Regional Revitalization through the Expansion of Smart Agriculture

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Abstract: This study investigates the impact of regional innovation initiatives on economic development in South Korea. Through a comprehensive analysis, the study demonstrates a compelling relationship between regional innovation efforts and positive economic outcomes. Key findings reveal that regional innovation activities led to significant improvements in the region's economic prowess, as evidenced by increased GRDP, investment levels, and average monthly wages. Research and development (R&D) expenditure and local government spending were identified as key drivers of economic revitalization, further contributing to enhanced employment rates in most regions. The study concludes that regional innovation plays a critical role in boosting the overall competitiveness of a region. By fostering economic growth, generating employment opportunities, and attracting investment, regional innovation initiatives pave the way for sustainable local development. This paper is highlighting the positive impact of regional innovation on economic development in South Korea.

Keywords: Regional Growth, Smart Agriculture, GRDP, R&D.

1. INTRODUCTION

While it is acknowledged that the progress in agriculture has been slower compared to other industries, agriculture remains an essential sector closely tied to our sustenance, requiring continuous attention and investment. Many advanced countries, including the United States and EU member states, have long recognized the significance of agriculture. They have consistently invested in its development, leading to the growth of agriculture as a large-scale industry. This growth signifies not only the achievement of food self-sufficiency in these countries but also the transformation of agriculture into a significant industry generating high added value through exports.

Reflecting global trends and addressing the challenges in South Korea's agriculture sector while ensuring its sustainable growth is now a critical juncture. The development of agriculture is intricately tied to regional progress. To transform South Korea's agriculture into a high-value industry, the introduction of smart farming is imperative. Smart farming entails leveraging data and artificial intelligence (AI) across all stages of the agricultural value chain, including production, processing, distribution, and consumption, to drive agricultural innovation (Byun, 2022).

In this context, a smart farm refers to a farm equipped with Internet of Things (IoT), big data, AI, and robotics technologies, primarily applied in facilities like greenhouses, glasshouses, livestock barns, etc., allowing remote and automated control of crop and livestock environments to maintain optimal conditions (Byun, 2022). While smart farms primarily focus on the production aspects of agricultural products through environmental control, smart farming is a more comprehensive concept encompassing not only production but also the entire agricultural structure, including distribution and consumption.

The innovative growth of agriculture also signifies regional development. South Korea exhibits stark regional disparities, with large cities continuously growing through advanced industries, while other regions focus on labor-intensive industries like manufacturing, construction, or agriculture. This divergence is challenging to bridge. Historically, the nation's economic development policies centered around an imbalanced growth strategy, fostering

industrial complexes in non-metropolitan areas. However, the core of innovation, such as technology startups and innovative activities, predominantly occurs in the metropolitan area, contributing to weakened regional industrial competitiveness and deepening regional disparities (Hong et al., 2019).

Recently, efforts have been made to strengthen regional industrial capabilities by establishing industry clusters on a regional basis, aiming to promote the growth of related industries and regional development. Nevertheless, these initiatives have not yet translated into innovative regional growth.

Regional innovation and growth are crucial elements for achieving balanced development in South Korea. When growth is achieved through regional innovation, the influx of highly skilled personnel from the capital region to non-metropolitan areas has a positive impact on regional economic vitality. This effect contributes to enhancing regional competitiveness and improving the quality of life for local residents. Research conducted by Lim (2021) has shown that innovation cities built for national balanced development benefit from the influx of young population from the capital region, positively affecting regional economic activity.

Moreover, when regional economies become more vibrant, they can serve as drivers of regional growth. A higher regional economic level can lead to increased investments in research and development (R&D) or greater allocation of budgets for innovation-related initiatives, thus aiding in the development of regional innovation capabilities. Regional innovation capabilities can be summarized as the ability to utilize local resources for the purpose of sustainable regional growth (Kim & Kim, 2022). The flow of regional economic revitalization leading to expanded investment, additional job creation, and enhanced regional competitiveness underscores the importance of preserving regional economies. From the perspective of establishing hubs for balanced national development and new growth industries, regional innovation is indispensable.

