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Regional Concentration of Agricultural Production and Supply Variability*

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농업 생산의 지역 집중과 공급 변동성

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국문요약: 이 논문에서는 기존의 집적경제(agglomeration economies) 효과에 대한 논의가 평균 생산 측면에만 국한되어 이루어져 왔다는 점에 착안하여, 생산의 지역집중이 생산의 변동성에 미치는 효과에 대한 실증 분석을 시도하였다. 이를 통해 생산성의 평균 효과에 국한된 집적경제의 논의를 분산(변동성) 효과로 확장할 수 있었다. 본 연구에서 활용된 이론적 방법론은 변이계수 분해법이며, 이를 통하여 생산의 변동성을 순수 생산성 효과, 재배면적 효과, 그리고 이 두 가지의 교차효과 등 세 부분으로 분해하였다. 본 연구의 실증분석으로는 농업부문을 대상으로 하여 특정 농산물 생산의 지역 집중이 생산의 변동성에 미치는 영향을 분석하였다. 본 연구는 배추, 고랭지배추, 무, 양파, 파, 마늘 등 6가지 품목의 지역별 생산량 및 재배면적 자료를 이용하여 생산의 변동성을 순수 생산성 효과, 재배면적 효과, 그리고 이 두 가지의 교차효과 등 세 부분으로 분해하였다. 분석결과, 총공급(총생산)의 변동성은 품목별로 유사한 변화 패턴을 보이는 반면, 생산 변동성의 요인은 품목에 따라 매우 다른 양상을 보이는 것으로 나타났다. 특히 생산의 지역집중도가 증가할수록 순수 생산성 변화에 따른 생산의 변동성이 커지는 것으로 분석되었다. 이러한 결과는 농업생산의 경우 생산의 지역집중에 따라 변동성(위험)이 함께 증가할 수 있다는 것을 의미한다. 이에 따라, 본 연구는 농업생산에는 지역집중에 따른 평균효과를 나타내는 집적경제적 측면이외에도

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분산효과를 나타내는 집적불경제(agglomeration diseconomies)적 측면이 있음을 실증적으로 보였다는 점에서 시사하는 바가 크다고 할 수 있다.

Key Words: agglomeration diseconomies(집적불경제), decomposition(분해), supply variations(공급변동성), pure yield effects(순수 단수효과), pure cultivation area effects(순수 재배면적 효과), regional production concentration(지역생산집중)

1. Introduction

Regional concentration issue has been a quite important research topic in regional economics literature. In particular, research on the issues of regional concentration of production recognizes positive productivity-increasing/cost-reducing benefits widely known as agglomeration economies (e.g., Henderson, 1986; Krugman, 1991; van der Panne, 2004). In agricultural production, some products tend to be produced at a major production area taking advantage of favorable climatic conditions, technology spillovers, the proximity to market, and/or other cost advantages. Among them, favorable climatic conditions and technology spillovers generate benefits of productivity increase in a major production area. These productivity-increasing effects, i.e., mean-increasing effects of regional concentration in agricultural production are well documented in agricultural location theory (e.g., von Thünen, 1826; Winsberg, 1980).

However, questions still remain beyond these mean effects. Going beyond mean effects of regional concentration in agricultural production is an interesting issue for both farmers and policy makers in that variance effect related to the 2nd moment is usually associated with risk in general. Often risk increase results in welfare loss for a risk averse agent. Therefore, going beyond mean effects can capture possible costs involving agglomeration diseconomies. Given this observation, we focus on the following questions in this paper: What are the 2nd moment effects of agglomeration and to what extend do we need to take these beyond mean effects associated with agglomeration economies or diseconomies into consideration? More specifically, we want to address the following questions in this paper: Does regional concentration of agricultural production contribute to variance reduction or variance increase in terms of productivity due to agglomeration externalities? If regional concentration of agricultural production is associated with variance increase in productivity, then what are the factors affecting these results and what are the impacts of these factors on supply/price variations? Following this line of questions, investigating the 2nd moment effects associated with regional concentration of agricultural production can provide valuable insight on the benefits or costs associated with agglomeration of agricultural production. To do this, we need to first identify major sources of supply variations and then link these sources with the degree of regional concentration of production. In this context, this paper develops a conceptual model decomposing supply variations into several factors including yield, cultivation area and interaction of these two factors. A coefficient of variation (CV) approach is utilized to derive the decomposition results. As well known, coefficient of variation involves both first and second moments.

