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Factors Affecting the Labor Productivity of the Food Manufacturing Industry: The Case of South Korea

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Abstract:
The role and location of food manufacturers are crucial to regional economic sustainability and solving problems related to local employment. This study aims to create a foundation for future regional economic and alternative governmental policies by analyzing the factors that influence food manufacturing productivity in South Korea and reassessing their efficiency in the agricultural industry. This study uses a functional formula to select variables based on food manufacturer data and regional accomplishments. It then applies quantile regression analysis to measure the effects of labor productivity on food manufacturers at a regional level and prevent sample bias. The analysis results show that the impact of corporate elements is greater when the company is larger and permanent positions are more prevalent. Regarding regional characteristics, the horizontal link between industries, spatial agglomeration, and national government financing is influential, along with the local government financing policy. While little research has been conducted on the growth of Korean food manufacturers based on the unit of region, the significance of this study is that it focuses on various connections and agglomeration effects at the regional level and addresses the influence of regional characteristics. Based on the unit of region, this study identifies the factors that affect the labor productivity of food manufacturers while analyzing their effects. The scientific novelty of this paper lies in its analysis of the factors that influence food manufacturing productivity in South Korea and reassessment of their efficiency in the agricultural industry. This approach provides new insights into the growth of Korean food manufacturers based on the unit of region, given that the food manufacturing industry is closely related to the sustainability of the regional economy, the settlement of social issues, the protection of agriculture and farming areas, the fostering of small and medium-sized firms, and balanced regional development.

Keywords: food manufacturers, value-added productivity of labor, spatial agglomeration, horizontal link between industries, quantile regression.

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影响食品制造业劳动生产率的因素：以韩国为例

摘要：
食品制造商的作用和位置对于区域经济可持续性和解决与当地就业相关的问题至关重要。本研究旨在通过分析影响韩国食品制造业生产力的因素并重新评估其在农业产业中的效率，为未来的区域经济和替代政府政策奠定基础。本研究使用函数公式根据食品制造商数据和区域成就来选择变量。然后，它应用分位数回归分析来衡量劳动生产率在区域层面对食品制造商的影响，并防止样本偏差。分析结果表明，当公司规模越大、固定职位越普遍时，公司因素的影响就越大。对于区域特征，产业之间的横向联系、空间集聚和国家政府融资以及地方政府融资政策都有影响。虽然很少有人以区域为单位对韩国食品制造商的成长进行研究，但本研究的意义在于它关注区域层面的各种联系和集聚效应，并解决区域特征的影响。本研究以区域为单位，识别影响食品生产企业劳动生产率的因素，并对其进行效果分析。本文的科学创新点在于分析了影响韩国食品制造业生产率的因素，并重新评估了它们在农业产业中的效率。鉴于食品制造业与区域经济的可持续性、社会问题的解决、农业和耕作地区的保护密切相关，这种方法为以地区为单位的韩国食品制造商的增长提供了新的见解， 扶持中小企业, 地区均衡发展发展。

关键词：食品制造商，劳动增加值，空间集聚，产业横向联系，分位数回归。

1. Introduction

In the food manufacturing sector of South Korea, the employment inducement coefficient, measured by the number of people who become employed for one billion South Korean won in final demand for industrial goods and services, is 17.8 persons per billion won, which is the highest compared with those in manufacturing-related fields and higher than the mean of employment inducement coefficients in the entire industry (Statistics Korea, 2015). Moreover, due to the low price and income elasticity of demand in the food manufacturing industry, the industry accommodates small- and medium-sized businesses that are unlikely to implement a mass production system. Furthermore, in urban and rural complexes, the number of people working in the food manufacturing industry accounts for 18.5% and 8.1% in the county (Gun) and city (Si) regions, respectively. Based on agricultural and fishing regions, this proportion indicates that the number of people working in the food manufacturing industry is higher than those working in other industries, including the manufacturing industry (Statistics Korea, 2011).

From an industrial perspective, economies of scale are generally found in manufacturing firms. Because of the characteristics of the foods considered, the economy of scope can also be applied in the food manufacturing industry. In other words, the degree of food diversity and the amount of the food's added value increase through manufacturing and distribution, which is referred to as from land to mouth (Capps et al., 1988; Henderson & McNamara, 2000). Therefore, farmers, fishermen, manufacturers, distributors, and dealers establish a regional business supply chain in which they are connected to each other. Furthermore, while the South Korean central and local governments focus on vitalizing regions by promoting the influx of workers and corporate capital to overcome the economic depression that has gradually intensified since 2008, the Korean government incorporated food and fisheries into the Ministry of Agriculture and Forestry in 2008 and has since allocated the national budget to projects on food clusters in order to develop the food industry.

However, except for a few studies, for example, Choi & Kim (2021), little research has been conducted on the growth of Korean food manufacturers based on the unit of region, given that the food manufacturing industry is closely related to the sustainability of the regional economy, the settlement of social issues, the protection of agriculture and farming areas, the fostering of small and medium-sized firms, and balanced regional development. Thus, based on the unit of region, this study identifies the factors that affect the labor productivity of food manufacturers while analyzing their effects.

To this end, we applied quantile regression while conducting the analysis to prevent sample bias and measure the effects of labor productivity on food manufacturers based on the unit of region. We set the temporal range as a cross-section of 2015 and the spatial range as sum of 230 Si, Gun, and borough (Gu) regions. We further selected food and beverage manufacturing industries as the analytic targets. We conducted the analysis based on the data of economic census microdata, census of agriculture, forestry, and fisheries, a national wealth survey, a local finance integrated open system, census of the characteristics of establishments in South Korea, and statistical geographic information (Statistics Korea, 2015). We used statistical programs such as Arc-Gis 10.0 and STATA 13.1.

