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Impact of the Robotics Industry in the Local Governments - Focusing on Regional Productivity and Employment Competitiveness -

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Abstract: When the population outflow from local governments in Korea is intensifying and the aging population and job shortages are increasing, it is significant to examine the impact of the robotics industry on the local economy. Therefore, this study was conducted to analyze empirically the impact of the robotics industry on local communities from the perspective of local jobs and productivity. For the analysis, the panel data was constructed based on the current status data of regional robot companies from 2010 to 2017 published by the Ministry of Trade, Industry, and Energy, and empirical analysis was attempted through panel regression analysis. This Data was a secondary data analysis on the robotics companies, production, and human resources in metropolitan local governments in Korea. The results show that the ratio of the regional robotics industry harms regional employment competitiveness, despite it has a positive impact on regional productivity. In terms of regional competitiveness, regional robotics company production value and regional robotics company workforce have a positive effect on regional competitiveness, while the regional robotics industry ratio and the number of regional robotics companies have a negative effect. These results imply the following. First, the robotics industry certainly results in a reduction in the number of jobs in local employment. However, the robotics industry has a role in increasing the productivity of other industries. This paradoxical result has implications for developing the robotics industry in Korea. To secure the sustainable competitiveness of the country and local communities despite the shrinking number of working people due to the low birthrate and aging population in Korea, it is imperative to address these issues by developing the robotics industry and utilizing of robots. Second, while fostering small and medium-sized enterprises is important in fostering the robotics industry, it is also necessary to expand the competitiveness of Korea's robotics giants, which means that fostering a concentrated industry through SMEs and large enterprises could have a positive policy effect. The findings of this study could be utilized in implementing policies that could foster the positive impact of robotics industry in the country.

Keywords: Employment Competitiveness, Productivity, Regional Competitiveness, Robotics Industry

1. Introduction

The robotics industry, being a convergence of various advanced technologies with diverse

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functionalities and a wide range of applications, has a significant industrial impact[1][2]. In Korea, the government enacted the "Act to Promote the Development and Dissemination of Intelligent Robots" in 2008 and continues to make efforts towards the development of the robotics industry, with a budget of 1.2 trillion won to be invested from 2020 to 2035[3]. Notably, not only the government but also major Korean companies view robots as core components and are expanding their investments in this field. For instance, Hyundai Motor Group acquired Boston Dynamics, a global robotics company, for about 1 trillion won, and LG established a robotics business development strategy in 2017, continuing to expand the robotics market for home, commercial, and industrial applications.

In line with this trend, local governments are also formulating strategies to foster the robotics industry and implement policies to support policies to support local robotics companies to promote the industry. Most policymakers and researchers concur on the necessity and bright future of the robotics industry. Nevertheless, there is disagreement on whether its growth will enhance the competitiveness of local governments.

Researchers with a negative perspective argue that the expansion of the robotics industry leads to increased productivity in other sectors, resulting in the loss of many standardized jobs and the creation of only a few higher-paying jobs. This negative perspective has a detrimental impact on national productivity and competitiveness, as it widens the wage gap[4]. This issue is particularly pronounced in manufacturing-oriented countries like Korea. In such countries, skilled workers tend to concentrate in metropolitan areas, leading to a constant decline in the population of local governments. Moreover, the industrial structure of local areas often centers around low-wage small and medium-sized manufacturing industries, further reducing local job opportunities.

On the other hand, the positive perspective argues that the rapid transformation of industries has predominantly resulted in the creation of more jobs. While many jobs could be lost as old structured industries shrink, the emergence of new demands and consumption patterns results in the creation of more jobs[4][5]. If we look at the experience of past industrial revolutions or major changes in industry, we could see that employment actually continued to grow[6][7]. Similarly, Korea has adapted to industry fluctuations, creating new jobs and bolstering industrial competitiveness.

While the robotics field is actively engaged in this discussion, there remains a lack of research on this issue at the regional level. Many studies have focused on specific robotics sectors or the job impacts [4][7], and some studies have been conducted at the economic level[8]. Therefore, this study aims to fill the gap by examining the impact of the robotics industry on regional competitiveness, considering factors such as productivity, jobs, and the local economy simultaneously. Consequently, it becomes essential to discuss regional policies for the robotics industry.