Relying on our conceptual model capable of decomposing supply variations into pure yield effects, pure cultivation area effects, and interaction effects of these two factors based on a coefficient of variation approach, this paper investigates the effects of regional concentration of production on supply variations. Our focus is given to a pure yield effect component of total supply variations in relation to production concentration in a regional level. This effort is expected to shed some light on the nature of agglomeration externalities in terms of both the 1st and the 2nd moments of agricultural production. In particular, our discussion on the 2nd moment effects associated with agglomeration externalities will provide new insight into the regional concentration and agglomeration literature.

As an empirical study, we apply our methodology to Chinese cabbage and seasoning vegetable product data during 2009-2013. The reason behind the selection of these agricultural products in our empirical study is that the degree of price variations of Chinese cabbage and seasoning vegetables such as onion, green onion, garlic, pepper and radish is quite high relative to other agricultural products in Korea (Ahn, 2002; Ahn and Kim, 2008; Yoon and Yang, 2004; Cho et al., 2013). And a high degree of price variation is often associated with high supply variation at least for a short term (since demand is relatively stable for a short term). Understanding the sources of supply variations and linking these to agglomeration literature should shed light on new aspects of supply variations and agglomeration economies. The decomposition results in relation to regional concentration of production suggest that pure yield effects of supply variations have a positive and statistically significant relationship with the degree of regional concentration of production in Chinese cabbage and seasoning vegetable products. This finding of positive 2^{nd} moment effects of supply with respect to regional concentration can provide useful information for policy makers in designing a set of customized policy measures targeting the stability of supply specifically suitable for an agricultural product under attention. That is, the pattern of regional concentration needs to be considered to develop the policy measures for reducing the supply variability of each vegetable crop.

The structure of the article proceeds as follows. The next section develops a conceptual model describing the decomposition scheme of supply variations. In section 3, we discuss the data set used for our empirical analysis. Section 4 reports the results of total supply variations, their decomposition of selected vegetable products, and the relationship between a pure yield component and the degree of production concentration. Section 5 concludes that policy makers should consider the characteristics of regional concentration patterns of vegetable production since the decomposition components of supply variation are quite different across products.

2. Conceptual Model

2.1. Decomposition of Supply Variations

Focusing on the supply side of vegetables in understanding price variations of vegetables, we let the supply of vegetable i, i = {1, ⋯, N} at time t be determined by the product of cultivation area at time t and yield at t. Thus, it is given by

$$S_{it} = Q_{it} * Y_{it}, \quad (1)$$

where S_{it} is the supply of vegetable i at time t, Q_{it} is the cultivation area of vegetable i at time t, and Y_{it} is the yield of vegetable i at time t. It is noted that both cultivation area and yield involve their own determination process. For example, cultivation area at t can be affected by its autoregressive parts (i.e., Q_{it-j}, j = 1, 2, …), expected price at time t and relevant policy variables at time t and t-j, j = 1, 2, …. Yields can be explained by stochastic weather factors (e.g., temperature, rainfall, etc.), diseases and pests. Yields can also be affected by non-stochastic factors such as farm household characteristics and production locations at time t.

Given the above supply determination scheme, one can expect that the variation of supply of vegetable i at time t can be decomposed into cultivation effects and yield effects. This decomposition scheme is consistent with the notion where at least for a short-term, supply variation plays an important role in the determination of price variation and thus understanding the sources of supply variation can shed light on price variation of vegetables at least for a short term given the assumption of stable demand. Variations can be measured by several approaches including a coefficient of variation approach[1)] (Ahn and Kim, 2008). A coefficient of variation measures the degree of relative variations by normalizing standard deviation by its mean. Given the above discussion on the supply determination, the coefficient of variation of supply can be Taylor approximated (Wilkinson, 1961) as follows:

$$CV_S^2 \approx CV_Q^2 + CV_Y^2 + 2\rho CV_Q * CV_Y, \quad (2)$$

where CV_S, CV_Q, CV_Y are coefficients of variation for supply, cultivation area and yield, respectively. And ρ is correlation coefficient. Note that in deriving equation (2) independence assumption between Q and Y is not needed thereby potential interaction effects between cultivation area and yields are explicitly incorporated into the analysis.[2)] This differentiates our approach compare to that of Kim and Ha (2015) where independence assumption between Q and Y is necessary. Given equation (2), supply variations reflecting price variation under stable demand assumption can be decomposed into three components: pure yield variation effects, pure cultivation variation effects and interaction effects between yield and cultivation variations. The following equation (3), (4) and (5) describes a relative measure of these three components to total variation, respectively:

