

# Impact of IoT on social innovation in Japan

Social  
innovation in  
Japan

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## Abstract

**Purpose** – Recently, the discussion on the impact of the Internet of Things (IoT) in theory and in practice is increasing. While some proponent envisage that the IoT will bring about positive radical change in the modern society, others argue that the IoT will introduce more disadvantages in the long run (mainly in terms of job losses) than advantages. The purpose of this paper is to arbitrate this controversy by examining the impact of IoT on the Japanese society.

**Design/methodology/approach** – While previous studies have largely been qualitative in nature, in this study, a quantitative approach was used. A multi-dimensional analysis was carried out and the statistical method known as the one-way analysis of variance was used to process the data obtained during this study.

**Findings** – The results show that indeed the IoT has a positive impact on the daily lives of the Japanese people, however the change it brings are mainly incremental change and not radical. Furthermore, rather than reducing job opportunities, it has created more opportunities and simplified operation processes.

**Research limitations/implications** – However, a limitation of this study is in its narrow scope. It is important to note that further studies on an international level or perhaps multi-national level is needed. Furthermore, there may be other underlining factors, such as culture, social, economic, geographical location, technology capacity, that may contribute to the impact of the IoT on daily life. Therefore, future research needs to verify if indeed this is the case.

**Originality/value** – This research successful arbitrates the argument about the impact of the IoT on the society by specifically showing that the advantages brought by the IoT out-ways its disadvantages. Furthermore, the uncertainty (fear of job losses) expressed by some experts was addressed in this study. The results obtained showed that the diffusion of the IoT has no correlation with job loss but rather supports improved working environment and creation of jobs.

**Keywords** Internet of things, Industry 4.0, Incremental innovation, SMART society

**Paper type** Research paper

## Introduction

The concept of the Internet of Things (IoT) has grown since the emergence of the co-existence of the real and virtual world. Day by day the concept of a virtual world is growing and is gradually becoming a norm in the society. The main guiding principle of the IoT is to make computers process information without receiving help from a human being



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(Gubbi *et al.*, 2013; Hsu and Yeh, 2016; Li *et al.*, 2019). The key component that enables this capacity is the present of high speed internet with the capability of connecting various objects across a wireless network. The IoT-enabling devices include the radio frequency identification (RFID), Bluetooth, telephonic data services, embedded sensor and actuator nodes, in addition to Wi-Fi connections (Atzori *et al.*, 2010). The emergence of the IoT has revolutionized the manufacturing sector by enhancing the speed and quality of production. The IoT improves the performance of SMART factories by ensuring flexibility in production, product customization improvements, integration of roles (customers, companies and suppliers) and supports sustainable development (Shrouf *et al.*, 2014; Haller *et al.*, 2009). According to Wang *et al.* (2016), SMART factories involve a vertical integration of many parts in the system, to reconfigure and implement flexibility within the factory in the emerging fourth industrial revolution (Industry 4.0). An important aspect of Industry 4.0 is the use of the blockchain technology that is relevant to the IoT. A key benefit of the blockchain technology is to enhance the security of the IoT (Skwarek, 2017). According to Boireau (2018), the blockchain is a technology that consists of a decentralized, distributed ledger technology with the capability to provide historical records of transactions on a peer-to-peer network.

