Analysis of Recovery of Production Capacity of Natural Hazards: Case Study of 2016 Kumamoto Earthquakes

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Abstract This paper aims to propose an estimation methodology of recovery of production capacity in the industrial sectors by a natural disaster and apply it to the case of the 2016 Kumamoto Earthquakes. The production capacity is fundamental information to capture the economic loss due to natural hazards. This paper focuses on the analysis and comparison of the recovery process according to time from different initial damage states. In the estimation of recovery of production capacity, survival analysis and multinomial logistic model are selected to estimate the extent of damage and recovery of production capacity. The results of multinomial logistic model are then compared with the results of survival analysis in an attempt at model validation.

Key Words : production capacity, 2016 Kumamoto Earthquakes, multinomial logistic model, survival analysis, initial damage states

1. Introdution

The 2016 Kumamoto earthquake sequence started with an M_{JMA} 6.5 earthquake at a shallow depth in Kumamoto Prefecture, which is in the central part of Kyushu Island, southwest Japan, at 21:26 Japan Standard Time (JST) on April 14, 2016 (12:26 UTC on April 14, 2016). A larger earthquake of M_{JMA} 7.3 occurred at 01:25 JST on April 16, 2016 (16:25 UTC on April 15, 2016), just 28 h after the M_{JMA} 6.5 earthquake (Asano and Iwata¹⁾, 2016). Estimate of the economic impact on the prefecture worth ¥3.8 trillion. Homes suffered the worst damage at about ¥2 trillion, with approximately 170,000 houses affected including around 8,000 that were completely destroyed. Damage to the business sector, including factories and hotels, was estimated at ¥820 billion and damage to roads, bridges and other public infrastructure at ¥268.5 billion (Kumamoto prefectural government²), 2016).

The production capacity losses caused by the earthquakes are considered as one of the most significant factors to the severe economic impact (Fig.1). In order to effectively reduce the losses induced by largescale disasters in the future, it is vital to study in detail the economic losses, including the structure of complex damage propagation and to reflect upon them (Kajitani and Tatano³), 2014). Analysis of recovery of production capacity can provide an important source of information for understanding the scale of an economic disruption in an industrial sector, especially the dimension of its output.

In consideration of this background, this paper aims to propose an estimation methodology of recovery of production capacity in the industrial sectors by a natural disaster and apply it to the case of the 2016 Kumamoto Earthquakes. This research focuses on the analysis and comparison of the recovery process according to time from different initial damage states. Meanwhile, this research seeks to advance the estimation of recovery process of production capacity in different industrial sectors considering initial damage states. Firstly, recovery process of three different industrial sectors from five initial operation levels are estimated by multinomial logistic model. Secondly, the survey data is applied to survival analysis, which is a fundamental methodology for recovery probability of production capacity. Thirdly, the results of multinomial logistic model are then compared with the results of survival analysis in an attempt at model validation.

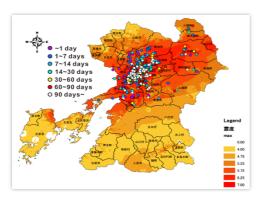


Fig.1 Recovery time to maximum operation level.

2. Methodology

In statistics, multinomial logistic regression is a classification method that generalizes logistic regression to multiclass problems with more than two possible outcomes. It is a model that is used to predict the probabilities of the different possible outcomes of dependent variables, given a set of independent variables (Greene and William H^{4}). 2012).

(1) Outline of the model

Firstly, operation capacity is divided into five different states. Secondly, the probability of operation capacity at recovery time T from five operation states are estimated by multinomial logistic regression. Thirdly, the recovery process from all operation states are estimated by the weighted average of five operation levels (Fig. 2).

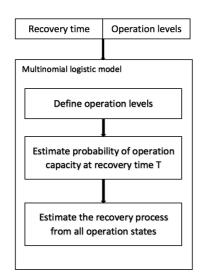


Fig.2 Framework of proposed methodology.

(2) Multinomial logistic model

a) The model

First, operation capacity is divided into five different levels as Table 1.

Table.1 Categories of operation levels.

J=1	J=2	J=3	J=4	J=5
Opera-	Operation	Operation	Operation	Oper-
tion level	level	level	level	ation
About 0	1~25%	25~50%	50~75%	level
				>75%

For the multinomial logistic regression model, we equate the linear component to the log of the odds of a *jth* observation compared to the *Jth* observation. That is, the *Jth* category is considered to be the base-line category, where logits of the first J - I categories are constructed with the baseline category in the denominator.

$$\log\left(\frac{\pi_{ij}}{\pi_{ij}}\right) = \log\left(\frac{\pi_{ij}}{1 - \sum_{j=1}^{J-1} \pi_{ij}}\right) = \sum_{k=0}^{K} x_{ik} \beta_{kj}$$

 $i = 1, 2, ..., N$
 $j = 1, 2, ..., J - 1$
(1)

 π_{ii} can be solved as:

$$\pi_{ij} = \frac{e^{\sum_{k=0}^{K} x_{ik}\beta_{kj}}}{1 + \sum_{j=1}^{J-1} e^{\sum_{k=0}^{K} x_{ik}\beta_{kj}}}$$
(2)

$$\pi_{iJ} = \frac{1}{1 + \sum_{j=1}^{J-1} e^{\sum_{k=0}^{K} x_{ik} \beta_{kj}}}$$
(3)

 x_{ik} stands for recovery times, which are continuous time series. π_{ij} stands for the probability of observing the *jth* value of the dependent variable for any given observation in the *ith* time.

b) Parameter estimation

The kernel of the log likelihood function for multinomial logistic regression models is:

$$L(\beta|y) \cong \prod_{i=1}^{N} \prod_{j=1}^{J} \pi_{ij}^{y_{ij}}$$
(4)

By replacing the *Jth* terms and substituting π_{ij} and π_{ij} by equations (2) and (3), it can be transformed as:

$$\prod_{i=1}^{N} \prod_{j=1}^{J-1} e^{y_{ij} \sum_{k=0}^{K} x_{ik} \beta_{kj}} \cdot \left(1 + \sum_{j=1}^{J-1} e^{\sum_{k=0}^{K} x_{ik} \beta_{kj}}\right)^{-n_i}$$
(5)

