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RESEARCH ARTICLE

Evaluation of determinant factors for entrepreneur-marketing stabilization of pork in South Korea by canonical correlation analysis.

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Abstract

This study was performed by canonical correlation analysis (CCA) for prediction of relationship between supply and demand factors of pork in South Korea. The canonical correlations between the supply and demand factors were 0.996 for the first canonical pair ($p<0.01$). Beginning stocks of domestic pork (BSDP) and production of domestic pork (PDP) provided high contribution to form the first fair of demand factors (W_1), whereas ending stocks of domestic pork (ESDP), consumption of domestic pork (CDP), population with age 15 and above (PA15A), and population of employment (PE) highly contributed to the first fair of supply factors (V_1). In addition, BSDP, ESDP, PDP and CDP have a strong predictive powers for the changes of the pork market. Therefore, it is suggested that the results of CCA are able to establish a strategy for stabilizing pork market by the appropriate modification or control of the related factors to domestic pork supply based on the domestic pork demand.

Introduction:-

Pork is not only one of the most widely consuming meat in most countries, but also is of steadily increasing meat with the growth of per capita GNI, because the pork is the source of high quality protein, vitamins and minerals (Choe et al., 2015). Per capita consumption of pork in South Korea was 21.8 kg at 2014 (Statistics Korea, 2016), which pork was the most consumption among meat at that year which ranks seventh worldwide (National Pork Board, 2014). Based on consumption, pork has been recognized as one of the most important products in annually agricultural GDP in South Korea. The price and quantity of pork trading the market are determined by the interrelations between the various factors to affect supply and demand. When the demand of pork increases under a given supply of pork, its price rises in a market. As a result, consumers motivate to search substitutes and withdraw the additional purchases of pork, but producers motivate to supply more pork. These two forces will eventually bring the demanded and supplied quantities back into balance (Gwartney et al., 2011). Therefore, the establishment of relationship between the variables related to supply and demand of pork has important implications for a stable marketing strategy of the pork, in time that the bilateral free trade agreements (FTA) is expanding.

Canonical correlation analysis (CCA), which firstly introduced by Hotelling (Wood and Erskine, 1976), is an useful multivariate technique for measuring together a number of dependent variables as well as independent variables. CCA derives the equation that combines the linear variables from the correlation of variables in a respective set and then analyzes their correlation from the derived equation. CCA is the most appropriate method when a researcher desires to examine the relationship between two variable sets (Sherry and Henson, 2005). This powerful multivariate technique has been adopted in many fields such as psychology, social science, political science, ecology, education, sociology-communication and marketing (Jaiswal et al., 1995). Nevertheless, the technique has been still selected by a low frequencies in the animal husbandry field (see Sahin et al., 2001; Akbas and Takma, 2005; Yang et al., 2006; Cankaya and Kayaalp, 2007; Mendes and Akkartal, 2007; Yapraket al., 2008), and the applied research for canonical correlation between demand and supply of meats remains still to be studied.

The purpose of this study is to estimate associations between variables sets related with supply and demand of the pork market in South Korea using CCA for business start-up. The knowledge derived from our study will assist to establish strategies for entrepreneur-marketing stabilization of pork to cope risk caused by the imbalance of supply and demand in the domestic pork market.

Materials and methods:-

Data collection:-

The applied secondary data for this study were collected from Korean Statistical Information Service (KOSIS), National Agricultural Cooperative Federation (NACF) and Korea Meat Trade Association (KMTA). All the data were monthly collected from 2003 to 2015 (156 months), and the employed price data presented the real prices based on the consumer price index (CPI) 2010 (2010=100). Beginning stocks of domestic pork (BSDP), production of domestic pork (PDP), imports of pork (IP) and average wholesale price of domestic pork (AWPDP) among the collected data were selected as the dependent or criteria variable set owing to characteristic of supply function for pork. Otherwise, population with age15 and above (PA15A), population of employment (PE), ending stocks of domestic pork (ESDP), consumption of domestic pork (CDP), exports of pork (EP), average consumer price of domestic pork (ACPDP) and average consumer price of Hanwoo beef (ACPHB) were selected as the independent or predictor variable set owing to characteristic of demand function for pork. PA15A was presented as a scale of consumer, and PE was selected as a demand variable owing to determination of the consuming capacity. In addition, Hanwoo beef is a same red meat with pork, is similar with pork in the method of cooking, and is a high preference of consumer in South Korea. Since these reasons have been generally recognized as a substitute for pork, ACPHB was selected as a variable. Import and export of pork were selected as variables depending on a trend that free trade has expanded in recent global market. Descriptive statistics for the examined supply and demand factors were showed in Table 1.