The concept of Industry 4.0 originally came from Germany and comprises cloud-based manufacturing, RFID, IoT, enterprise resource planning (ERP) and social product development (Lu, 2017). One of the main drivers of the industry 4.0 is the IoT; hence, it is important to understand the impact of the IoT on social life in the evolving Industry 4.0 economy. According to Hofmann and Rüsçh (2017) and Vaidya *et al.* (2018), the fourth industrial revolution has been identified by many names in literature that include SMART manufacturing, cloud-based manufacturing, IoT, industry internet and integrated industry. The main characteristics of Industry 4.0 are the digitization and intelligentization of manufacturing processes, which involve the use of the IoT amongst other things (Vaidya *et al.*, 2018). The impact of the IoT affects every aspect of the modern day life; hence, its impact on social behavior cannot be overlooked. According to Ng and Wakenshaw (2017), the IoT has changed the way marketing is done today through digitization, SMART technologies, nanotechnology and energy-scavenging technologies. Other areas of life the IoT has impacted positively include communication, health care, education, finance, recreation, social networking and security (Ai *et al.*, 2018; Ding *et al.*, 2018; Ahmed *et al.*, 2016). Because of the overall effect of the IoT on the human life and the changes it introduces, it is considered a social innovation. Shin (2017), in his research on the impact of the IoT in small- and medium-sized enterprise (SME) in South Korea, argues that the IoT brought about destructive and open innovation. This type of innovation cumulates into social innovation within the society.

Van der Have and Rubalcaba (2016) posits that social innovations (SIs) are new ways of creating and implementing change in the society. The IoT has been instrumental in the promotion of innovation, improving the exchange of ideas and the development of knowledge management systems. It is a disruptive innovation that is altering the way in which information and knowledge is managed within organizations to foster knowledge flows, open flow of knowledge and knowledge management systems (Santoro *et al.*, 2018). Shin (2014), in his research (that focused on studying the relationship between the IoT and humans), provided a socio-technical analysis of the development of the IoT in Korea. While Tyler (2002) argued that the internet has not changed the way people live their lives, rather it simply brings about new ways of doing old things, other researchers argued otherwise. The IoT has led to the development of SMART environments for humans while ensuring the conservation of water and energy (Curry *et al.*, 2018; Reka and Dragicevic, 2018). On the

other hand, while [Balaji and Roy \(2016\)](#) concludes that the IoT seeks to bridge the gap between the digital world and the real world, [Wijk et al. \(2019\)](#) classified SI into three categories, namely, micro (individual-level interaction), meso (diverse actor interaction) and macro level (institutional-level interaction). However, in this research, the impact of the IoT on SI in the Japanese society will be examined (on a macro level). Furthermore, the approach that will be used herein will involve an empirical analysis relating to real life data on the IoT in Japan.

### *Theoretical background*

*Linear social change theory.* Social change occurs when there is a change in the behavior, culture or the value system of a group of people within a society. [Reeler \(2007\)](#) classified social change theories into three categories that include emergence change (an evolution of day to day life brought about by conscious and unconscious learning from experience), transformative change (a form of change that develops from the need to solve an ongoing crisis) and predictable change (a change that evolves from a conscious execution of well thought out plans to solve a problem). While emergence and predictable change are relatively linear, transformative change is not and often takes a concave or convex shape. In this study, however, we shall assume that the impact of the IoT in the society is linear and test this assumption in the course of this research; using the social linear model. The social linear models (evolutionary models) involve a process of cumulative, non-repetitive and permanent change ([Social change bibliography, 2002](#)). These models study the effects of change while considering several factors. According to [Çam and Kayaolu \(2014\)](#), some of the causes of social change include differentiation (change in complexity of the society) and integration (integration as a result of changes in societal complexity). Social change can occur in various aspects of human life, but according to [Landheer \(1960\)](#), changes occur in the social reality, value systems, informal and formal structure of a social group. The aim of this research is to use the linear social change theory to study the impact of the IoT in Japan and understand its impact on the daily lives of the average Japanese people. Therefore, this research presents itself as one of the earliest studies that use the social change model to study the impact of the IoT on SI. In this study, the impact of the IoT will be considered from a linear social change perspective to consider its impact on the social life and businesses in Japan.