$$\alpha = CV_Y^2 \ / \ \{CV_Q^2 + CV_Y^2 + 2_\rho \ CV_Q{*} \ CV_Y\}, \quad (3)$$

$$\beta = CVQ2 \ / \ \{CVQ2 + CVY2 + 2\rho \ CVQ{*} \ CVY\}, \quad (4)$$

$$\gamma = 2\rho CVQ{*} \ CVS \ / \ \{CVQ2 + CVY2 + 2\rho \ CVQ{*} \ CVY\}, \quad (5)$$

where α denotes pure yield variation effects, β measures pure cultivation variation effects, and γ denotes interaction effects between yield and cultivation variations. First, note that $\alpha+\beta+\gamma = 1$. Second, under independence between Q and Y, γ is equal to 0 since $\rho = 0$. This implies that when γ is different from 0, it can be interpreted as the evidence against the independence assumption between Q and Yin relation to total supply. Furthermore, the size of γ reflects the degree of interaction effects between yield and cultivation variations apart from zero interaction effects under independence. For example, when $\alpha = 0.75$, the proportion of pure yield variation in supply variation is about 0.75 implying that 75% of total supply variation can be explained by pure yield variation effects. Note that the decomposition scheme discussed in equations (3)-(5) provides a basis of evaluating the effects of cultivation area and yield on supply variations in our empirical analysis below.

2.2. Measures of Regional Concentration of Production

In general, there are two types of measures for the degree of concentration of economic activities quantifying the extent to which economic activities are spatially concentrated (McCann, 2013). One is the extent to which a specific industry is spatially concentrated or dispersed. This measures the extent to which an economic activity or industry is evenly distributed spatially throughout the country. And the other identifies the extent to which the economic structure of a specific region is specialized or diversified. It shows the degree of the relative contribution of each industry in a regional industrial structure. These two concepts of regional concentration of economic activities can be applied to an agricultural sector.

The first measure quantifies the extent to which a specific farming activity is spatially concentrated, e.g., the extent to which vegetable production is spatially specialized. The Herfindahl index has been widely used as a measure of market concentration among industrial organization economists and public policy analysts. In this study, we apply Herfindahl index to measure the extent to which the production of major vegetables is spatially concentrated in Korea. Original version of the Herfindahl index is defined as the sum of the square of each firm's market share, $H=\Sigma_i s_i^2$. Here, si is the market share of i-th firm. H has a value close to 0 when a market is composed of an infinite number of firms and each of which has an infinitesimal market share, while it has a value 1 when the market is a pure monopoly. This study calculates the Herfindahl index for major vegetable products in Korea. The Herfindahl index for i-th vegetable is defined as the sum of the square of each region's production proportion, $H_i=\Sigma_r s_r^2$. Here, s_{ir} is the share of region r's planting area for i-th vegetable. Hi has a value close to 1 when the production of i-th vegetable is spatially concentrated.

Note that the Herfindahl index has not been widely used as a concentration measure for industry in general. This is because it requires data on the market shares of all firms and this kind of data is not easily available. It is also difficult to find the intuitive meaning attached to the index in particular regarding the link between concentration and monopoly power (Kelly, 1981). In this study, we rely on crop cultivation area data of each region for calculating Herfindahl index, thus the shares of cultivation area for all vegetable products can easily be evaluated. Moreover, this study uses Herfindahl index as a regional concentration measure and does not try to find any implications related to monopoly power.[3)]