Meanwhile, Korea's aging population crisis and the growing concerns about future population decline and job shortages, it will reach nearly every aspect of South Korean society, including the economy and national security. Rising social welfare costs must be met even as state revenues decline, and South Korean industry has to be revamped to foster more resilient high-tech supply chains. In the midst of this, researching the relationship between the robot industry and national competitiveness is meaningful. Robots are not only expected to address the stagnation of the national economy due to aging and population decline, but they are also anticipated to have a significant ripple effect on new industries utilizing robotic technologies.

Therefore, the research question of this study is 'What are the key factors influencing the improvement of competitiveness in the regional level through Robotics industry?' It will assess the impact of the robotics industry on local employment, productivity, and the overall local economy. Findings of the study are important in (1) offering feedback on promoting the local robotics industry; and (2) enhancing suggested directions direction for strengthening local competitiveness.

2. Theoretical Background

2.1 Concept and Scope of Robotics Industry

The robotics industry creates high-added value by converging and combining various technologies, leading to emergence of new business areas such as product design, application software, content production, and various services. This industry is gaining attention as a new growth engine, as it continues to converge and diffuse with the widespread adoption of artificial intelligence and Internet of Things technologies[2][9].

Defining the scope of the robotics industry is challenging due to its combination with various technologies. However, the International Federation of Robotics (IFR) has provided a classification and concept for robots, defining the robotics market as the robotics industry through an annual global robotics industry status survey. The IFR categorizes the robotics industry into two main segments: industrial robots and service robots, with service robots further divided into professional divided into professional service robots and personal service robots[3]. The classification is based on the intended use of the robots.

The concept and scope of robots are defined in ISO 8372:2012 According to this standard, an industrial robot is described as a multipurpose manipulator that can be automatically controlled, reprogrammed (able to change its behavior or auxiliary functions through programming without physical alterations), and programmed in three or more axes (linear or rotary motion directions). These robots can be installed in specific locations or used for mobile applications in industrial automation. The category includes linear robots (including orthogonal and gantry robots), SCARA robots, articulated robots, parallel/delta robots, and cylindrical coordinate robots[10].

A service is designed to perform useful tasks for humans or equipment, except for industrial automation. Personal service robots refer to those that serve non-commercial purposes for individuals, such as automatic wheelchairs and personal mobility assistants. On the other hand, professional service robots are used for business tasks and are typically operated by humans with appropriate training. Examples of professional service robots include public space cleaning robots, office and hospital delivery robots, firefighting robots, rehabilitation robots, and surgical robots[10].

In Korea, the IFR international classification primarily focused on the manufacturing industry, was adapted and supplemented to align with the domestic context, resulting in the establishment of a special classification table for the robot industry[11]. As per this classification, the robotics industry is divided into seven sectors: robots for manufacturing, robots for professional services, robots for personal services, robot parts manufacturing and software development and supply, robot system manufacturing, robot embedded product manufacturing, and robot-related services.

First, manufacturing robots are defined as automatically controlled, re-programmable, multi-purpose, three-axis or more-axis, self-adjusting devices for performing in-process tasks from production to shipment at industrial manufacturing sites. Professional service robots, on the other hand, are defined as robots that provide specialized services for an unspecified number of people. Personal service robots are defined as human-symbiotic interpersonal support robots that provide various services in different aspects of human life.Robot parts manufacturing and software development and supply are considered intermediate products used to produce manufacturing robots, personal service robots, and professional service robots. Robotic system manufacturing is defined as an aggregate of machines, devices, etc., including robots, to realize the required functions. Robotic embedded product manufacturing is defined as parts and products that do not have the appearance of robots but have robot technology applied to them. Finally, robot-related services are defined as the act of utilizing robots to provide physical and mental services needed by humans[11].

