Estimating the number of welfare facilities for the elderly in Korea with system dynamics

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ABSTRACT

This research estimates the number of welfare institutions for the elderly and predicts the shortage of welfare facilities in the future as a result of Korean society's move toward a super aged society. Although the population of Korea is predicted to decrease, the elderly population is expected to increase in the future; thus it is evident that a shortage of welfare facilities will occur. Based on this forecasting result presented within this paper, the Korean government should prepare for entrance into an aged society by expanding the social infrastructure through increased support to residential and medical welfare institutions. An analysis of the results tells us that additional 1,368 residential and 10,956 medical welfare facilities will be needed in maximum to satisfy the future demands of the increasing elderly population, compared to the number of the two types of welfare facilities in 2007.

KEYWORDS: welfare institution, growth rate, birth/death rate, system dynamics, aging/aged society, welfare facilities

INTRODUCTION

Overall, the world is moving toward an aged society. The population of the elderly who aged 65 years and over is growing rapidly; this population is estimated to double from 11% in 2007 to 22% in 2050 over the world (Chiou *et al.* 2009).

Korea's population is moving along the same trend as the rest of the world. The Korean government officially announced that the elderly would constitute 10.3% of total population in 2008, 14.3% in 2018, and 38.2% in 2050 although the total population is estimated to decrease after 2018 (refer to Table 1 and Table 2). It means that Korea already entered aging society and will enter the aged society in 2018 and the super aged society in 2050[1] (Korea Ministry of Health, Welfare, and Family Affairs 2009, Korean National Statistical Office-KNSO 2005).

This is largely because of low birth rate and expanded life expectancy. Birth rate in Korea has decreased steadily from 874,030 in 1975 to 466,000 in 2008. Korea's life expectancy was 79.6 years in 2007 and is estimated to be 86 years in 2050 (KNSO 2005). This means that the total population is decreasing due to a low birth rate and the portion of old people aged 65 and over increases due to a low death rate. As this trend continues, the Korean government has prepared for upcoming aged society by launching

[1] Aging, aged, and super aged societies are differentiated by the portion of the elderly aged 65 and over to total population, 7, 14, and 20%, respectively (Future population estimation result report 2005, Park and Yang 2005).

the long term welfare insurance for the elderly in 2008 and initiating an increase in the number of welfare institutions for the elderly in 2006.

It is necessary to investigate whether the Korean government's efforts are effective in satisfying the future demands put on welfare institutions by the increasing elderly population. Therefore, this research shall examine the number of welfare institutions necessary to support future demands and the shortage of welfare institutions that this estimation predicts in spite of government efforts. Additionally, the optimal government policy regarding the expansion of welfare institutions will be discussed.

CURRENT STATUS IN KOREA

According to future population estimation result report (2005) issued by the KNSO, total population is estimated to reach 42.3 million in 2050 and 38% of total population will be aged 65 and over (refer to Table 1 and Table 2). Total population utilizes the cohort component method to estimate the total population and Table 1 below shows the estimated population until 2050. As shown in Table 1, total population is estimated to increase until 2018, and then decrease.

Table 1 Estimation of total population and growth rate

Year	1980	1990	2000	2005	2010	2018	2020	2030	2050
Total population (In thousand)	38,124	42,869	47,008	48,138	48,875	49,340	49,326	48,635	42,343
Growth rate* (%)	1.57	0.99	0.84	0.21	0.26	0.02	-0.02	-0.25	-1.07

* Growth rate is calculated based on the population of the previous year.

Source: Future population estimation result report 2005, KNSO

Table 2 shows us the estimated population structure. The population is classified into three cohorts according to age: age 0-14, 15-64, and 65 and over. The cohort of "0-14" is estimated to decrease while "65 and over" cohort is estimated to increase year by year. The working age population cohort, "15-64", is estimated to have a different trend. It is expected to increase slightly until 2018 and then drop down to 53% in 2050.

Table 2 Estimated population structure **(Unit: %)**

Cohort	1970	1980	1990	2000	2005	2010	2018	2020	2026	2030	2050
0 14	42.5	34	25.6	21.1	19.2	16.2	12.7	12.4	11.7	11.4	8.9
15 64	54.4	62.2	69.3	71.7	71.7	72.9	72.9	72	67.5	64.4	53

65 and over	3.1	3.8	5.1	7.2	9.1	11	14.3	15.6	20.8	24.3	38.2

Source: Future population estimation result report 2005

There are three rates to be considered in estimating population: birth rate, death rate, and international transfer rate. The birth rate is estimated to decrease while death rate is estimated to increase as shown in Figure 1 below. The dotted line indicates death rate and the solid line is birth rate. The increase in the death rate is caused by an increase in the population of "65 and over" cohort. Even though death rate of "0-14" and "15-64" cohorts decreases, total population is estimated to decrease.

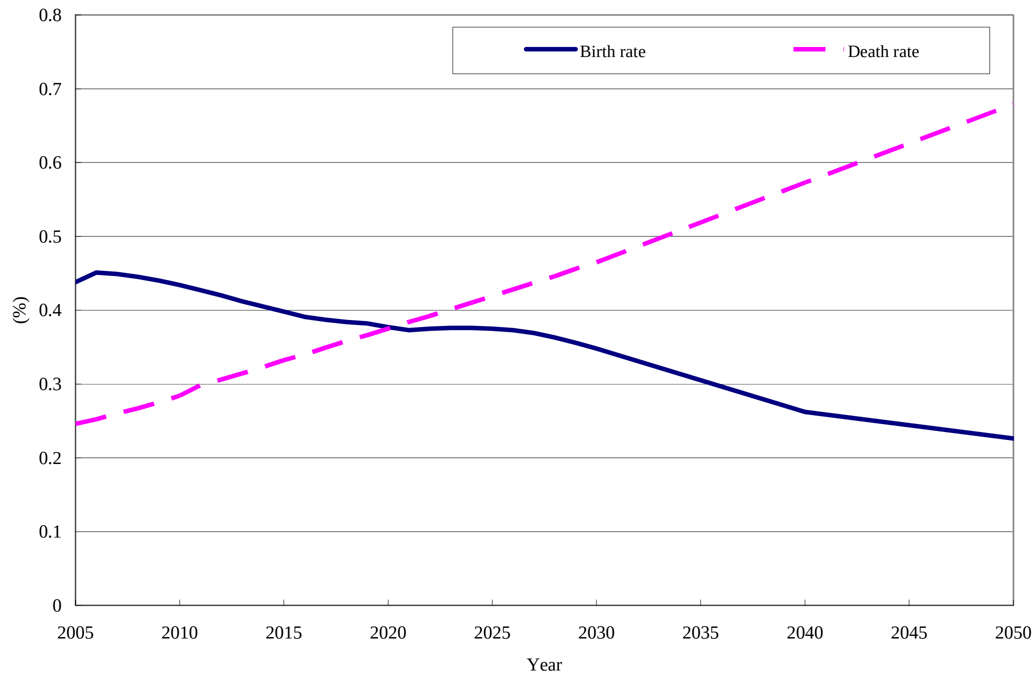

Figure 1 Future birth rate and death rate

Data source: Future population estimation result report 2005, KNSO

Regression analysis with the KNSO data is performed to obtain equations representing the trend of these two rates for simulation. The equations obtained are as follows:

$$BR_t = 9.92 - 4.7 * 10^{-3} * t , \quad (1)$$

$$DR_t = -18.59 + 9.39 * 10^{-3} * t\,, \tag{2}$$

where *t* is time, and BR_t and DR_t are total birth rate and death rate at *t*.

The international transfer rate is estimated to decrease as time progresses (KNSO 2005). This means that Korean people who transfer to foreign countries will increase while foreigners reside in Korea will decrease. The equation of this rate is as follows:

$$ITR_t = 1122531 - 541.289 * t \tag{3}$$

where ITR_t is international transfer rate at time *t*.

According to the yearbook of health, welfare, and family statistics (2009) issued by the Korea Ministry of Health, Welfare, and Family Affairs, welfare institutions for the elderly are largely categorized into two types of facilities: residential welfare facilities and medical welfare facilities. Table 3 below shows us the status of these two facilities for the period of 2000-2008. The total plan for expanding welfare infrastructure (2006-2010) of the Korean government has been implemented. The total number of welfare facilities has increased to 2,081 in 2008. As shown in Table 4, as construction for 1,399 welfare facilities by 2010 has been planned, the total number of welfare facilities for the elderly will be 2,221 by 2010. Strength is the total residents when utilization factor is one (1), that is, when a facility is utilized in maximum so strength is inferred to be the maximum residents of a facility and “residents/strength” term means capacity utilization factor that shows how much a facility is utilized.

Table 3 Status of welfare institutions

Year		2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	No. of facilities	247	284	240	351	488	813	1,166	1,498	2,081
	Residents/ Strength	0.735	0.756	0.768	0.782	0.775	0.784	0.775	0.778	0.826
	Strength	18,438	21,513	19,049	25,109	31,070	41,094	53,098	64,324	81,912
	Residents	13,558	16,261	14,627	19,641	24,094	32,228	41,143	50,032	67,676
Residential welfare institution	No. of facilities	119	122	120	119	131	270	351	384	327
	Residents/ Strength	0.647	0.667	0.665	0.713	0.736	0.722	0.706	0.722	0.713
	Strength	8,800	9,165	9,017	8,257	8,188	11,131	12,509	13,014	11,697
	Residents	5,694	6,114	5,997	5,887	6,024	8,033	8,829	9,402	8,345

Medical welfare institution	No. of facilities	128	162	120	232	357	543	815	1,114	1,754
	Residents/ Strength	0.816	0.822	0.86	0.816	0.79	0.807	0.796	0.792	0.845
	Strength	9,638	12,348	10,032	16,852	22,882	29,963	40,589	51,310	70,215
	Residents	7,864	10,147	8,630	13,754	18,070	24,195	32,314	40,630	59,331

Source: Yearbook of health, welfare, and family statistics 2009

Table 4 Brief annual plan for expanding welfare facilities for the elderly

Year	2006	2007	2008	2009	2010	Total
No. of facilities	338	472	477	77	35	1,399

Source: Plan for aging society of the Korean government 2006

The strength and number of residents of the two kinds of welfare facilities are increasing but the ratio of residents to strength is not linearly related with time. The maximum ratio is 0.736 and 0.860 for residential and medical facilities and 0.826 in total. The average strength per facility can be analyzed by the formula of (Strength/No. of facilities). As shown in Table 5, the average strength per facility has totally decreased from 2000 to 2008. The minimum value is 34 for residential and 40 for medical welfare facilities. This means small-sized facilities have been constructed recently.

Table 5 Average strength per facility type

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Residential	74	75	75	69	63	41	36	34	36
Medical	75	76	84	73	64	55	50	46	40

For an accurate simulation, the regression analysis is performed with the dependent variable of residents and the independent variable of the population of “65 and over” cohort. As a result of regression analysis, two equations for both types of facilities are obtained as follows:

- Residential welfare facility: $R1_t = 0.003 * P_t^{65+} - 5160.8$ (4)

- Medical welfare facility: $R2_t = 0.038 * P_t^{65+} - 137772$ (5)

where $R1_t$ = the total number of residents in residential welfare facilities at time *t*, $R2_t$ = the total number of residents in medical welfare facilities at time *t*, and P_t^{65+} = the population of “65 and over” cohort at time *t*.

Levin & Roberts (1976) propose the lifecycle of an agency by four stages: start-up, growth, maturity, and decay (25-26). As the number of residents is proportional to the “65 and over” cohort which is estimated to increase exponentially, it is inferred that the demand for welfare facility will be on the stage of start-up or growth until 2050.

SIMULATION

This research shall be performed in Vensim™ program developed by Ventana systems Inc. The simplified cohort model shall be applied to formulate the simulation model. Subordinate cohorts of 5-age interval shall be planted in this model. That is to say, even though, as mentioned above, there are three large cohorts of age “0-14”, “15-64”, and “65 and over.” To analyze, the “0-14” cohort shall be divided into “0-4”, “5-9”, and “10-14.” The “15-64” shall be divided into 10 subordinate cohorts, and the “65 and over” shall be divided into “65-69”, “70-74”, “75-79”, and “80 and over” subordinate cohorts. This cohort model starts from birth rate. The birth rate for every time period is calculated by birth rate equation (1) listed above. The transfer rates between subordinate cohorts can be simply expressed by $\frac{P_t^i}{LT}$ where P_t^i =the population of i^{th} cohort at time *t* and LT = the lead time = 5 years.

