and competitiveness. The 4IR could also change firms’ interaction

within a cluster, by either changing the dynamics within the cluster, such as the increasingly important role of research-oriented universities, or adding new players into a cluster, such as cloud-based big data providers. Together, firm strategies and new cluster dynamics should improve productivity but may come at a cost of employment with the threat of automation that replaces current low-skill jobs.

Between the macro (national) and micro (firm) level, macro-level policies and results set the context and therefore impact the micro-level dynamics. Also, the firm level results on competitiveness and employment from the 4IR would also change the country level results and national competitiveness, which in turn impact 4IR-related policies.

## DISCUSSION

This section further discusses the ecosystematic approach of competitiveness under the 4IR (Figure 1), with a particular focus on the impact of the 4IR on competitiveness definitions and theories, and its policy and managerial implications. Future research directions are also addressed here.

### Definitions and Theories of Competitiveness under the 4IR

First, the technological advancement and the economic development have shifted the focus of competitiveness from the cost & market share-based view to the productivity-based view. Extreme automation in the 4IR has the potential to take over low cost labours, and therefore make nations and firms which rely on low cost labours less competitive. Similarly, nations and firms that currently suffer from high labour costs could become more competitive by using automation. With the 4IR, we see the increasing importance of innovation and the need to improve productivity to sustain and gain competitiveness at all levels. This has an important policy implication – to achieve prosperity, the goal for economic and business policies should be to facilitate companies to access emerging technologies and incorporate these technologies into companies' innovation and operational processes.

Second, applying the technology advancement of the 4IR to theories of competitiveness, we need to focus on the role of technology in forming a nation's competitiveness and the technological transfer from developed countries to the emerging markets, following the path of the technology-gap theory. There are two opposing ways in which the 4IR could potentially affect comparative advantage of nations. On the one hand, extreme connectivity facilitates the transfer of technology and therefore reduces the gap between countries in technology-based and knowledge-based comparative advantages. On the other hand, because of its well-developed infrastructure and the pools of high-skill works, developed nations could take advantage of the 4IR in ways that emerging markets cannot, which leads to a larger gap of competitive/comparative advantages between these countries. It is an empirical question with regard to which effect dominates and how different country-level institutions and developments can mitigate the effect, which calls for future research.

### Ecosystematic Approach of Competitiveness under the 4IR

Using Figure 1 as a framework, this article suggests that government, business, society, and individuals respond to the 4IR in a systematic way, as the 4IR significantly influences all parties involved. First, the development of the 4IR requires a nation to provide innovation-friendly

institutions where regulations and social norms promote innovation, creativity, entrepreneurship, and collaboration. For instance, as intellectual property (IP) becomes vital in the 4IR, a nation's robust IP protection will contribute to its competitiveness. This is because strong IP protection will encourage innovators to capitalise on their idea and attract investors, such as venture capital and angel investors, which eventually improves the whole ecosystem and clusters of innovation. Also, local policies which reduce the cost and the number of days of opening and registering a business can also help promote entrepreneurial ideas.

Protections for investors, such as the creditors' right and minority shareholder protection, are also vital to allow the well-functioning of financial markets that fund innovations. This is particularly important for new ways of entrepreneurial finance, such as equity or debt crowdfunding – the practice of funding a project or business online by raising funds from a large number of people. Crowdfunding, along with venture capital and angel investors, makes it easier for companies and entrepreneurs to raise fund for new business ideas and various forms of innovation. Stable interest rates and exchange rates also allow investors to better manage risk, thereby better encouraging investors to fund innovations.

Second, the 4IR changes the combination of factors of production for a firm to be successful. While traditional businesses depend on heavy investment in tangible assets and human capital to achieve economies of scale, new businesses in the 4IR are able to use a small amount of capital and human resources investment and fewer tangible assets to achieve economies of scale. This is achieved again through the extreme automation and connectivity. Examples include the sharing economy and the crowdsourcing models of doing business. Besides the benefit it brings, the 4IR also requires significant advancement of the factors of production, including (1) education systems that teach content and competence relevant to the 4IR and equip students to work in a complex, digital, and changing environment, (2) high-skilled workers who are able to understand new technology more effectively and to adapt and maximise subsequent economic returns, and (3) better information and communication technology (ICT) infrastructure to support new developments, such as blockchain, big data and cloud computing, and to ensure cyber security (UBS, 2016).