2.2 Economic Effects of the Robotics Industry

The demand for robots will continue to grow, leading to an expansion of robotics markets and industries. Robotics has the potential to increase productivity in related industries[12] and reduce the cost of manual labor in various service sectors. However, some argue that the increased use of robots may result in greater polarization of the labor market and wage imbalances, which could adversely affect the overall productivity and competitiveness of the economy in the future[4]. This argument is because as robots become more widespread, the productivity of the robotics industry and the labor market is likely to increase. However, this adoption might also might also lead to job displacement for low-skilled workers, causing them to exit the labor market due to technological advantages[13].

According to estimates from the White House Council of Economic Advisers, approximately 83% of U.S. jobs with hourly wages of $20 or less are affected by robotics[14]. An empirical study conducted in France argued that the expansion of robotics leads to a reduction in overall employment, particularly impacting less educated workers[15]. Several empirical studies have also highlighted the continuous decline of structured jobs involving repetitive and regular tasks, resulting in the growing occupational polarization of the domestic labor market[16-20].

However, past experience contradicts this claim. In the past, innovations aimed at increasing a firm's productivity have been passed on to consumers in the form of lower costs and to workers in the form of higher wages[13]. This, in turn leads to an expansion in consumption, creating new jobs and positively impacting regional competitiveness[5].The International Labor Organization has found that productivity and employment grow simultaneously in the medium term[6]. Additionally a study by Van Ark et al.(2004) also provides evidence of simultaneous growth in per capita income, productivity, and employment in the medium term[7]. It has been argued that companies that do not invest in robots to keep pace with these technological advances may lose their competitiveness in the long run, potentially leading to entire industries facingcrises that negatively impactthe economy[4].

In such a situation of conflicting opinions, this paper focuses on the robotics industry of South Korea. South Korea has been among the leading countries in industrial robot usage worldwide, faster to adopt robots because of its heavy concentration on manufacturing. Korea has adopted industrial robots more quickly than the United States, Japan, and Germany — so fast that it is expected to start affecting the employment rate of humans and even their wage increases. Based on 2019 data, electric and electronic products including chips and display materials, petrochemical products. and transportation equipment accounted for more than half of the country's manufacturing production. In those industries, it is relatively easier for robots to replace human workers as many of the tasks involved in production are simple and repetitive. In this situation, it is crucial to discuss Korea's robot industry, employment, and productivity.

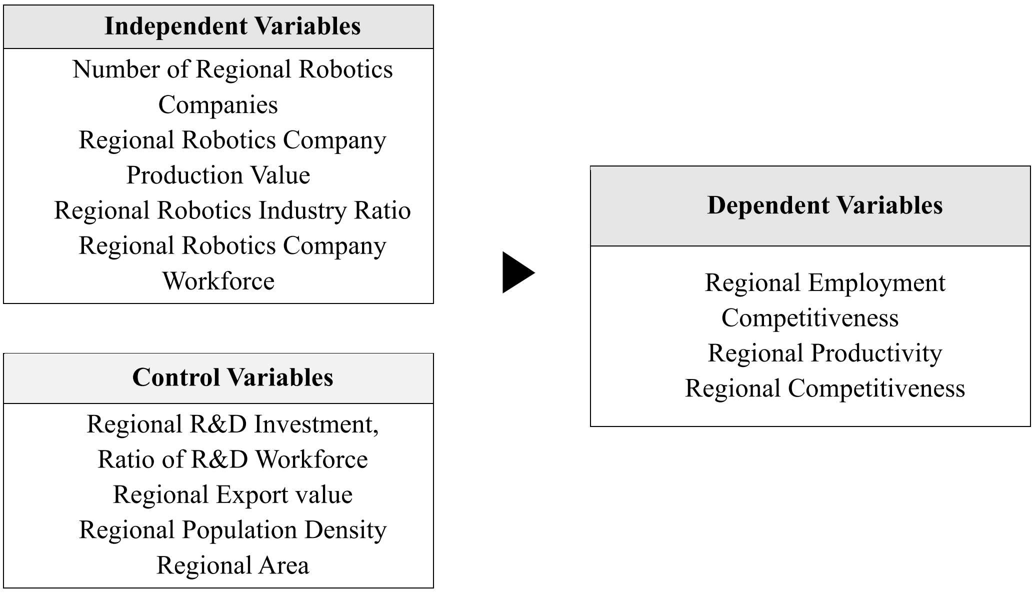
This paper started with a local with a local labor market approach and then turned to a more detailed analysis of the local economy. This allowed for the analysis on whether various attributes of the robot industry have a causal effect on regional employment, regional productivity, and regional competitiveness to take place. This analysis is the first in the literature to comprehensively address the impact of the rise of robots on local labor markets and economies.