The total death rate shall be calculated by death rate equation (2). The death rate for each cohort can’t be found so the alternative is to calculate each death rate by $TotalDeathRate * PopulationRatio * adjustment$ and apply it to this model. The “population ratio” is calculated by the formula of (cohort population/total population). This alternative equation can be used to distribute the total death rate to the death rate of each cohort proportional to the population ratio. The “adjustment” is necessary to simulate matched with the KNSO data with accuracy, at least 95% accuracy. In other words, adjustment is calculated to estimate with the least error within 5% compared with the KNSO data. To improve the accuracy of this model, the adjustment shall be differentiated by the three large cohorts and by the timeframe for “65 and over” cohort because this cohort is estimated to have different slopes in the back and forth of 2028 year. As a result, adjustment is set to be 1 for “0-14” cohort, 0.08 for “15-64”, and 5.7 for the period of from 2007 to 2027 and 2.6 for the period of from 2028 to 2050 for the

"65 and over" cohort[2]. This means that on average the "15-64" cohort has the lowest death rate and the "65 and over" cohort has the highest death rate: the death rate of "65 and over" cohort decreases as time progresses.

The international transfer rates shall be calculated using the same method as the death rate but without adjustment. The total international transfer rate calculated by equation (3) shall be distributed to each cohort proportional to the population ratio. The population sector in this model is depicted in Figure 2 and Figure 3 below.

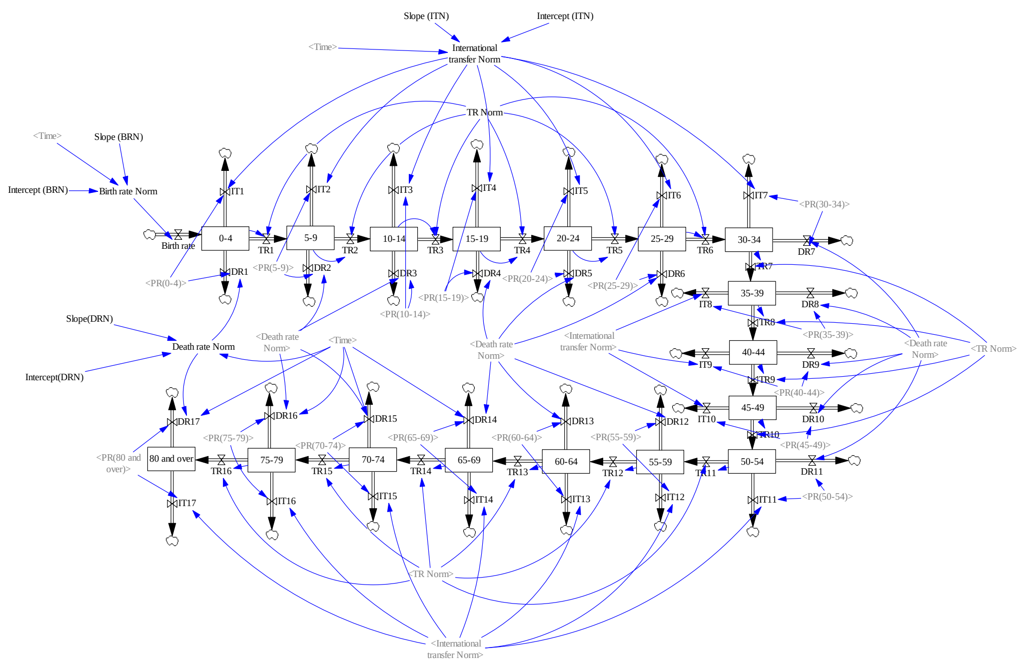

Figure 2 Population sector

The populations of subordinate cohorts except the first "0-4" cohort are calculated by

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2 Let's simply assume $a_1 + a_2 + a_3 = n$. Weights will be inserted to a_2 and a_3 in this equation with no change in total number of right term. New equation can be written as follows:

$a_1 + w_1 a_2 + w_2 a_3 = n$.

$a_1 + w_1 a_2 + w_2 a_3 = a_1 + a_2 + a_3$.

$(1 - w_1) a_2 = (w_2 - 1) a_3$, where $0 \le w_1 < 1$ and $w_2 \ge 1$.

Thus, $w_2 = (1 - w_1)\dfrac{a_2}{a_3} + 1$.

$$P_t^i = \int_{t_0}^{t} (TR_t^{i-1} - TR_t^i - DR_t^i - ITR_t^i)dt + P_{t_o}^i \quad (i \geq 2 \text{ and } t \geq t_0)$$

where P_t^i is the population of the ith cohort at time *t*, $P_{t_o}^i$ is the initial value of the ith cohort, TR_t^{i-1} is the inflow transfer rate from the (i-1)th cohort to the ith cohort at *t*, TR_t^i is the outflow transfer rate of the ith cohort to the (i+1)th cohort at *t*, DR_t^i is the death rate of the ith cohort at *t*, and ITR_t^i is the international transfer rate of the ith cohort at *t*. We understand that $TR_t^i = 0$ for the "80 and over" cohort because it is the last cohort and t_0 =2007 in this model.

The population of the "0-4" cohort is expressed as

$$P^1 = \int_{t_0}^{t} (BR_t - TR_t^1 - DR_t^1 - ITR_t^1)dt + P_{t_0}^1$$

where BR_t is the birth rate at *t*. This model utilizes BR_t instead of TR_t^{i-1} for this cohort since it is the first cohort.

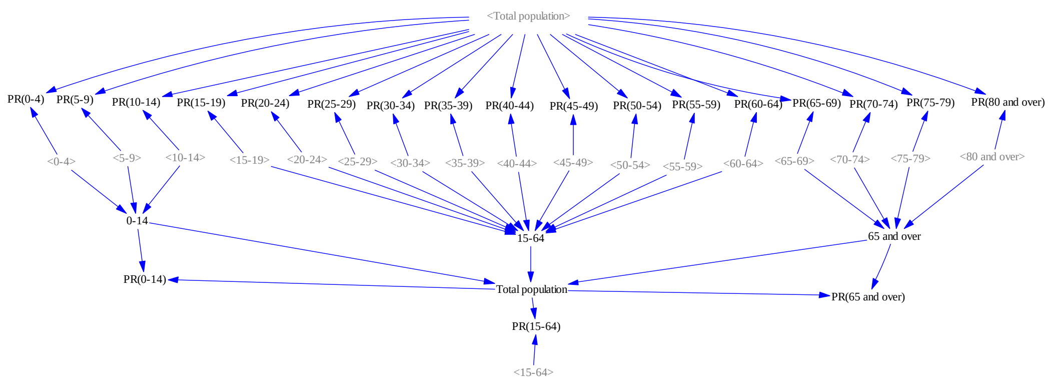


Figure 3 Population ratio

The cohort population of age 65 and over is calculated by

$P_t^{65+} = \sum_{i=14}^{17} P_t^i$ where i means the ordinal number of the subordinate cohort.