Table 1:- Descriptive statistics for *X* and *Y* variable sets from South Korea in 2003~2015

X variable set (n=156)		*Y* variable set (n=156)	
supply factors	mean±SD	demand factors	mean±SD
X_1 = BSDP (tons)	27,849±8,325	Y_1 = PA15A (1,000 persons)	40,141±1,789
X_2 = PDP (tons)	61,052±7,584	Y_2 = PE (1,000 persons)	23,890±1,197
X_3 = IP (tons)[1]	18,389±8,893	Y_3 = ESDP (tons)	27,806±8,313
X_4 = AWPDP (KRW/kg)[2]	3,967±819	Y_4 = CDP (tons)	60,328±7,720
		Y_5 = EP (tons)	69±173
		Y_6 = ACPDP (KRW/kg)[3]	16,578±2,441
		Y_7 = ACPHB (KRW/kg)[4]	30,376±7,832

SD, standard deviation; BSDP, beginning stocks of domestic pork; PDP, production of domestic pork; IP, imports of pork; AWPDP, average wholesale price of domestic pork; PA15A, population with age 15 and above; PE, population of employment; ESDP, ending stocks of domestic pork; CDP, consumption of domestic pork; EP, exports of pork; ACPDP, average consumer price of domestic pork; ACPHB, average consumer price of Hanwoo beef.

[1] Imports and exports are based on quarantine.

[2] Wholesale price of pork is based of pork carcass scalding.

[3] Consumer price of pork is based on belly.

[4] Consumer price of Hanwoo beef is based on rump or topside.

Canonical Correlation Analysis (CCA):-

CCA is a useful technique that establishes the interrelation between two sets of variables as well as quantifies the percentage of variance common to the two groups (Ventural et al., 2011; Kim et al., 2016). CCA indicates the correlation between linear combinations of dependent and independent variable sets, which the linear combinations of variables are useful for predictive or comparative purposes (Akbas and Takma, 2005; Sahin et al., 2011). Therefore, the aim of CCA is to find the best linear combination between two multivariate datasets that maximize the correlation coefficient between them (Malacarne, 2014). Linear combinations of the original variables can be defined as canonical variates (V_i and W_i) as follows:

$$V_i = a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{ip}X_p$$

$$W_i = b_{i1}Y_1 + b_{i2}Y_2 + \cdots + b_{iq}Y_q$$

The correlation between V_i and W_i can be defined to canonical correlation. CCA is repeatedly looking coefficients *a* and *b* to maximize the correlation between dependent variables set (V_i) and independent variables set (W_i).

The maximum number of canonical function that can be extracted equals the number of variable in the smallest canonical variate (Dattalo, 2014), which is four in this study (a number of pork supply factor variables). The first canonical function is derived to maximize the correlation between V_i and W_i variables. The second canonical correlation has always values smaller than that of the first one (Laessig and Duckett, 1979).

The standardized canonical coefficients and canonical loadings were used to evaluate the relative importance of variables in the model (Dattalo, 2014). The standardized coefficients are interpreted in a similar to the standardized regression coefficients in multiple regressions. Therefore, CCA is to estimate canonical coefficients ($a_{i1}, a_{i2}, \cdots, a_{ip}$ and $b_{i1}, b_{i2}, \cdots, b_{iq}$) when the canonical correlation is at the maximum (Akbas and Takma, 2005). The canonical loading reflects the variance that the observed variable can be shared with the canonical variate and interpreted like a factor loading to assess the relative contribution of each variable to each canonical function (Safari et al., 2013).

The redundancy index (RI) is proposed for calculation of each canonical correlation to determine how much of the variance in one set of variables is accounted by the other set of variables (Sharma, 1996; Akbas and Takma, 2005; Safari et al., 2013). The value is derived by multiplying the shared variance of the variate and the squared canonical correlation (Cankaya and Kayaalp, 2007; Sahin et al., 2011). In addition, the squared multiple correlations indicate predictive power between the dependent and independent variables. Through CCA determines association between two sets of variables, in this study, it makes more economically sense to conceptualize the pork supply factors as dependent or criteria variables and the pork demand factors as independent or predictor variables.

