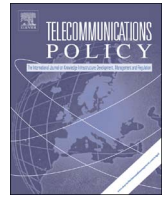




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The evolution of the internet of things industry and market in China: An interplay of institutions, demands and supply

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ABSTRACT

This paper seeks to provide some explanation as to how demand-, supply- and institutions-related factors in China have affected the creation and diffusion of Internet of Things (IoT)-related products and services. Concerning demand side factors the paper demonstrates how potential market size and existing technology trajectory work in favor of IoT diffusion. As a related demand side factor the paper argues that, in terms of the technological trajectory, China has started farther from the frontier than most industrialized countries. The degree of incremental benefit from the IoT is thus higher in the country. As to the supply side factors, the article promotes an understanding of how Chinese technology companies have capitalized on a huge user base to develop IoT-based applications. It also suggests that technologies and expertise provided by foreign multinationals have also played crucial roles. Regarding formal institutions, the government's proactive policies have been a major factor in the IoT's evolution. It is also in the Chinese government's interest to develop IoT products to make censorship and surveillance more effective. Regarding informal institutions, Chinese consumers are less concerned than Westerners about being tracked and monitored, which provides a favorable condition for the adoption of IoT-enabled devices. Nonetheless, this condition is changing due to increasing abuse of consumer privacy. China and the U.S. are compared in terms of diffusion, key determinants, performance indicators and impacts of the IoT in order to understand the areas that China outperforms—and underperforms—the U.S. Some indicators are proposed to gauge the IoT-related performance and the impacts of the IoT.

1. Introduction

The Internet of Things (IoT) is bringing fundamental changes in economic, environmental, healthcare, social and political realms in the developing world (Kshetri, 2016a). It is probably fair to say that among developing countries, China has the most developed IoT industry and related infrastructure. Commenting on the development of the IoT industry and market, one analyst noted that China is “the only big bloc in the world that can still coherently steer on infrastructure, law, spectrum management, hardware, identity management and preferred applications areas” (Sterling, 2013). Some go as far as to say that whereas the U.S. led the PC revolution and Europe played a major role to facilitate the global diffusion of cellphones in the early stage, China is likely to emerge as a global leader in innovation and adoption of the IoT (Friedman, 2014).

Before proceeding, some clarifying definitions are offered. The IoT is the network of physical objects or ‘things’ (e.g. machines, devices and appliances, animals or people) embedded with electronics, software and sensors, which are provided with unique identifiers and possess the ability to transfer data across the Web with minimal or no human interventions. By doing so, the inter-

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connected devices can enhance operational efficiency and create new business and economic opportunities. According to [Gartner \(2016\)](#), there are three components of an IoT service: the edge, the platform and the user. The edge is the location where data originates or is aggregated. Data may also be reduced to the essential or minimal parts. In some cases, data may be analysed. The data then goes to the platform, which is typically in the cloud. Analytics are often performed in the cloud using algorithms. A real-time data streaming decides if some actions need to be taken right away or if the data needs to be stored for future use. The user engages in a business action. Machine to machine (M2M) connections can be considered to be a subset of the IoT, which use wireless networks to connect devices to each other and with the Internet. The IoT can be viewed as an evolution of M2M, which requires the coordination of multiple vendors' machines, devices and appliances connected to the Internet through multiple networks ([GSMA, 2014](#)).

IoT technologies in China are being integrated in traditional industries such as agriculture and manufacturing as well as in newly emerging industries such as new energy and new materials ([Bughim, Chui, & Manyika, 2015](#); [english.gov.cn, 2015](#); [Kshetri, 2016b](#)). According to the GSMA association, which represents 800 operators worldwide in the mobile phone ecosystem, as of 2013, China had over 50 million M2M connections, which made it the world's largest M2M market ([GSMA, 2015a](#)). Note that M2M connections are the dominant form of IoT deployment. It is also worth noting that during 2010–2013, Asia, which is the world's largest regional IoT market, added about 55 million M2M connections, of which 39 million were in China ([McEnaney, 2014](#)). According to GSMA Intelligence and the China Academy of Information and Communications Technology (CAICT), as of the mid-2016, China had about 100 million cellular M2M connections, which is expected to increase to 350 million by 2020 ([Waring, 2016](#)).

While it is not surprising that China, due to its size, is going to be the largest market for some domains of the IoT, there are two points that should be noted about China's IoT industry. First, China has demonstrated an improving trend in IoT-related innovative activities compared to previous generations of technologies. For instance, according to the U.K. Intellectual Property Office, during 2004–2013, China's ZTE ranked #1 on a list of companies worldwide with the most IoT patents. ZTE had about 300 patents during the period. China accounted for 38% of all IoT patents globally ([GBTIMES, 2015](#)). Second, Chinese companies have created some innovative IoT-related products and services. For instance, as of the mid-2015, the Chinese smartphone manufacturer, Xiaomi had over ten IoT-based connected devices such as wristbands, air purifiers, blood pressure monitors and smart TV ([Griffiths, 2015](#)). The company has also created and sold products related to its Mi Smart Home system. In March 2016, Mi Air Purifier was offered for sale in Singapore ([Millward, 2016](#)). Other notable IoT products include Baidu's smart chopsticks to detect food contaminants and an app that has been developed by microblogging service, Sina Weibo and appliance maker Hisense, which can be used to turn on air conditioners using Weibo ([Higginbotham, 2014](#)).

In order to better understand the above observations, it is important to look at the key factors that influence the performance of an innovation. Previous studies have extended our understanding of the roles of demand- and supply-related factors ([Bessant, 1991](#); [Dosi, 1982](#); [Freeman, 1994](#); [Katz & Phillips, 1982](#)) and formal and informal institutions ([Dosi, 1982](#); [North, 1990, 1996](#); [Rothwell & Wissema, 1986](#)) in shaping an innovation's path. It is argued in this paper that new conceptually grounded models are needed to provide new ways of understanding how these factors affect the path of the IoT.

In light of the above observations, this paper's goal is to provide some explanation as to how demand-, supply- and institutions-related factors have affected the creation and diffusion of IoT-related products and services in China. We provide IoT deployment examples from key areas of development such as agriculture, health and environment as well as commercial activities such as manufacturing and retail. Examples, data, and information related to the creation of IoT-related products and innovations are also used to assess China's position in IoT.

Specifically, this paper contributes to the research on the creation and diffusion of technologies by examining the interplay of institutions, industry and market from the IoT's perspective. This issue has several important policy and theoretical implications because the IoT has been touted as the "next major technology revolution after the Internet" which has the potential to transform the global economy and society ([Ashton, 2015](#)). It is thus important for policy makers, technology developers and users to observe this rapidly evolving phenomenon and share insights, reflections and observations. China may serve as a testbed for other emerging markets in the development and deployment of IoT products. For instance, in 2014, China's largest venture capital companies and the International Finance Corporation (IFC) launched initiatives to build a cloud for the IoT in China. The IFC was interested in bringing some of the ideas to other emerging markets ([Friedman, 2014](#)).

The paper is structured as follows. We proceed by first providing a review of relevant literature on factors likely to affect the path of an innovation. Next, we provide a case study of China's IoT sector and develop a framework that links the impacts, performance indicators and determinants related to China's IoT sector. The final section provides discussion and conclusion.

2. Literature review

This section is organized around three themes stated in the objective: demand side factors, supply-side factors and institutional factors.

2.1. Demand side factors

[Rosenberg and Mowery \(1979 p. 31\)](#) noted that "market is important in determining successful innovations".

2.1.1. Potential market size

Potential market size is an important determinant of profits. Markets use a reward/penalization mechanism in order to check

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