Taking the natural log of equation (5) gives us the log likelihood function for the multinomial logistic regression model as:

$$l(\beta) = \sum_{i=1}^{N} \sum_{j=1}^{J-1} \left(y_{ij} \sum_{k=0}^{K} x_{ik} \beta_{kj} \right) - n_i \log \left(1 + \sum_{j=1}^{J-1} e^{\sum_{k=0}^{K} x_{ik} \beta_{kj}} \right)$$
(6)

Taking the derivative of the log likelihood and setting to 0, we get

$$\frac{\partial l(\beta)}{\partial \beta_{kj}} = \sum_{i=1}^{N} y_{ij} x_{ik} - n_i \pi_{ij} x_{ik} \equiv 0$$
(7)

Thus, parameter can be estimated by equation (7).

3. Model application based on survey data

(1) Application of multinomial logistic model for industrial sectors

Based on the survey data, multinomial logistic model is applied to estimate the recovery process of production capacity from five different initial operation levels. In this research, manufacturing, construction, wholesale and retailing industries are analyzed.

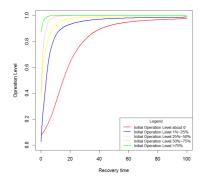


Fig.3 The recovery process of production capacity of manufacturing industry.

Taking manufacturing industry as an example, the recovery process is illustrated in **Fig.3**. The red line

represents the recovery process from initial operation level at about 0. The blue line represents the recovery process from initial operation level at $1\% \sim 25\%$. The yellow line represents the recovery process from initial operation level at $25\% \sim 50\%$. The pink line represents the recovery process from initial operation level at $50\% \sim 75\%$. The green line represents the recovery process from operation level at > 75%.

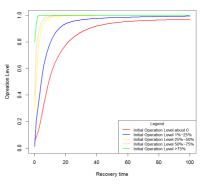


Fig.4 The recovery process of production capacity of construction industry.

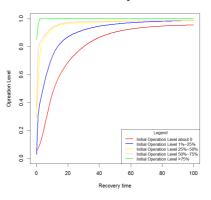


Fig.5 The recovery process of production capacity of wholesale and retailing industry.

(2) Application of survival analysis model for industrial sectors

In this research, Kaplan-Meier estimator of survival analysis model is adopted to conduct statistics of recovery probability regarding recovery time. The results of survival analysis are set to be a standard to evaluate the estimation results from multinomial logistic model.

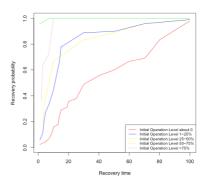


Fig.6 The recovery probability of manufacturing industry.

Taking manufacturing industry as an example, the recovery probability is illustrated in **Fig.6**. The red line represents the recovery probability from initial operation level at about 0. The blue line represents the recovery probability from initial operation level at $1\% \sim 25\%$. The yellow line represents the recovery probability from initial operation level at $25\% \sim 50\%$. The pink line represents the recovery probability from initial operation level at $50\% \sim 75\%$. The green line represents the recovery probability from initial operation level at $50\% \sim 75\%$. The green line represents the recovery probability from operation level at 27%.

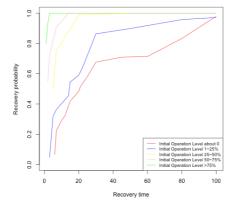


Fig.7 The recovery probability of construction industry.

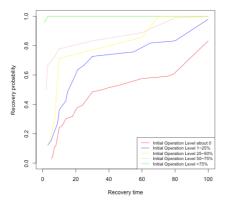


Fig.8 The recovery probability of wholesale and retailing industry.

(3) Model validation

The estimation results of the recovery process from multinomial logistic model are compared with the statistics results of recovery probability from survival analysis model as model validation. The comparison results are illustrated as **Table.2**. The recovery probabilities on recovery days 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 30, 40, 60, 80, 100 are selected to compare in the graph.

