WHAT IS REQUIRED FOR RECOVERING FROM DISASTER: THEORETICAL AND EMPIRICAL VERIFICATION

Koki Arai[1] and Emi Morimoto[2]

[1] *Faculty of Business Studies, Kyoritsu Women's University, 2-2-1 Hitotsubashi, Chiyoda-ku, Tokyo, Japan*

[2] *Research Center for Infrastructure Management, National Institute for Land and Infrastructure Management, 1 Asahi, Tsukuba City, Ibaraki, 4305-080, Japan*

The Great East Japan Earthquake, which occurred on March 11, 2011, had a magnitude of 9.0. The massive tsunami that followed caused extensive damage in coastal districts, resulting in 19,747 deaths and 2,556 missing persons. In terms of reconstruction, there are three main areas of focus: 1) support for the disaster victims (the number of evacuees has been reduced from 470,000 to 43,000 by responding in detail to issues that arise as reconstruction progresses), 2) reconstruction of homes and towns (housing reconstruction is progressing steadily, with most of the construction work completed; the relocation of housing areas to higher ground and the construction of public disaster housing is expected to be completed in FY2020), and 3) revitalisation of industries and livelihoods (production facilities have been mostly restored, production levels in the three affected prefectures have largely recovered, and support for tourism promotion is underway but is currently difficult due to COVID-19). This study examines the necessary and sufficient conditions for proceeding with this recovery, restoration, and revitalisation from an economic theoretical perspective and from public procurement data empirically, exploring their applicability in the post-COVID-19 world. Demand control measures are the first necessary condition to recover from significant damage, including that to infrastructure. Besides, supplier support measures are a sufficient condition to provide more effective and efficient construction services. As a tentative conclusion, an analysis of Japan's public procurement data shows that short-term demand-boosting measures have worked well. However, medium- and long-term supply stimulus measures need further efforts. In Japan, these practices are being applied in response to COVID-19. Specifically, it emphasizes productivity improvement through partnering and the use of new technologies.

Keywords: demand control; Great East Japan Earthquake; necessary condition

INTRODUCTION

On March 11, 2011, the Great East Japan Earthquake of magnitude 9.0 followed by a massive tsunami caused extensive damage in coastal districts. Japan has learned lessons from this experience and has been quick to undertake all possible measures in the event of a disaster, as seen in the string of floods in recent years, the heavy snowfall of winter 2021. Disaster prevention and mitigation, as well as national land

[1] koki.arai@nifty.ne.jp

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resilience, have been firmly promoted, and various reconstruction efforts have been realised.

Some argue that a low efficiency-oriented approach is needed to deal with natural disasters (Ingirige, 2016). In addition to such preparedness, efficiently rebuilding robust infrastructure in the event of a disaster is thought to be vital, and that the concept of pre-disaster recovery, which involves planning for a disaster before it occurs, is also being discussed (Otsuyama and Maki, 2018). Alternatively, there have been various studies about post-disaster reconstruction, and it is necessary to summarise how the market, including public procurement and the response of businesses to it, has evolved from the perspective of reconstruction (a so-called necessary condition). In addition, from the perspective of economic realities and management of the incentive structure of business operators, it would be an appropriate approach for construction management research to analyse the transition of such public procurement (considered to be a so-called sufficient condition). Based on these considerations, this paper analyses the role of the market and the impact of policy measures in the recovery from the earthquake, based on data.

In Japan, the Earthquake of magnitude 9.0 occurred on March 11, 2011. The massive tsunami caused extensive damage in coastal areas and destroyed many districts, resulting in 19,747 deaths and 2,556 missing persons. In terms of reconstruction, there are three main areas of focus: support for the disaster victims, reconstruction of homes and towns and the relocation of housing areas to higher ground and the revitalisation of industries and livelihoods but is currently difficult due to COVID-**19(**Data is based on Reconstruction Agency, 2021). This paper examines the impact of the Earthquake on public procurement of general civil engineering works, based on data from eight regional organisations in Japan from FY2006 to FY2019.

It also explores the potential applications of demand control methods in a post-COVID-19 world. To recover from the enormous damage including to the infrastructure, demand control measures are considered to be the first prerequisite. In addition, supply control measures that provide more effective and efficient construction services would be a sufficient condition. At the time of the disaster, the construction of emergency temporary housing and the reconstruction of infrastructure were vigorously undertaken as short-term efforts, and in the medium to long term, seamless support was continued according to the stage of reconstruction. Japan is applying these lessons in its response to COVID-19. Specifically, in the short term, stable orders are placed, and in the medium to long term, the focus is on partnering and improving productivity using new technologies to support businesses.