*IOT and social innovation in Japan.* While the IoT is relatively new, in Japan its use is growing by the day, and it has found its way into the daily life and business production processes mostly in the field of telecommunication and electronics. The growth in the utility of the IoT in many aspects of the Japanese economy makes it a suitable case study in examining the impact of the IoT. Furthermore, extensive data exist on the usage of the IoT in Japan that can be used to study trends and the impacts it has on the daily lives of its people. The growth of the IoT in Japan is fostered by the development of technology in the field of telecommunications and electronics ([Naito, 2016](#)). One of the key areas that the IoT has positively impacted, in the Japanese society, is the farming sector. According to [Hoshi et al. \(2017\)](#), while the problem of aging population continues to be a major issue in Japan, the IoT has revolutionized green farming by helping farmers improve their automation. Furthermore, the IoT has made farming convenient for the aging population by improving the food production output in Japan. The technological development brought by the IoT has been examined by various researchers in the past. These research studies focus on the types of process and product innovation. For example, [Kodama and Shibata \(2017\)](#) argued that the development and deployment of the IoT and digital economy is bringing about technology development in the Japanese machine tool industry. The construction companies in Japan

have also adopted the IoT to improve their proficiency. Japan is one of the few countries in the world that has used the IoT to advance building information modeling (BIM), and RFID in the construction of homes (Zhong *et al.*, 2017). BIM is a 3D intelligent building technique used in planning, designing and construction of buildings, while RFID is a form of wireless communication device. Both BIM and RFID are enabled by IoT.

SI in the Japanese society – with community participation in social projects – is on the rise. According to Maruyama *et al.* (2007), SI in Japan has brought about social economic change in the field of renewable energy technology. Japan is currently utilizing the IoT to bring about innovation in solving real life issues in the society. To enhance the positive impact of the IoT on productivity and innovation in the daily lives of the Japanese people, the Japanese Government launched the u-Japan and i-Japan strategies in 2008 and 2009, respectively (Xu *et al.*, 2014). According to Zhang *et al.* (2019), the u-Japan project was an initiative of the Ministry of Internal Affairs and Communications, and the aim of the project is to establish connections between things and people as well as people and things in a network within the society. On the other hand, the i-Japan strategy was designed by the IT strategy headquarter of Japan, and its aim is to ensure digital information technology was available to all, like water and air in every corner of the Japanese society and with specific interest in areas such as e-governance, health care, education and various industrial sectors (Liu, 2017). According to Vakali *et al.* (2014), Japan is one of the countries in the world that is deploying the IoT in its quest in developing SMART cities across the country. Furthermore, the development of SMART factories is on the rise in Japan. Japanese firms such as Kawasaki, Sony and Toyota are leading the way in the development and implementation of SMART factories (Lee and Trimi, 2018). Chen (2012) posits that during disasters, the IoT has been used in Japan in various dangerous missions. While the IoT in Japan is widely used and affects the daily life of the Japanese people, an empirical analysis that shows the way and manner in which it does this is yet to be studied. Previous studies on the IoT in Japan have largely been qualitative and unilateral; hence, in this study, a quantitative analysis using a multi-dimensional approach, examining the effects of the IoT on the Japanese people and their businesses will be carried out.

## Methodology

### *Data and variables*

In this study, a multi-variant approach to study the relationship between the dependent variable and independent variables will be carried out. The secondary data, used herein, were compiled from the Organisation for Economic Co-operation and Development (OECD) iLibrary (Table I).

The first stage of analysis in this study will be to test for any case of adverse collinearity of the independent variables used herein. The result of this examination will be presented in the Table AI. The limit for adverse collinearity set in this research is  $\pm 0.8$ . Based on the results in Table AI, there is no case of adverse collinearity recorded because the collinearity factor of all the variables considered is less than 0.8. Next the data collected will be processed using the statistical method called the one-way analysis of variance (one-way ANOVA). This method provides an effective way of analyzing the relationship between multiple variables. The variables used in this study have previously been used in a single variant form; however, a collected effective of their impact is yet to be studied. This research seeks to bridge this gap. Table II contains a reference to previous research studies that have used these variables in a unilateral way. By carrying out a multi-level analysis, this study seeks to answer the question on whether each of these independent variables are interrelated and how they impact the dependent variable.