In relatively underdeveloped regions, economic activities often revolve around agriculture, based on rural communities that produce and distribute crops to generate income. Given the direct impact of agriculture on our lives, it is crucial to pursue regional innovation by improving traditional agriculture in these areas rather than simply reducing its size through the introduction of new growth industries. By leveraging the expertise and knowledge of the existing workforce in agriculture and incorporating information and communication technology (ICT), it is possible to create a new paradigm for the agricultural value chain. This approach not only preserves the unique characteristics of the region but also brings about economic revitalization through regional growth.

2. PURPOSE OF THE PAPER

This study emphasizes the necessity of adopting smart farming practices. Smart agriculture is an essential component for improving the resilience of our rural areas as we face the era of Agriculture 4.0. Currently, smart farming in South Korea is primarily focused on the first generation, characterized by relatively low technological sophistication and small-scale implementations. When examining the adoption rates of smart farming across generations in South Korea, as of 2020, first-generation smart farms accounted for 84.2%, second-generation farms represented 15.8%, while third-generation adoption remained limited (Byun, 2022).

By actively promoting the adoption of smart farming, establishing third-generation technology becomes more feasible. This advancement, driven by data-driven stable growth environments, minimizes the risks associated with historical agricultural fluctuations. It enhances the efficiency and competitiveness of agricultural operations, exerting a substantial influence on regional development. Additionally, the introduction of smart farming improves agricultural efficiency, reducing input costs and labor requirements. It also facilitates the enhancement of distribution structures through data analysis.

Analyzing market trends and consumer demands for agricultural products through smart farming can positively impact the price and quality competitiveness of agricultural products. This can lead to new market opportunities, including overseas exports, contributing to the establishment of regional global networks and growth. Smart farming can also serve as a foundation for young individuals in non-metropolitan areas to engage in active economic activities. As related industries thrive, regions can become hubs for young entrepreneurs, helping to address youth unemployment issues and stimulate regional economic vitality by attracting exceptional talents to the area.

This study aims to emphasize the importance of smart farming and formulate strategies for regional development through the expansion of smart agriculture. It will investigate the reasons behind the necessity of smart farming, the

impact of smart farming on regional development, and the direction for achieving regional innovation. The goal is to encourage data sharing among farmers, establish standards for agricultural data, and enable systematic management of data, which is an essential element in constructing the agricultural value chain. Additionally, this study seeks to foster expertise, enhance collaboration with other industry experts, and elevate technological standards. Beyond policy considerations, the aim is to facilitate the full integration of smart farming in practical terms, enabling it to play a proactive role in regional innovation.

This research will conduct empirical analyses related to smart farming and economic assessments of the need for its expansion. The primary areas of empirical analysis will include facility distribution and diffusion, data collection and utilization, technological levels and research and development (R&D), as well as perception and education. In the facility distribution and diffusion segment, the analysis will encompass trends in facility adoption within specific agricultural sectors such as greenhouse horticulture and livestock farming. This will be broken down by operation scale, generational trends, specific crop or livestock adoption, and age groups of farm operators.

For data collection and utilization, the study will examine the current state of ICT data collection and utilization in smart farming, the establishment of regulatory frameworks, and the status of data platforms. In the technological levels and R&D sector, the analysis will focus on the technological standards in South Korea, the allocation of R&D funding, and the achievements of smart farm research centers.

The perception and education segment will explore the awareness and education levels of producers and consumers regarding smart farming, workforce development, and the accomplishments of Smart Farm Innovation Valleys. In addition to these facets, the study will employ diverse methods, including surveys of producers and consumers, and big data analysis, to comprehensively evaluate the outcomes and shortcomings of smart farming development projects and policies. To ensure an objective assessment, consultations will be held with relevant agencies and organizations such as the Rural Development Administration, and expert opinions will be sought. International cases will also be compared and analyzed to derive insights.

Based on these findings, the study aims to identify the factors through which smart farming influences regional development and to understand its correlation with regional economies. This research seeks to explore how smart farming can substantively impact regional innovation.

This study distinguishes itself by going beyond the analysis of the effects of smart farming and the justification of its necessity. It explores the positive impact of smart agriculture on regional economies and derives the role of smart farming in regional innovation. Furthermore, it employs a variety of research methods, including economic analysis, big data analysis of related industries, and surveys, to enhance the credibility of the research findings. By examining the relationship between smart farming and regional development, this research aims to identify the need for smart farming in fostering regional innovation and draw practical insights.