Previous Research

There is a dearth of research in the field of construction management on the changes in the economic conditions around construction projects in natural disasters and reconstruction. An analysis of the effects of public investment using a Keynesian model that examines endogenisation of inflation and deflation situations (Hino, *et al.,* 2012), factors that contribute to the speed of relief activities by local construction companies (Takeya and Ohashi, 2013), a comparative study on debt support measures for condominiums between Japan and Taiwan (Meno and Nakabayashi, 2018), and studies on risk assessment and economic damages from insurance payments (Kim, *et al.,* 2019), which have focused on individual factors. However, there are not many studies that critically examine these issues and how the entire market around the construction industry has responded to the earthquake and changed.

In fact, various studies have been conducted on the change in peoples' sense of trust due to natural disasters such as earthquakes (Crowley and Elliott, 2012; Naoi, *et al.,* 2012; Veszteg, *et al.,* 2014; Hanaoka, *et al.,* 2018). Research analysis and recommendations for various individual issues have also been conducted on topics such as pond embankment damage and rehabilitation (Suzuki, 2013), analysis of regional consultant orders (Sakamoto and Hara, 2018), change of motivation and impact of construction managers (Hori and Watanabe, 2019), preplanning for post-disaster relocation projects (Shioji, *et al.,* 2015), and the introduction of construction managers in reconstruction projects (Hosokawa and Minami, 2019).

Among the studies of disaster agreements involving responses to large-scale disasters in rural areas, one analysed the movements of companies that concluded agreements and examined the necessary conditions for building such cooperation systems, which is useful from the perspective of total response (Morizane, *et al.,* 2015). Furthermore, some studies have examined road administration in terms of overall infrastructure management from a broader perspective. One of them underscores the importance of building a framework for continuous improvement and developing a cross-organisational system for on-site management practices. It also specifies new measures for disaster response in addition to normal operations, focusing on maintenance and productivity, amid chronic staff shortages (Mori, *et al.,* 2017). As the reach of these studies, the need for preparedness and organizational readiness to respond to disasters is considered to be examined. In contrast, these papers summarise a number of factors though they do not examine how public procurement has been managed and what effects it has had. Based on this, this paper clarifies the actual situation of post-disaster recovery efforts from the perspective of public procurement.

METHODOLOGY

This study shows how supply and demand are affected by shocks due to the earthquake and tsunami and how they respond to these shocks through model-based reasoning and empirical verification. The study focuses on the Tohoku Regional Development Bureau as this region was severely damaged by the 2011 earthquake. Inferences are drawn based on the model by critically examining previous studies, and theoretical analysis is verified by quantitative analysis based on the publicly available data of public procurement. The results are examined, and the implications and future actions summarised.

FINDINGS

Public procurement and business behaviour in post-disaster reconstruction

The earthquake was an unexpected event, and a shift in the demand and supply curve is thus expected. Due to its unprecedented nature, both demand and supply were hit hard, and their curves expected to shift significantly to the left. As a result, while the equilibrium price could go either up or down, but the equilibrium quantity was expected to decrease significantly (Fig 1 and Fig 2).

In other words, the earthquake caused considerable damage, causing the supply and demand to shrink significantly. The demand curve shifts from D1 to D2 and the supply curve from S1 to S2. The equilibrium point E1 before the earthquake shifts to the equilibrium point E2 after it. This in turn, shifts the price P1 and quantity Q1 of the initial equilibrium to the price P2 and quantity Q2 of the new equilibrium.

Depending on the status of this shift in the demand and supply curves, Fig 1 or Fig 2 is realised.