Since $P_t^i = \int_{t_0}^{t} (TR_t^{i-1} - TR_t^i - DR_t^i - ITR_t^i)dt + P_{t_0}^i$, the equation above can be expressed by

$$P_t^{65+} = \sum_{i=14}^{17} \left(\int_{t_0}^{t} (TR_t^{i-1} - TR_t^i - DR_t^i - ITR_t^i)dt + P_{t_0}^i \right).$$

This equation can be re-written as

$$P_t^{65+} = P_{t_0}^{65+} + \int_{t_0}^{t} \sum_{i=14}^{17} (TR_t^{i-1} - TR_t^i - DR_t^i - ITR_t^i)dt$$

where $P_{t_0}^{65+} = P_{t_0}^{14} + P_{t_0}^{15} + P_{t_0}^{16} + P_{t_0}^{17}$.

If $OF_t^{65+} = \sum_{i=14}^{17} (DR_t^i + ITR_t^i)$, the equation above yields

$$P_t^{65+} = P_{t_0}^{65+} + \int_{t_0}^{t} (TR_t^{13} - OF_t^{65+})dt.$$

The flow rate of “65 and over” cohort is

$$\dot{P}_t^{65+} = TR_t^{13} - OF_t^{65+}.$$

The residents of each facility is calculated by equation (4) & (5)

- Residential welfare facility: $R1_t = a_1 * P_t^{65+} + b_1$
- Medical welfare facility: $R2_t = a_2 * P_t^{65+} + b_2$.

The total number of each facility is

- Residential welfare facility: $F1_t = \frac{R1_t}{SI1} * \frac{1}{S1} = \frac{a_1 * P_t^{65+} + b_1}{SI1 * S1}$
- Medical welfare facility: $F2_t = \frac{R2_t}{SI2} * \frac{1}{S2} = \frac{a_2 * P_t^{65+} + b_2}{SI2 * S2}$

where $SI1$ and $SI2$ are the ratios of residents to strength for each type of facility and $S1$ and $S2$ are the strength of each facility.

The number of necessary facility is

- Residential welfare facility: $F1_t - F1_{t_0} = \dfrac{a_1 * P_t^{65+} + b_1}{SI1 * S1} - F1_{t_0}$

- Medical welfare facility: $F2_t - F2_{t_0} = \dfrac{a_2 * P_t^{65+} + b_2}{SI2 * S2} - F2_{t_0}$

where $F1_{t_0}$ and $F2_{t_0}$ are the number of facilities at time t_0.

These $F1_t$ and $F2_t$ can be expressed by

- Residential welfare facility: $F1_t = \dfrac{a_1 * (P_{t_0}^{65+} + \int_{t_0}^{t} (TR_t^{13} - OF_t^{65+}) dt) + b_1}{SI1 * S1}$

- Medical welfare facility: $F2_t = \dfrac{a_2 * (P_{t_0}^{65+} + \int_{t_0}^{t} (TR_t^{13} - OF_t^{65+}) dt) + b_2}{SI2 * S2}$.

These equations are simplified as

- Residential welfare facility: $F1_t = \dfrac{a_1}{SI1 * S1} * \int_{t_0}^{t} (TR_t^{13} - OF_t^{65+}) dt + F1_{t_0}$

- Medical welfare facility: $F2_t = \dfrac{a_2}{SI2 * S2} * \int_{t_0}^{t} (TR_t^{13} - OF_t^{65+}) dt + F2_{t_0}$

where $F1_{t_0} = \dfrac{a_1 * P_{t_0}^{65+} + b_1}{SI1 * S1}$ and $F2_{t_0} = \dfrac{a_2 * P_{t_0}^{65+} + b_2}{SI2 * S2}$.

Figure 4 exhibits the SFD (stock-and-flow diagram) for the welfare institution sector, including both residential and medical facilities.

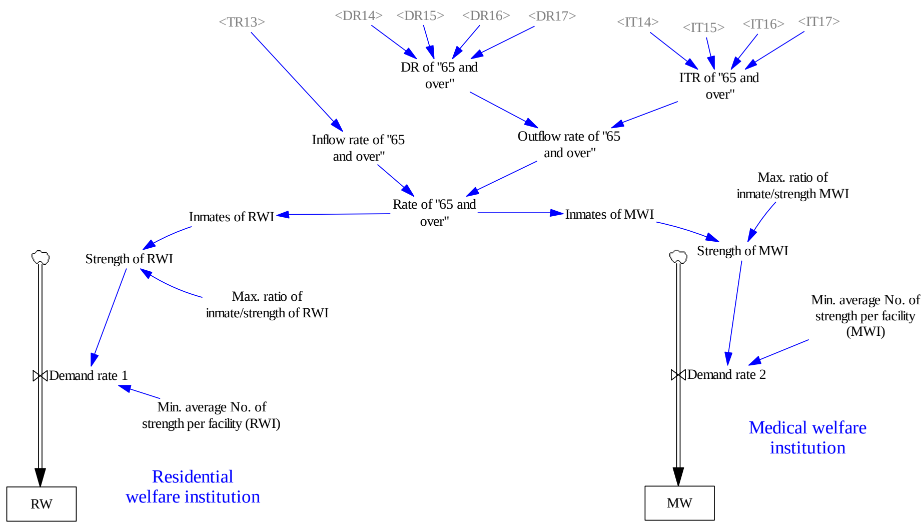


Figure 4 Diagram of welfare institution sector

If Korean government plans to construct N welfare facilities for every 5 years and the portions of residential and medical welfare facilities to total the number of facilities are R_1 and R_2, total number of each type of facility is

- Residential welfare facility: $PF1_t = \int_{t_0}^{t} R_1 * \frac{N}{DP} dt + F1_{t_0}$

- Medical welfare facility: $PF2_t = \int_{t_0}^{t} R_2 * \frac{N}{DP} dt + F2_{t_0}$

where DP is the duration of plan, that is, five years and $R_1 + R_2 = 1$. R_1 and R_2 are flexible so if the demand of residential welfare facilities is satisfied, R_1 (residential) will become zero and R_2 (medical) will be one.

Finally, the shortage of each type of facility is

- Residential welfare facility: $S1_t = F1_t - PF1_t$

- Medical welfare facility: $S2_t = F2_t - PF2_t$

Figures 5 and 6 exhibit the Korean government's structure for accommodation and planning of the need for residential and medical facilities.

