Article

Using IoT in Supply Chain Risk Management, to Enable Collaboration between Business, Community, and Government

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Abstract: The internet of things (IoT) and social media provide information related to disasters that could help businesses to strategically mitigate risks and optimize their supply chain during difficult times. This paper proposes a framework to show how business or supply chain enterprisers can collaborate with community and government in disaster supply chain risk management. Businesses must have an established risk mitigation plan, update it periodically and implement promptly. Community collaboration can build a resilient society, and government should play an important role in leading both financial and non-financial support during natural disasters and pandemic management. The IoT and social media are new mechanisms as a vocal point to enable government, ensuring trustworthiness of information, to provide the community with a means to express needs and feedback, and to assist business services to meet the changeable preferences under risk threats. Social media can be a collaborative effort between all the parties and helps make value added decisions efficiently in supply chain risk management.

Keywords: risk mitigation; social media; intervention policy; internet of things; community collaboration

1. Introduction

In analyzing supply changing risk, the internet of things (IoT) has become an integral part of people's lives on a global scale, leading to challenges in supply chain risk management and contingency planning. Societies, businesses, and governments need to build resilience to cope with the associated and unpredicted risk in supply chain management.

There is extensive literature on risk management from the point of view of supply [1], information material and product flow risk [2], and global risk [3]. However, risk management frameworks have not widely included the IoT as part of 'traditional' strategies. The IoT has enabled the efficient propagation of social media, which has forced corporations to collaborate not only with industry sectors but also with political sectors [3] and social enterprises [4]. Di Domenico et al. [4] stated (p. 887):

> These collaborations involve the formation of a political-economic arrangement that seeks to reconcile wealth creation with social justice, and the efficient functioning of markets with the welfare of communities.

This has urged us to seek a new framework for IoT-driven supply chain risk management. This study uses an online open access survey data to discover how the community, business, and government can coordinate in building resilience during the COVID pandemic. An IoT based-supply chain risk management framework is developed to illustrate risk management strategies in this paper.

2. Supply Chain Risk Management

In this paper, we have emphasized the partners of collaboration to include the business, individual economic (consumers), and political (policy makers) sectors. We therefore reconceptualised the supply chain risk management definition, and we did so by combining the definitions of [5–7]:

> *The management process of supply chain activities for maximizing customer satisfaction and realizing a sustainable competitive benefit through the coordination and collaboration of every partner in the network both in physical process and information flows.*

In this definition, data on activities, customer satisfaction, and expected benefit can be achieved by IoT, social media, and traditional communication tools.

Due to globalization as well as unpredictable natural disasters, the definition of supply chain risk management can be redefined as follows, based on the previous definition of [6,8]:

> *The management of supply chain risks through coordination or collaboration among all supply chain partners to create a dynamic perspective of knowledge creation and transfer and to ensure profitability and continuity.*

Under this definition, supply chain risk management looks at the sources of risk discussed in [3,9] as:

- supply risks: inventory, raw material price, quality of material and design of material
- operation risks: manufacturing capacity and process, changes in technologies and operating
- demand risks: market changes and demand distortion
- information security risks: information system security, freight, and transportation breaches
- macroeconomic risks: changes in wage rates, interest rates, exchange rates, and commodity prices
- policy risks: national regulation restrictions and international/geographical sanctions
- competitive risks: market shares between competitors and technological advantages
- resource risks: resource scarcity, dated technology, finance, and market.

Risk management aims to mitigate the risks, and ensure that the supply, demand, product, and information sectors are profitable and that there is continuing collaboration with all partners, including community and political agencies.

Previous research has discussed coordination and collaboration in risk management through IoT [10,11], and there are many theories on how social media affects citizens' resilience [12,13] and the involvement of political agencies [3]. However, there is no theoretical framework for bringing all businesses, communities, and policy makers into one network, linked by IoT and social media, to improve supply chain risk resilience.

3. Political Coordination in Supply Chain Risk Management

When supply chain risk is caused by globalization or a natural disaster, businesses and communities face unpredictable risks from economic, political, logistical, competitive, cultural, infrastructure, and environment challenges [3,14]. Generally, one supply chain player's operation system may be disrupted and then in turn interrupt other supply players. If resources in the environment face a supply challenge, the allocation of resources impact community welfare, so political intervention becomes necessary. Policy makers can act as negotiators and decide to mitigate risks and maximize benefits, thereby contributing to the welfare of the whole community. Policies need to consider how to support vulnerable businesses as well as the social and environmental impacts.