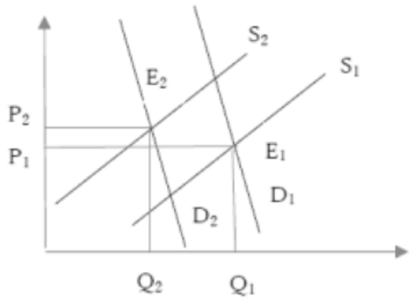

Figure 1: Demand-supply curve shift (Large supply shocks)

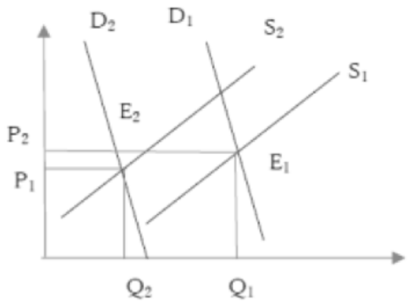

Figure 2: Demand–supply curve shift (Large demand shocks)

In terms of the Japanese public procurement market, there is a kind of ceiling price, set by the procurement authority as a scheduled price. What is considered to be the price can be considered as a ratio to this planned price, which is set for each project. The number of public procurements can be considered as a quantity. Also, although the earthquake occurred on March 11, 2011, the Japanese fiscal year ran from April to March of the following year. Hence, the period from FY2006 to FY2010 was considered as pre-earthquake, and the period from FY2011 to FY2019 as post-earthquake.

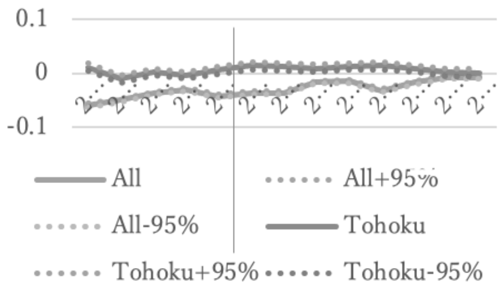

Figure 3: Changes in the bid award rate

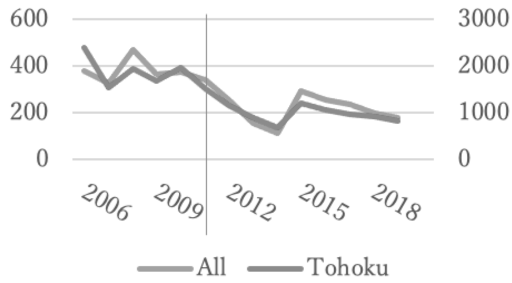

Figure 4: Number of public procurements

Fig 3 shows a regression in the winning bid rate with year dummies, controlling for the lower limit price (with the low-price survey standard price as a covariate), the coefficients of the year dummies and the upper and lower limits of 95% and -95%, respectively, on the same graph (based on 2019).

According to this result, the bid price in Tohoku is significantly higher from 2011 until 2015. Then, it has been decreasing, and since 2016, it has been almost the same as the base year (2019).

Fig 4 shows the change in quantity by year. These results show that the volume of public procurement in Tohoku has not increased significantly since FY 2011.

Under normal circumstances, both supply and demand could have been reduced due to a major shock, but both the price and the quantity were not significantly reduced, suggesting that there was appropriate demand management and supplier support. The reason why the prices were raised without increasing quantities is believed to be because the demand, which could have shrunk, increased investment ahead of time, thereby increasing the total amount of public procurement. This is seen in the change in the total planned prices by year (the comparison is made using an index with FY2019 as 100). This total scheduled price is likely to be determined exogenously (by policy necessity and so on) rather than by factors determined by the market and can be considered a powerful method of demand control.

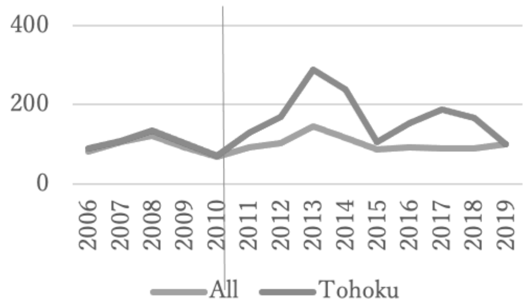

Figure 5: Trends in the total planned public procurement prices

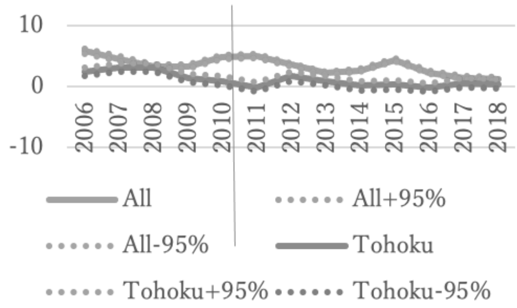

Figure 6: Trends in the number of suppliers

Since FY 2011, the Tohoku Regional Development Bureau has been paying more for total planned prices than the rest of Japan. In response to this, the situation regarding the supply (suppliers), which is usually considered to fall due to large damages, is as follows. Here, supply can be seen in terms of trends in the number of participants (based on 2019).