The research object of this paper is the food manufacturing industry in South Korea. The criteria for

selecting this research object are based on several factors. First, the role and location of food manufacturers are crucial to regional economic sustainability and solving problems related to local employment. Second, the food manufacturing industry accommodates small- and medium-sized businesses that are unlikely to implement a mass production system. Third, in urban and rural complexes, the number of people working in the food manufacturing industry accounts for a significant proportion of the population in both county (Gun) and city (Si) regions. Fourth, the food manufacturing industry is closely related to the sustainability of the regional economy, the settlement of social issues, the protection of agriculture and farming areas, the fostering of small and medium-sized firms, and balanced regional development. These factors make the food manufacturing industry in South Korea a relevant and important research object for this study. The main steps of the research process for this paper are summarized in Figure 1.

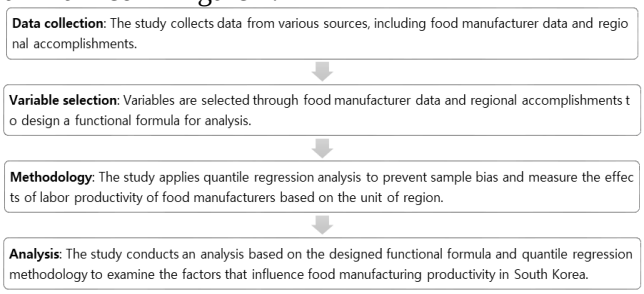

Figure 1. Flowchart of the research process of this study

2. Review of Theories and Literature

2.1. The Agglomeration Theory

The economies of agglomeration refer to the external economies or diseconomies generated when several economic entities gather to perform business activities, especially corporate production activities, in the same region. Marshall (Marshall, 1890) found that firms operating in similar industries gather in the same region because this process generates profits. The concentrations of certain and general industries, respectively, classify economies of agglomeration into internal and external effects. Hoover (1937) defined the effects of localization and urbanization economies, respectively. The localization economy is related to special geographical features that affect certain activities, whereas the urbanization economy is related to the concept of size, such as population and economic diversity (Viladecans-Marsal, 2004).

The benefits of agglomeration in the localization economy include a decrease in the cost of transport between closely located firms. A decrease in the cost of transport and an increase in knowledge diffusion are also possible observations, as suppliers, consumers, and labor markets are closely placed in the same region (Marshall 1920; Arrow, 1962; Romer, 1986). These effects are defined as Marshall-Arrow-Romer (MAR) externalities (Glaeser et al, 1992) Agglomeration benefits in the urbanization economy include an increase in productivity following an increase in the size of city based on various types of industrial structures. In addition, when firms belonging to different industries interact, various types of labor markets, an abundant amount of labor force, and an increase in knowledge diffusion based on the theory of the urbanization economy arise (Schere & Frederic, 1982; Jacob, 1969; Rosenberg, 1963). Thus, the growth of industries generally requires large-scale and diverse urban environments.

2.2. Supply Chain Theory

In the 1980s, the supply chain (SC) theory was developed to represent a comprehensive system that can manage the entire process of product delivery from suppliers to end consumers. In 1982, Oliver developed the term supply chain management (SCM). To increase the efficiency, SC theory focuses on forward integration between producers and suppliers throughout product delivery. Therefore, it differs from the value chain theory, which emphasizes backward integration based on the formation of values from the perspective of consumers. However, the global supply chain forum (GSCF) held in 1998 states that the main management processes for the delivery of products, services, and information are integrated from original suppliers to end consumers in order to create added value for customers and investors (Feller et al., 2006), indicating that the distinction between both theories has diminished.

Based on this concept, end consumers can also be included in SC theory. Moreover, SC theory refers to the combination of the upper and lower parts or the network of organizations related to various activities and processes performed to generate the forms and values of services and products that are ultimately delivered to consumers. In other words, the SC theory consists of various firms that belong to the upper (i.e., supply) and lower (i.e., distribution) processes and end consumers, as shown in Figure 2 (Mentzer, 2001).

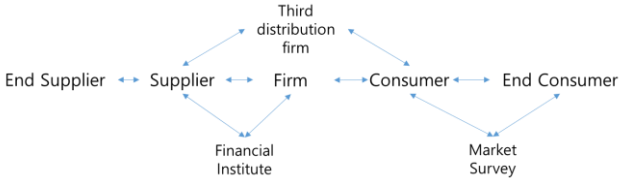

Figure 2. The ultimate supply chain

The performance of corporate activities according to the SC causes an increase in productivity (Cha & Kim, 2006; Armsead and Mapes 1993; Chen et al., 2000; Levi 2000).

2.3. A Review of Previous Research

Research on the food manufacturing industry is divided into two types: those that individually examine

clusters and related industries to analyze the performance of the industry and those that comprehensively examine the factors that affect the productivity of food manufacturers.

Previous studies have focused on clusters (Kim et al., 2009; Jeon, 2013; Jeongho Kim et al., 2004; Seongmin Kim, 2009; Jungwook Kim et al., 2012) and their impacts on food manufacturing-related industries based on food characteristics (Lee et al., 2001; Choi et al., 2007; Ahn, 2010; Sung et al., 2011). However, research on clusters either proposes policy directions for the establishment of food clusters or focuses on networking without considering agglomeration, which is a fundamental factor in clusters. Research on related businesses mostly focuses on reviving the agriculture sector, which is now experiencing downturn. Consequently, the findings of such studies are unlikely to be related to the food manufacturing industry.