Year	Households with internet access at home (%)	Innovation and technology researchers (per thousand employed)	Science, technology and innovation gross domestic expenditure on R&D (% of GDP)	Businesses with a broadband connection – both fixed and mobile (%)	Average annual hours actually worked
2005	57	10,38639728	3.41	68.1	1775
2006	60.5	10,3787601	3.41	73.6	1784
2007	62.1	10,2885344	3.46	75.9	1785
2008	63.9	9,888060713	3.47	76.8	1771
2009	67.1	9,987963189	3.36	76.9	1714
2010	68.76	10,01667328	3.25	79.7	1733
2011	70.23	10,03209839	3.38	83.4	1728
2012	70.48	9,916795802	3.34	91.8	1745
2013	71.71	10,07626356	3.48	91.5	1734
2014	78.87	10,35785786	3.59	93.1	1729
2015	80.35	9,998051948	3.34	94.5	1719
2016	82.95	9,95581284	3.48	90.8	1714
2017	82.96	10,01453399	3.59	91.2	1710

Source: OECD (2019)

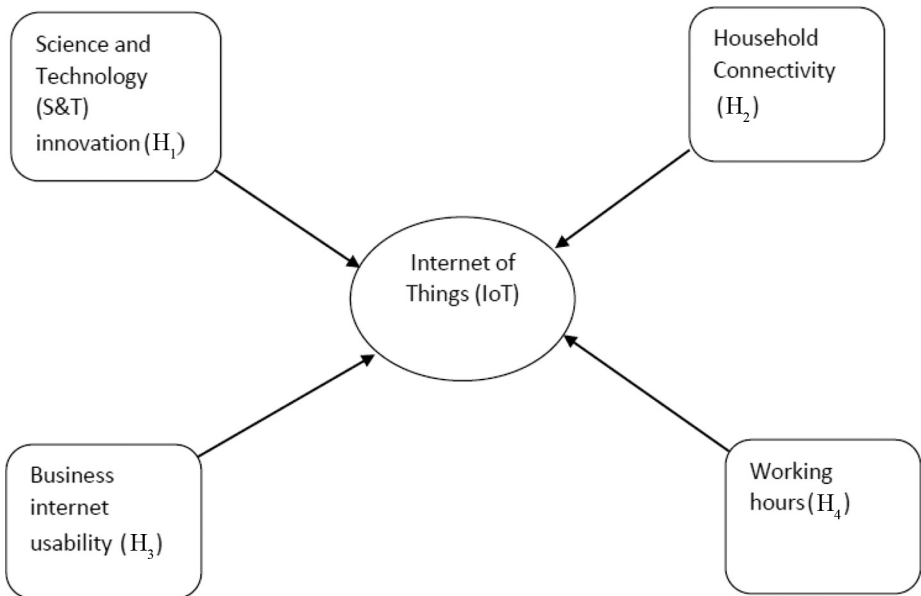
*Analytical framework*

The social linear theory adopted in this research will be used to develop the analytical framework used herein (Figure 1). Based on the analytical framework, the following hypotheses will be examined:

- H1. There is a positive relationship between the number of households with internet access and the number of innovation and technology researchers. The assumption in this study is that the number of households with internet access is a representation of the diffusion of the IoT. This is because one of the main infrastructure in which the IoT thrives is the internet. Therefore, the first hypothesis to be tested in this study will be the relationship that exists between the number of households with internet access and the number of researchers in the field of science and technology.
- H2. The number of households with internet access is positively related to the science, technology and innovation gross domestic expenditure on R&D. In this study, we

**Table II.**  
List of variables

Dependent variable	Independent variables	Reference
Households with internet access ( $Y_1$ )	Innovation and technology researchers ( $x_1$ )	<a href="#">Alaa et al. (2017)</a>
Households with internet access ( $Y_1$ )	Science, technology and innovation gross domestic expenditure on R&D ( $x_2$ )	<a href="#">Scheerder et al. (2017)</a>
Households with internet access ( $Y_1$ )	Businesses with a broadband connection -includes both fixed and mobile ( $x_3$ )	<a href="#">Reisdorf and Groselj (2015)</a>
Households with internet access ( $Y_1$ )	Average annual hours actually worked ( $x_4$ )	<a href="#">Syverson (2017)</a>



**Figure 1.**  
Research analytical framework

make the assumption that as the IoT diffuses, the R&D expenditure of the private and public sector will continue to increase. As such, the relationship between the number of homes with access to the internet and the total R&D expenditure in Japan will be examined.