In 2011 (before the earthquake), the number of suppliers in Tohoku almost decreased, and the following year, they increased and then levelled off. In other words, when suppliers were about to be severely affected, a large increase in public procurement resulted in an increase in suppliers, which is believed to have led to a smooth recovery.

As shown below, this relationship is estimated by a simple regression Eqn. (1). In other words, the changes in the total estimated price, which is set by exogenous factors, before and after the earthquake is estimated by fixed effects for each local development bureau using the earthquake dummy.

$$PP_t = \alpha_1 + \sum \beta_{1,t} Region \times TED + \sum \beta_1 Region\,(fixedeffect) + +\varepsilon_1 \qquad (1)$$

where the subscript t denotes the month. PP is a variable that represents the total expected price for a given month, Region represents the regional development bureau, and TED is the Tohoku earthquake dummy (TED), which is a dummy variable that takes the value 0 for the months before the earthquake and 1 for the months after the earthquake. The coefficients to be obtained are α1, α2, α3, and α4. The coefficients to be calculated are α1, β1, r, β1, and rt; ε is the error term.

The data used here are the public procurement data from FY2006 to FY2019 for general civil engineering projects in the eight regional development bureaus of the Ministry of Land, Infrastructure, and Transport and Tourism (MLITT) (Kanto, Kinki, Kyushu, Shikoku, Chugoku, Chubu, Tohoku and Hokuriku). The results are shown in Table 1.

According to the results in Table 1, the Tohoku Regional Development Bureau, which was hit hard by the earthquake, has seen a clear increase in public procurement costs since the disaster, showing its significant increased while other regions have been forced to reduce their public works.

Dependent Variable:	Log(PP)	Method: Pooled Leas	n=1,326	
	Coefficient	Std. Error	95% upper	95% lower
C	22.192	0.052	22.293	22.091
Kanto*TED	0.181	0.179	0.532	−0.170
Kinki*TED	0.499	0.179	0.850	0.149
Kyushu*TED	−0.002	0.179	0.349	−0.353
Shikoku*TED	0.232	0.185	0.594	−0.131
Chugoku*TED	−0.175	0.180	0.177	−0.528
Chubu*TED	0.128	0.183	0.487	−0.232
Tohoku*TED	0.820	0.180	1.173	0.466
Hokuriku*TED	−0.214	0.180	0.138	−0.566
Fixed Effects	Yes			
R−squared	0.124			
Adjusted R−squared	0.114			
Durbin−Watson stat	1.510			

Table 1: Movement of total estimated prices by district since the earthquake

Dependent Variable:	ANoP	Method: Pooled Leas	n=1,326	
	Coefficient	Std. Error	95% upper	95% lower
C	−0.288	1.319	2.298	−2.874
Log(PP)	0.385	0.059	0.501	0.269
Kanto*TED	0.072	0.384	0.825	−0.681
Kinki*TED	0.202	0.385	0.957	−0.552
Kyushu*TED	−1.307	0.384	−0.555	−2.060
Shikoku*TED	−1.502	0.397	−0.725	−2.280
Chugoku*TED	0.164	0.385	0.919	−0.591
Chubu*TED	0.107	0.394	0.879	−0.664
Tohoku*TED	−2.204	0.390	−1.440	−2.968
Hokuriku*TED	−2.430	0.385	−1.675	−3.185
Fixed Effects	Yes			
R−squared	0.303			
Adjusted R−squared	0.294			
Durbin−Watson stat	1.167			

Table 2: Movement of the average number of participants by district since the earthquake

The following Eqn. (2) is used to estimate how this has changed the number of suppliers. To see how the average number of participants is affected, under the same formulation, changing the dependent variable to the average number of participants and including the total expected price as an exogenous variable, the equation becomes

$$ANoP_t = \alpha_2 + \beta_2 \log PP_t + \sum \beta_{2,t} Region \times TED + \sum \beta_{2f} Region\,(fixedeffect) + \varepsilon_2. \qquad (2)$$

Here, the same subscripts are the same as in the previous Eqn. (1) ANoP (Average Number of Participants) is a variable that represents the average number of participants in a given month; PP is a variable that represents the Predetermined Price.