Applications of CCA:-

CCA was used to evaluate the relationships between the groups of supply and demand factors by PROC CANCORR procedure of SAS program for Windows version 9.2. The canonical correlation coefficients and the correlation between the original variables and the related canonical variates were estimated depending on the correlation matrix among the eleven factors used in this study.

Results:-

Correlation among original factors:-

Bivariate correlations among the supply and demand factors of pork market in South Korea was shown in Table 2. The correlations between the supply and demand variables were presented by relatively high values among each factor. Especially, higher positive values of correlation were observed in following datum sets: 0.935 between PA15A and PE, 0.896 between BSDP and ESDP, 0.866 between PDP and CDP, and 0.764 between AWPDP and ACPDP. On the contrary, ACPHB had negative correlations with PA15A and PE. These results showed relatively high correlations between the supply and the demand, and between the wholesale price and retail price (P<0.01). Although the supply factors are important indicators for demand factors in pork market, it is extremely difficult to explain simultaneously the relationship between the variable factor sets. Therefore, instead of bivariate correlations, in this study, CCA were introduced to explain together the relationship between the supply and demand factors in pork market.

Table 2:- Correlation matrix for the supply and demand factors of pork market

variables	BSDP	PDP	IP	AWPDP	PA15A	PE	ESDP	CDP	EP	ACPDP
PDP	0.334*									
IP	0.089	-0.168								
AWPDP	-0.070	-0.481*	0.557*							
PA15A	0.454*	0.254	0.562*	0.372*						
PE	0.390*	0.254*	0.499*	0.383*	0.935*					
ESDP	0.896*	0.441*	0.164	-0.114	0.509*	0.421*				
CDP	0.491*	0.866*	-0.208*	-0.391*	0.261*	0.278*	0.377*			
EP	-0.004	-0.004	-0.451*	-0.365*	-0.515*	-0.469*	-0.105	0.061		
ACPDP	-0.248	-0.423*	0.482*	0.764*	0.422*	0.446*	-0.231*	-0.415*	-0.500*	
ACPHB	-0.433*	-0.238*	-0.427*	-0.249*	-0.882	-0.824	-0.459*	-0.276*	0.361*	-0.223*

* P<0.01.

BSDP, beginning stocks of domestic pork; PDP, production of domestic pork; IP, imports of pork; AWPDP, average wholesale price of domestic pork; PA15A, population with age 15 and above; PE, population of employment; ESDP, ending stocks of domestic pork; CDP, consumption of domestic pork; EP, exports of pork; ACPDP, average consumer price of domestic pork; ACPHB, average consumer price of Hanwoo beef.

Measurements of overall model fit for canonical correlation analysis:-

The results of CCA for the four pairs of canonical variate due to variables of 4 supply factors in smaller variable set were outlined in Table 3. The first canonical correlation was 0.996, which represented the highest possible correlation between any linear combinations of the supply factor variables (V_1) and the demand factor variables (W_1) in domestic pork market. The second, third and fourth pairs of canonical correlation were 0.782, 0.659 and 0.455, respectively. It is indicated that all the coefficients are significant relationships between the canonical variables (P<0.01).

Table 3:- Summary of results from canonical correlation analysis

Canonical variate pair	Canonical correlation	Squared canonical correlation	Eigenvalue	DF	Likelihood ratio	Pr> F
V_1W_1	0.996	0.991	114.465	28	0.0015	<.0001
V_2W_2	0.782	0.612	1.575	18	0.1742	<.0001
V_3W_3	0.659	0.434	0.767	10	0.4487	<.0001
V_4W_4	0.455	0.207	0.262	4	0.7926	<.0001

V_1, V_2, V_3, and V_4; 1st, 2nd, 3rd, and 4th supply factor variables, W_1, W_2, W_3, and W_4; 1st, 2nd, 3rd, and 4th demand factor variables.

The standardized canonical coefficients for variables of pork supply factors showed that BSDP and PDP contribute importantly to the first canonical variable (V_1) as 0.663 and 0.562, respectively (Table 4). On the other hand, the coefficients for variables of the demand factors showed that ESDP and CDP contribute largely to the first canonical variable (W_1) as 0.640 and 0.576, respectively. Furthermore, BSDP and PDP had positive relationships with ESDP and CDP according to our results, respectively.