*H3.* The number of households with internet access is positively related to the number of businesses with broadband connections (both fixed and mobile). Another key assumption in this study is that as the use of the IoT increase, the number of businesses that use the IoT in various aspects of their operations will also be on the rise. This will be tested in the course of this research.

*H4.* The number of households with internet access has a positive impact on the average annual hours worked. To determine whether the IoT has a positive or negative impact on jobs in Japan, the relationship between the diffusion of the IoT and the average working time of employees in Japan will be tested.

### Analytic results

Data used in this study were processed using the one-way ANOVA statistical method and the results are presented in [Table III](#).

The results obtained in this study show that the diffusion of the IoT has a positive co-relationship with SI in Japan. It shows that as the IoT increases its reach, the number of researchers employed in the field of information technology to study and improve innovation (with regards to the IoT) is on the rise. Furthermore, as the IoT diffuses, funding in the field of science and technology is on the rise. This rise is particularly observable in research relating to the IoT. Also, the IoT improved the use of internet-based platforms in businesses across Japan and the working hours of employees. However, the nature of the relationship between the independent and dependent variables varies in proportion. From [Table III](#), it can be observed that the IoT influenced the number of businesses that use various forms of the internet the most. Number of research in the field of science and technology, research funding and average working hours follow sequentially. [Figure 2](#) shows the results of the relationship between the dependent and independent variables. It can be observed that the model relationship is indeed linear and satisfies the linear social change theory used herein in this study.

### Discussion

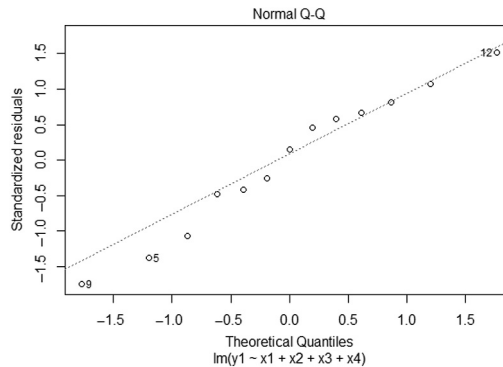
This research started off with the aim of providing answers to the argument on the impact of the IoT on the lives of the people living in Japan. Japan is one of the earliest countries to

Independent variables	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Innovation and technology researchers (per thousand employed, full-time equivalent)	1	159.66	159.66	18.2112	0.0027336**
Science, technology and innovation gross domestic expenditure on R&D (% of GDP)	1	213.11	213.11	24.3070	0.0011491**
Businesses with a broadband connection -- both fixed and mobile (%)	1	369.78	369.78	42.1769	0.0001892***
Average annual hours actually worked	1	77.12	77.12	8.7967	0.0179829*
Residuals	8	70.14	8.77		