On the other hand, the second measure quantifies the extent to which a specific region is specialized in producing a certain farm product, e.g., the extent to which a region is spatially specialized in producing a specific vegetable. In the following analysis, this study relies on this measure since our focus in given to the relationship between the spatial concentration and the supply variability of major vegetables in Korea. One of the most popular measures of the spatial concentration is location quotient (LQ). It describes a share of specific economic activity on a given region relative to a national share of the same economic activity. An original version of regional location quotient LQ_{ir} is defined as the ratio of the regional proportion of an economic activity (e.g., the share of employment in i-th industrial sector in region r) relative to the national proportion of the same economic activity (e.g., the share of employment in i-th industrial sector of the nation n), i.e., $LQ_{ir} = (E_{ir}/E_r)/(E_{in}/E_n)$. When we apply this measure to an agricultural sector, E_{ir} can be interpreted as the cultivation area of the i-th crop in region r, E_r is the total cultivation area of region r, Ein is the national cultivation area of the i-th crop, and E_n is the total national cultivation area for all crops. Note that if LQ_{ir} is bigger than 1, then the region is said to be relatively specialized in the production of i-th crop. It is also noted that one should be careful in using a LQ measure because of its empirical limitation which is related to strong assumptions such as uniform consumption pattern across the nation, national self-sufficiency and the dependency on the level of aggregation. However, these problems turn out to be not critical in our study, because vegetable consumption pattern is not much different across the nation and the vegetables included in this study are mostly self-sufficient in Korea. In addition to that, there are no aggregation problems because LQ in our study is measured for each vegetable product.

2.3. Identifying the Relationship between Regional Concentration of Production and Supply Variations

The investigation of the effects of regional concentration of production on supply variations relies on a correlation coefficient approach where two relevant random variables are pure yield effect measure and LQ measure of spatial concentration of vegetable production. The identification of the relationship between these two random variables could be done in a more sophisticated way such as regression analysis, which would allow for the investigation of determinants of pure yield effect components in relation to regional concentration of production. Due to data limitations regarding potential factors affecting the pure yield effects (e.g., technological factors and/or weather factors),[4] this study focuses on simple statistical treatment on two random variables. Under the maintaining hypothesis that high yield effects in explaining supply variation are likely to be associated with high production concentration reflecting potential positive 2nd moment effects of yield associated with agglomeration, we investigate whether correlation coefficient between pure yield effect component and LQ measure of production concentration is positive and statistically significant or not. This would shed light on the identification of new aspect of production concentration, i.e., risk-increasing effects of production concentration.

3. Data

We investigate empirically supply variation of vegetables and its decomposition in relation to regional concentration of production using a dataset from Korea. The dataset includes supply, yield and cultivation area information of Chinese cabbage, highland Chinese cabbage, pepper, garlic, green onion, onion and radish, collected in a Farm Product Survey from the year of 2009 to the year of 2013 by the National Statistical Office. The sample size of this survey is about 8,000 sites that are systematically sampled from 931,000 farmland survey sites, representing Korean agricultural farmland and its production status.

Descriptive statistics on the regional variables (e.g., supply, yield and cultivation area information on Chinese cabbage, highland Chinese cabbage and selected seasoning vegetables including radish, green onion, onion, and garlic) used in our analysis are shown in Table 1 and 2. In terms of cultivation area, garlic is ranked first followed by radish and onion. The production of highland Chinese cabbage seems quite concentrated at Kangwon province being a major production region. Onion and garlic are also spatially specialized vegetables while the production of radish and green onion looks relatively dispersed across region.

First, we identify positive mean effects associated with agglomeration externalities, which are measured by correlation coefficient between yield and LQ, for the most of vegetable products under study (0.649 for garlic, 0.550 for green onion, 0.240 for highland Chinese cabbage, 0.227 for Chinese cabbage) with the exception of radish (=-.005). In terms of variation, the variance of cultivation area of radish and garlic is estimated to be high, while that of Chinese cabbage and highland Chinese cabbage is estimated to be relatively low. At a regional level, the variance of cultivation area for major production regions (e.g., Jeonnam for onion, Jeonnam and Kyungnam for garlic) is estimated to be much higher than that of other regions. And the variance of the yield of Chinese cabbage and onion is found to be relatively high and that of garlic and