Political intervention aims to provide high resilience for both business and individual economic agents, through financial subsidies to reduce their level of risk impact so that they can recover from the disruption as quickly as possible. On the other hand, a policy may also create a barrier for risk mitigation, if it has not been updated to accommodate the new risk phenomenon for the supply chain. In addition, policy regulation is characterized as having a limited capacity to mitigate large-scale social and environmental risks, so it may not be able to strengthen social resilience [15]. Sometimes, policies have generated additional costs by their unintended effects on competing social groups [15,16]. Therefore, the power of a policy may be derived from social actions or social order derived from human action [16], both of which can be obtained from IoT.

4. IoT for Community Collaboration in Supply Chain Risk Management

IoT has linked the digital technology of the internet, wireless network, and sensors to physical technologies [11] such as computers and mobile phones. The literature has focused on the application of IoT to business operation and communication in the supply chain. [7] discussed how to use a smart supply chain in a business system, and [11] defined IoT based on a review of technology, interpersonal communication, application, business, environment, analytics, development, process, and networking. The consumer feedback loop has been discussed in [17] for a blockchain-based demand forecast system that consumer preferences can be fed into. This paper defines IoT based on [11] (p. 938):

Technology, which is intuitive, robust, and scalable, that enables digital transformation of the connected world and people through internet and communicates all the relevant information in real time across the value chain.

Social media is a well applied communication tool using IoT technologies that can capture social actions in risks and uncertainty, provide the community with needed information when disruptive phenomenon happen, and help reduce the uncertainty of the situation [12]. Social media is closely linked to social domain, a domain response to a disaster through knowledge accumulated through case studies, the anthography of the social group, systematic discussions and actions, and the use of narrative to analyze social groups. Social media is influenced by social networks, which are the relationships between people and the structures that are formed by understanding their interaction patterns. Each member in the domain is tied to one another, demonstrating the structure and process of the social network [18]. In addition, a social domain and network are dynamically bonded in a risk situation by the IoT technologies. Social media empowered by IoT can include social domain or network in supply chain risk management.

Cross-sector community and policy collaboration require an open information system, where each actor can share their perception of risk levels and impacts; some researchers call this an inter-organizational collaboration [19]. The major contributor of social media is through internet podcasting or chat platforms, such as Facebook, signal, Viber, Telegram, WhatsApp, Microsoft, Band, WeChat, Skype, Twitter, and so on. Some of the information is transferred by traditional channels, such as TV, newspapers, telephone, radio, etc.

Because supply chain risks are complex, to mitigate the risks, there is a need to bring in the outside players of government and community using IoT and social media to help tackle the issue of being more prompt, dynamic, and connected.

5. Build an IoT Based-Supply Chain Risk Management Framework

This study uses COVID-19 pandemic online shopping as a case study to argue how the IoT has been utilized to resolve the risk situation. The data used are open access data and reports that have been published via the internet, such as the survey results shared by International Post Corporation, Australia Post, the Australia Bureau of Statistics, and government documents.

First, community members are under stress and panic during a disaster and uncertainty, if they have never experienced the same type of disaster and they do not know how to cope. When people have different perspectives that are related to their sociodemographic backgrounds, they respond differently from one to another. Sometimes, a relatively small number of the public react in a typical way which could amplify the issue into a society-wide issue. The public has a natural instinct to change their demands for goods (which may be more than they need) and consequently, this demand may affect supply. Businesses who have to learn and cope with these consumer-driven changes in order to keep a stable supply chain during a disaster could overcome and thrive from the disaster with success.

Consumers' panic buying has been shown as the norm in many disasters if they are foreseeable; for example, the COVID-19 city curfews from March 2020 caused a toilet paper shortage in Australia. The public is generally concerned about material shortages, service shortages, or inconveniences. While, the situation can be softened by providing support to

the community, issuing accurate and positive media information, promoting high social responsibilities, increasing the supply of goods, and creating policy interventions on supply.