Table.2	The co	omparison	results c	of recovery	probability	of two

Recovery day	s 1	2	3	4	5	6	7	8	9	10
Manufacturing										
Multinomial logistic										
IOL about 0	0.204	0.222	0.241	0.261	0.281	0.301	0.322	0.343	0.364	0.384
IOL 1~25%			0.479							
IOL 25~50%	0.251	0.656	0.671	0.686	0.702	0.717	0.732	0.746	0.761	0.774
IOL 50~75%			0.869							
IOL >75%	0.972	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Survival analysis										
IOL about 0	0.022	-	-	-	0.044			0.089		L 0.156
IOL 1~25% IOL 25~50%	0.056	-	0.111			-	0.333	-	-	0.444
IOL 25"50%	-	0.264	0.167	0.333	-	-	0.727		2	0.667
IOL >75%	0.958	0.504	0.050	-	-	-	1.000		-	1.000
	0.550						1.000	·		
Construction										
Multinomial logistic IOL about 0	0 177	0 217	0.259	0 202	0 249	0 200	0 420	0 466	0 409	0 5 2 7
IOL 1~25%			0.259							
IOL 25~50%			0.573							
IOL 50~75%			0.777							
IOL >75%			1.000							
Survival analysis										
IOL about 0	-	-	-	-	-	0.065	0.226	-	-	0.290
IOL 1~25%	-	-	0.045	-	0.318		0.364	-	-	-
IOL 25~50%	-	-	-	-	0.500		0.750	-	-	-
IOL 50~75%	-		0.727	-	-	-	0.909	-	-	-
IOL >75%	0.800	0.933	1.000	-	-	-	-	1.000	-	-
Wholesale and Retailing										
Multinomial logistic										
IOL about 0			0.238							
IOL 1~25% IOL 25~50%			0.497 0.603							
IOL 23 30%			0.860							
IOL >75%			1.000							
Survival analysis	0.575	0.555	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
IOL about 0	-	-	-	-	0.030	0.045	0.106	0.121	-	0.242
IOL 1~25%	-	-	0.121	-	0.152	0.182	0.212	0.242	0.273	3 0.364
IOL 25~50%	-	-	-	0.143	-	-	0.286	0.429	-	0.714
IOL 50~75%	-		0.667	-	-	-	0.722	-	-	0.778
IOL >75%	0.956	5 -	1.000	-	-	-	1.000	-	-	1.000
Recovery days	1	5	20	30		40	60	80		100
Recovery days	1	5	20	30		40	60	80		100
Aanufacturing Aultinomial logistic										
Manufacturing Multinomial logistic OL about 0	0.4	82	0.566	0.68	89 0.	.774	0.884	0.94	14 (0.974
Anufacturing Aultinomial logistic DL about 0 DL 1~25%	0.4	82 38	0.566 0.872	0.68	89 O. D6 O.	.774 .926	0.884 0.956	0.94	14 (0.974 0.987
Anufacturing Aultinomial logistic OL about 0 OL 1~25% OL 25~50%	0.4 0.8 0.8	82 38 30	0.566 0.872 0.869	0.68 0.90 0.91	89 0. 06 0. 13 0	.774 .926 .939	0.884 0.956 0.971	0.94 0.97 0.98	14 (76) 87	0.974 0.987 0.994
Manufacturing Aultinomial logistic DL about 0 DL 125% DL 25%50% DL 50~75%	0.4 0.8 0.8 0.9	82 38 30 96	0.566 0.872 0.869 0.999	0.68 0.90 0.91	89 0. 06 0. 13 0 99 0	.774 .926 .939 .999	0.884 0.956 0.971 1.000	0.94 0.97 0.98 1.00	4 (76 (37 (0.974 0.987 0.994 1.000
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 50~75% DL >75%	0.4 0.8 0.8	82 38 30 96	0.566 0.872 0.869	0.68 0.90 0.91	89 0. 06 0. 13 0 99 0	.774 .926 .939	0.884 0.956 0.971	0.94 0.97 0.98	4 (76 (37 (0.974 0.987 0.994
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 50~75% DL >75% urvival analysis	0.4 0.8 0.8 0.9	82 38 30 96 00	0.566 0.872 0.869 0.999	0.68 0.90 0.91	89 0. 06 0. 13 0 99 0 00 1	.774 926 .939 .999 .000	0.884 0.956 0.971 1.000	0.94 0.97 0.98 1.00 1.00	14 (76 (37 (00 (0.974 0.987 0.994 1.000
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 50~75% DL >75% urvival analysis DL about 0	0.4 0.8 0.8 0.9 1.0	82 38 30 96 00 89	0.566 0.872 0.869 0.999 1.000	0.68 0.9(0.9) 0.9) 1.0	89 0. 06 0. 13 0 99 0 00 1 89 0	.774 .926 .939 .999 .000	0.884 0.956 0.971 1.000 1.000	0.94 0.97 0.98 1.00 1.00	14 (76 (37) 00) 33	0.974 0.987 0.994 1.000 1.000
Anufacturing Aultinomial logistic DL about 0 DL 17-25% DL 25~50% DL 25~50% DL 25~50% DL 25~50% UL 25~50% UL 25~50% DL 25~50% DL 25%	0.4 0.8 0.9 1.0 0.2	82 38 30 96 00 89 78	0.566 0.872 0.869 0.999 1.000 0.356	0.68 0.90 0.91 0.92 1.0	89 0. 06 0. 13 0 99 0 00 1 89 0 89 0	.774 .926 .939 .999 .000	0.884 0.956 0.971 1.000 1.000 0.667 0.899	0.94 0.97 0.98 1.00 1.00 0.83 0.95	14 (76) 37) 00) 33) 58)	0.974 0.987 0.994 1.000 1.000 0.980
Anufacturing Aultinomial logistic DL about 0 DL 1*25% DL 25*50% DL 50*75% UL 575% urvival analysis DL about 0 DL 1*25% DL 1*25% DL 1*25%	0.4 0.8 0.9 1.0 0.2 0.7	82 38 30 96 00 89 78	0.566 0.872 0.869 0.999 1.000 0.356 -	0.68 0.90 0.91 1.0 0.48 0.88	89 0. 06 0. 13 0 99 0 00 1 89 0 89 0	.774 .926 .939 .999 .000	0.884 0.956 0.971 1.000 1.000 0.667 0.899	0.94 0.97 0.98 1.00 1.00 0.83 0.95	14 (76) 37) 00) 33) 58)	0.974 0.987 0.994 1.000 1.000 0.980 0.990
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 50~75% urivial analysis DL about 0 DL 1~25% DL 25% DL 25% DL 25% DL 25% DL 25% DL 25% DL 25~50% DL 25~75%	0.4 0.8 0.9 1.0 0.2 0.7	82 38 30 96 00 89 78	0.566 0.872 0.869 0.999 1.000 0.356	0.68 0.90 0.91 1.0 0.48 0.88	89 0. 06 0. 13 0 99 0 00 1 89 0 89 0	.774 .926 .939 .999 .000	0.884 0.956 0.971 1.000 1.000 0.667 0.899	0.94 0.97 0.98 1.00 1.00 0.83 0.95 0.95	14 (76) 37) 00) 33) 58)	0.974 0.987 0.994 1.000 1.000 0.980 0.990
Anufacturing Aultinomial logistic DL about 0 DL 1-25% DL 25~50% DL 50~75% UL >75% urvival analysis DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 25~50% DL 50~75%	0.4 0.8 0.9 1.0 0.2 0.7	82 38 30 96 00 89 78	0.566 0.872 0.869 0.999 1.000 0.356	0.68 0.90 0.91 1.0 0.48 0.88	89 0. 06 0. 13 0 99 0 00 1 89 0 89 0	.774 .926 .939 .999 .000	0.884 0.956 0.971 1.000 1.000 0.667 0.899 0.958	0.94 0.97 0.98 1.00 1.00 0.83 0.95 0.95	44 (76) 70) 70) 70) 70) 70) 70) 70) 70	0.974 0.987 1.000 1.000 0.980 0.990 -