Moreover, little study has been conducted to analyze the productivity and efficiency of food manufacturers while considering the vertical coordination in industries. Regarding the latter research, Schmit and Hall (2013) conducted an ordered logistic regression analysis by establishing a ratio of increase in the number of firms in the manufacturing industry as a dependent variable and applying firm- and region-level variables into an explanatory function to examine how they influence food manufacturers' productivity. Based on the analytic results, they found that an increase in the number of employees, which was a corporate element, and the frequency of purchasing agricultural products positively influenced the productivity of food manufacturers. However, the population density variable has a negative effect.

Further, by assuming a general production function, Jeon and Park (2011) examined the effects of agglomeration in the food industry. In their study, the target regions were classified into capital and southeast areas. Regarding the explanatory variables, the localization economy, urbanization economy, and market linkage effects were subdivided into degrees of specialization and competition, diversity and population, and market access. Consequently, they conducted an analysis to examine the effects of these variables. Based on the analytic results, they found that the variables of localization economy and market linkage effects positively influenced the productivity of food manufacturers and that the variables of urbanization economy had negative effects. Moreover, they indicated that when a food cluster is established, a competitive relationship between firms operating in the same industry might positively influence labor productivity per person.

However, previous research on the productivity of food manufacturers was conducted based on the entire manufacturing industry, while the food manufacturing industry was considered to be part of the middle category. Furthermore, only the effects of economies of agglomeration are analyzed. This study thus attempts to discover the elements that affect the labor productivity of food manufacturers while examining their effects based on the unit of region.

3. Model and Variables

3.1. The Analytic Model

Regarding the production function, we assumed a flexible production function that applies the general form of the Cobb-Douglas function, as shown below.

$$Y = A(\cdot)\cdot F(K,L) \quad (1)$$

Under the assumption of constant returns to scale, we divided the added value by the number of workers and used the log of both sides to transform the aforementioned function into the following polynomial expression:

$$\ln(Y_{lt}/L_{lt}) = \ln A_t + \boldsymbol{\alpha}\ln(K_{lt}/L_{lt}) \quad (2)$$

Total factor productivity (A_t), which is an index that represents the efficiency of the entire economy, is a function of policy, structure, and technology (Radelet et al., 1997). In other words, it is written as A_t=A (governmental policy, geographical and industrial structure, technological enhancement). Thus, we derived the final equation in the form of a linear equation:

$$\ln(Y_{it}/L_{it}) = \ln A_{it}(\text{policy, structure, technology}) + \alpha\ln(K_{it}/L_{it}) \quad (3)$$

Furthermore, we converted the equation for analyzing factors that affect the labor productivity of food manufacturers into a quantile regression equation, as shown below:

$$Y_i^{\tau} = \beta_{\tau,1} + \beta_{\tau,2}X_{2i} + \cdots + \beta_{\tau,k}X_{ki} + \epsilon_i^{\tau} \quad (4)$$

In the process of estimating significant coefficients based on consistency and asymptotic distribution under quantile regression, treatment effects occur when the estimated value of x is converted into x_0 and x_0 +1 (Koenker & Hallock, 2001).

3.2. Selecting Variables

3.2.1. Dependent Variables

Efficiency based on labor can be easily identified, making labor the most important production element among the production input elements. Consequently, this element is frequently used by firms. Instead of outputs, we selected the added value as the amount of production because information on the intermediate input was not obtained. In this regard, value-added labor productivity calculated by Statistics Korea (2015) was established as the dependent variable.

3.2.2. Control Variables

Control variables include the mean wage of food manufacturers and the degree of capital intensity per employee calculated from the production function

(Ministry of Economy and Finance, 2015). These variables were based on data for the number of workers (2015, Statistics Korea) and the amount of capital stock. Regarding the number of workers, regardless of wages, we included the number of employees in the food manufacturing industry to consider the practical status of labor (2015, Statistics Korea). The amount of depreciation was established as the amount of capital stock, given that fixed capital consumption is required in the product production. This analogy is consistent with the concept of depreciation from an economic perspective (OECD, 2007). The mark is expectedly positive, as an increase in the capital input per person increases the number of input elements. Wages directly affect production and corporate profits. Manufacturing firms might find regions with low labor costs because these regions experience low management costs (McNamara, 1988). However, higher wages should increase productivity because the mean wage represents human capital, including the degree of work proficiency and the quality of labor.

3.2.3. Explanatory Variables

Explanatory variables refer to factors that affect value-added labor productivity. The elements of policy, structure, and technological enhancement were classified into corporate and regional characteristic. We included the variables of corporate scale and status of employees in the corporate category and the variables of food-related industries, agglomeration, fiscal policies for the agriculture, forestry, and fisheries industries, and potential purchasing power in the regional characteristics category (Table 1).

Table 1. Explanatory variables that affect the productivity of food manufacturers

Items		Variables	Descriptions	Predicted signs
Dependent variables		Labor productivity (ln_PerRev)	Added value labor productivity per person	+
Control variables		Capital (ln_KperL)	Degree of capital intensity per employee	+
		Mean wage (SAL.PerL)	Mean wage in food manufacturing industries	+
Corporate elements	Structure	The existence of large firms (Above 300)	A food manufacturing industry with 300 or more employees Otherwise 0 (Reference group)	+
		The status of workers (TEMP.PerFULL)	The ratio of daily and temporary to regular employees	+,-
Regional characteristics	Vertical industrial connection	The status of industrial-educational cooperation related to local food (foodUniv)	The departments of food engineering in universities Otherwise 0 (Reference group)	+
		The connection of agriculture, forestry and fisheries industries (ln_Farmers)	The number of workers who are 15 years old or above and mainly work in the fields of agriculture, forestry, and fisheries	-
		Connection between the wholesale and retail industries (R_500 DISTRI.W)	The ratio of workers who belong to food-related firms that have more than 50 employees in the wholesale and retail fields (%)	+
		Connection with the distribution industry (LN_DRIVE)	The number of food-related distribution firms (H491-494,H50,51,52)	+
	Agglomeration	Spatial agglomeration (AGGRE_FOODM)	Potential cluster region: 1 Related regions: 2 Specialized regions: 3 Unrelated regions: 4 (reference group)	Potential (++) Related (+) Specialized(+)
	Market potential	Purchasing power (gravities)	An interaction with a city with a population of 500,000 or more	-
	Financial policies	Fiscal expenses related to agriculture, forestry, and fisheries (FISCALEXP)	The amount of fiscal expenses related to agriculture, forestry, and fisheries based on regions per food manufacturer	+