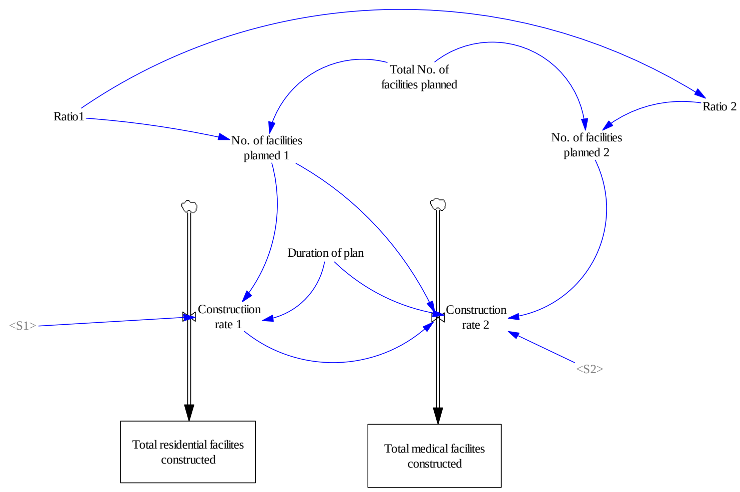


Figure 5 Diagram of Government planning sector

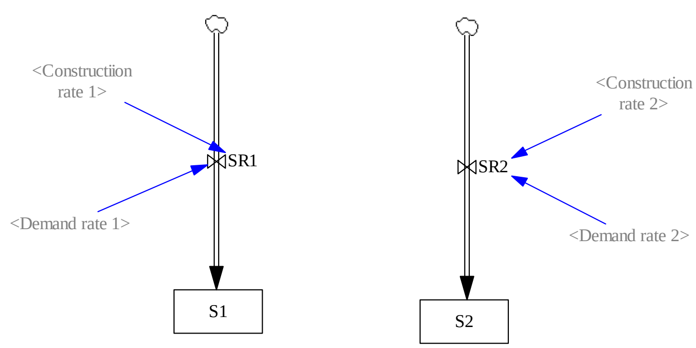


Figure 6 Diagram of shortage sector

Simulation is set to start at the year of 2007 and finish at 2050 with the time interval of 0.25 year.

RESULT

The validity test shall be performed by comparing the estimated total population by the KNSO. Figure 7 shows the total populations estimated by KNSO and by this simulation.

Two of the results are moving along the same trend even though there are deviations between the two estimation results. The mean absolute percent deviation (MAPD) is adapted to calculate the model error. Based on the estimation result of KNSO, the MAPD of total population was calculated to be 0.6%[3]. Total population in 2007 was recorded to be 48,456,400 and the maximum population was estimated to be 49.6 million in 2017 but the total population decreases to 42.1 million in 2050.

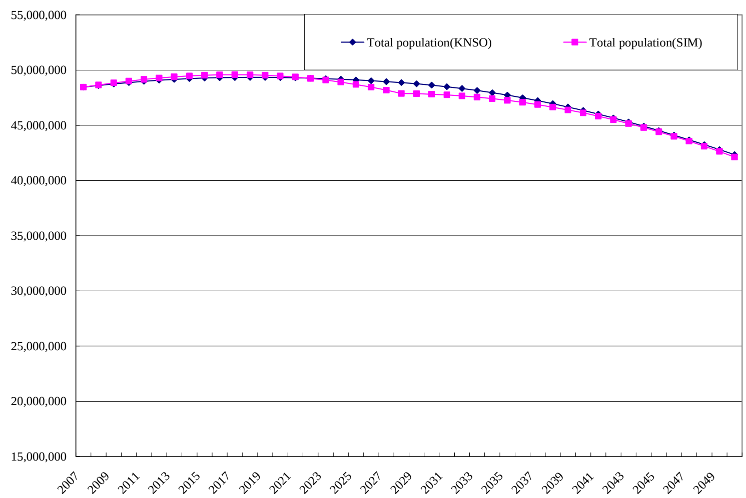


Figure 7 Comparison the estimation results

Additionally, the populations of the three large cohorts are compared in Figure 8. The calculated MAPD's for "0-14", "15-64", and "65 and over" cohorts are 2.3%, 1.3%, and 2.7%, respectively. Figure 8 tells us that the population of the "0-14" cohort decreases continuously, that of the "15-64" cohort increases for the next 10 years but then decreases until 2050, and that of the "65 and over" increases continuously. Specifically, for the "0-14" cohort, the population eventually decreases from 8.77 million in 2007 to 3.815 million in 2050. For the "15-64" cohort, the population in 2007 is 34.9 million, the maximum is estimated to be 35.67 million in 2013, and it is estimated to be 22.12 million in 2050. The population of the "65 and over" cohort in 2050 is estimated to be 16.2 million, over 3 times the cohort population in 2007.

3 $MAPD = \frac{\sum |D_t - F_t|}{\sum D_t}$, where D_t is the estimated value by KNSO and F_t is the estimated value in this model (Russell & Taylor 2006, 499).

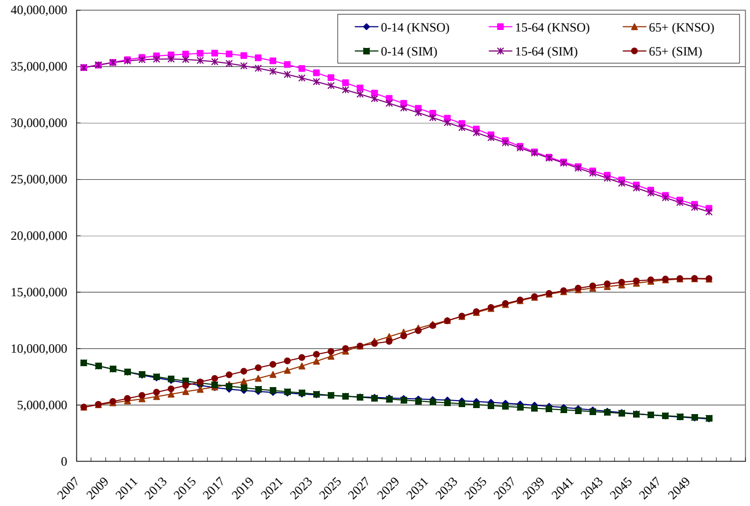


Figure 8 Comparison of cohort population

As the populations of three large cohorts change, the population structure changes dynamically. Figure 9 shows the population ratio of each cohort. The ratios largely move in the same direction with the cohort populations. The population ratios of the "0-14" and the "15-64" cohorts largely decrease but the ratio of the "65 and over" cohort increases because of the rapid increase in the cohort population. The population aged 65 and over is estimated to be 38.5% of the total population in 2050.