Table 4:- Standardized canonical coefficients for the supply and demand factors of pork

	X variable set					Y variable set						
	BSDP	PDP	IP	AWPDP		PA15A	PE	ESDP	CDP	EP	ACPDP	ACPHB
V_1	0.663	0.562	-0.001	0.008	W_1	-0.010	0.015	0.640	0.576	0.018	0.001	0.026
V_2	0.263	0.002	0.404	0.684	W_2	0.393	-0.030	0.327	-0.238	0.030	0.663	-0.041
V_3	-0.731	1.081	-0.168	0.732	W_3	0.130	0.191	-0.766	0.907	-0.197	0.320	0.237
V_4	0.333	-0.039	-1.144	0.932	W_4	-2.493	0.410	0.853	0.609	0.426	1.551	-0.842

Analysis of canonical loadings:-

The canonical loadings of the original variables with their canonical variables were shown in Table 5. Canonical loading presents the product-moment correlation between the original variable and its corresponding canonical variate (Kim et al., 2016). These value reflects degree of a variable to be represented by a canonical variate (Yaprak et al., 2008; Tahtali et al., 2012). In terms that variables with larger canonical loadings are more contributions to the multivariate relationships between the variables of supply and demand factors in pork market, the loadings for the supply factors are suggested that BSDP (0.850) and PDP (0.780) are more effects than IP (-0.032) and AWPDP (-0.310) to form the first fair of supply factor variables (V_1). On the other hand, the loadings for ESCP (0.845) and CDP (0.813) were a strong effect compared to the other factors to form the first fair of demand factors (W_1). However, the influence of PA15A (0.459) and PE (0.406) showed a fairly good correlation with consumption activity of domestic pork, while ACPHB and ACPDP presented negative correlations with the factor as -0.424 and -0.399, respectively. The related structure of the first canonical correlation on V_1 and W_1 was illustrated in Figure 1 (see also Table 3 and 5). It was showed that the number of dimension explaining the relationships between the variable sets was reduced from 11 to 2 by CCA. The results indicated high correlation between the supply factor variables set (V_1) and the demand factor variables set (W_1) as 99.6%.

Table 5:- Canonical loadings of the original variables with their canonical variables

	X variable set					Y variable set						
	BSDP	PDP	IP	AWPDP		PA15A	PE	ESDP	CDP	EP	ACPDP	ACPHB
V_1	0.850	0.780	-0.032	-0.310	W_1	0.449	0.406	0.845	0.813	-0.008	-0.399	-0.424
V_2	0.251	-0.307	0.808	0.890	W_2	0.769	0.724	0.287	-0.283	-0.553	0.832	-0.584
V_3	-0.437	0.513	-0.006	0.170	W_3	0.184	0.283	-0.439	0.495	-0.293	0.306	-0.078
V_4	0.152	-0.185	-0.588	0.289	W_4	-0.339	-0.207	-0.029	0.008	0.384	0.208	0.267

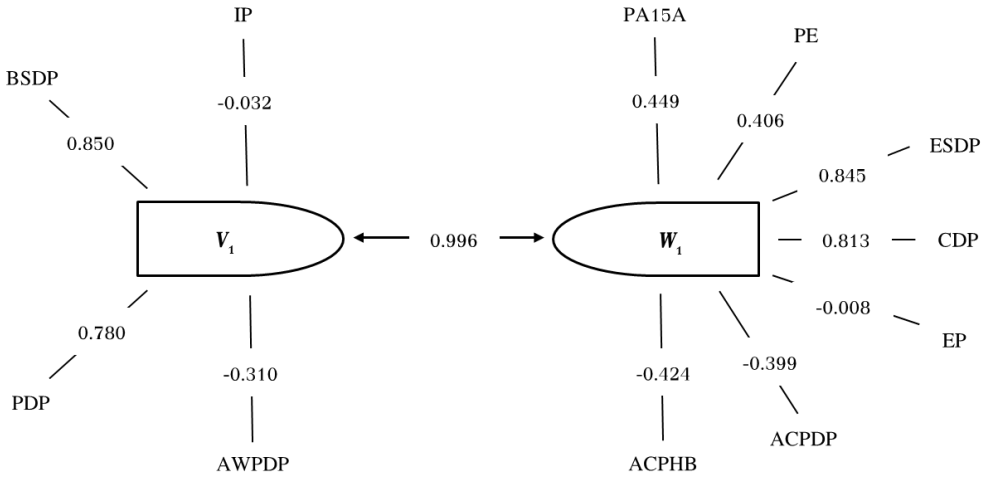

Fig. 1:- Correlations between the pair of canonical variate V_1 and W_1, and their canonical variables and original variables. The value between V_1 and W_1 was originated from CCA. The values between V_1 and canonical variables were derived from canonical loadings of the original variables.

