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Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing

Georg Reischauer

WU Vienna University of Economics and Business, Welthandelsplatz 1, 1020 Vienna, Austria

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ABSTRACT

We are witnessing an increasing adoption of digital technologies in manufacturing industries around the globe. This trend is often debated under the label Industry 4.0. A key claim put forward in these debates is that Industry 4.0 represents a revolution that will reshape manufacturing industries akin to previous industrial revolutions. Despite the popularity of this claim, it provides little help to clarify the identity of Industry 4.0. Such a clarification is however much needed given the worldwide proliferation of digital technologies in manufacturing industries. I address this gap by arguing to view Industry 4.0 as policy-driven innovation discourse in manufacturing industries that aims to institutionalize innovation systems that encompass business, academia, and politics. This clarification of the identity of Industry 4.0 adds to a better understanding of the relationship between manufacturing and politics as well as technological change in manufacturing.

1. Introduction

Around the globe we are witnessing an increasing adoption of digital technologies in manufacturing industries. This trend is especially debated under the label of Industry 4.0. A key claim put forward in these debates is that we are at the beginning of a long-term economic up heal also known as long wave that reshapes economic and social life (Ayres, 1990; de Groot and Hans Franses, 2009; Kondratieff, 1935; Korotayev et al., 2011). In essence, it is claimed that Industry 4.0 is a major technological revolution that will reshape manufacturing industries and social and economic life more broadly. In other words, we stand at the beginning of a new industrial revolution (Li, forthcoming; Schwab, 2016; Sung, forthcoming).

Despite the popularity of this claim, it provides little help to clarify the identity of Industry 4.0. Such clarification is however much needed given the worldwide proliferation of digital technologies in manufacturing industries. A case in point for the usefulness of a clarification of the identity of a rapidly emerging phenomenon based on digital technologies is the recent work by Acquier et al. (2017) on the sharing economy, a rapidly diffusing economic phenomenon that puts platforms center stage (Mair and Reischauer, 2017). The authors proposed an organizing framework to clarify the identity and basic characteristics of the sharing economy and thereby provided an important clarification of this phenomenon.

In the spirit of this work, I argue for an innovation-discursive view to clarify the identity of Industry 4.0. This view suggests to consider Industry 4.0 as policy-driven innovation discourse in manufacturing industries that aims to institutionalize innovation systems that encompass business, academia, and politics, an innovation system mode known as Triple Helix mode of innovation. In other words, I argue to think of Industry 4.0 as broader communicative action that mobilizes actors to innovate collaboratively and that is driven yet not determined by politics. With this view, I offer a clarification of the core identity of Industry 4.0 (policy-driven innovation discourse in manufacturing), the intended outcome of Industry 4.0 (innovation systems that encompass business, academia, and politics), and the stability of the intended outcome (institutionalized innovation systems).

The proposed innovation-discursive view follows the advice of Schumpeter (1939) to put the common mobilization amongst enterprises to innovate center stage and the advice of Kim (forthcoming) to more closely consider how politics shapes Industry 4.0. In line with this interdisciplinary work, the proposed view connects key insights from studies of innovation systems (Etzkowitz and Leydesdorff, 2000; Leydesdorff and Etzkowitz, 1998; Späth and Rohracher, 2010) and discursive approaches to institutional theory (Lawrence and Suddaby, 2006; Phillips et al., 2004; Phillips and Hardy, 2002). The innovation-discursive view provides several gains for analyzing the relationship between manufacturing and politics and for analyzing technological change in manufacturing.

The remainder of this paper is organized as follows. In a first step, I briefly elaborate on the Industry 4.0 debate. After that, I illustrate that the long wave theory faces limits to clarify the identity of Industry 4.0. I then suggest and illustrate an innovation-discursive view as alternative view to clarify the identity of Industry 4.0 and demonstrate the

E-mail address: georg.reischauer@wu.ac.at.

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accuracy of this view with an empirical case. I close with discussing the implications of the innovation-discursive view for further analyses as well as policy makers and mangers in manufacturing.

2. Industry 4.0

It is not for the first time that scholars are debating how digital technologies are reshaping manufacturing industries. With the end of the 1950, debates centered how computer-integrated manufacturing (CIM) allows enterprises to improve manufacturing processes (Tchijov, 1989). As Ayres (1990: 6) suggested, manufacturing industries back then are part of an "'post-industrial' society, in which information and telecommunication services are the primary generator of wealth and engine of growth". In a similar vein, around the end of the millennium scholars diagnosed a digital economy where manufacturing industries that provide digital equipment constitute the digital infrastructure (Kim, 2006). In what follows, I briefly turn to Industry 4.0, an important current debate on how new digital technologies are about to change manufacturing. The label is used especially in European nations such as Germany, UK, Italy but also beyond, for example in Korea (Kim, forthcoming; Sung, forthcoming).[1] As this brief discussion will demonstrate, the term Industry 4.0 originated in the context of a innovation policy (Borrás and Edquist, 2013; Laranja et al., 2008; Morlacchi and Martin, 2009).