During the COVID-19 period, there has been a shift of online purchasing from international retailer to domestic retailers. Figure 1 shows the survey conducted by International Post Cooperation [20]. In Australia, there has been an increased demand in using smart technologies of mobile phone, laptop computer, tablet, and Smart TV for shopping [20,21]. In Figure 2, 57% of shoppers started to support local retailers, and from the business side there were 73% of small and medium Australian businesses who expressed that they changed their business operations model to help build company and society resilience and mitigate the challenges [21]. The buyers were also increasing their utilizations of different devices, with 91% using mobile phone in 2020 compared with 87% in 2019. It is surprising that Smart TVs have become popular shopping equipment, increasing up to 60%. This followed a high usage of credit cards to buy online. These utilizations of smart technology present new opportunities for businesses.
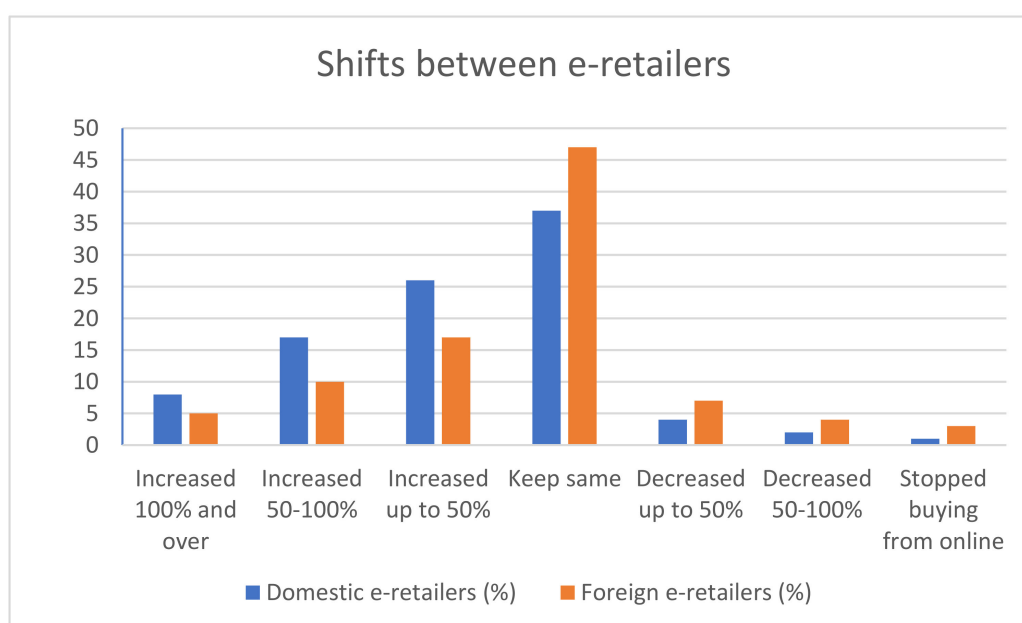

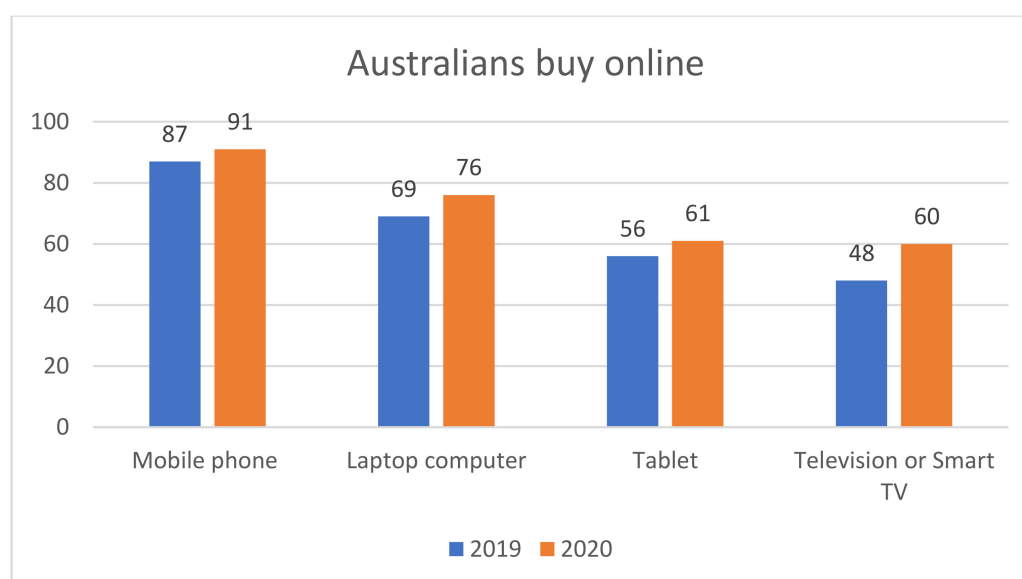**Figure 1.** Domestic e-retailers vs foreign e-retailers during COVID-19.