3. LITERATURE REVIEW

Huh (2014) argued that regional innovation capabilities have an impact on regional economic revitalization. To investigate the relationship between regional innovation capabilities and regional economic revitalization, variables such as research and development (R&D) expenditure, skilled technical personnel, trade volume, venture enterprises, and instances of technological innovation were considered as indicators of regional innovation capabilities. As smart farming continues to grow, R&D expenditure, investments, and the number of venture enterprises are expected to increase. Moreover, the influx of skilled technical personnel and sustained technological innovation through research will further enhance the multifaceted impact of smart farming on regional innovation capabilities.

Additionally, Lee (2020) asserted that regions with high technological diversity in related industries differ in terms of regional innovation capabilities from those with low technological diversity. This study demonstrated that technological diversity has an impact on regional innovation capabilities. Hong et al. (2019) analyzed the national economic ripple effects of smart farms and derived that smart farms have a significant correlation with specific industry sectors. In essence, smart agriculture influences the growth of related industries through its associations with these sectors, and this correlation signifies a meaningful enhancement of regional innovation capabilities. It is therefore worthwhile to thoroughly examine the development of regional innovation capabilities through smart agriculture and its subsequent ripple effects leading to regional economic revitalization from the perspective of regional innovation.

Regional innovation capabilities are utilized to describe the competence, potential, and conditions within the regional innovation system (Schiuma & Lerro, 2008; Yoon & Choi, 2022). This concept encompasses various factors, including regional networks, financial capacity, learning capacity, culture, relationships among stakeholders, and learning processes, and it differs based on geographical characteristics and policies within a region (Lundvall, 1998; Morgan & Neuwelaer, 1999; Asheim & Gertler, 2005; Yoon & Kim, 2017; Yoon & Choi, 2022). In essence, regional innovation capabilities can be regarded as tangible and intangible assets that operate as innovation elements differing regionally and play an essential role in the success of regional innovation and the enhancement of regional competitiveness.

If regional innovation capabilities are considered as a means to achieve regional innovation, then regional innovation is closely intertwined with the concept of a regional innovation system. In contrast to the national innovation system, which often has a large analytical scope and may overlook regional specificities, the notion of a regional innovation system has emerged. A regional innovation system can be defined as a network assembly that leverages regional infrastructure to generate knowledge and innovation. It encompasses a complex of actors and institutions involved in innovation-related activities (Cooke, 2007; Yam et al., 2011; Yoon & Choi, 2022). Kim & Kim. (2022) explain that the regional innovation system encompasses all the characteristics of an innovation system and the theoretical development process of a national innovation system, distinguishing it as a unit specific to the region.

4. STATUS OF SMART AGRICULTURE

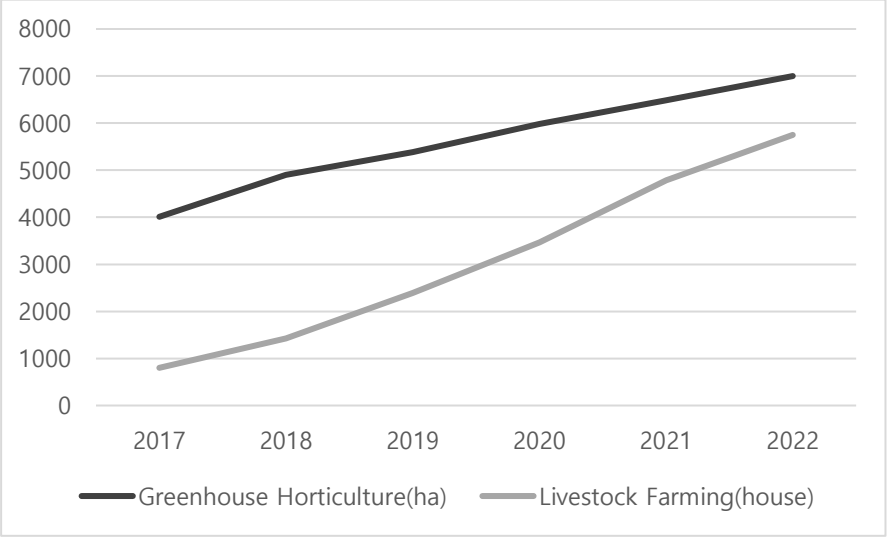

Fig 1. The current status of smart farm adoption by sector.