Economies of scale: The scale or size of an industry that affects productivity, profits, an increase in the number of employees, innovation outcomes, and the selection of location is a variable for the localization economy (Hanerson, 1997; Feser, 2005; Kambhampati, 2007). Economies of scale are considered facilitators of efficient production. The existence of a large firm with 300 or more employees was established as a variable representing economy of scale in the form of a dummy variable. It is generally expected that the value based on the experimental group compared to the reference group will be positive (+).

The types of employment: Firms make their organizations flexible when levels of competition and uncertainty increase. Following the change in the economic system after a foreign exchange crisis, large firms increased their temporary employment. Consequently, temporary employment policies were also implemented. Temporary employment is classified into subcontractors, part-time workers, and temporary workers. Previous research on the relationship between temporary employment and productivity has yielded different results on this issue. On the one hand, temporary employment positively influences cost reduction, productivity (Frayne, 2000), the introduction or accumulation of new knowledge (Matusik, 1998),

and innovation (Storey, 2002). On the other hand, another study stated that temporary employment negatively influences innovation (Michie & Sheehan, 2003). Moreover, temporary employment increased the potential cost related to work proficiency and organizational harmony and negatively influenced productivity and profits in the long term. However, this may temporarily reduce labor costs (Lee, 2008). In this study, the ratio of regular employees to temporary employees was set as a variable for the types of employment. Both the increase in the number of temporary employees and the decrease in the number of regular employees were indicators of underemployment in firms.

Regional characteristics: Vertical industrial connection: In modern society, organizations are not self-sufficient. In particular, firms rely on vertical cooperation with external entities based on input and supply to achieve their corporate goals (Tolossa, 2013). This phenomenon is called SCM in terms of organizational management methods. It facilitates the efficient management and operation of assets, products, information, and cash flow in the SC. Generally, SCM includes the management of supply and demand, such as the purchase and storage of raw materials and their distribution to consumers. Firms use supply chain structures in regions as a means of SCM. First, food manufacturers are located in the raw material market to minimize preprocessing costs. If food manufacturers produce products that are large in volume, greatly moisturized, easy to rot, or impossible to transport, they are often located in regions that incur low transport costs (Capps et al., 1988; Connor 1987). Therefore, it is estimated that the efficiency of food manufacturers will increase because of the externalities derived in regions in which many agricultural products are generated or those that have several distribution-related workers. According to the classification of value chains developed by Porter (Porter, 1985), the number of people aged 15 years or older who mainly worked in the agriculture, forestry, and fisheries industries was selected as the main activity variable, reflecting a backward linkage industry based on food manufacturers. Regarding the wholesale and retail industries regarded as the forward linkage industries, the number of employees in large food firms was established as a variable because it was related to the scale of relevant industries in the relevant regions. Moreover, the number of food-related firms in the distribution industry was selected as the supporting activity variable. The data of the universities that operated the Department of Food Engineering and performed industrial and educational cooperation in regions for research activities were set as dummy variables. An increase in the scale of related primary industries and wholesale and retail industries has led to an increase in the production efficiency of food manufacturers (Schmit, 2013). Consequently, in the estimation, the value related to the number of workers in the agriculture, forestry, and fisheries industries will be negative. Moreover, the value related to the number of workers in wholesale and retail firms with 50 or more employees will be positive. Further, the value related to the number of distribution firms, which is a supporting activity variable, is expected to be positive. The value related to the region in which industrial and educational cooperation is performed is expected to be positive, unlike that related to the region that does not perform industrial and educational cooperation (Wakelin, 2001).

Economies of agglomeration: Variables for the localization economy generally refer to the degree of concentration of firms that belong to the same industry in a certain region. In this study, LQ and Getis-Ord G* were set as nominal variables and used as dummy variables. A level of significance of 0.05 was applied to a hot spot that exhibited many employees in the food manufacturing industry in a region. Consequently, regions with a level of significance greater than 0.05 were classified into cluster regions (Lee and Shim 2011). Regarding the status of specialization, an LQ value of 3 was set as a standard (Malmberg & Maskell, 2002) to classify regions into potential clusters: specialized, unrelated, and related regions, which serve as nominal variables (Table 2, Figure 3).