Figure 2. How Australians buy online.

Second, businesses are the central risk-mitigating players in a disaster. The successful suppliers are the ones who have turned their business orientation to online marketplaces named software as a service, including updating online stores and social media profiles and building up strong social connections with customers via online channels as well facilitating order fulfillment for stock, delivery, and pick up point. These companies have also improved the availability of real time data, for example, by providing delivery information via mobile phone messages and by using photographic evidence rather than signature receiving. The IoT based-supply chain management has helped successful companies to connect with customers in the COVID-19 lock down period. It can also measure customer satisfaction. Figure 3 shows the survey satisfaction [20]. Parcel tracking and delivery speed show more space for improvement than the delivery location, cost, and return. This feedback information can be a part of big data generated via online software services to further develop the adding value decision.
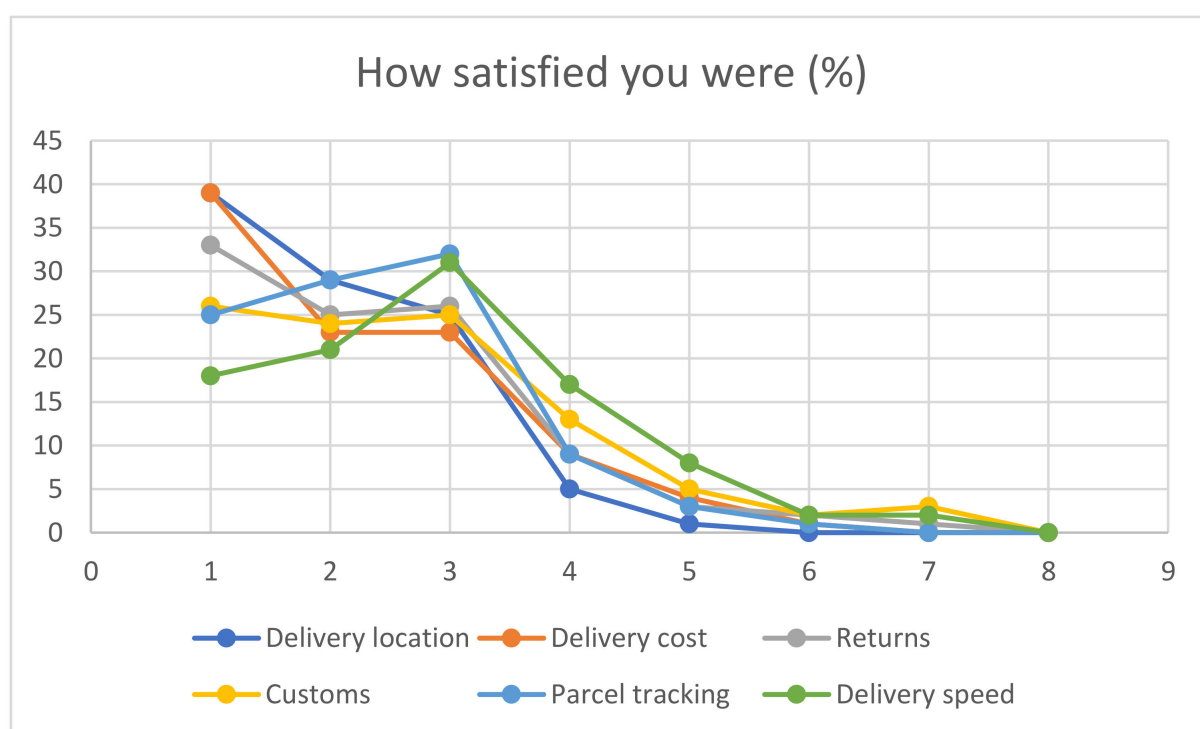

Figure 3. Satisfaction feedback for value adding projects.

Business owners need updated business plans that can incorporate different levels of risk impacts, and flexible structures to cope with limited resources or disruptive situations while keeping their business competitive. Internally, they will need to periodically review and build flexible procurement processes and flexible delivery channels for customers; for example, developing extra qualified suppliers or a close relationship with customers to be able better understand their unpredicted needs and therefore deliver required product. Businesses need to satisfy consumers and, at the same time, establish good communication with the political regulations that are issued to respond to the specific disaster. Businesses also need to consolidate their integrity and ethically gain profit without taking advantage of the disaster. On the other hand, the disaster can be a chance for a company to build a reputation and goodwill for future profit. Businesses need to execute special product distribution strategies and ensure higher social welfare to benefit the maximum number of community numbers.