The cross loadings represented the correlations between original variables and opposite canonical variables. Variables with larger canonical loadings contributed more multivariate relationships between the supply and demand factors. According to the cross loading, the first pair of canonical variables BSDP (0.847) and PDP (0.777) provided the relatively strong contribution to canonical variate W_1, whereas ESDP (0.841) and CDP (0.810) highly contributed to V_1 (Table 6). Otherwise, PA15A (0.447) and PE (0.404) presented fairly good contribution to V_1, while ACPHB (-0.437) and ACPDP (-0.397) had inverse contribution.

Table 6:- Cross loadings of the original variables with opposite canonical variables

	X variable set					Y variable set						
	BSDP	PDP	IP	AWPDP		PA15A	PE	ESDP	CDP	EP	ACPDP	ACPHB
W_1	0.847	0.777	-0.031	-0.308	V_1	0.447	0.404	0.841	0.810	-0.008	-0.397	-0.423
W_2	0.196	-0.240	0.632	0.696	V_2	0.601	0.566	0.224	-0.221	-0.433	0.651	-0.457
W_3	-0.288	0.338	-0.004	0.112	V_3	0.121	0.186	-0.289	0.326	-0.193	0.202	-0.051
W_4	0.069	-0.084	-0.268	0.132	V_4	-0.154	-0.094	-0.013	0.004	0.175	0.095	0.122

Canonical redundancy Analysis

Canonical redundancy analysis was examined to know how the original variables are well-predicted from the canonical variables (SAS, 2009). The redundancy index (RI) indicates the total proportion of variance to be shared by the two sets of original variables. It was designed to overcome the inflated correlations (Laessig and Duckett, 1979).

As the results of canonical redundancy analysis, 33.7% of the shared variance in supply factors (X variable set) was explained by first pair of canonical variable V_1. Otherwise, it was estimated that RI of 0.354 for the first canonical variable was explained by 35.4% of the proportion for canonical variable W_1, where RI (0.354) was derived by multiplying the shared covariance (0.357) and the squared canonical correlation (0.991). In addition, it was found that 29.7% of total variation in the demand factors (Y variable set) was explained by first pair of canonical variate W_1. RI of 0.295 for first canonical variable was explained by 29.5% of the proportion for canonical variate V_1 (Table 7). Therefore, the results of canonical redundancy analysis to explain 35.4% and 29.5% of variance showed that the pair of canonical variables predicts overall well for the opposite set of variables.

Table 7:- Redundancy analysis for the pair of canonical variables

X variable set					Y variable set			
	Shared variance		Redundancy	canonical R^2		Shared variance		Redundancy
V_1	0.357	W_1	0.354	0.991	W_1	0.297	V_1	0.295
V_2	0.400	W_2	0.245	0.612	W_2	0.374	V_2	0.229
V_3	0.121	W_3	0.053	0.434	W_3	0.105	V_3	0.046
V_4	0.122	W_4	0.025	0.207	W_4	0.060	V_4	0.013

Table 8 showed the squared multiple correlations as a predictor of factors. The results indicated that the first canonical variable of the supply factors has high predictive power for BSDP (0.717) and PDP (0.603), but almost do not the power for IP (0.001) and AWPDP (0.095). Furthermore, the first canonical variables of the demand factors were a strong predictor for ESDP (0.708) and CDP (0.656), a poor predictor for PA15A (0.205), PE (0.163), ACPDP (0.157) and ACPHB (0.179), and nearly useless for EP (0.001).

Table 8:- Analysis of squared multiple correlations between criteria and the first M canonical variables of predictors

	X variable set						Y variable set				
M[1]	BSDP	PDP	IP	AWPDP	PA15A	PE	ESDP	CDP	EP	ACPDP	ACPHB
1	0.717	0.603	0.001	0.095	0.200	0.163	0.708	0.656	0.001	0.157	0.179
2	0.755	0.661	0.401	0.579	0.561	0.484	0.758	0.704	0.187	0.581	0.387
3	0.838	0.775	0.401	0.592	0.576	0.519	0.842	0.811	0.224	0.622	0.390
4	0.843	0.782	0.472	0.609	0.600	0.528	0.842	0.811	0.255	0.631	0.404

[1] M has various values from 1 to 4 as the number of canonical correlations.