However, according to the results in Table 2, the number of participants in the Tohoku Regional Development Bureau after the earthquake has been trending negatively and is no longer significant. This is further broken down by year for further examination.

This is analysed in further detail by the total amount of public procurement in the Tohoku region by year. The same type of estimating Eqn. (3), with the independent variable being the total expected price (PP) for the Northeast region, is used to analyse year-to-year changes in policy.

$$\log PP\_Tohoku_t = \alpha_3 + \sum \beta_{3,t} Year + \beta_3 \log Others_t + \varepsilon_3. \qquad (3)$$

Here, the variable PP_Tohoku is the total estimated price of the Tohoku Regional Development Bureau for the year, and the variable Others is the combined value (logarithmic value) of the other seven regional development bureaus outside Tohoku, which was included as a variable to control the trend of public investment in the whole country. The results of this estimation are as shown in Table 3.

According to this result, the total expected price was positive from FY2012 to FY2014, but it became insignificant in FY2015.

Now, let's examine the changes in suppliers in the Tohoku region.

In Eqn. (4), the same subscripts as in the previous equations stand for the same parameters. NoP_Tohoku (Number of Participants Tohoku) is a variable that indicates the average number of bidders for each project in that month of the year, and

Period is a dummy variable that indicates the year, taking the value 1 if it is a certain year and 0 otherwise. Period is a dummy variable indicating the fiscal year. The results are shown in Table 4.

$$NoP\_Tohoku_t = \alpha_4 + \sum \beta_{4,t} Period + \beta_{4,1,t} \log PP\_Tohoku_t + \sum \beta_{4,t} Regions + \varepsilon_1. \quad (4)$$

Dependent Variable:	log(PP_Toh	Method: Pooled Leas	n=155	
	Coefficient	Std. Error	95% upper	95% lower
C	−0.862	2.304	3.655	−5.378
2006	0.121	0.350	0.808	−0.566
2007	0.024	0.342	0.693	−0.646
2008	−0.029	0.342	0.641	−0.698
2009	−0.054	0.342	0.616	−0.724
2010	0.209	0.351	0.897	−0.479
2011	0.245	0.350	0.932	−0.441
2012	0.672	0.342	1.341	0.002
2013	0.876	0.335	1.532	0.219
2014	1.032	0.334	1.687	0.378
2015	0.418	0.342	1.088	−0.252
2016	0.850	0.335	1.507	0.194
2017	1.151	0.342	1.822	0.481
2018	0.818	0.342	1.488	0.148
log(Others)	0.951	0.093	1.134	0.769
R-squared	0.512			
Adjusted R-squared	0.464			
Durbin-Watson stat	1.799			

Table 3: Yearly movement of total estimated prices since the earthquake

Dependent Variable:	Nop_Tohoku	Method: Least Squar	n=155	
	Coefficient	Std. Error	95% upper	95% lower
C	−2.098	3.417	4.600	−8.795
2006	3.340	1.060	5.417	1.262
2007	2.550	0.985	4.481	0.620
2008	2.166	0.892	3.914	0.418
2009	2.154	0.887	3.893	0.416
2010	1.436	1.079	3.551	−0.680
2011	1.572	1.048	3.627	−0.482
2012	3.342	0.989	5.280	1.404
2013	1.957	0.848	3.618	0.295
2014	1.181	0.886	2.918	−0.555
2015	1.699	0.937	3.535	−0.138
2016	0.326	0.823	1.939	−1.287
2017	1.901	0.812	3.493	0.309
2018	0.697	0.805	2.275	−0.881
log(PP_Tohoku)	0.121	0.146	0.408	−0.165
Other Regions NoP	Yes			
R-squared	0.501			
Adjusted R-squared	0.422			
Durbin-Watson stat	1.807			

Table 4: Yearly movement of suppliers since the earthquake

According to the results, the number of bidders (suppliers) increased in FY2012 and FY2013, but the number of suppliers has not been significantly affected since FY2014.

Therefore, in response to the shock of the earthquake, the amount of total planned prices for public procurement is expected to have increased in FY 2012-2014 as a measure to stimulate demand. In the previous Figs. 1 and 2, this situation could have been represented by Fig 2 (Table 3). In contrast, the demand expansion measures shifted the D2 demand curve to D3, and the price realised did not fall below the original price. As a result, the situation where the number of suppliers could have fallen temporarily recovered in FY2012 and FY2013 (Table 4). However, demand stimulus measures alone would not be enough to maintain and secure the number of suppliers, and hence, they have been declining since FY2014.