Third, policy makers, who hold the power as an authority coordinator, need to intervene and maintain stability. They need to provide financial and non-financial support and release the right information to the public and businesses to mitigate risk. Policies for

supporting individuals and households have been spread in many countries to reduce the economic impact of the Coronavirus. For example, in the US, there are several economic and various fiscal and monetary policy implementations to cope with the COVID-19 crisis. The EU has implemented a recovery plan for Europe, where there will be €1.8 trillion of stimulus package to reboot a green, digital. and resilient Europe [22].

In Australia, due to the unemployment rate reaching a high of 13.8%, 1.8 million people had their work reduced in the COVID lock down period in the second quarter of 2020. The Australian Government provided support for employers and employees with the JobKeeper Payment Program. Payments were provided to eligible employers from the 30 March to the 27 September 2020, then extended at a reduced level from the 28 September 2020 to the 31 March 2021 for eligible income recipients, allowed temporary access to superannuation to 31 December 2021, and provided pensioners, seniors, and careers and concession card holders to receive two separate $750 payments and two additional payments of $250 each [23]. After August 2020, there was a job recovery (except in Victoria where lockdowns persisted). By March 2021, the economic environment is almost back to normal [24]. These stimulus packages contributed to a year over year increase in demand for household goods, while after Job-Keeper ended, the retail industry still faces big challenges.

Since social media should be validated and updated to reduce confusion and therefore enable the public to obtain the best information they need to make their decisions. The government can regulate businesses to enable the best outcome for the community and the allocation of natural resources. Normally, governments have quickly set up community-supporting services, the most powerful ones providing financial subsidies together as well as calling for volunteers, to help communities survive a disaster. Governments also have stronger influence in disaster strategic decision-making; a well-considered disaster plan with the quick set up of an expert team for decision-making would help society to build resilience. A social media resource established by government is considered to be trustworthy by community and businesses. In addition, the government can easily centralise leadership in a disaster.

During the COVID-19 pandemic, the setting of a curfew showed government leadership and a quick response to mitigate the disaster. The Australia Government shifted to using Facebook media as its official news channel to issue updates in case numbers in order to get larger audiences. They urged businesses to issue restrictions on the number of people in-store and limit the number of high-demand goods, such as toilet paper and milk in Australia. They also decided which businesses or services should open or close. The government also quickly created additional services for older people to help them with their shopping. Since, in general, older people do not use the internet, traditional communication methods such as phone calls were used.

An IoT based-supply chain risk management framework will help researchers and practitioners quickly access the necessary and prioritized information from abundant sources. This framework is a collaborative structure between businesses and external players of government and community, with an information flow that is appropriate and efficiently applied in supply chain risk management. How can a framework help reduce risk impacts by collaboration?

The framework (Figure 4) shows supply chain material flow, information flow, and political intervention process flow, as well as related risks. Under low-risk circumstances, supply chain management runs as normal to maximize profit: products are processed to transport to consumers according to market demand, IoT, and social media coordinate with business operations and common market promotions, policy, and regulation intervene for long-term business environment and material.

Supply chain management changes pace when disasters and uncertainty take place. The media provides information for a typical disaster, then the public, businesses, and governments receive the media and make their own decisions or action plans. Some of