3. Research Methods

3.1 Research Model

This study aimed to verify the effect of the robot industry on the local economy, as discussed in the theoretical background. Although there have been studies on the macro-level, such as the national labor market[14][15], and the socio-economic impact[6][7],there is still a need for further research to quantify the impact at the micro level. Thus, this study sought to investigate the relationship between the local robot industry, local employment, and the local economy. Based on empirical studies that the robot industry is closely related to employment [6][7][16-20] and empirical studies that confirmed the positive effect between the robot industry and productivity[6][7], Korea's regional robot industry and employment, and the economy were investigated.

This study aims to determine the impact of the robotics industry on the local economy. By analyzing data from local robot companies,including production value, industry ratio, and manpower. The researchers tried to determine the influence of the robotics industry on local employment, productivity, and the overall local economy. [Fig. 1] presents the model for this study.



[Fig. 1] Research Model

3.2 Data and Variables

This study used regional employment competitiveness, regional productivity, and regional competitiveness as dependent variables to measure the regional economic effects of robots. Regional employment competitiveness refers to the percentage of employed people aged 15 and older in a region, while regional productivity refers to the size of gross output relative to the number of employed people. Regional competitiveness was measured using GRDP.

The following independent variables were used to measure the impact on the robotics industry: robotics company production value, robotics company industry ratio, number of robotics companies, and number of robotics company employees. This indicator is because the production value of the robotics companies, the number of robotics companies, and the number of robotics employees are useful for measuring the activity and concentration of the robotics industry[8]. To explain each of these concepts, robotics company production value refers to the amount of money produced by the robotics companies in the region, robotics company industry ratio refers to the proportion of financing accounted for by the robotics industry among all industries, the number of robotics companies refers to the number of robotics companies located in the region, and the number of robotics company employees refers to the number of personnel employed in robotics companies in the region.

Moreover, since the dependent variable consists of employment and gross output, there are several factors that could influence it. To account for these factors, various control variables such as national R&D investment, R&D workforce ratio, export value, population density, and regional area were used.

The main data used in the empirical analysis was the "Robot Industry Survey" data. This survey is an annual survey of robot companies conducted by the Ministry of Trade, Industry, and Energy, Korea Robot Industry Promotion Agency, and the Korea Association of Robot Industry, and is an approved statistic by Statistics Korea. It is known as the only survey to measure the robot industry. The survey examines the current situation each year, and relevant results are announced at the end of the subsequent year's survey.

This study’s attempt was to onduct an analysis using secondary data that processed data on the status of robotics companies, production, and manpower for the designated locale. The survey targets businesses included in the special classification of the robotics industry. This study utilized seven years of data from 2011 to 2017 for analysis. [Table 1] shows the variable names and definitions.

[Table 1] Variable Names and Definitions of Variables

Dis.	Variable name	Contents	Source
Dep. var.	Regional Employment Competitiveness	Percentage of the region's population over the age of 15 who are employed	Statistics Korea, "Economically Active Population Survey"[21]
	Regional Productivity	Real gross regional product as a percentage of employed people	Statistics Korea, "Economic Activity Survey", "Local Income"[22][23]
	Regional Competitiveness	GRDP: The sum of the market value of all final goods and services produced within a defined economic area over a period of time	Statistics Korea, "Local Income"
Indep.var.	Number of regional robotics companies	Number of robotics companies in the region	Ministry of Trade, Industry and Energy. "Robot Industry Survey"[23]
	Regional robotics company production value	The sum of the production value of manufacturing robots, professional service robots, personal service robots, robot parts and components, robot systems, robot embedded, and robot service companies in the region	
	Regional Robotics Industry Ratio	The Ratio of the robotics industry production value to the total industrial production value in the region	
	Regional Robotics company workforce	Number of employees of robotics companies in the region	
Cont. var.	Regional R&D Investment	National R&D expenditure in the region	Ministry of Science and ICT·KISTEP "Research and Development Activity Survey"[24]
	Ratio of R&D Workforce	The Ratio of R&D personnel to population in the region	
	Regional Export Value	The amount of goods and services produced in the region and sold to other countries through trade	Korea International Trade Association, “Export Value”[25]
	Regional Population Density	Population with resident registration in the region	Ministry of the Interior and Safety, "Resident Registration Population"[26]
	Regional Area	Area of cities and towns by administrative district and residential, commercial, industrial, and green areas by zoning district	Korea Land and Housing Corporation, "City Status"[27]