In other words, to recover from the damage including that to the infrastructure, demand control measures are considered to be the primary necessary condition followed by supply control measures for more effective and efficient provision of construction services. As a preliminary conclusion from the analysis of demand and supply in public procurement, short-term demand-boosting measures have been quite successful. However, further efforts are required for medium- to long-term supply stimulus measures.

CONCLUSIONS

This study analysed and examined the effects of demand control and supply stimulus in public procurement after the Great East Japan Earthquake. The bidding data of general civil engineering works of the Regional Development Bureau of the MLITT from FY2006 to FY2019 was used for the analysis. The results show that demand control measures are the first prerequisite to recover from extensive damage, including infrastructural damage, and this was implemented appropriately. In addition, it is necessary to take measures to control supply to provide construction services effectively and efficiently, and further measures are desirable to stimulate supply from a medium- to long-term perspective.

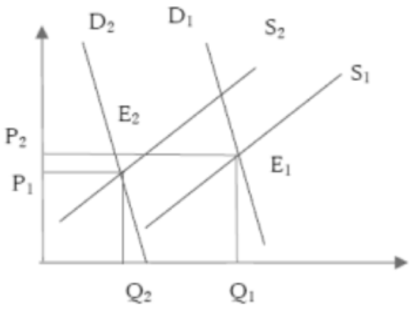

Figure 2 (Reprint)

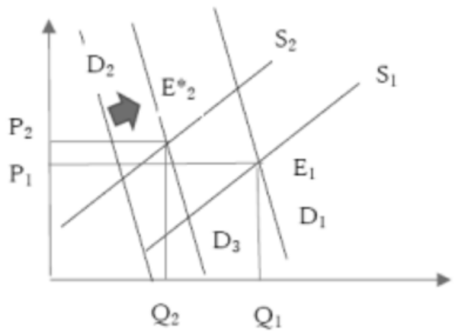

Figure 7: Demand–supply curve extend shift

For this purpose, i-Construction, which focuses on the use of ICT in national land transportation policy, has been systematically and actively implemented since FY2016. For details, refer to Arai and Morimoto (2020), who promote i-Construction based on the rapid development of satellite positioning technology and IoT. Their report summarises the perspectives for promoting i-Construction based on the rapid development of the IoT as "turning construction sites into state-of-the-art factories," "introducing state-of-the-art supply chain management to construction sites," "breaking down the existing old ways of thinking and old regulations at construction sites" and ""continuous kaizen." For example, "full use of ICT (ICT earthwork)," "introduction of total optimisation (standardisation of concrete work standards, etc.)," and "equalisation of construction time" are set. As a mechanism to promote i-Construction, the government established a promotion system and a public-private consortium, used big data, and collaborated with other outdoor industries.

In Japan, these lessons have been applied to the COVID-19 crisis. According to the MLITT data from August 2020, the number of construction projects subject to ICT construction is expanded annually. The ratio of ICT construction to the number of public notices is increasing. The number of companies with multiple experiences has increased by about eight times from 107 at the end of FY 2016 to 873 at the end of FY 2019, accounting for approximately 60%.

The originality and novelty of this research is due to the fact that few studies have analysed of demand management and supply stimulation in the public procurement market of the construction industry after natural disasters from the perspective of construction management. The contribution of this study to construction management research is that it not only tracks supply and demand trends but also organises them from the standpoint of shifting equilibrium in the market and shifting demand and supply curves. In addition, statistical analysis and reduction based on data processing are considered to contribute to the advancement of construction management as a science. One of the limitations of this study is that it is a case study based in Japan. However, an analysis of the incentives of participants in public procurement in response to a major natural disaster that could shake the country has implications that go beyond a case study. In Japan, the experience of managing supply and demand in the aftermath of the earthquake is being utilized in response to COVID-19. This is where stable orders are being placed in the short term, and where the importance is given on improving productivity to support businesses in the medium to long term.

REFERENCES

Ingirige, B (2016) Theorizing construction industry practice within a disaster risk reduction setting: Is it a panacea or an illusion? *Construction Management and Economics*, **34**(7-8), 592-607.