As of 2020, the distribution of smart farm and smart barn adoption by generation is as follows. The basic 1st generation models, which rely on fundamental IT technology, accounted for over 80% of the adoption in both smart farms and smart barns. The more advanced 2nd generation models had significantly lower adoption rates, with 15.8% in smart farms and 14.6% in smart barns compared to the 1st generation. The adoption of 3rd generation models, aiming for complete unmanned automation, was non-existent. To promote a more active spread of smart agriculture, it appears essential to increase the adoption rates of 2nd and 3rd generation models.

Table 1. Generation-wise Adoption Percentage of Smart Agriculture (2020)

Generation	Smart Farm	Smart Barn
1st	84.2%	85.4%
2nd	15.8%	14.6%
3rd	0%	0%

The Ministry of Agriculture, Food and Rural Affairs is actively implementing policies to promote smart agriculture. First, it is nurturing young farmers and conducting various education programs through the Smart Farm Innovation Valley and Smart Farm Youth Startup Incubation Centers. To support the development of smart agriculture-related

technologies, it is executing R&D projects totaling over 300 billion KRW by 2027. Additionally, to facilitate the widespread adoption of smart farms in Korea, initiatives are underway to reduce the financial burden on farmers. Furthermore, efforts are being made to enhance the competitiveness of domestic smart agriculture by promoting the export of Korean-style smart farms.

5. RESULTS

In terms of innovation outcomes, we examined the number of patent applications. Kim et al. (2018) utilized the number of patent applications per capita as a metric to measure regional innovation performance. Since innovation activities often lead to the introduction of new technologies, there is a higher likelihood of an increased number of patent applications as innovation activities become more active. Therefore, it was deemed appropriate to use the number of patent applications as a measure of innovation outcomes.

Table 2. Regional patent application counts

Classfication	Patent Application Counts		
	2011	2021	Rate
Seoul	43,132	54,042	25.29%
Busan	4,132	6,504	57.41%
Daegu	3,568	5,037	41.17%
Incheon	6,139	7,095	15.57%
Gwangjoo	2,093	3,549	69.57%
Daejeon	10,112	11,374	12.48%
Ulsan	2,722	2,209	-18.85%
Sejong	-	922	-
Gyeonggi	40,109	57,830	44.18%
Gangwon	1,638	2,898	76.92%
Chungbuk	2,574	4,353	69.11%
Chungnam	4,923	7,274	47.76%
Jeonbuk	3,051	4,354	42.71%
Jeonnam	1,942	4,050	108.55%
Gyeongbuk	7,008	6,733	-3.92%
Gyeongnam	4,415	6,964	57.73%
Jeju	461	1,046	126.90%

According to the table above, it is evident that not only in the metropolitan area but also in non-metropolitan regions, the overall trend has shown an increase in patent applications. Except for Ulsan and Gyeongbuk, most regions have seen a significant increase in patent applications. In cities such as Busan, Gwangju, Gangwon, Chungbuk, Jeonnam, Gyeongnam, and Jeju, the number of patent applications in 2021 has increased by over 50% compared to 2011. Among them, Jeju, which was classified as having a weaker capacity for innovative growth and had the lowest ranking in the Comprehensive Innovation Capacity Index, showed a remarkable increase of 126.9%, while Jeonnam increased by 108.55%, and Gangwon by 76.92%. This indicates that innovation and its outcomes have been ongoing and prevalent not only in regions with high innovation capacity but also in regions with lower capacity.

In his study, Kim (2020) analyzed the causal relationship between innovation activities and regional economic growth, and for measuring the economic growth of each region, he utilized the Gross Regional Domestic Product (GRDP)

size of each region. GRDP serves as an indicator that can provide an overall view of the economic scale of each region. Therefore, this study examined the regional economic situation based on GRDP as a reference point.