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Anufacturing Aultinomial logistic OL about 0 OL 25% OL 25% OL 25% OL 30~75% Urvival analysis OL about 0 OL 17*25% OL 25% OL 25% OL 25% OL 25% OL 25% OL 25% Aultinomial logistic OL about 0 OL 4000 0 OL 4000 0 OL 4000 0 OL 4000 0 OL 1*25%	0.4 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 793	0.566 0.872 0.869 1.000 0.356 - - - - - 0.684 0.846	0.68 0.90 0.91 1.0 0.48 0.83 - - - - 0.7	39 0. 06 0. 13 0 99 0 000 1 39 0 89 0 89 33 (760 915	774 926 939 999 .000 .556 -	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - -	0.94 0.97 0.98 1.00 1.00 0.83 0.99 - 1.0 3 0.9 5 0.1	14 (76) 00 00 33 358 90 000 000	0.974 0.987 0.994 1.000 0.980 0.990 - - 1.000 0.951 0.998
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Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 55% DL 55% University of the second seco	0.4 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 78 525 793 998 967	0.566 0.872 0.869 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.48 0.83 - - - 0.7 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	39 0. 13 0 99 0 000 1 39 0 89 33 760 915 999 996	774 926 939 .000 .556 -	0.884 0.956 0.971 1.000 0.667 0.899 - - - - 0.878 0.988 1.000 0.998	0.94 0.97 0.98 1.00 1.00 0.83 0.95 - 1.0 3.0,95 - 1.0 3.0,95 0.1,0 9.0,1	4 (0 76 (0 33 33 358 90 000 900 900 900 999	0.974 0.987 0.994 1.000 0.980 0.990 1.000 0.951 0.958 1.000 1.000
Anufacturing Aultinomial logistic DL about 0 DL 25°50% DL 25°50% DL 50°75% urvival analysis DL about 0 DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL about 0 DL 425% DL about 0 DL 425% DL 25°50% DL 25°50% DL 50°75% DL 50°75%	0.4 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 78 525 793 998	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - 0.684 0.846 0.995	0.68 0.99 0.99 1.0 0.48 0.83 - - - 0.7 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	39 0. 13 0 99 0 000 1 39 0 89 33 760 915 999 996	774 926 939 .000 .556 -	0.884 0.956 0.971 1.000 0.667 0.899 - - - - 0.878 0.988 1.000 0.998	0.94 0.97 0.98 1.00 1.00 0.83 0.95 - 1.0 3.0,95 - 1.0 3.0,95 0.1,0 9.0,1	14 (76 (70) 70) 73 3 75 8 90) 70 0 70 0 70 0 70 0 70 0 70 0 70 0 7	0.974 0.987 0.994 1.000 0.980 0.990 1.000 0.951 0.958 1.000 1.000
Anufacturing Aultinomial logistic OL about 0 OL 25% OL 25%50% OL 50~75% OL 35%5 OL about 0 OL 1~25% OL 25%50% OL 25%50% OL 50~75% OL 575% Aultinomial logistic OL about 0 OL 1~25% OL 25%50% OL	0.4 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 78 525 793 598 567 000	0.566 0.872 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.90 0.90 1.0 0.88 0.88 - - - 0.7 0.8 - - 0.7 0.9 - - 0.7 0.9 - - - - - - - - - - - - - - - - - - -	39 0. 06 0 13 0 99 0 13 0 39 0 33 (760 115 999 999 9996 000	774 926 939 999 .000 .556 - 0.889 - - 0.889 - 0.889 1.000	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - - 0.878 0.985 1.000 0.999 1.000	0.94 0.97 0.98 1.00 0.99 0.99 - 1.0 3 0.99 - 1.0 3 0.99 5 0.9 0 1. 9 0.2 0 1.	44 (0 66 (1 33) 333 58 90 900 900 9222 995 9000 9999 9000	0.974 0.987 0.994 1.000 0.980 0.990 - 1.000 0.951 0.998 1.000 1.000
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 25~50% DL 35~75% urvival analysis DL about 0 DL 1~25% DL 50~75% DL 50~75% DL 50~75% DL 35% DL 1~25% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25	0.4 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 79 30 867 700 00	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.48 0.83 - - - 0.7 0.5 0.9 0.0.9 - - - - - - - - - - - - - - - - - - -	39 0. 06 0 13 0 99 0 13 0 89 0 33 (760 915 999 996 000 6777	774 926 9399 9999 0000 1.556 - - - 0.889 - - - 0.881 0.952 1.000 0.999 1.000 0.710	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - - - - - - - - - - - - - - - - -	0.94 0.97 0.98 1.00 0.83 0.99 - 1.0 5 0.99 - 1.0 5 0.91 - 1.0 9 0.1. 9 0.1 4 0 0	44 (0 66 (1 37 (1) 33 (1) 58 (2) 90 (1) 90 (0.974 0.987 0.994 1.000 0.980 0.990 1.000 1.000 1.000 1.000 0.980
Anufacturing Aultinomial logistic DL about 0 DL 25°50% DL 25°50% DL 25°50% DL 35°75% UL 35% DL about 0 DL 17°25% DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL 25°50% DL 17°25% DL 35°75% Aultinomial logistic DL about 0 DL 17°25% DL 50°75% DL 50°75% DL 50°75% DL 50°75% DL 50°75% DL 50°75% DL 50°75%	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 593 998 567 900 119 545	0.566 0.872 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.48 0.83 - - - 0.7 0.9 0.9.9 - - - - - - - - - - - - - - - - - -	39 0. 06 0. 13 0 99 0 1389 0 333 (760 715 999 996 000 677 884	774 926 939 999 .000 .556 -	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - 0.878 0.958 - - - 0.876 0.958 - - 0.958 - - 0.958 - - 0.958 0.956 0.956 0.956 0.971 1.000 0.956 0.971 1.000 0.956 0.971 1.000 0.957 0.956 0.957 1.000 0.956 0.957 1.000 0.956 0.957 1.000 0.956 0.957 1.000 0.957 0.956 0.957 1.000 0.957 0.959 0.958 0.958 0.958 0.959 0.958 0.959 0.958 0.0958 0.0958 0.0958 0.0958 0.0958 0.0958 0.0958 0.0958 0.000 0.958 0.000 0.0958 0.0000 0.0000 0.0000 0.0000 0.00000 0.000000	0.94 0.97 0.98 1.00 0.99 0.99 - 1.0 3 0.9 5 0.9 - 1.0 3 0.9 5 0.9 0 1. 9 0. 0 1. 9 0. 9 0. 9 0.	44 (0 76 (1 87) 100 100 133 158 190 100 100 100 100 100 100 100	0.974 0.987 0.994 1.000 0.990 1.000 1.000 0.998 1.000 1.000 0.980 0.972