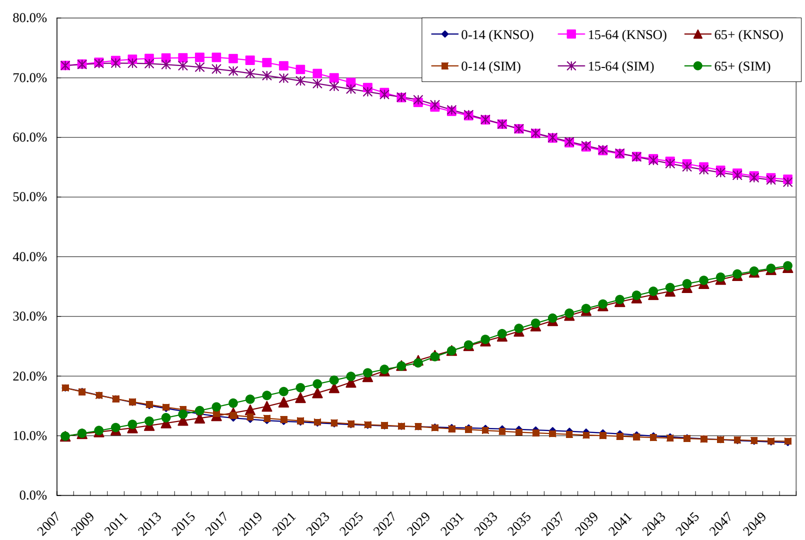


Figure 9 Population ratio

The demand for each welfare institution increases as the “65 and over” cohort population increases. The demand for the medical welfare institutions is estimated to be much greater than that of the residential welfare institutions. It is estimated that the demand for the residential welfare institutions increases from 384 in 2007 to 1,752 in 2049 and that of the medical welfare institutions is also expected to increase from 1,114 in 2007 to 12,070 in 2049 with the ratios of residents to strength of 0.736 and 0.86 for residential and medical welfare facilities, respectively (refer to Figure 10).

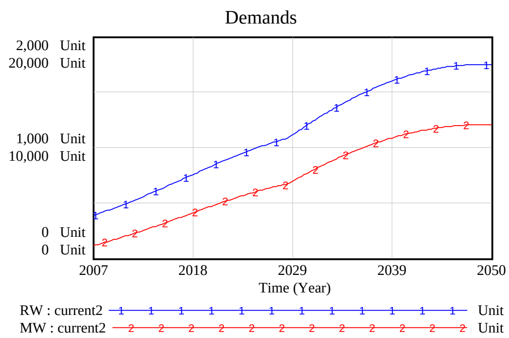


Figure 10 Demand for welfare institutions

Figure 11 shows the residents of both types of welfare facilities. Residents will reach 43,827 and 477,490 in maximum at the year of 2049 for residential and medical facilities.

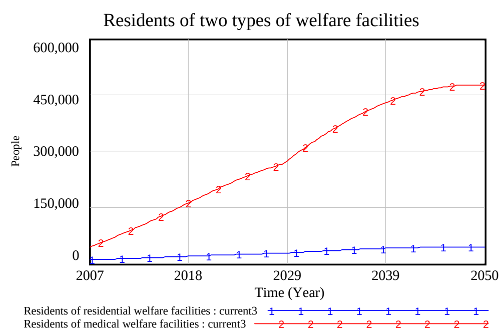
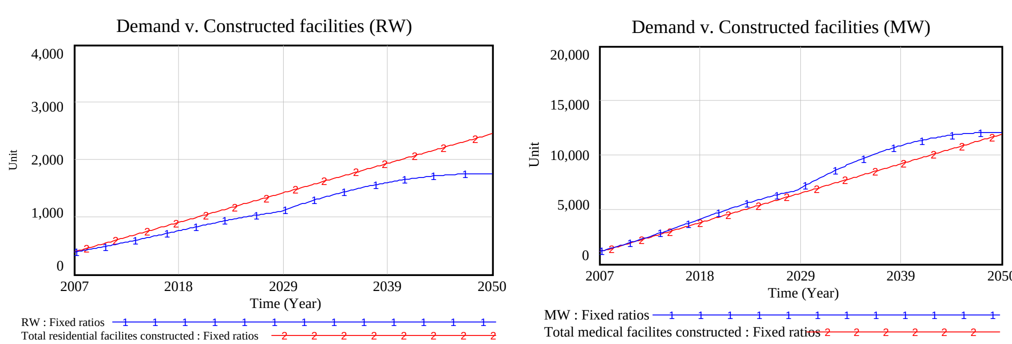


Figure 11 Residents of welfare facilities

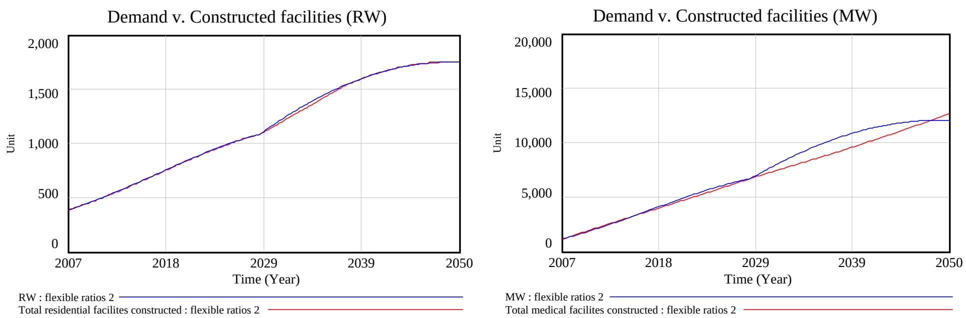
The first plan for expanding the welfare facilities was started in 2006 and will be finished in 2010. So, the second plan will be presented in 2010 by the Korean government and implementation should begin in 2011. According to the first plan, the number of welfare facilities in 2010 is estimated to be 1,399. As the needs of welfare facilities will increase due to the increase of aged population, we assume that Korean government makes a plan to construct 1,500 welfare institutions totally every five years. Of total number of welfare facilities, the residential type takes 16% and the medical 84%, based on the data about the number of facilities in 2007. As the plans are implemented, the relationship between the demand and the plan shall be investigated. In other words, we shall examine and investigate how much the demand will be satisfied by the government plan for welfare institution construction. The simulation result of these two fixed ratios case is shown in Figure 12. It tells us that there will be the surplus of residential welfare facilities and the shortage of medical welfare facilities in the future. So, we shall try to decrease the shortage of medical welfare facilities and the surplus of residential welfare facilities by adopting the flexible ratios between two types of welfare facilities. We shall decrease the surplus of residential welfare facilities by lowering the construction rate with the formula of “if then else (S1>=0, "No. of facilities planned 1"/Duration of plan, 0)” where S1 means the shortage of the residential welfare facilities. This formula will let the construction rate of residential welfare facilities lower and that of medical facilities higher simultaneously as the total number of facilities in the government plan is assumed to be constant.