〈Table 1〉 Descriptive statistics for cultivation area and yield

Products		Variable	Total	Kyungki	Gangwon	Chungbuk	Chungnam	Jeonbuk	Jeonnam	Kyungbuk	Kyungnam
Chinese cabbage	Cultivation Area (ha)	Mean	14,766.2	1,956.0	1,009.0	1,727.0	2,020.6	1,501.2	3,002.2	1,623.8	1,064.8
		Std. Dev.	1,589.1	167.6	160.9	277.6	267.2	197.4	571.7	148.9	199.0
		Min	13,408.0	1,831.0	800.0	1,401.0	1,763.0	1,265.0	2,353.0	1,458.0	839.0
		Max	17,326.0	2,228.0	1,186.0	2,075.0	2,401.0	1,805.0	3,605.0	1,821.0	1,382.0
	Yield (kg/10a)	Mean	10,104.4	9,997.6	8,782.2	8,161.4	10,032.2	10,662.6	11,484.4	9,678.2	10,574.0
		Std. Dev.	918.8	1,034.5	1,130.0	819.7	858.2	936.0	1,266.3	1,279.9	956.0
		Min	8,773.0	8,358.0	7,035.0	7,055.0	8,877.0	9,628.0	10,547.0	7,824.0	9,016.0
		Max	10,948.0	10,830.0	9,789.0	8,877.0	11,210.0	12,162.0	12,986.0	11,427.0	11,566.0
Highland Chinese cabbage	Cultivation Area (ha)	Mean	5,233.2	0.0	4,661.2	0.8	0.0	314.4	0.0	148.2	108.6
		Std. Dev.	396.1	0.0	366.2	1.8	0.0	122.7	0.0	74.4	26.7
		Min	4,691.0	0.0	4,153.0	0.0	0.0	195.0	0.0	88.0	74.0
		Max	5,553.0	0.0	5,099.0	4.0	0.0	506.0	0.0	278.0	139.0
	Yield (kg/10a)	Mean	3,399.2	0.0	3,333.0	811.4	0.0	3,929.2	0.0	3,865.8	4,178.6
		Std. Dev.	450.4	0.0	496.3	1,814.3	0.0	231.5	0.0	117.3	1,112.4
		Min	2,769.0	0.0	2,643.0	0.0	0.0	3,600.0	0.0	3,664.0	2,556.0
		Max	3,802.0	0.0	3,756.0	4,057.0	0.0	4,235.0	0.0	3,966.0	5,339.0
Radish	Cultivation Area (ha)	Mean	20,408.8	2,689.2	3,318.0	1,133.4	2,400.2	2,806.2	2,167.6	1,841.0	642.4
		Std. Dev.	3,517.3	871.3	435.2	231.9	499.1	570.9	277.4	255.8	114.5
		Min	16,090.0	2,034.0	2,970.0	813.0	1,988.0	2,227.0	2,024.0	1,503.0	514.0
		Max	23,780.0	4,100.0	4,036.0	1,408.0	3,228.0	3,684.0	2,663.0	2,115.0	762.0
	Yield (kg/10a)	Mean	5,408.2	5,415.4	3,293.4	4,539.6	5,577.2	7,348.4	6,732.2	4,111.6	5,960.8
		Std. Dev.	427.5	517.1	245.2	269.7	889.6	888.3	641.9	291.6	793.1
		Min	4,768.0	4,550.0	2,869.0	4,284.0	4,204.0	6,539.0	5,733.0	3,686.0	4,952.0
		Max	5,949.0	5,870.0	3,482.0	4,983.0	6,304.0	8,672.0	7,513.0	4,437.0	7,014.0
Green onion	Cultivation Area (ha)	Mean	16,837.6	2,845.2	789.6	705.6	1,941.4	989.6	5,424.2	1,224.8	618.0
		Std. Dev.	1,761.5	737.1	210.0	113.6	177.0	155.5	345.4	141.7	200.4