Anufacturing Aultinomial logistic OL about 0 OL 25% OL 25% OL 25%5% OL 30%75% OL 75% urvival analysis OL about 0 OL 1~25% OL 25%50% OL 50%75% OL 50%75% OL 30%75% OL 125% OL 25%50% OL 75% UN 25% OL 25%50% OL 25% OL 30%75% OL 25% OL	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 79 30 867 700 00	0.566 0.872 0.999 1.000 0.356 - - - - - - - - - - 0.684 6 0.999 0.984 1.000 0.984 0.999 0.984 1.000	0.66 0.99 0.99 1.0 0.44 0.83 - - 0.7 0.83 - - 0.7 0.9 9 0.9 9 0.9 9 1.0 0.4 9 0.9 1.0 0.4 1.0 0.4 1.0 0.4 1.0 0.9 9 1.0 0.9 9 1.0 0.9 9 1.0 0.9 9 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 1.0 0.0 0	39 0. 06 0 13 0 99 0 13 0 89 0 33 (760 915 999 996 000 6777	774 926 9399 9999 0000 1.556 - - - 0.889 - - - 0.881 0.952 1.000 0.999 1.000 0.710	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - 0.878 0.958 - - - 0.876 0.958 - - 0.958 - - 0.958 - - 0.958 0.956 0.956 0.956 0.971 1.000 0.956 0.971 1.000 0.956 0.971 1.000 0.957 0.956 0.957 1.000 0.956 0.957 1.000 0.956 0.957 1.000 0.956 0.957 1.000 0.957 0.956 0.957 1.000 0.957 0.959 0.958 0.958 0.958 0.959 0.958 0.959 0.958 0.0958 0.0958 0.0958 0.0958 0.0958 0.0958 0.0958 0.0958 0.000 0.958 0.000 0.0958 0.0000 0.0000 0.0000 0.0000 0.00000 0.000000	0.94 0.97 0.98 1.00 0.99 0.99 - 1.0 3 0.9 5 0.9 - 1.0 3 0.9 5 0.9 0 1. 9 0. 0 1. 9 0. 9 0. 9 0.	44 (0 66 (1 37 (1) 33 (1) 58 (2) 90 (1) 90 (0.974 0.994 1.000 1.000 0.980 0.990 1.000 0.990 1.000 1.000 0.998 1.000 0.998 1.000
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 50~75% urvival analysis DL about 0 DL 1~25% DL 50~75% DL 50~75% DL 575% Aultinomial logistic DL about 0 DL 1~25% DL 1~25% DL 25~50% DL 575% UL 25~50% DL 25~50% DL 25% DL 2	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 593 998 567 900 119 545	0.566 0.872 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.44 0.83 - - 0.5 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9	39 0. 06 0. 13 0 99 0 000 1 39 0 89 0 333 0 760 760 999 999 996 000 6777 864	774 926 939 999 .000 .556 - - - 0.889 - - - 0.881 0.952 1.000 0.710 - 1.000	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - - - - - - - - - - - - - - - - -	0.94 0.97 0.98 1.00 0.93 0.99 - 1.00 1.0 1.0 5 0.9 - 1.0 5 0.9 - 1.0 9 0 1. 9 0 1. 9 0 1. 0 9 0 1.0 1.0 0 0 0	14 (0 76 0 70 0 70 0 70 0 73 3 75 8 90 0 70 0 70 70 0 70 0 7	0.974 0.987 0.994 1.000 0.990 - 1.000 1.000 1.000 1.000 0.980 0.980 0.980 0.980 0.980 0.971
Anufacturing Aultinomial logistic OL about 0 OL 25°50% OL 50°75% OL 575% urvival analysis OL about 0 OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 30°00 OL 1°25% OL 30°00 OL 1°25% OL 30°50% OL 50°75% OL 30°50% OL 50°75% OL 30°50% OL 30°50% OL 30°50% OL 50°75% OL 1°25% OL 25°50% OL 50°75% OL 50°75% OL 50°75% OL 50°75% OL 50°75% OL 50°75% OL 50°75%	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 593 998 567 900 119 545	0.566 0.872 0.869 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.44 0.83 - - 0.5 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9	39 0. 06 0. 13 0 99 0 39 0 89 33 760 313 915 399 939 0 760 315 915 399 900 677 864 - - -	774 926 .939 .999 .000 .556	0.884 0.956 0.971 1.000 0.667 0.889 0.958 - - - - - - - - - - - - - - - - - - -	0.94 0.97 0.98 1.00 0.93 0.99 - 1.00 1.0 1.0 5 0.9 - 1.0 5 0.9 - 1.0 9 0 1. 9 0 1. 9 0 1. 0 9 0 1.0 1.0 0 0 0	14 (0 76 0 70 0 70 0 70 0 73 3 75 8 90 0 70 0 70 70 0 70 0 7	0.974 0.987 0.994 1.000 0.990 - 1.000 1.000 1.000 1.000 0.980 0.980 0.980 0.980 0.980 0.971
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 55% DL 55% DL 50~75% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 1~25% Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 50~75% DL 50~75% DL 25~50% DL 50~75% DL 35% SU about 0 DL 1~25% DL 35% SU about 0 DL 1~25% DL 35% SU about 0 DL 1~25% DL 35% SU about 0 DL 1~25% DL 35% SU about 0 DL 1~25% SU about 0 DL 1~25% SU about 0 DL 1~25% SU about 0 DL 50~75% SU about 0 DL 1~25% SU about 0 DL 50~75% SU about 0 DL 1~25% SU about 0 SU abo	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 593 998 567 900 119 545	0.566 0.872 0.869 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.44 0.83 - - 0.5 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9	39 0. 06 0. 13 0 99 0 39 0 89 33 760 313 915 399 939 0 760 315 915 399 900 677 864 - - -	774 926 .939 .999 .000 .556	0.884 0.956 0.971 1.000 0.667 0.889 0.958 - - - - - - - - - - - - - - - - - - -	0.94 0.97 0.98 1.00 0.93 0.99 - 1.00 1.0 1.0 5 0.9 - 1.0 5 0.9 - 1.0 9 0 1. 9 0 1. 9 0 1. 0 9 0 1.0 1.0 0 0 0	14 (0 76 0 70 0 70 0 70 0 73 3 75 8 90 0 70 0 70 70 0 70 0 7	0.974 0.987 0.994 1.000 0.990 - 1.000 1.000 1.000 1.000 0.980 0.980 0.980 0.980 0.980 0.971