Third, demand conditions and the clusters of related and supporting industries have also been changed, in particular by the Internet of Things which brings consumers closer to its production. Companies can get instant feedback from customers through social media, which leads to more sophisticated and demanding consumers. This also eliminates some players in the value chain (i.e. different levels of wholesalers), ultimately changing the structure of a cluster. Another example is the use of big data that allows businesses to better understand consumers' needs and patterns, thereby cutting costs, boosting profits, and increasing competitiveness. Big data also change the composition of business clusters as big data providers, software firms, and cyber security companies are now important players.

Fourth, firms need to design strategies and structures that take advantage of the 4IR. For instance, with the increased connectivity among various stakeholders of a company, information becomes more available and organisational structure becomes more flattened. The degree of competition is also likely to change with more business selling on the Internet. On an international level, while trade was once dominated by large (multinational) companies, today low costs of communication and transactions open up international business to smaller firms and entrepreneurs around the world. This shift

changes companies' global strategies and competition dynamics, which requires businesses, large and small, to be prepared for and take advantage of.

Fifth, we also need to understand some potential threats of the 4IR to national prosperity and standard of living. As the 4IR leads to extreme automation, low-skill jobs (e.g. assembly line work), which have already been heavily affected by basic automation, could be further impacted. In addition, an increasing range of middle-skill jobs will also become vulnerable (UBS, 2016). One example is the rise of robo-advising in banks and asset management – algorithm-based financial advising that automatically allocate and manage clients' assets with minimal human intervention, which has started to take away some jobs from human advisors. Automation from the 4IR leads to an increase in unemployment rate, imposing a negative impact on the standard of living of the unemployed.

Another potential challenge is the de-centralised global system enabled by the blockchain technology, which relies for its existence on the interconnection of a large number of computers without a centralised supervision and monitoring agent. While it has many advantages, such as keeping unchangeable and permanent records and significantly lowering cross-border transaction costs, it imposes challenges for tracking cross-border capital flows, and its anonymity encourages crimes. Future research needs to address these threats and challenges that the 4IR may impose on prosperity and competitiveness, and empirically tests the pros and cons of the 4IR in various areas.

## CONCLUSIONS

This article conducts a systematic literature review on the definitions, theories, and determinants of international competitiveness. The literature review addresses links among competitiveness at country, industry, and firm levels, as well as the interconnection between macroeconomic drivers and the micro-level firm strategies. This calls for an ecosystematic approach to model competitiveness under the Fourth Industrial Revolution, which this article does. Implications for the country level policies, as well as the firm level strategies are also discussed.

This article is limited in the following ways. First, as the concept of the 4IR and its many technologies are still in the early stage, many of the arguments on policy and managerial implications are based on the author's speculation, without much theoretical or empirical support. Second, with the early stage of many technologies, their real impacts have yet to be materialised and therefore this study is at best exploratory.

The 4IR has been affecting and will continue to change our understanding of international competitiveness. This calls for more future theoretical research which will model the 4IR into the competitiveness framework and empirical works to examine the impact of the 4IR. This could be achieved either through adding extreme automation and connectivity as new factors and sources to current competitiveness frameworks or by examining how technology and new business model impact the effect of current factors. This effect can also be examined under different national institutional and economic conditions. Another potential strand of literature is to explore the country-level evidence of the 4IR and its impact on productivity and the standard of living. Yet another direction of future research is to evaluate whether current competitiveness measures are still capturing the true competitiveness and if not, to build some theoretical work to guide the weights assigned to competitiveness drivers, considering the impact of the 4IR.



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#### Author

##### Chen Liu

Assistant Professor in Finance at the School of Business at Trinity Western University (Canada). PhD in Finance from the Smith School of Business at Queen's University (Canada). Research areas include finance, financial technology (FinTech), entrepreneurship, and international business. Extensive experience in finance and entrepreneurship teaching and consulting.

**Correspondence to:** Dr. Chen Liu, School of Business, Trinity Western University; 7600 Glover Road, Langley, B.C., Canada; e-mail: [Chen.Liu@twu.ca](mailto:Chen.Liu@twu.ca)

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