		Min	14,872.0	2,023.0	478.0	539.0	1,774.0	763.0	4,969.0	1,075.0
		Max	19,666.0	4,000.0	1,020.0	820.0	2,227.0	1,170.0	5,793.0	1,449.0
	Yield (kg/10a)	Mean	2,549.4	2,650.0	2,571.6	2,441.6	2,004.4	2,573.4	2,761.4	2,154.8
		Std. Dev.	117.3	147.8	212.1	171.9	101.9	113.5	299.6	48.2
		Min	2,391.0	2,399.0	2,317.0	2,183.0	1,945.0	2,498.0	2,370.0	2,073.0
		Max	2,661.0	2,786.0	2,855.0	2,616.0	2,183.0	2,765.0	3,053.0	2,195.0
Onion	Cultivation Area (ha)	Mean	20,920.8	79.2	35.0	83.8	456.4	1,264.6	10,982.2	2,440.6
		Std. Dev.	1,748.0	49.9	11.5	26.0	98.3	174.0	934.6	142.7
		Min	18,514.0	33.0	22.0	56.0	362.0	961.0	10,124.0	2,368.0
		Max	22,976.0	158.0	53.0	114.0	615.0	1,393.0	12,166.0	2,695.0
	Yield (kg/10a)	Mean	6,514.6	4,019.0	4,599.2	3,858.8	4,941.2	5,568.0	6,274.6	7,091.4
		Std. Dev.	611.3	1,187.7	1,197.9	214.8	1,239.1	469.4	755.0	596.6
		Min	5,703.0	2,778.0	2,892.0	3,509.0	3,936.0	5,064.0	5,441.0	6,433.0
		Max	7,412.0	5,405.0	6,064.0	4,053.0	6,313.0	6,198.0	7,395.0	7,880.0
Garlic	Cultivation Area (ha)	Mean	26,080.4	655.8	407.4	699.0	2,498.0	676.8	8,441.6	3,781.0
		Std. Dev.	2,881.7	102.7	35.9	66.2	349.9	60.6	852.3	633.1
		Min	22,414.0	549.0	364.0	623.0	2,072.0	581.0	7,484.0	3,019.0
		Max	29,352.0	767.0	449.0	792.0	2,910.0	733.0	9,168.0	4,495.0
	Yield (kg/10a)	Mean	1,280.0	799.6	817.6	706.8	1,183.6	992.6	1,168.0	1,355.8
		Std. Dev.	94.3	120.7	97.2	88.9	140.6	89.5	103.7	101.9
		Min	1,199.0	689.0	653.0	588.0	1,047.0	890.0	1,068.0	1,254.0
		Max	1,405.0	965.0	896.0	815.0	1,386.0	1,098.0	1,320.0	1,518.0

green onion is found to be low. However, unlike the variance of cultivation area, the variance of yield does not seem to be high in major production regions in particular for spatially specialized vegetables (e.g., onion and garlic). In terms of price variation reflected by supply variations, garlic shows the highest variance of price followed by green onion. However, radish and onion shows relatively low variance of price.

It is noted that pepper, which is one of the significant seasoning vegetables (e.g., an important ingredient for Kimchi), is excluded from our analysis. This is because as far as cultivation area is concerned, pepper has a unique feature, which is different from other seasoning vegetables: pepper is usually harvested many times during a production period for a given cultivation area. Up to the last harvest as a red pepper product, pepper tends to be harvested several times as a green pepper product. This makes cultivation area information inaccurate unless information on the number of harvest is available. Unfortunately, this kind of data for an aggregated level is often unavailable. Thus pepper is excluded from our analysis not because it is not an important seasoning vegetable but because data on cultivation area is not suitable for our analysis.

〈Table 2〉 Descriptive statistics for vegetable prices

Products	Mean	Std. Dev.	Min	Max
Chinese cabbage	505.2	249.8	252.0	814.0
highland Chines cabbage	784.4	232.5	442.0	1066.0
radish	538.0	164.9	319.0	784.0
green onion	1518.8	319.3	1141.0	1898.0
onion	827.4	216.4	663.0	1205.0
garlic	4718.2	1095.8	3017.0	5700.0

4. Results

The concentration ratio measured by a Herfindahl index for a set of selected vegetable products are 0.7982 for highland Chinese cabbage, 0.3354 for onion, 0.1792 for garlic, 0.1597 for green onion, 0.1236 for Chinese cabbage, and 0.1000 for radish, from the highest to the lowest. These concentration ratios being differentiated across selected vegetable products represent the degree of production concentration. If a Herfindahl index is close to 1, it means that production is very specialized in a specific region making this region as a major production area while a close to 0 Herfindahl index captures a very dispersed production system across region. The high Herfindahl index measured for highland Chinese cabbage is consistent with common belief that highland Chinese cabbage can only be produced in a major production region (e.g., Kangwon province) mainly due to weather factors suitable for producing highland Chinese cabbage. And the low Herfindahl index for radish and green onion are also consistent with the observation that these seasoning vegetables tend to be produced nationwide reflecting a dispersed production system.