Anufacturing Aultinomial logistic DL about 0 DL 25~50% DL 25~50% DL 35~75% uurival analysis DL 25~50% DL 25~50% <td>0.44 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -</td> <td>82 38 30 96 00 89 78 525 593 998 567 900 119 545</td> <td>0.566 0.872 0.869 1.000 0.356 - - - - - - - - - - - - - - - - - - -</td> <td>0.68 0.99 0.99 1.0 0.44 0.83 - - 0.7 0.9 0.83 - - 0.7 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9</td> <td>89 0. 06 0 13 0 99 0 89 0 89 0 89 0 33 0 760 999 996 000 6777 864 - -</td> <td>774 926 .939 .999 .000 .556</td> <td>0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - - - - - - - - - - - - - - - - -</td> <td>0.94 0.97 0.92 1.00 1.00 0.99 - 1.0 8 0.99 - 1.0 8 0.9 5 0.9 9 0.1 9 0.1</td> <td>4 (6 5) 7 00 33 58 90 000 999 9000 833 - - - -</td> <td>0.974 0.987 0.994 1.000 0.990 1.000 1.000 0.998 1.000 1.000 0.980 0.972</td>	0.44 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 525 593 998 567 900 119 545	0.566 0.872 0.869 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.44 0.83 - - 0.7 0.9 0.83 - - 0.7 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9	89 0. 06 0 13 0 99 0 89 0 89 0 89 0 33 0 760 999 996 000 6777 864 - -	774 926 .939 .999 .000 .556	0.884 0.956 0.971 1.000 0.667 0.899 0.958 - - - - - - - - - - - - - - - - - - -	0.94 0.97 0.92 1.00 1.00 0.99 - 1.0 8 0.99 - 1.0 8 0.9 5 0.9 9 0.1 9 0.1	4 (6 5) 7 00 33 58 90 000 999 9000 833 - - - -	0.974 0.987 0.994 1.000 0.990 1.000 1.000 0.998 1.000 1.000 0.980 0.972
Anufacturing Aultinomial logistic OL about 0 OL 1~25% OL 25~50% OL 50~75% OL 75% Urvival analysis OL about 0 OL 1~25% OL 25~50% OL 25~50% OL 50~75% Aultinomial logistic OL about 0 OL 1~25% OL 25~50% OL 25~50% OL 50~75% UL 25% OL 50~75% OL 50~7	0.4 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 996 000 89 78 78 793 3958 3667 7000 419 545 - -	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.44 0.83 - - 0.7 0.8 0.83 - - 0.7 0.5 0.9 0.1 0.0 0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0	39 0.06 0.0 13 0 999 0 999 0 0 1 899 0 1 333 0 9933 0 0 1 1 999 933 0 0 1 999 990 0 0 0 0 6777 8644 - - - - - - 695 695	774 926 939 999 .000 .556 - - - 0.881 1.000 0.999 1.000 0.710 - 1.000	0.884 0.956 0.971 1.000 0.667 0.895 - - - - - - - - - - - - - - - - - - -	0.94 0.97 1.00 1.00 0.93 0.95 0.95 1.00 1.0 1.0 0 1.1 9 0.1 0 1.4 0 9 0 3 0.2	44 (1 37) 30) 33 38 39) 30) 30) 30) 33 38 39) 30	0.974 0.987 0.994 1.000 0.990 - 1.000 0.980 0.990 1.000 0.988 1.000 1.000 0.988 0.972 - 1.000
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 55% Urivial analysis DL about 0 DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL	0.44 0.8 0.9 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 00 89 78 78 593 998 667 593 998 667 - - - - - - - - - -	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.66 0.9 0.9 0.9 1.0 0.44 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8	89 0. 06 0. 13 0 99 0 89 0 89 0 33 0 760 33 999 999 996 000 6777 864 - - 695 802	774 926 939 939 .000 .556 - -	0.884 0.956 0.971 1.000 0.667 0.899 - - - - - - - - - - - - - - - - - -	0.94 0.97 0.98 1.00 0.88 0.99 0.99 0.99 0.10 0 1. 9 0. 0 1. 9 0. 0 1. 9 0. 8 0. 8 0. 8 0. 8 0. 9 0.	44 (1 37) 30) 33 38 39) 30) 30) 30) 33 38 39) 30	0.974 0.987 0.994 1.000 0.990 0.990 1.000 1.000 0.998 1.000 0.998 1.000 0.972 - 1.000 0.972 -
Manufacturing Aultinomial logistic DL about 0 DL 25*50% DL 1*25% DL 25*50% DL 25*50% DL 1*25% DL 25*50% DL 1*25% <	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 338 396 000 89 78 78 579 3998 567 000 119 545 - - - - - - - - - - - -	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.92 1.0 0.44 0.84 0.84 0.84 0.84 0.84 0.84 0.	39 0. 06 0 13 0 99 0 13 0 89 0 89 0 33 0 760 915 999 996 000 677 8864 - - - 695 802 999 999	774 926 939 999 .000 .556 - - -	0.884 0.956 0.971 1.000 0.667 0.899 - - - - - - - - - - - - - - - - - -	0.94 0.97 0.95 1.00 1.00 0.93 0.99 - 1.0 3 0.9 0 1. 4 0 9 0 3 0. 8 0. 9 0 0 1.	44 (0 76 (0 77) 70) 70) 73 3 73 3 74 9 75 9 75 9 913 930 , 76 9 76 9 77 9 76 9 77 9 7 7 7 7 7 7 7 7 7 7 7 7 7	0.974 0.987 0.994 1.000 0.990 0.990 1.000 1.000 0.951 0.095 1.000 0.972 - 1.000 0.980 0.972 - 0.951 0.000
Anufacturing Aultinomial logistic OL about 0 OL 25°50% OL 50°75% OL 50°75% Urvival analysis OL about 0 OL 25°50% OL 25°50% OL 50°75% OL 50°75% OL 50°75% OL 50°75% OL 25°50% OL 25°50% OL 25°50% OL 50°75% OL 25°50% OL 50°75% OL 50°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50% OL 25°50%	0.44 0.8 0.8 0.9 1.0 0.2 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7	82 38 30 96 97 89 78 93 998 967 900 119 545 - - - - - - - - - - - - - - -	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.66 0.9 0.9 0.9 1.0 0.4 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8	39 0. 06 0 13 0 99 0 13 0 89 0 89 0 33 0 760 915 999 996 000 677 8864 - - - 695 802 999 999	774 926 939 939 .000 .556 - -	0.884 0.956 0.971 1.000 0.667 0.899 - - - - - - - - - - - - - - - - - -	0.94 0.97 1.00 0.92 0.92 - 1.00 1.01 0.92 0.92 0.1.0 9 0.1 0 1.0 9 0.1 0 1.0 9 0.1 0 1.0 9 0.1 0 1.0 9 0.1 0 1.0 9 0.1 9 0.1 1.00 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0	44 (0 76 (0 77) 70) 70) 73 3 73 3 74 9 75 9 75 9 913 930 , 76 9 76 9 77 9 76 9 77 9 7 7 7 7 7 7 7 7 7 7 7 7 7	0.974 0.987 0.994 1.000 0.980 0.990 1.000 1.000 1.000 0.951 0.995 1.000 0.980 0.972 - 1.000 0.980 0.972 0.950 0.950