Table 2. Analysis of the agglomeration of food manufacturers according to classified items

Items		**LQ**	
		3 or more	**Below 3**
Gi*	1.96 or more	A (Potential) cluster	A related region
	Below 1.96	A specialized region	An unrelated region

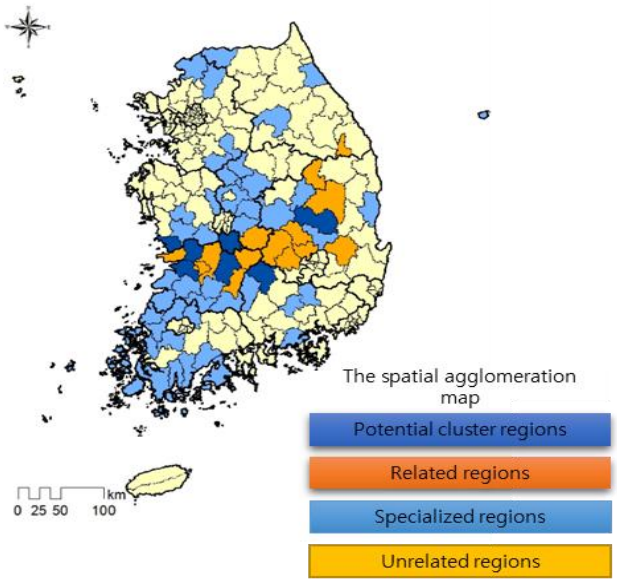

Figure 3. The spatial agglomeration map (Statistics Korea, 2015)

A related region with an LQ value of 3 or more and a Getis-Ord Z of 1.96 or more was selected as the

reference group. Under the assumption of MAR externalities, the dummy variables of potential cluster and specialized regions should have significantly positive values. Under the assumption of spatial autocorrelation, the dummy value of potential cluster regions should be higher than that of specialized regions. Thus, the dummy variable of potential cluster regions is expected to have the highest value, followed by those of specialized regions, related regions, and the reference group.

Market potential: Markets represent the size of purchasing power, which affects productivity. The main variables related to the market include the size and density of the market and the distance to the market (Crone, 2000; Blair and Premus, 1987). Firms are located in markets to incur minimum distribution costs while distributing their final products (Connor & Shiek, 1977). The product market is also considered the ultimate demand (Hanerson, 2000). As proximity to the product market is generally related to the entire production cost of firms and the distribution of their final products, the importance of this factor increases for firms that produce goods based on demand and location (Capps et al., 1998). Market potentials can effectively ensure demand related to the supply of manufactured products, which are compared with the products of competing firms. In other words, a larger scale in the potential market is advantageous in terms of lower transport costs and increased competitiveness. In this regard, the product market is expected to positively influence the productivity of food manufacturers. We used a gravity model (Duarte et al., 2019) based on spatial interaction by applying the elements of market size and distance to the market as variables. Regarding the gravity model, the degree of interaction between regions is generally assumed to be proportional to the size of their economies and inversely proportional to their physical distance. To express the basic gravity model equation, we set the size of the economy in a region as P, the distance between regions as d, and both regions as i and j. We applied this model equation to identify the degree of interaction between the regions.

$$G_{rautiy} = \frac{grdp_i * grdp_j}{d_{ij}^2} \quad (5)$$

The number of variables affecting productivity will change based on a change in the effects of the potential product market and the distance to the market.

Fiscal expenses of local governments: Local governments establish general financial goals such as the efficient distribution of resources, the redistribution of income, and economic growth and stability through expenditure-related activities (Lynch, 2004; Bartik, 1991). In particular, economic development expenditure, which is a part of local finance, is used as a policy through loans, investments, or subsidies to private goods. It is also used for investments in major strategic industries in regions through local government expenditure based on Keynesian economic theory. As local government expenditure for investment significantly affects the amount of regional aggregate production, research on efficient methods of resource distribution based on local government expenditure has been actively conducted (Lee, 2013). Thirteen fields and 51 sectors were established for the classification of local government expenditures by function. Additionally, the entire amount of expenditure in the fields of agriculture, forestry, maritime affairs, and fisheries totaled 10,158 billion won, accounting for 7% of the entire expenditure (the local finance system and the financial abstract of the local government). This amount of expenditure exceeds 10% of the sales of agricultural products and food manufacturers. In this study, we divided the expenditure for the development of the industries of agriculture, forestry, maritime affairs, and fisheries, which is one of the factors that influence economic development, based on the classification of local government expenditure by function, by the number of food manufacturers and established it as a variable. The expected mark is positive.

4. Analytical Results

4.1. An Analysis of Fundamental Statistics

We converted the non-normal distribution of variables to natural logarithms for normalization and established data based on the normalized distribution (Table 3). The 20 regions in which the labor productivity of food manufacturers was high included four legal districts in metropolitan cities and provinces, Daedeok-gu, four Si regions such as Cheongju-si, and 12 city Si regions in an urban and rural complex form such as Pyeongtaek-si. The input of capital per employee, which was a control variable, was the greatest in Hongcheon-gun, Gangwon-do due to the effects of location based on a process industry. Data from Dong-gu and Ulsan-si were unavailable; therefore, they were omitted from the values counted and thus considered missing values.

The mean wage was the highest in Jung-gu, Incheon Metropolitan City and the lowest in Nam-gu, Daegu Metropolitan City. Regarding corporate elements, large food manufacturers with 300 or more employees were located in 30 Si, Gun, and Gu regions, including Cheongwon-gun. The ratio of temporary employees was two persons per 100 regular employees in Jeungpyeong-gun, thus being the lowest. Ulreung-gun exhibited the highest ratio of temporary employees, followed by Goheung-gun and Wando-gun. Regarding the vertical industrial connection variable, the universities that operated the Department of Food Engineering were located in 22 regions, including Sangju-si and Gyeongsangbuk-do. Following Sangju-si and Gyeongju-si, Jeju-si exhibited the highest number of people aged 15 years or older and mainly worked in the industries of agriculture, forestry, and fisheries.