(a) Residential **(b) Medical**

Figure 12 Demand v. No. of constructed facilities in the case of fixed ratios

Figure 13 shows the simulation result of the flexible ratios case. The flexible ratio means values of R_1 and R_2 change as the surplus of residential facilities occurs. That is to say, in case of the surplus in the total number of a type of welfare facilities compared with the demand, the residential welfare facilities in this research, the construction of this type of facility shall stop and the other type of facility shall be constructed more. The figure in the left side depicts the demand and the number of facilities constructed for the residential type and the figure in the right side for the medical type in Figure 13.

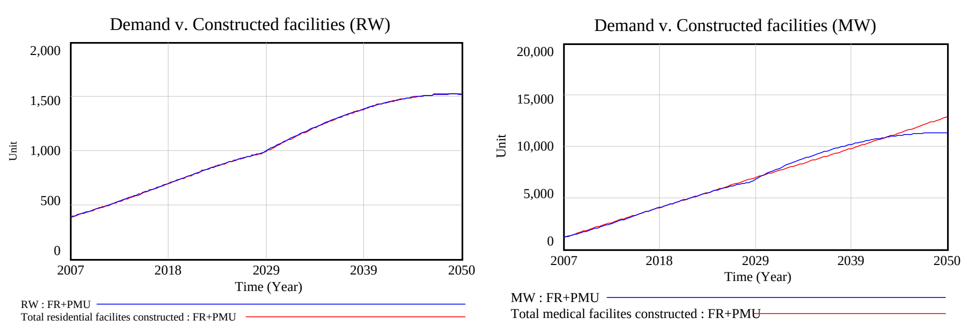


(a) Residential **(b) Medical**

Figure 13 Demand v. No. of constructed facilities with the flexible ratios

From Figure 13 above, we see that the government plan satisfies the demand for the residential facilities better than for the medical facilities. Some gaps occur between the demand and the government plan for the medical facilities in the period of from 2030 to 2049. This shows the limitation of facility construction caused by the uniform budget policy for welfare facility construction. As the aged population increases, the demand also increases proportionally while the budget for welfare facility construction stays constant so it causes the gap.

Additionally, a simulation shall be performed for the case of flexible ratios and partial maximum facility capacity utilization that means if there is a shortage of a type of welfare facility the ratio of residents to strength will become one, i.e., the facility capacity will be fully utilized. Figure 14 depicts the simulation result for two types of welfare facilities.

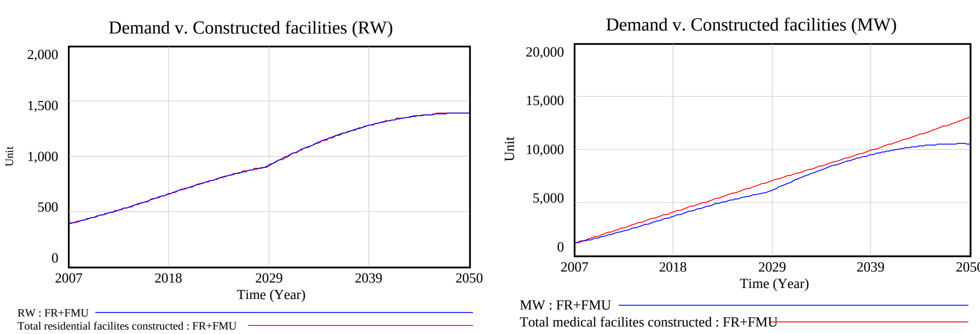


(a) Residential **(b) Medical**

Figure 14 Demand v. No. of constructed facilities with the flexible ratios and partial maximum capacity utilization

The government construction plan satisfies the demand for residential facilities almost perfectly but doesn’t satisfy the demand for medical facilities. However, the shortage is decreased more than the former two cases (refer to Figure 12, Figure 13, and Figure 14). But there will be estimated to have the surplus for the medical welfare facilities after 2040 so it will be appropriate to decrease the facility construction after 2040.

Finally we shall perform a simulation for the case of flexible ratios and constant maximum ratios of residents to strength of both types of facilities. The maximum ratio of residents to strength is one which means the capacity is utilized fully so the number of residents is same with the strength of facility consequently. This case means all welfare institutions will be utilized fully all the time in the future. Figure 15 illustrates the demand versus the number of facilities for residential and medical welfare facilities, respectively. The demand for residential facilities is satisfied with the government plan almost perfectly, as it is in the case of the flexible ratio and the partial maximum capacity utilization. For the medical welfare facilities, the number of facilities constructed will be greater than the demand. This implies that the demand can be satisfied by the government plan as the ratio of residents to strength changes in the range from 0.86 to 1.



(a) Residential **(b) Medical**

Figure 15 Demand v. No. of constructed facilities with the flexible ratios and the maximum capacity utilization

Figure 16 compares the shortage of medical facilities for four cases that we already simulated. The fixed ratios case shows the largest shortage among four cases and the case of the flexible ratio and the maximum capacity utilization the negative shortage, that is, the surplus. The shortage of both types of welfare facilities for four cases is summarized in Table 6 below. It tells us that the variation of shortage of both types of facilities decreases as we perform simulations with offering the flexibility in construction ratios and maximizing the capacity utilization. The maximum demands of both types of facilities are decreased in the last two cases because of the increased number of residents per facility caused by capacity utilization maximization. The maximum shortage of medical welfare facilities is revealed to be 1,674 in 2039, 1,287 in 2038, and 502 in 2037 for three cases except the fourth, respectively and the fourth case doesn't have the shortage. Thus, the maximum shortage and the year of maximum shortage are reduced as we offer the cases the flexibility in construction ratios and maximizing the capacity utilization.