the reactions are rapidly shared on social media, and they form a dynamic and interactive information system through IoT.
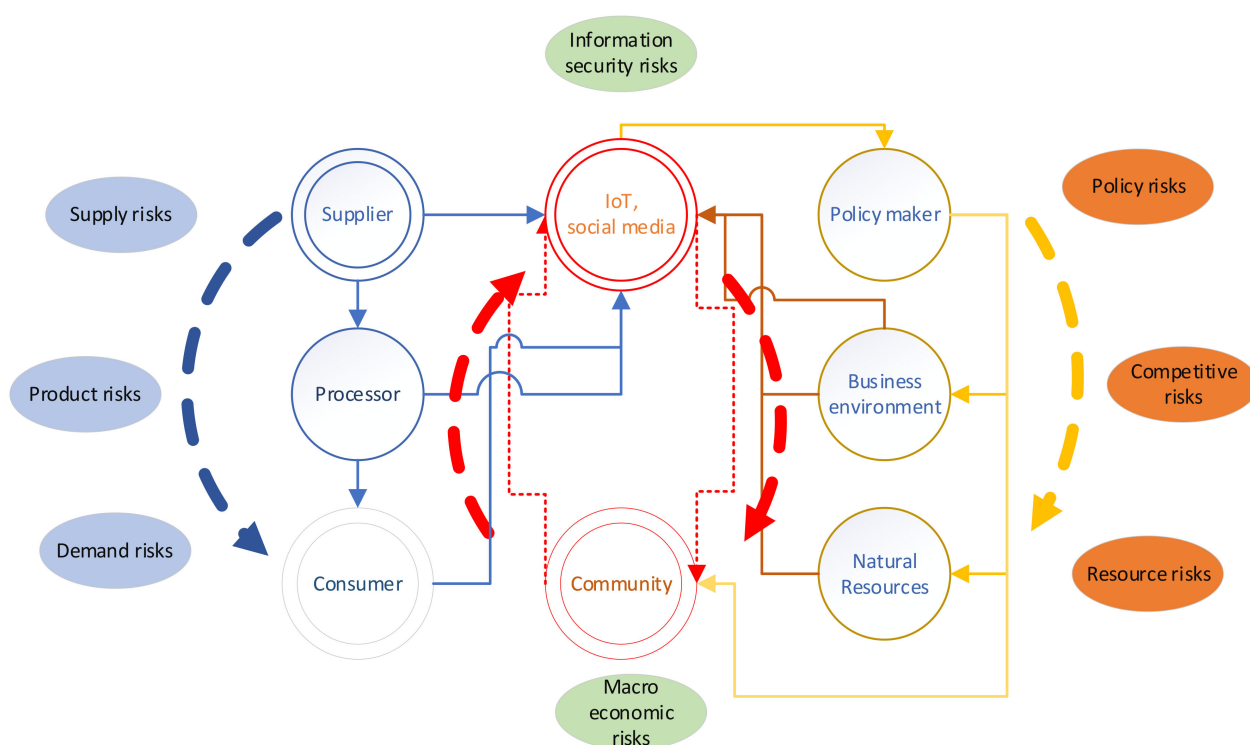

Figure 4. IoT-based supply risk chain management and information flow.

6. Validating the Framework through Case Studies

The COVID-19 pandemic is new to society, and countries that successfully coped with the pandemic showed high awareness in business markets, quick adaption and high resilience. This showed in other disasters, such as earthquakes in Japan, drills are conducted regularly, so people have built a resilience in dealing with earthquakes. In Australia, bushfire prevention and decision-making to cope with bushfires have been widely implemented across the community.

In the disasters, businesses were heavily impacted by restricted opening hours, restricted customer attendance, and logistics disruptions. In some countries, there were financial subsidies for businesses and workers which has stimulated a different economic phenomenon, for example, COVID-19 has accelerated online shopping, and the countries that had the lowest proportion of online shopping had the biggest increase. While, it also generates the biggest bottleneck that was the delivery of online purchases during the lockdown, and online shopping for some services was closed because of a lack of delivery services. A systematically designed supply chain network is needed, such as by providing the closest pick-up spots, etc., to optimise transport and minimise the bottleneck impacts.

From the discussion what we saw during the COVID-19 pandemic, the proposed framework demonstrates good utilisation of IoT and social media, which helps external partners to collaborate in mitigating risk during a disaster. In addition, there are some other issues, such as supply chain network and community support, they can be tackled by the support of an IoT- based system. Overall, the framework can be used for supply chain risk mitigation by following these steps:

(1) Collect/validate/release necessary information via social media
(2) Communicate and update the risk level and its potential impacts
(3) Develop and implement risk mitigation plans
(4) Encourage support and build resilience for community and business

Under the framework, the community would seek the best opportunities to adapt to risk influencing the situation, while businesses will need to respond quickly and accordingly to cater to community needs and provide IoT-based services to meet demands and to collect feedback. Policy makers always are an invisible hand to influence the level of resilience to be built in community and businesses for healthy economic environments.

7. Conclusions

To create an effective risk mitigation instrument, only validated information should be shared; flexible business supply chain models should be established; the powerful risk mitigation enabler of government should create right strategies and supports (financially and non-financially); and there must be resilience in community and business. The use of effective information tools for collaborations would help mitigate risk during disasters.

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