Seocho-gu and Gangnam-gu, Seoul Metropolitan City Jung-gu, Seoul Metropolitan City, had the highest ratio of wholesale and retail firms with 50 or more employees. Gangseo-gu, Seoul Metropolitan City, had the highest number of people working in the distribution industry, followed by Nowon-gu, Seoul Metropolitan City, and Changwon-si, Gyeongsangnam-do. Regarding the index of purchasing power based on a short distance and a large scale of the product market, Jongro-gu, Seoul Metropolitan City, exhibited the greatest purchasing power, followed by Dongnae-gu, Busan Metropolitan City, and Cheongwon-gun, Chungcheongbuk-do. In terms of fiscal expenses related to agriculture, forestry, and fisheries, Ongjin-gun exhibited the greatest number of such expenses, followed by Taean-gun and Hwacheon-gun.

Table 3. Fundamental statistics

Variables	Observation	Mean	Standard deviations	Minimum	Maximum
Labor productivity	230	3.70	0.69	1.67	6.02
Capital per employee	229	0.76	1.49	-5.00	3.72
Mean wage	230	2.53	0.72	0.11	4.03
The existence of large firms	230	0.13	0.34	0	1
The status of employees	230	0.48	0.71	0.02	7.32
The status of local food-related industrial-educational cooperation	230	0.10	0.29	0	1
The number of people working in agriculture, forestry, and fisheries-related industries	230	8.10	1.87	0.69	10.24
The number of people working in wholesale and retail related industries	230	9.02	8.54	0	40.87
The number of people working in the industry of distribution	230	6.66	1.28	3.47	8.80
Potential cluster regions	230	0.03	0.17	0	1
Related regions	230	0.06	0.24	0	1
Specialized regions	230	0.20	0.40	0	1
Purchasing power	230	5.71	26.48	0.00	365.04
Fiscal expenses related to agriculture, forestry, and fisheries	230	220.76	233.96	0	1982.33

4.2. Results of Model Estimation

In an integrated model of firms and regional variables, we considered significant coefficient marks based on the values of generalized least squares (GLS), which were used to calibrate the heteroskedasticity of polynomial regression equations, consistent with those based on quantile regression equations (Table 4). The effects of the degree of capital intensity per employee, which was a control variable calculated based on a production function formula, were significantly greater as the respective region belonged to a higher quantile range. Moreover, labor productivity increased as the amount of the food manufacturers' mean wage, which was a proxy variable used to examine labor quality, increased.

Regarding corporate elements, productivity was considered greater in regions including food manufacturing industries with 300 or more employees than in regions without such manufacturing industries. However, productivity in regions with food manufacturers that had a higher ratio of temporary employees than regular employees was negatively affected.

The marks of the status of industrial and educational cooperation related to local food and the number of distribution firms, which were the supporting activity variables of the vertical industrial connection variable, were positive. However, regarding the number of people working in agriculture, forestry, and fisheries-related industries and the ratio of employees in wholesale and retail firms with 50 or more employees, which were the main activity variables, a large scale of the vertical industry positively but insignificantly affected the productivity of food manufacturers. In terms of economies of agglomeration, productivity was greater in regions that had specialized food manufacturing industries than in regions that did not have a specialized food manufacturing industry. Productivity was greater in the cluster regions than in the non-cluster regions. Furthermore, the difference was insignificant. Regarding the index of potential purchasing power, we considered the mark of the coefficient value based on a gravitation index negative. The mark of fiscal expenses related to agriculture, forestry and fisheries, which represented the performance of local finance, was considered positive.

Regarding the mean coefficient values calculated based on GLS, the order of explanatory variables that significantly affected the labor productivity of food manufacturers is indicated below. The mean wage of food manufacturers had the greatest average effect of 0.53%(+), followed by the potential purchasing power index, financial policies of local governments, the degree of capital intensity per employee, the status of employees, and connection with the distribution industry, which had average effects of 0.1%(-), 0.1%, 0.08%, 0.08%(-), and 0.0008%(+), respectively. The effects of dummy variables were greater by 0.19% in regions where industrial and educational cooperation was performed than in regions where cooperation was

not performed. The effects were also greater by 0.13% in regions that had a specialized food manufacturing industry than in regions that did not have a specialized food manufacturing industry.

Table 4. Estimation results of the quantile regression model robust (P-value in parentheses; *** p < 0.01, ** p < 0.05, * p < 0.1)

Models	**OLS**	**A low-quantile range**		**A medium quantile range**	**High quantile range**	
	GLS	**q1**	**q25**	**q5**	**q75**	**q9**
Variables	**Labor productivity**	**Labor productivity**	**Labor productivity**	**Labor productivity**	**Labor productivity**	**Labor productivity**
Capital	0.078** (0.024)	0.046 (0.531)	0.077** (0.035)	0.033 (0.447)	0.103* (0.069)	0.197** (0.013)
Mean wage	0.529*** (0.000)	0.499*** (0.002)	0.477*** (0.000)	0.557*** (0.000)	0.512*** (0.000)	0.357** (0.044)
The existence of large firms	0.366*** (0.001)	0.111 (0.512)	0.273*** (0.001)	0.377*** (0.000)	0.534*** (0.000)	0.604*** (0.001)
The status of employees	-0.084*** (0.000)	-0.067 (0.414)	-0.091** (0.027)	-0.095* (0.056)	-0.133** (0.037)	-0.126 (0.157)
The status of industrial-educational cooperation related to local food	0.187* (0.062)	0.108 (0.541)	0.156* (0.080)	0.135 (0.206)	0.312** (0.024)	0.164 (0.394)
Connection of agriculture, forestry, and fisheries	-0.026 (0.318)	-0.015 (0.680)	-0.066*** (0.001)	-0.046** (0.042)	-0.026 (0.364)	-0.008 (0.837)
Connection between the wholesale and retail industries	0.006 (0.265)	0.002 (0.804)	0.001 (0.776)	0.001 (0.842)	0.003 (0.681)	0.016 (0.101)
Connection with the distribution industry	0.081** (0.029)	0.145* (0.055)	0.100*** (0.009)	0.102** (0.025)	0.067 (0.251)	0.059 (0.470)
Potential cluster regions	0.031 (0.780)	0.385 (0.198)	0.247* (0.099)	0.059 (0.744)	-0.146 (0.527)	-0.096 (0.766)
Related regions	0.051 (0.620)	0.121 (0.575)	0.128 (0.235)	0.103 (0.428)	-0.152 (0.363)	-0.188 (0.421)
Specialized regions	0.127* (0.083)	0.378** (0.012)	0.303*** (0.000)	0.119 (0.186)	0.070 (0.543)	0.034 (0.836)
Purchasing power	-0.001*** (0.003)	-0.000 (0.898)	-0.001 (0.261)	-0.001 (0.260)	-0.002 (0.180)	-0.003 (0.140)
Fiscal expenses related to agriculture, forestry, and fisheries	0.001*** (0.001)	0.000 (0.426)	0.000*** (0.010)	0.001*** (0.001)	0.001* (0.076)	0.000 (0.405)
Constant terms	1.750*** (0.000)	0.961 (0.154)	1.859*** (0.000)	1.702*** (0.000)	2.183*** (0.000)	2.577*** (0.000)
Observation values	229	229	229	229	229	229
R2	0673					
Pseudo R2		0.437	0.466	0.497	0.507	0.522