Discussion:-

The consumption of meat has been significantly increased depending on the rise of per capita GNI, and pork is an important food which accounts for the largest consumption in the consumption of meat (Kim et al., 2016). In addition, the strong preference and high demand for pork belly in South Korea compared to the other parts of pork have been led to an imbalance in the supply and demand of pork production (Choe et al., 2015). In pork market, when the consumer price of pork rises, consumer tends to increase consumption of alternatives instead of decrease of pork consumption in order to achieve consumption of meats in a given expendable income. Based on these consumer behavior, when the price of pork rises, policy maker is possible to achieve a price stabilization with enlargement for the supply of beef as an alternative meat or with increase of the pork import from other countries.

The simple correlation analysis has been commonly used to investigate the bivariate correlation which represents only the relationship between two variables regardless of variables related to another at the same time (Akbas and Takma, 2005). According to correlations between the supply and demand factors of pork market in South Korea, the correlations within sets maintained relatively high values as follows: 0.896 between BSDP and ESDP, 0.866 between PDP and CDP, and 0.870 between AWPDP and ACPDP. These results present that BSDP is referred to ESDP, and PDP has a direct impact on CDP, and ACPDP determines on the basis of AWPDP. In addition, IP was positive correlations with AWPDP, ACPDP and PA15A. Whiles EP was very low correlation with other factors, it was evaluated owing to low impact on the domestic pork distribution market according to interruption of export by domestically occurred foot and mouth disease (FMD).

The distribution of pork have interrelationships among a variety of factors for supply and demand. In order to prove these phenomena, CCA is very useful technique for examination of relationships between supply factors such as BSDP, PDP, IP and AWPDP, which play critical roles as predictors for the chain evaluation of pork market, and demand factor variables such as PA15A, PE, ESDP, CDP, EP, ACPDP and ACPHB, which play important roles as criteria. The first pair of canonical variables was significant canonical correlation of 99.6% ($P<0.01$).
From the results of canonical loading, it is assumed that BSDP and PDP are a major impact for variable set (V_1) of the supply factors, whereas PA15A, PE, ESDP, CDP, ACPDP and ACPHB play an important role for the demand of domestic pork. BSDP and PDP provided the relatively high contribution to canonical variate W_1 which is the supply factor set of pork. Likewise, PA15A, PE, ESDP, CDP and ACPDP determined the scale of the consumption market, and ACPHB as a substitute goods also played an important role for canonical variate V_1 which is the demand factor set of pork. In other words, the domestic pork market may be activated by increases of BSDP and PDP. Otherwise, the supply of pork may be increased owing to promotion of production for domestic pigs through increases of PA15A, PE, ESDP and CDP. Contrariwise, a shrinking phenomenon of the pork supply appeared to cause the rising of ACPDP and ACPHB. However, despite pork trade is expanding, IP and EP narrowly influence on the production and consumption of pork in South Korea up to date. The demand of consumer for wholesome animal products exerts a powerful influence upon quality, production method and strategies. Recent increases in expendable income of consumers have tendencies to stimulate greater demand not only for quality but also quantity of meat products (Adesehinwa, 2003). Therefore, consumer's purchasing power is an important factor to induce the activation of modern pork industry (Suckling, 2012). In other words, when the disposable income of consumer is increased by growth in PE, it is predicted that meat consumption including pork may be further expanded.

From the results of canonical redundancy analysis, 35.7% of variance in the X variables set is accounted by the canonical variate V_1, while 33.2% of variance in the Y variables set is accounted by the canonical variate W_1. In particular, the squared multiple correlations as the predictor of factors indicate that the first canonical variables of the supply and demand factors have high predictive power for BSDP, PDP, ESDP and CDP. In addition, PA15A, PE, ACPDP and ACPHB have a little predictive power in domestic pork market. Therefore, it is suggested that adequate modification or control for these factors induces the stabilization of the domestic pork production or consumption market. Likewise, these findings may be a useful input as a conceptualizing model for coping with acute demand for pork (Adesehinwa, 2003). Furthermore, even if imports and exports of pork were analyzed to have the weakly impact on the domestic pork market, these results may be explained by the influence of the export interruptions due to FMD occurred in South Korea, and the import embargo due to bovine spongiform encephalopathy (BSE) has occurred in other countries (Oh and Whitley, 2011). However, despite the difficult domestic environment, global pork markets in future will be more competitively expanded in the flow of the bilateral FTA (Choe et al., 2015). Therefore, in order to activate the domestic pork industry, it is suggested that venture policy options recover as soon as possible on the status of disease free country, and then adjusts the export and imports of pork corresponding to the variations of supply and demand in the domestic pork market.

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