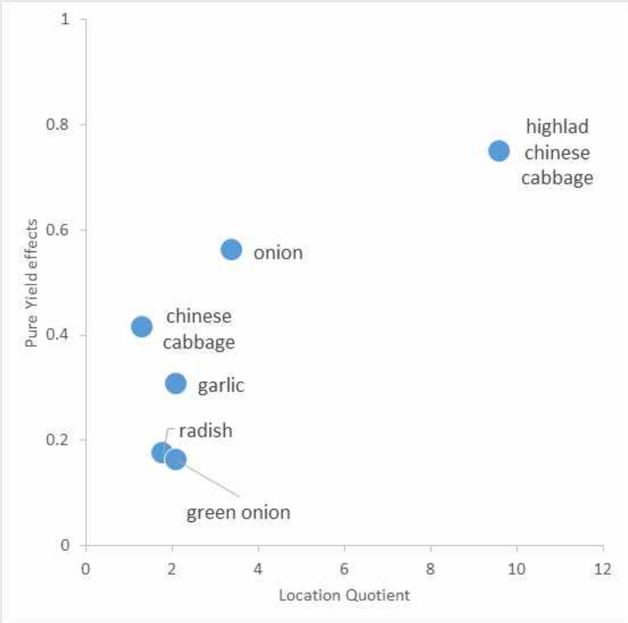
The degree of spatial concentration measured by LQ for a set of selected vegetable products for a major production region is consistent with the Herfindahl index. If LQ is greater than 1, it means that production is spatially concentrated in a specific region characterizing this region as a major production area while less than 1 LQ captures a very dispersed production system across region. LQ for highland Chinese cabbage is 9.6141, 3.4086 for onion, 2.1051 for garlic, 2.1020 for green onion, 1.7974 for radish, and 1.3156 for Chinese cabbage, from the highest to the lowest. These concentration ratios being differentiated across selected vegetable products represent the degree of production concentration varies across vegetable products.

The decomposition scheme described in equations (3)-(5) provides a basis for the investigation of the relationship between yield effects and the degree of production concentration for a set of selected vegetable products. As shown in Table 3, the decomposition results suggest that while supply variations (as measured by coefficient of variation of production) across seasoning vegetable products show a similar pattern ranging from 0.112 to 0.199 during the recent 5 years (2009-2013) with the exception of onion (CV = 0.090), pure yield effects measured by α are shown to be quite different across vegetable products. Pure yield effects of highland Chinese cabbage are found to be highest (α = 0.7482), implying that pure yield effects can explain 74.8% of total supply variations in the case of highland Chinese cabbage. However, in the case of green onion, they are estimated to be the lowest (α = 0.1621), implying that only 16.2% of total supply variations can be explained by pure yield effects. This suggests that pure cultivation area effects are found to be a major factor affecting supply variations in green onion. Pure yield effects of onion, Chinese cabbage, and garlic are found to be 0.5599, 0.4137 and 0.3063, respectively, highlighting moderate yield effects in explaining total supply variations.

〈Table 3〉 Spatial Concentration and Decomposition results (i.e., pure yield effects, pure cultivation effects and interaction effects in ratio)

Vegetable products	Total supply variation (CVS)	Pure yield effects (a)	Pure cultivation effects (b)	Interaction effects (g)	Herfindahl index	Location Quotient (LQ)
Chinese cabbage	0.184	0.4137	0.5795	0.0068	0.1236	1.3156
Highland Chinese cabbage	0.199	0.7482	0.2441	0.0077	0.7982	9.6141
Radish	0.170	0.1743	0.8287	-0.0031	0.1000	1.7974
Green onion	0.112	0.1621	0.8377	0.0002	0.1597	2.1020
Onion	0.090	0.5599	0.4440	-0.0038	0.3354	3.4086
Garlic	0.164	0.3063	0.6895	0.0042	0.1792	2.1051

The relationship between pure yield effects in ratio (measured by α) and the degree of production concentration is depicted in Figure 1. As is shown, for selected vegetable products, there tends to be a positive relationship between two variables. Next, a correlation coefficient approach is used to refine this relationship in a statistical sense. Table 4 shows the correlation coefficients measuring the relationship between pure yield effects and the degree of production concentration. These measures (0.8995 for pure yield effects in level and LQ, 0.8164 for pure yield effects in ratio and LQ) are found to be positive and statistically significant, indicating that the maintaining hypothesis of positive 2nd moment effects of supply variation in terms of yield effects associated with agglomeration diseconomies (i.e., pure yield effects being increasing with the degree of production concentration) is validated.[5] This implies that as production gets concentrated, the yield effects in explaining total supply variations tend to be more important. This finding might be associated with regional weather shocks and/or diseases affecting the yield of product within a major production region. When these shocks and/or diseases are limited in a spatial sense in terms of their effectiveness, a specialized production system tends to get full impacts while a dispersed system tends to find a way to get around these shocks.