The results of the calculation based on quantile regression classified the quantile ranges of 10% and 25% under low range, the quantile range of 50% under medium range, and those of 75% and 90% under high range. In low-quantile regions, variables such as the degree of capital intensity per employee and the mean wage of food manufacturers and corporate elements such as the existence of large firms and the ratio of temporary employees significantly affected the labor productivity of food manufacturers. Regarding the variables of vertical industrial connection, the connection of the agriculture, forestry, and fisheries industries, the status of industrial and educational cooperation, and the connection with the distribution industry significantly affected the labor productivity of food manufacturers. The effects of agglomeration were greatest in specialized regions, followed by potential clusters and unrelated regions. Variables such as the financial policies of local governments and the scale of interaction with a city with a population of 500,000 or more did not affect the labor productivity of food manufacturers. On the other hand, corporate elements such as the existence of large firms and the ratio of temporary employees significantly affected the labor productivity of food manufacturers in regions that belonged to the quantile ranges of 75% and 90% and exhibited high productivity of food manufacturers. Regarding the vertical industrial connection variables, only the status of industrial and educational cooperation had significant effects. None of the variables related to agglomeration had any significant effects. The fiscal expenses variable for local governments also had significant effects in high-quantile regions.

5. Discussion and Conclusions

5.1. Main Findings of This Study

This study examines the factors that influence food manufacturing productivity in South Korea and reassesses their efficiency in the agricultural industry. The study applies quantile regression analysis to prevent sample bias and measure the effects of labor

productivity on food manufacturers based on the unit of region. This study identifies variables that affect the value-added labor productivity of food manufacturers based on sum of 230 Si, Gun, and Gu regions by considering the importance of food manufacturers in different regions as well as the characteristics of industries and food. Productivity is measured as the value-added productivity of labor. The two classifications measure the productivity of labor: corporate elements and regional characteristics. With the corporate elements variables of company size and employee status, the regional characteristic variables are the horizontal link between industries, the formation of agglomerations, national and local financing policies, and accessibility, while the control variables are the amount of investment put in by the owner and the average income of food manufacturers. The study further estimates the effects of these variables. Owing to the difference between the nonparametric probability density function and the canonical map of the productivity of labor, we conducted an analysis based on the quantile regression method while considering that on average, the regression coefficient values based on GLS can be overestimated or underestimated following the difference in structural regional characteristics. The analysis results show that the impact of corporate elements is greater when the company is larger and permanent positions are more prevalent. Regarding regional characteristics, the horizontal link between industries, spatial agglomeration, and national government financing is influential, along with the local government financing policy.

5.2. Comparison with Other Previous Studies

Previous research has concentrated on clusters (Kim et al., 2009; Jeon, 2013; Kim et al., 2004; Kim, 2009; Kim et al., 2012) and their effects on food manufacturing-related industries (Lee et al., 2001; Choi et al., 2007; Ahn, 2010; Sung et al., 2011). However, few studies (with the exception of Schmit and Hall, 2013; Jeon and Park, 2011) have examined the productivity and efficiency of food manufacturers while taking vertical coordination industries into account. The impact of the size of the manufacturing industry, local government policies, and the location of firms on productivity and employment has been studied both theoretically and empirically. However, except a few studies, such as Choi and Kim's (2021), little empirical research has been conducted on the growth of Korean food manufacturers based on the unit of region, although the food manufacturing industry is closely related to the sustainability of the regional economy, the resolution of social issues, the protection of agriculture and farming areas, the fostering of small and medium-sized firms, and balanced regional development. Thus, based on the unit of region, this study sought to identify and analyze the elements that influence the labor productivity of food manufacturers. We carried out a cross-sectional analysis to examine the effects of variables that affected the value-added labor productivity of food manufacturers in sum of 230 Si, Gun, and Gu regions as of 2015. The distribution of the data from the 2015 economic census can help analyze these variables from diverse perspectives. This study's findings align with those of other studies that have explored the impact of food manufacturing on regional economic development and employment. The distinction of this study is that it identifies the factors affecting the labor productivity of food manufacturers based on the unit of region.