**Notes:** Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1'

**Table III.**  
Results of  
computation

**Figure 2.**  
Relationship plot of  
model equation



use the IoT in developing its infrastructures and businesses; hence, this makes it a suitable candidate to use as a case study. While SI in Japan is on the increase, as a result of the IoT, the results obtained in this study shows that the change it brings are incremental. This incremental change leads to gradual changes in the daily lives of the Japanese people. The first relationship considered in this study was the interaction between the IoT and employment within the science and technology field. The results obtained showed that as a result of the rising number of research focused on the integration of the IoT, the number of researchers in this field has been on the rise. While [Ng et al. \(2015\)](#) posit that the IoT, in production processes, brings about a reduction in productivity of humans, which may result in job losses, [Islam et al. \(2015\)](#) argued that the IoT has not only improved the quality of lives but also created new opportunities in the health sector. The results obtained in this research support the latter argument, because it shows that the IoT improves job opportunities in Japan. The second relationship studied in this research was the association that exists between the IoT and the research expenditure in the field of science and technology in Japan. It was discovered that the IoT improved funding in the field of science and technology. This may be as a result of increasing demand and efficiency of social technologies spurred by the adaptation of the IoT. The need for automation, led by the IoT and RFID, by enterprise all around the world is on the increase ([Yan and Huang, 2009](#)). According to [Gershensfeld et al. \(2004\)](#), all around us, there is an upsurge in the improvement of everything as a result of the IoT. Therefore, as efficiency grows, demand likewise intensifies with time.

On the other hand, the third relationship studied herein is the link between the IoT and business operations in Japan. Based on the analysis of results obtained in this study, the IoT has penetrated the business environment in Japan. This is because business operations are becoming more and more internet based and the IoT offer businesses improved efficiency and effectiveness in their operations. According to [Glova et al. \(2014\)](#), the use of the IoT in business has reduced the life cycle of production and services; however, this change requires new business models to accommodate them. The final relationship studied was the interaction between the IoT and the time spent averagely on jobs over time with the introduction of the IoT. While some researchers say that the IoT brings about a reduction in working hours (for example, [Glova et al., 2014](#)), the results obtained in this study prove otherwise. The results show that while the IoT diffuses, the working hours continue to increase. This may be explained by the decrease in the working population in Japan. Because the population continues to decrease, many are compelled to take on multiple roles and perhaps multiple jobs. According to [Yuji et al. \(2012\)](#) in Japan, as a result of the aging population, demand for health-care services is more than supply. Hence, many doctors have



to work overtime. Based on the linear social change theory used in this research, the change that the IoT drives is incremental and not radical. Furthermore, the advantages of the IoT to businesses and homes in Japan are positive, and the IoT complements a better living standard rather than threaten it in the Japan's case.

## Conclusion

The development of the IoT to solve societal issues is growing with many developed countries leading the way. However, just like every innovation, the uncertainty surrounding the deployment of the IoT has led to divided opinions amongst experts in the field. While some experts posit that impact of the IoT in our daily lives will lead to radical innovations that will reform the way we live in a negative way (because of the cost and change required), others have argued that the change will be incremental, allowing for the development of prerequisite infrastructure and proper readjustment in the society to accommodate the change. The aim of this study is to try to answer the questions raised by the underlining debate through a study of the IoT and its impact on the Japanese people. Japan was chosen in this study because it is one of the leading countries that has adopted the use of the IoT in many sectors of its economy. The results obtained in this study show that indeed the IoT brings about change in the society, but the change is mainly incremental and not radical. This change has accommodated SI within the Japanese society by building on already existing infrastructure and through making these infrastructures more effectively. Further revelations deduced from this research show that the IoT has been able to bridge the gap between a declining workforce and efficient management by optimizing production and creating a balance of an automated working environment with human participation. However, a limitation of this study is in its narrow scope. It is important to note that further studies on an international level or perhaps multi-national level are needed. Furthermore, there may be other underlining factors, such as culture, social, economic, geographical location, technology capacity, that may contribute to the impact of the IoT on daily life. Therefore, future research needs to verify if indeed this is the case.

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Variables	1	2	3	4
Innovation and technology researchers (per thousand employed, full-time equivalent)	1.0000000	0.26394584	-0.4172873	0.54818761
1. Science, technology and innovation gross domestic expenditure on R&D (% of GDP)	0.2639458	1.0000000	0.2821487	-0.06086882
2. Businesses with a broadband connection – both fixed and mobile (%)	-0.4172873	0.28214868	1.0000000	-0.70669501
3. Average annual hours actually worked	0.5481876	-0.06086882	-0.7066950	1.0000000
4.				

**Table AI.**  
Co-linearity matrix of the independent variables

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