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 25~50% DL 375% Unive analysis DL about 0 DL 1~25% DL 25~50% DL 350~75% UNIVE analysis DL about 0 DL 1~25% Vholesale and Retailing Aultinomial logistic DL about 0 DL 1~25% DL 35% Vholesale and Retailing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 25~50% DL 1~25% DL 1~	0.4 0.8 0.8 0.9 1.0 0.2 0.7 - - - - - - - - - - - - - - - - - - -	82 38 30 96 97 89 78 97 89 89 89 89 89 89 89 89 89 89 80 90 80 90 80 97 97 80 97 80 97 97 80 97 97 80 97 97 97 97 97 97 97 97 97 97 97 97 97	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.99 0.99 1.0 0.88 0.88 0.88 0.88 0.88 0.88 0.99 0.99	39 0. 13 0 99 0 13 0 89 0 89 0 33 0 760 915 999 933 000 677 8864 - - - 695 802 999 931 000 6731	774 926 939 999 .000 .556 - - -	0.884 0.956 0.971 1.000 0.667 0.899 - - - - - - - - - - - - - - - - - -	0.94 0.97 0.95 1.00 0.93 0.99 0.95 0.95 0.10 0 1.00 0 1. 1.00 0 1. 1.00 0 1. 1.00 0 1. 1.00 0 1. 1.00 0 9 0.00 0 1. 1.77 0.00 0 1.00 0 9 0.00 0 1.00 0 9 0.00 0 0 0.00 0 0.000 0 0.000 0 0 0.000 0 0.00000000	14 (1) 76 (1) 737 (1) 738 (1) 739 (1) 700 (1) 737 (1) 738 (1) 739 (1) 739 (1) 739 (1) 739 (1) 739 (1) 739 (1) 730 (1) 731 (1) 74 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1) 75 (1)	0.974 0.987 0.994 1.000 0.990 0.990 1.000 1.000 0.998 1.000 0.950 1.000 0.980 0.972 1.000 0.980 0.972 1.000
Anufacturing Aultinomial logistic DL about 0 DL 1~25% DL 25~50% DL 25~50% DL 3~75% urvival analysis DL about 0 DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 25~50% DL 35% Chabout 0 DL 1~25% DL 35% DL 35%	0.44 0.8 0.8 0.9 1.0 0.2 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7	82 38 39 96 00 89 78 793 998 793 998 793 998 793 998 793 998 793 9967 000 119 543 - - - - - - - - - - - - - - - - - - -	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.66 0.9 0.9 0.9 1.0 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0	89 0.0 06 0 13 0 999 0 89 0 89 0 933 0 915 999 930 0 6777 8864 - - 6955 8022 9999 9311 0000 485	774 926 939 999 000 556 - - - 0.889 - - - 0.881 0.0952 1.000 0.710 - 1.000 0.710 0.0710 0.0710 0.0844 0.0999 0.0515	0.884 0.956 0.971 1.000 0.667 0.899 - - - - - - - - - - - - - - - - - -	0.94 0.97 0.98 1.00 0.99 - 1.0 0.9 - 1.0 3 0.9 0 1.0 9 0.1 9 0 1 4 0 9 0 3 0 0 1 1 4 0 9 0 2 0 9 0 1 0 9 0 1 0 9 0 1 0 9 0 1 0 0 9 1.00 0.95 - 0.10 0.95 - 0.10 0.95 - 0.10 0.95 - 0.10 0.95 - 0.10 0.95 - 0.10 0.95 - 0.10 0.95 - 0.10 0.95 - 0.00 0.00 - 0 -	44 (0 37 (0 37 (0) 33 (0) 33 (0) 33 (0) 39 (0) 30 (0)	0.974 0.987 0.994 1.000 0.990 0.990 1.000 1.000 0.998 1.000 1.000 0.972 - 1.000 0.972 - 1.000 0.955 1.000 0.955 1.000 0.955 1.000
Manufacturing Aultinomial logistic D1 about 0 D2 25%50% D2 5%50% D2 1~25% D2 150~75% D2 150~25% D2 150% D2 10000 D1 10000 <td< td=""><td>0.44 0.8 0.8 0.9 1.0 0.2 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7</td><td>82 38 30 96 00 89 78 573 998 89 778 </td><td>0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -</td><td>0.66 0.9 0.9 0.9 1.0 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0</td><td>39 0.0 06 0.0 13 0 999 0 89 0 89 33 695 300 6777 864 - - 6955 8022 9999 931 0000 4855 7277</td><td>774 926 939 939 .000 .556 - -</td><td>0.884 0.956 0.971 1.000 0.667 0.895 - - - - - - - - - - - - - - - - - - -</td><td>0.94 0.97 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.0</td><td>44 (1 37) 33) 36) 37) 38) 39) 30) 30) 31)</td><td>0.974 0.987 0.994 1.000 0.990 - 1.000 0.980 0.990 1.000 0.988 1.000 1.000 0.988 1.000 1.000 0.980 0.972 - 1.000 0.985 1.000 0.955 1.000</td></td<>	0.44 0.8 0.8 0.9 1.0 0.2 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7	82 38 30 96 00 89 78 573 998 89 778 	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.66 0.9 0.9 0.9 1.0 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0	39 0.0 06 0.0 13 0 999 0 89 0 89 33 695 300 6777 864 - - 6955 8022 9999 931 0000 4855 7277	774 926 939 939 .000 .556 - -	0.884 0.956 0.971 1.000 0.667 0.895 - - - - - - - - - - - - - - - - - - -	0.94 0.97 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.0	44 (1 37) 33) 36) 37) 38) 39) 30) 30) 31)	0.974 0.987 0.994 1.000 0.990 - 1.000 0.980 0.990 1.000 0.988 1.000 1.000 0.988 1.000 1.000 0.980 0.972 - 1.000 0.985 1.000 0.955 1.000
Manufacturing	0.44 0.8 0.8 0.9 1.0 0.2 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7	82 38 39 96 00 89 78 793 998 793 998 793 998 793 998 793 998 793 9967 000 119 543 - - - - - - - - - - - - - - - - - - -	0.566 0.872 0.869 0.999 1.000 0.356 - - - - - - - - - - - - - - - - - - -	0.68 0.9 0.9 0.9 1.0 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0	89 0.0 06 0 13 0 999 0 89 0 89 0 933 0 915 999 930 0 6777 8864 - - 6955 8022 9999 9311 0000 485	774 926 939 999 000 556 - - - 0.889 - - - 0.881 0.0952 1.000 0.710 - 1.000 0.710 0.0710 0.0710 0.0844 0.0999 0.0515	0.884 0.956 0.971 1.000 0.667 0.895 - - - - - - - - - - - - - - - - - - -	0.94 0.97 0.95 1.00 0.93 0.99 0.95 0.9 0.10 0 1. 0 1. 0 1. 0 9 0 3 0. 3 0. 3 0. 3 0. 5 0. 1. 0 1. 1. 0 9 0 0 1. 1. 0 9 0 0 1. 1. 0 9 0. 1. 0 9 0. 0 9 0. 0 9 0. 1. 0 9 0. 0 9 0. 0 0. 1. 0 9 0. 0 0. 1. 0 9 0. 0 0. 1. 0 0. 0 0	44 (1 37) 33) 36) 37) 38) 39) 30) 30) 31)	0.974 0.987 0.994 1.000 0.990 0.990 1.000 1.000 0.950 0.950 1.000 0.980 0.972 - 1.000 0.980 0.972 1.000