5.3. Implications of the Study

We have derived the following implications from this study: First, the input of tangible fixed assets was higher in highly productive regions than in low-quantile regions. Moreover, the mean wage of employees has a comparatively low influence on productivity. This result indicates that the quality of labor affects labor productivity more than tangible fixed assets in low-productivity regions because the food manufacturing industry is inclined to be labor-intensive and includes small- and medium-sized firms.

Second, regarding the factors of firms located in a region, the existence of large firms with more than 300 employees significantly influenced the regions that exhibited high labor productivity. Evidently, the ratio of temporary employees decreased labor productivity, indicating that more efficient operations are performed in regions with large-scale food manufacturers. This result confirms the validity of statements (Michie et al., 2003; Lee, 2008) that a decrease in the employment of regular employees and an increase in the employment of temporary employees can reduce labor costs in the food manufacturing industry. Furthermore, such employment decisions increase potential costs by reducing work proficiency and organizational harmony, thereby negatively affecting the efficiency.

Third, the vertical industrial connection variable is likely related to low-quantile regions. However, the status of industrial-educational cooperation related to local food, which is a supporting activity variable, affects labor productivity regardless of quantile ranges. Regarding the connection variable with the agricultural industry, which is a main activity variable, an increase in the number of employees per unit in the low-quantile regions prompted a decrease in the size of production and had negative effects on the production efficiency of food manufacturers. Therefore, the scale of production in agricultural, forestry, and fishery-related industries should be expanded to increase the productivity of food manufacturers in the Si and Gun areas in farming, mountain, and fishing villages, which are in the low-quantile range. Regarding the supporting activity

variable, several distribution firms indicated that the reduction of time and cost related to distribution, such as the selection and methods of distributors, led to efficiency. We considered the implications based on regional variables in the high-quantile regions to be insignificant because these regions include large-scale food manufacturers that perform various activities for production, sales and distribution.

Fourth, we confirmed that food manufacturers also had agglomeration benefits in low-productive regions. Based on regions that belonged to the low-quantile range, the level of productivity was higher in specialized regions than in clustered and unrelated regions. This result indicates that the regions in which labor-intensive small- and medium-sized firms gathered exhibited a higher level of productivity. In contrast, the features of special and cluster regions did not influence the increase in the efficiency of food manufacturers in high-quantile regions. This result confirms the validity of MAR effects related to spatial agglomeration. In this regard, industrial geographic locations based on specialized and cluster regions can increase productivity.

Fifth, financial policies established by local governments on agricultural, forestry, and fishery-related industries and the scale of interaction with a city with a population of 500,000 or more positively and significantly affected Si, Gun, and Gu regions on average. However, these variables influenced neither low- nor high-quantitative regions. Based on this result, we inferred that financial policies significantly affect average regions or regions that are in the medium quantile range. Moreover, regarding the index of the potential purchasing power and interaction with a city with a market population of 500,000 or more consumers, distance between regions affected the productivity of food manufacturers more than the difference in economic power between regions.

Sixth, the productivity of food manufacturers in low-quantile regions can be enhanced through the application of advantages based on the economies of agglomeration, such as policies on industrial connections, including industrial and educational cooperation with universities, the development of the distribution industry, an increase in the scale of agriculture, and the specialization of food manufacturers. Furthermore, efforts should be made to persuade food manufacturers to locate in the areas closest to the market for their products. In high-quantile regions, local governments should persuade food manufacturers to participate in industrial and educational cooperation and simultaneously establish financial support policies for food manufacturers. In other words, the role of local governments in the productivity of food manufacturers is less significant in high- than in low-quantile regions.

5.4. Strengths and Limitations of the Study

The strengths of this paper lie in its analysis of the factors that influence food manufacturing productivity in South Korea and reassessment of their efficiency in the agricultural industry. The significance of this study is that it focuses on various connections and agglomeration effects at the regional level and addresses the influence of regional characteristics. This approach provides new insights into the growth of Korean food manufacturers based on the unit of region, given that the food manufacturing industry is closely related to the sustainability of the regional economy, the settlement of social issues, the protection of agriculture and farming areas, the fostering of small and medium-sized firms, and balanced regional development.

However, limitations of the application of the results obtained in this study include the fact that it is based on data from the 2015 economic census and therefore may not accurately reflect the current state of the food manufacturing industry. Additionally, the study was conducted in the Si, Gun, and Gu regions, which may not be representative of other regions or countries. The study also focused solely on food manufacturers and may not be applicable to other industries. Furthermore, the study used the quantile regression method instead of the more commonly used generalized least squares method, which may affect the accuracy of the results. The study also considered only certain variables, such as company size, employee status, and regional characteristics, and may have missed other important factors that affect labor productivity in the food manufacturing industry. Moreover, the study's implications may not be applicable to all food manufacturers in all regions. The recommendations provided are based on the specific characteristics of the Si, Gun, and Gu regions and may not be suitable for other regions. Finally, the study did not consider the potential impact of external factors such as changes in government policies, market demand, or technological advancements on the productivity of food manufacturers.

5.5. Recommendation for Future Research

The directions for further research are as follows: First, future research should consider factors such as industrial base, gross regional product, population, and fiscal size as variables to analyze the productivity of food manufacturing industries. Thus, it is necessary to closely analyze the causal relationship between the size, employment, employment type, and location conditions of the manufacturing industry and all factors affecting the local economy. Second, it would enhance the policy and empirical implications of the study if the structural characteristics and share of the food manufacturing industry in the local economy were analyzed, as well as various types of enterprises such as social enterprises and agricultural farmer cooperatives.

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Authors' Contributions

Conceptualization, Y.-S.R.; methodology, Y.-S.R.; validation, Y.-S.R.; writing-original draft preparation, Y.-S.R.; writing-review, and editing, K.-S.K. and K.-H.L.; funding acquisition, K.-H.L.

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