Crowley, K, Donovan, N and Elliott, J R (2012) Earthquake disasters and resilience in the global north: Lessons from New Zealand and Japan, *The Geographical Journal*, **178**(3), 208-215.

Veszteg, R F, Funaki, Y and Tanaka A (2015) The impact of the Tohoku Earthquake and Tsunami on social capital in Japan: Trust before and after the disaster, *International Political Science Review*, **36**(2), 119-38.

Hanaoka, C, Shigeoka, H and Watanabe, Y (2018) Do risk preferences change? Evidence from the Great East Japan Earthquake, *American Economic Journal: Applied Economics*, **10**(2), 298-330.

Hino, S, Momma, T, Koike, A, Nakano, T and Fujii, S (2012) Analysis of public investment effect by Keynesian model the endogenous inflation - deflation condition, *Journal of Japan Society of Civil Engineers*, F4, **68**(4), I_21-I_32 [in Japanese].

Hori, H and Watanabe, T (2019) Study of on the change of motivation and influence of CMR (Case of Reconstruction CM), *Journal of Japan Society of Civil Engineers*, F4 **75**(2), I_168-I_184 [in Japanese].

Hosokawa, T and Minami, M (2019) Consideration for the type of construction management method and the system on execution, as example of the reconstruction projects for the Great East Japan Earthquake, *Journal of Japan Society of Civil Engineers*, F4 **75**(2), I_58-I_72 [in Japanese].

Kim, J-M, Kim, T, Son, K, Bae, J and Son, S (2019) A quantitative risk assessment development using risk indicators for predicting economic damages in construction sites of South Korea, *Journal of Asian Architecture and Building Engineering*, **18**(5), 472-478.

Meno, F and Nakabayashi, I (2008) Support measures for reconstruction of condominiums damaged by earthquakes-Comparative study on the Hanshin-Awaji earthquake of 1995 in Japan and the 921 Chi-Chi earthquake of 1999 in Taiwan, *Journal of Asian Architecture and Building Engineering*, **7**(2), 325-332.

Mori, Y, Akiba, S and Seki, K (2017) Study on the future infrastructure management in the field of road administration, *Journal of Japan Society of Civil Engineers*, F4 **73**(4), I_120-I_129 [in Japanese].

Morizane, K, Nakawaki, N and Goso T (2015) A study on disaster relief agreements that can be used in the event of a large-scale disasters, *Journal of Japan Society of Civil Engineers*, F4 **71**(4), I_97-I_108 [in Japanese].

Naoi, M, Seko, M and Ishino, T (2012) Earthquake risk in Japan: Consumers' risk mitigation responses after the Great East Japan Earthquake, *Journal of Economic Issues*, **46**(2), 519-530.

Otsuyama, K and Maki N (2018) A comparative analysis and identification of issues on legislative systems for pre-disaster recovery planning in Japan and U.S, *Journal of the City Planning Institute of Japan*, **53**(2), 132-143.

Reconstruction Agency (2021) Current status of reconstruction and future efforts (Fukko no Genjo to Kongo no Torikumi), Reconstruction Agency, Available from: https://www.reconstruction.go.jp/topics/main-cat1/sub-cat1-1/20131029113414.html [in Japanese] [Accessed June 14, 2021].

Sakamoto, J and Hara T (2018) Analysis of the actual situation of the local civil engineering consultant companies since the Great East Japan Earthquake: Focusing on the bid information of Ministry of Land, Infrastructure, Transport and Tourism, *Japan Journal of Japan Society of Civil Engineers*, F4 **74**(2), I_182-I_191 [in Japanese].

Shioji, N, Goso, T and Kakuzaki T (2015) A study on pre-earthquake plan for relocation toward future earthquake disaster, *Journal of Japan Society of Civil Engineers*, F4 **71**(4), I_109-I_117 [in Japanese].

Suzuki, T, Morii, T and Kawai T (2013) Qualitative evaluation of restoration effect and damages situation of dam due to the large-scale earthquake disaster, *Journal of Japan Society of Civil Engineers*, F4 **69**(4), I_51-I_56 [in Japanese].

Takeya, S and Ohashi, S (2013) The regional factors of construction contractor's rapid emergency response at the Great East Japan Earthquake, *Journal of Japan Society of Civil Engineers*, F4 **69**(4), I_273-I_279 [in Japanese].