5. Conclusions

In this study, a probabilistic methodology for estimating recovery of production capacity of industrial sectors is proposed. The multinomial logistic regression model is adopted to estimate the recovery process regarding recovery time from different initial operation levels. By defining five operation levels, estimating the probability of the five operation levels at recovery time t, the recovery process of different industrial sectors is estimated. Meanwhile, Kaplan-Meier estimator of survival analysis is adopted to conduct statistics of recovery probability regarding recovery time. It is a generally applied analysis methodology for recovery of production capacity. Thus, the results of survival analysis are set to be a standard to evaluate the estimation results from multinomial logistic model.

By comparing with Kaplan-Meier estimator of survival analysis, there are two aspects that multinomial logistic model is superior. Firstly, by defining the five operation levels, the survey data can be expanded according to recovery time. As a result, the recovery days in the estimation results of multinomial logistic regression model are continuous, which makes the estimated recovery process continuous and more specific. On the other hand, Kaplan-Meier of survival analysis can only conduct statistics on existing recovery days in the survey data, which is not time-continuous. Secondly, only the companies that are recovered can be considered in the Kaplan-Meier of survival analysis. On the other hand, both recovered and unrecovered companies can be considered in the estimation of multinomial logistic model, which makes the model analyze larger amount of data and more comprehensive.

This research is significant in improving the estimation methodology of recovery process of production capacity from micro perspective for individuals considering more comprehensive states. But some improvements in this research can be done in the future work. Firstly, in the application of multinomial logistic model, the use of weighted average of the operation levels lead to the inaccuracy of estimation from initial operation level at about 0. Therefore, improvement of the methodology need to be researched in the future study. Secondly, the estimated probabilities of multinomial logistic model are larger than the standard results of survival analysis at earlier stages. Therefore, the factors that may lead to the difference need to be added in the evaluation model in the future study.

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