The perhaps most important proponents in the debate on Industry 4.0 are the German federal government and German federal ministries, especially the Federal Ministry of Education and Research (BMBF). A key driver in the initial debate was a report on the implementation of the "High-Tech Strategie" (High-Tech Strategy), "the first national concept to bring key innovation and technology stakeholders together in a common purpose of advancing new technologies" (GTAI, 2014: 12). Launched in 2006 by the German federal government, the "High-Tech Strategie" was a large-scale national innovation policy with a broad range of funding measures and activities on which reports were issued on a frequent basis. In a report on the implementation of the "High-Tech Strategie" that the BMBF issued in 2012, ten areas for future activities were defined. For each of these areas, it was discussed how key actors from business, academia, and politics in Germany should collaborate to generate innovation. Industry 4.0 - "Industrie 4.0" in German - was one of these ten areas (BMBF, 2013; GTAI, 2014). Also the updated "High-Tech Strategie" that was issued in 2014 explicitly refers to Industry 4.0 within the priority research and innovation policy area "digital economy and society". In fact, Industry 4.0 is listed as the first of eight core fields within this area put ahead of smart services, smart data, and cloud computing, amongst others (BMBF, 2014b).

Other key proponents in the debate on Industry 4.0 were interest groups and advisory councils. In 2013, the German interest groups BITKOM (Association for Information Technology, Telecommunications, and New Media), VDMA (Mechanical Engineering Industry Association), and ZVEI (Electrical and Electronic Manufacturers' Association) collaborated to establish the "Industrie 4.0 Plattform" (Industry 4.0 Platform). Launched in 2013, the platform sought to link these interest groups with respect to co-shaping important aspects related to Industry 4.0. In 2015, the "Industrie 4.0 Plattform" also opened up and included more representatives from business, associations, unions, academia, and politics. As of 2016, 250 representatives from over 100 organizations in the mechanical engineering industry, the electrical and electronic industry, politics, academia, and industry representation are part of the platform (BMBF, 2017). Further important players were acatech (Academy of Science and Engineering) and the "Forschungsunion Wirtschaft – Wissenschaft", an advisory council established to implement and refine the aforementioned "High-Tech Strategie". These two actors issued several important statement regarding Industry 4.0, amongst them a jointly written report with suggestions on how to implement Industry 4.0 that was issued in 2013 (Kagermann et al., 2013).

In the last years, the debates on Industry 4.0 have intensified in both academia and the broader public. Neologisms inspired by Industry 4.0 such as "Arbeit 4.0" (Work 4.0) (Botthof and Hartmann, 2015) and Innovation 4.0 (Reischauer and Leitner, 2016) were created and research on Industry 4.0 in the social and economic sciences (Reischauer, 2015; Reischauer and Schober, 2016). Also other European countries such as Austria, France, Italy, Switzerland, and UK have followed the example of Germany and created platforms as well as funding programs that use the exact same label in German (Austria and German-speaking Switzerland), exact translations (Italy and UK), and very similar labels (France). Moreover, globally active management consultancies such as Boston Consulting Group (BCG, 2015), McKinsey (McKinsey, 2015), and Roland Berger (Roland Berger, 2016) increasingly used the label of Industry 4.0 in their publications. Recently, also the founder and executive chairman of the World Economic Forum argued that we are in the midst of a fourth revolution. While he considers Industry 4.0 as one of several manifestations of this revolution, Industry 4.0 is a key driver of this ongoing revolution (Schwab, 2016).

Typically, two promises for enterprises are put forward in debates on Industry 4.0. First, enterprises can improve significantly in terms of productivity, flexibility, and efficiency (BMBF, 2013; Sung, forthcoming). Second, cyber-physical systems are considered as enabling technology that allows multiple innovative applications and also the innovation of an enterprise's business model (acatech, 2011; Reischauer and Leitner, 2016). Cyber-physical systems refer to technical systems that are embedded into larger systems such as devices, buildings, infrastructures, and production facilities. Cyber-physical systems capture, record, and interpret data from the environment and react to signals in the environment. In contrast to other technologies, cyber-physical systems regulate themselves as they are able to communicate with both human actors and other devices both at a local and global level (acatech, 2011).

Cyber-physical systems underpin the often quoted revolutionary scope of Industry 4.0. The revolutionary scope is already mirrored in the label: "4.0" stands for a fourth industrial revolution that starts today. The updated "High-Tech Strategie" provides a vivid illustration: "Industry now stands at the threshold of a fourth industrial revolution" (BMBF, 2014b: 16). Likewise, a report on Industry 4.0 by the BMBF states how a cluster provides "concrete solutions for the fourth Industrial Revolution" (BMBF, 2014a: 23). Thus, in contrast to earlier debates on the role of new technologies for manufacturing such as computer-integrated manufacturing (Tchijov, 1989), Industry 4.0 explicitly relates to the past revolutions in manufacturing.

3. Long wave theory and its limits of to clarify the identity of Industry 4.0

As the previous chapter illustrated, a key claim regarding Industry 4.0 is that it presents a large scale technological revolution that will reshape manufacturing industries. This claim is core to the long wave theory inspired by Schumpeter (1939) and Kondratieff (1935, originally published in German in 1926). As illustrated in the remainder of this chapter, despite the importance of long wave theory for analyzing economic and social changes, it faces limits to clarify the identity of Industry 4.0.

Long waves or Kondratieff waves are long-term economic up heals that drive the development of the economy and society more broadly. Analytically, a long wave consists of a prosperity phase, a recession phase, a depression phase, and a recovery phase (Coccia, 2010). As already indicated by Schumpeter (1939), innovations are a key driver

[1] In North America, similar debates frequently use the label „smart manufacturing" that also papers by the White House (2016) use. In China, the effects of digitalization on manufacturing are commonly debated under the label "Made-in-China 2025" (Li, forthcoming).