Table 3. Regional GRDP

Classfication	GRDP(unit: million won)		
	2011	2021	Rate
Seoul	343,756,313	432,406,018	25.79%
Busan	73,792,908	87,906,722	19.13%
Daegu	45,657,599	56,026,338	22.71%
Incheon	70,536,942	89,984,023	27.57%
Gwangjoo	31,011,787	41,118,247	32.59%
Daejeon	34,446,444	42,368,245	23.00%
Ulsan	71,517,190	69,621,279	-2.65%
Sejong	-	12,489,323	-
Gyeonggi	313,748,238	496,672,331	58.30%
Gangwon	36,296,644	46,476,220	28.05%
Chungbuk	46,066,868	70,139,551	52.26%
Chungnam	98,515,870	118,002,148	19.78%
Jeonbuk	43,285,951	50,398,818	16.43%
Jeonnam	66,697,766	77,027,126	15.49%
Gyeongbuk	94,466,406	104,960,491	11.11%
Gyeongnam	101,258,402	105,347,557	4.04%
Jeju	13,231,976	18,175,224	37.36%

According to the table above, it can be observed that the Gross Regional Domestic Product (GRDP) has generally increased. Notably, Gwangju, Gyeonggi, Chungbuk, and Jeju exhibited growth rates exceeding 30%. However, the growth rate in Gyeongnam was around 4%, showing no significant increase, while Ulsan demonstrated a declining trend. It is noteworthy that Gwangju, Gyeonggi, and Chungbuk, which occupy the top and middle ranks in the comprehensive index of innovation capacity, saw a substantial increase in GRDP. Conversely, Jeju, located in the lower rank, also displayed a significant growth rate. Although most regions experienced an increase in GRDP, and Ulsan exhibited high innovation base capacity, it is challenging to determine an absolute correlation between GRDP and regional innovation, as GRDP is influenced by various factors.

From a networking perspective, we considered the income from educational and research collaborations with industrial-academic cooperation organizations. As regional innovation becomes more active, the activities of joint research institutions like industrial-academic cooperation organizations are expected to increase. This signifies the establishment of networks among various institutions

Table 4. Educational and Research Income of Industrial-Academic Cooperation Organizations (Based on Local Governments)

Classification	Project Numbers	Project Amount (m won)

		2015	2021	Rate	2015	2021	Rate
Total	Sum	5,956	20,624	246.27%	228,203	337,018	47.68%
	Research	4,795	18,765	291.35%	173,953	246,979	41.98%
	Edu.	1,161	1,859	60.12%	54,250	90,039	65.97%
University	Sum	5,289	20,090	279.84%	195,799	296,107	51.23%
	Research	4,512	18,603	312.30%	163,337	240,559	47.28%
	Edu.	777	1,487	91.38%	32,461	55,549	71.13%
College	Sum	667	534	-19.94%	32,404	40,911	26.25%
	Research	283	162	-42.76%	10,615	6,420	-39.52%
	Edu.	384	372	-3.13%	21,788	34,491	58.30%

Most of the research on regional innovation has used variables representing manpower and capital, such as regional research and development (R&D) expenditure and R&D personnel. An increase in research personnel signifies the growth of the foundational workforce for regional innovation, while an increase in R&D expenditure represents the growth of capital in each region, which is a factor influencing regional innovation.

Table 5. Regional R&D Expenditure and Research Personnel by Region

Classfication	R&D			Research Presonnel		
	2012	2021	Rate	2012	2021	Rate
Seoul	99,167.2	162,043.4	63.40%	247,413	361,186	45.99%
Busan	10,306.0	17,627.4	71.04%	42,083	42,609	1.25%
Daegu	8,394.3	14,876.4	77.22%	23,473	35,896	52.92%
Incheon	21,318.7	32,269.9	51.37%	36,834	53,104	44.17%
Gwangjoo	6,727.9	11,089.0	64.82%	18,674	24,509	31.25%
Daejeon	55,709.5	94,428.0	69.50%	67,862	91,908	35.43%
Ulsan	7,214.4	6,533.9	-9.43%	13,911	18,298	31.54%
Sejong	251,818.2	519,571.3	106.33%	318,924	477,624	49.76%
Gyeonggi	3,513.9	6,859.0	95.20%	15,747	21,426	36.06%
Gangwon	9,548.2	21,306.6	123.15%	28,513	38,205	33.99%
Chungbuk	25,428.1	36,329.6	42.87%	38,047	46,142	21.28%
Chungnam	7,968.8	14,111.6	77.09%	21,014	28,187	34.13%
Jeonbuk	5,639.9	8,142.6	44.37%	10,827	15,190	40.30%
Jeonnam	21,366.6	27,750.8	29.88%	38,783	47,289	21.93%
Gyeongbuk	19,170.7	34,080.4	77.77%	37,820	56,835	50.28%
Gyeongnam	1,208.8	2,433.1	101.28%	4,400	6,362	44.59%
Jeju	-	11,899.6	-	-	11,890	-