〈Figure 1〉 The relationship between pure yield effects (in ratio) and Location Quotient

〈Table 4〉 Correlation coefficients between pure yield effects and Location Quotient

	Corr. coefficients	P-values
Level	0.8995	0.014
Ratio	0.8164	0.047

This finding can be utilized by policy makers for designing effective policy measures targeting to reduce supply variations. When product under consideration is associated with a specialized production system, potential policy measures for improving technology (e.g., a development of seed with increased resilience to weather and/or disease shocks) can be appropriate. On the other hand, under a dispersed production system, one can develop policy measures targeting to cultivation area adjustment (e.g., developing a better forecasting/outlook information for producers).

5. Concluding Remarks

Relying on a decomposition scheme developed in this paper for identifying factors affecting supply variations and yield and cultivation area data for a selected set of vegetables from a Farm Product Survey from the year of 2009 to the year of 2013 collected by the National Statistical Office, this article examines the relationship between a yield effect component in total supply variations and the degree of production concentration. We presented total supply variations and its decomposition results. The decomposition measures of total supply variations include pure yield effects, pure cultivation area effects and their interaction effects.

Our analysis uncovered several important findings. We found that while total supply variation across vegetable products demonstrate a similar pattern, its decomposition component, in particular pure yield effects show a quite different pattern across vegetable products. For example, pure yield effects of highland Chinese cabbage are found to be very big while those of green onion and radish are found to be relatively low. We also found that these varying pure yield effects are associated with the degree of production concentration in a positive way. We documented empirically the beyond mean effects of agglomeration diseconomies, i.e., positive 2^{nd} moment effects of yield in relation to the degree of production concentration.

This finding can provide useful information for policy makers in that they can develop differential policy measures across vegetable products in order to reduce supply variations. Our analysis suggests a need for future research in several areas. First, we focus only on a pure yield effect component and its relationship with spatial concentration of production. It would be useful to expand our analysis in such a way that the determinants of decomposition components including a cultivation area effect component can be fully investigated. Second, we focus mainly on supply side with the assumption of stable demand for a short run. Future study could be benefited by incorporating demand side analysis in a comprehensive way to fully utilize our decomposition approach in the investigation of price variations. Finally, it would be valuable to undergo similar analyses of other agricultural products to gain useful insights on supply variations and its decomposition in relation to production concentration.

Notes

1) The decomposition scheme based on a CV approach has an advantage over a well-known variance decomposition approach in that it can be used to compare decomposition results across agricultural products since it is a relative measure.
2) The existence of relationship between the size of cultivation area and yield is based on the economic theory called 'the economies of size.' There are many empirical studies that show the existence of the economies of size in an agricultural sector (e.g. Kim et al., 2016; Bang and Jun, 2017; Song, 2001).
3) There are also some variations of Herfindahl-type index that are commonly used in regional studies. One of the most popular Herfindahl-type spatial concentration index for industry *i* is defined as $HH_i = \Sigma R_i=1\ (x_{ir}-x_r)^2$, where x_{ir} is the share of i-th activity in each region r, x_r is the share of national i-th activity. This index captures the degree to which a particular economic activity's spatial distribution by the sum over all regions of the squared deviations of each region's share of national total. Hence, this is also used for the direct method of measuring the extent to which a given agricultural product is evenly distributed spatially across the country.
4) A future study could elaborate on this story by developing a comprehensive structural approach where determinant of pure yield effects and pure cultivation effects can be explicitly investigated.
5) The correlation coefficient between supply variation (CVs) and LQ is found to be positive at 0.3478, suggesting positive (but not statistically significant) 2^{nd} moment effects of total supply in terms of agglomeration economies. This means that as regional production gets spatially concentrated, the supply variation measured by CVs tends to be increased (with the statistical evidence being weak).

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※ **김관수(金寬秀)**는 University of Wisconsin-Madison 대학교에서 농업 및 응용경제학 박사학위를 취득하고, 현재 서울대학교 농경제사회학부 교수로 재직 중이다. 2000년대부터 농식품산업 분야의 리스크 관리와 국내외 식품산업 발전을 주제로 한 연구를 진행하여 국내 농식품 산업 발전에 기여했다. 주요 관심분야는 농식품산업의 위험관리, 농식품 관련 통계의 개선, 농식품산업의 발전 방안이 있다. 주요 논문으로는 "Specialization, Diversification and Productivity: A Panel Data Analysis of Rice Farms in Korea" 가 있다(kimk@snu.ac.kr).

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