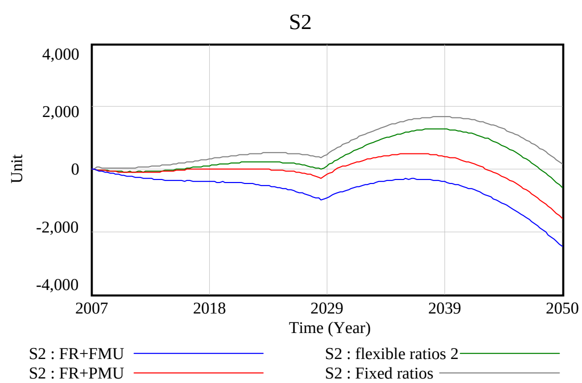


Figure 16 Comparison of shortages for four cases

Table 6 Summary of simulation results for four cases

Cases	Residential welfare facility				Medical welfare facility			
	Max. demand	Shortage			Max. demand	Shortage		
		Max	Min	Mean		Max	Min	Mean
Fixed ratios	1751.4	-4.7	-697.9	-271.8	12070	1673.6	-4.7	752.1
Flexible ratios	1751.4	31.2	-9.2	5.8	12070	1286.5	-586.3	411.9
Flexible ratios with the partial maximum capacity utilization	1521.7	13.3	-9.2	1.0	11309.9	502.0	-1574.4	-37.98
Flexible ratios with the maximum capacity utilization	1390.4	9.7	-9.3	-0.16	10536.2	-12.8	-2478.7	-643.9

Among four simulation results, the fourth case is extremely conditioned with the maximum capacity utilization. This condition is assumed to be maintained all the time though there is no shortage of welfare facilities. The third case is not of extreme conditions as it is assumed to have the maximum capacity utilization only when there is the shortage of facilities and is more rational than the fourth case because there is a room for capacity when there is no shortage or there is a surplus of capacities. In the two cases of fixed and flexible ratios, the capacity utilization is not controlled by terms of demand. The demand is assumed to be predetermined so the effort of government to satisfy the demand is mainly investigated in these two cases. These two cases are simpler than the third and fourth cases. Totally, the third case is best among 4 cases as we exclude the fourth case from the consideration set. Table 6 tells us the ranges of demands for welfare facilities. The demand of residential facilities is ranged from 1,391 to 1,752 and that of medical facilities from 10,537 to 12,070. The finding is that there will be an optimal ratio of residents to strength at which the demand is satisfied with the plan between the third and the fourth case. That is to say, the ratio of resident to strength will be between 0.736 (0.86) and 1 for the residential (medical) welfare facilities.

According to the calculation result from this simulation, the number of welfare facilities in the government plan should include these numbers shown in Table 7 below, to eliminate the facility shortage in the future. This table shows that there will need 2,218 facilities to satisfy the demand in maximum at the 6^{th} plan for the period of 2036 to 2040 and the need will decrease after 2040. These numbers remind us of the life cycle of an agency of Levin and Roberts (1976) and can explain the life cycle of welfare facilities. The number of welfare facilities shall increase until 2035 then decrease so the period of 2011 to 2035 can be regarded as the "growth" stage and 2036 to 2050 as the "maturity" stage. It is thought that there exists the "decay" stage after 2050 as the total population is estimated to decrease.

Table 7 Needed facilities to be reflected

Plan	Duration		RW	MW	Total
	From	To			
2nd	2011	2015	175	1,404	1,579
3rd	2016	2020	188	1,508	1,697
4th	2021	2025	167	1,338	1,505
5th	2026	2030	190	1,526	1,717
6th	2031	2035	246	1,972	2,218
7th	2036	2040	179	1,436	1,615

8th	2041	2045	104	831	934
9th	2046	2050	25	200	225

From Table 7, the average total number of needed facilities is calculated as 1,437. We performed simulations with the fixed number of facilities constructed for every 5 years, 1,500, but there are still the shortage of welfare facilities for all four cases. It tells us the importance of flexibility in policy making. If Korean government provides the flexibility in the number of welfare facilities to be constructed in policy making and reflect the numbers of needed facilities for every five years, it will be so effective to satisfy the demand perfectly and save the budget. If we assume the economy scale is proportional to the population, to reflect the flexible numbers will be more effective as the total population and working age population are estimated to decrease. As the economy scale is estimated to decrease, it will be better to prepare the future as early as possible.

CONCLUSION

In this research, the needs and the shortages of welfare institutions for the next 43 years in Korea was investigated. It is estimated that the residents of welfare facilities will reach 43,794 and 477,083 for residential and medical types in maximum, respectively. The demands are ranged from 1,391 to 1,752 and from 10,537, to 12,070 for residential and medical welfare facilities, respectively and are 3.63 to 4.56 and 9.46 to 10.83 times the number of welfare facilities in 2007, 384 and 1,114. This is mainly the result of evolving toward an aged society. As the population of the “65 and over” cohort increases rapidly, the demands for two types of welfare facilities also increase exponentially.

We investigated the shortages of two types of welfare institutions as the government plans to construct 1,500 welfare facilities for every five years. The shortage of the residential welfare facilities is estimated to be trivial compared to that of the medical welfare facilities. The medical facility type is forecasted to have a shortage until 2048 due to the limitation of construction caused by the limited budget in the case of the flexible ratios. It is inferred from the simulation results that there will be an optimal ratio of residents to strength at which the demand is satisfied between 0.736 (0.86) and 1 for residential (medical) welfare facilities.

Research result tells us that in the future more welfare institutions must be constructed as Korea enters an aged society. Furthermore, the demands for welfare facilities are estimated to increase exponentially until 2049 so it is necessary to prepare the upcoming increasing in demand now. It is time to make and implement the long term plan for an ever aging society.

According to the plan of the Korean government for aging society (2006), the Korean government has been trying to prepare for the aged society in various ways, such as launching or reinforcing public pension system for the elderly, health management system, job creation for the elderly or retirees, long term welfare insurance for the elderly, and infrastructure for social participation of the elderly. With this effort, the Korean government should try to utilize the elderly people because they are precious resources that can make important contribution to society (WHO 2002, Chiou *et al.* 2009). To provide a job to the elderly will be beneficial to both society and individuals. Older workers are revealed to be associated with fewer disabilities and a longer life expectancy (Kondo *et al.* 2005, Tokuda *et al.* 2008); social participation is helpful to maintain the autonomy and quality of later life (Miyata *et al.* 1997, Kawamoto *et al.* 1999, Tsutsui *et al.* 2001, Okamoto *et al.* 2006, Tokuda *et al.* 2008). Thus, social participation can help older people to become vigorous and healthy; thus, decreasing the demand for welfare facilities. If the demand is reduced, less welfare facilities will be necessary in the future. Even though the first plan of Korea government for 2006 to 2010 has been implemented faithfully, the residents of welfare facilities have increased exponentially. It shows us that the policy for job creation and social participation facilitation program for the elderly has not been effective enough to mollify the increase in the number of residents. Therefore, policy makers should try to make these programs effective to prepare for the aged society.

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