6. CONCLUSION

The study's comprehensive analysis demonstrates a compelling relationship between regional innovation initiatives and a range of economic metrics. Throughout the duration of regional innovation endeavors, substantial

enhancements were observed in the region's economic prowess, increased levels of investment, and improved employment rates. These economic advancements can be attributed to the surge in research and development (R&D) expenditure as well as heightened local government spending, which, in turn, fostered a more favorable environment for employment opportunities. Consequently, these findings underscore the considerable and positive impact of regional innovation activities on the overall enhancement of regional competitiveness, thus emphasizing the critical role of innovation in local development.

The fact that GRDP has increased confirms the positive impact of regional innovation activities on regional economic activation. Furthermore, it was confirmed that research and development (R&D) expenditure levels significantly increased in all regions except for Ulsan. Kim (2020) conducted an analysis of the causal relationship between innovation activities and regional economic growth. According to the research results, long-term economic growth in a region is followed by an increase in R&D investment, indicating a causal relationship between regional economic growth and R&D investment. Choi & Kim (2015) examined the effects of regional economic variables on regional employment growth. The results showed that an increase in regional gross domestic product (GRDP) and local government spending leads to long-term growth in regional employment. Looking at the average monthly wages in the table below, wages in most regions showed a significant growth rate of around 30-40%. This indicates that through regional innovation activities, an improvement in employment levels has been achieved. Additionally, the employment rate increased in most regions except for Seoul, Ulsan, Gyeongbuk, and Gyeongnam. Considering that the employment rate depends on various factors, including the overall economic situation, it is evident that regional innovation activities have had a positive impact, although some regions experienced declines in employment rates.

Table 6. Monthly Average Wages and Employment Rates by Region

Classfication	Monthly Wage			Employment Rate		
	2011	2021	Rate	2011	2021	Rate
Seoul	2,921,496	3,904,436	33.65%	60.0	59.2	-1.33%
Busan	2,356,022	3,288,414	39.57%	54.5	56.2	3.12%
Daegu	2,165,156	3,094,138	42.91%	56.8	58,2	2.46%
Incheon	2,410,840	3,309,353	37.27%	60.7	60.9	0.99%
Gwangjoo	2,226,364	3,141,221	41.09%	56.6	57.7	2.83%
Daejeon	2,487,288	3,401,031	36.74%	56.9	62.6	7.03%
Ulsan	2,822,173	3,515,389	24.56%	59.8	61.1	-3.51%
Sejong	-	3,530,820	-	-	61.4	-
Gyeonggi	2,467,899	3,611,344	46.33%	59.3	63.3	3.04%
Gangwon	2,242,956	3,166,772	41.19%	56.2	63.0	9.25%
Chungbuk	2,299,646	3,313,149	44.07%	59.5	61.2	6.39%
Chungnam	2,488,080	3,564,920	43.28%	61.0	64.6	3.28%
Jeonbuk	2,307,304	3,082,279	33.59%	57.6	61.0	6.25%
Jeonnam	2,557,058	3,352,080	31.09%	62.3	60.7	3.69%
Gyeongbuk	2,439,738	3,452,111	41.50%	61.9	67.4	-1.45%
Gyeongnam	2,436,641	3,399,502	39.52%	60.7		0.00%
Jeju	2,033,316	2,906,566	42.95%	66.0		2.12%

In summary, it has been confirmed that during the period of regional innovation, the region's economic power, investment, and employment levels have improved. Regional economic revitalization is driven by the increase in research and development (R&D) expenses and local government spending. The growth in regional economic revitalization and local government spending leads to an increase in employment levels. Through this process, it can be concluded that regional innovation activities contribute to enhancing the overall competitiveness of the region.

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