3.3 Analytical Model

The inclusion of μ is a crucial factor in determining the suitable model for panel analysis, as it pertains to the attributes of the panel entities within the dataset. In a linear regression model, the error term(μ) can be considered either as a random effect or as a fixed effect.

Assuming that the panel entities were regarded as randomly drawn samples from the population, it can be conclude that the error term(μ) follows a probability distribution. Nonetheless, if the x term is correlated with the μ term, the equation no longer holds. In this scenario, estimating the coefficient as a random effect would lead to an inconsistent estimate. If the aforementioned assumption is not satisfied, it is necessary to estimate using a fixed-effects model in order to obtain a consistent estimate.

$$y_{ti} = a + \beta_1 x_{1it} + \beta_2 x_{2it} + \beta_3 z_i + \mu_i + e_{ti} \quad (1)$$

Since the error term varies in most survey cases, estimating the model requires calculating the error term. The Hausman test can determine whether the assumption is true and identify the appropriate estimated model. If the Hausman test yields similar values, the random effects model is suitable; otherwise, the fixed effects model should be used.

The panel analysis models in this study were three models, and the input variables, Number of regional robotics companies(Nm), Regional robotics company production value(Prod), Regional robotics industry ratio(Rate), and Regional robotics company workforce(worker), were used as independent variables, and Regional R&D investment(RndIn), Ratio of regional R&D workforce(RndWo), Regional export value(Export), Regional population density(Pop), and Regional area(Area) were used as control variables. The dependent variables were Regional employment competitiveness(RegEmpl), Regional productivity(RegProd), and Regional competitiveness(RegComp). Each calculation formula is as follows.

$$(RegEmpl_t) = a_t + \beta_1(Nm_t) + \beta_2(Prod_t) + \beta_3(Rate_t) + \beta_4(Worker_t) + \beta_5(RndIn_t) + \beta_6(RndWo_t) + \beta_7(Export_t) + \beta_8(Pop_t) + \beta_9(Area_t) + \mu_i + e_{ti} \quad (2)$$

$$(RegProd_t) = a_t + \beta_1(Nm_t) + \beta_2(Prod_t) + \beta_3(Rate_t) + \beta_4(Worker_t) + \beta_5(RndIn_t) + \beta_6(RndWo_t) + \beta_7(Export_t) + \beta_8(Pop_t) + \beta_9(Area_t) + \mu_i + e_{ti} \quad (3)$$

$$(RegComp_t) = a_t + \beta_1(Nm_t) + \beta_2(Prod_t) + \beta_3(Rate_t) + \beta_4(Worker_t) + \beta_5(RndIn_t) + \beta_6(RndWo_t) + \beta_7(Export_t) + \beta_8(Pop_t) + \beta_9(Area_t) + \mu_i + e_{ti} \quad (4)$$

4. Analysis Results

4.1 Impact on Regional Employment Competitiveness

The results of the panel regression analysis with regional employment competitiveness as the dependent variable are shown in [Table 2]. Before the analysis, the Hausman test was conducted to select the fixed-effect model and the random-effect model of the panel data, and the statistical value of Hausman was 1.94 and the probability of significance was 0.164, which was not significant, so the null hypothesis (fixed-effect model) was rejected under the significance level and the random effect was utilized.

According to the analysis results, when it comes to regional robotics company production value, regional robotics company workforce, and the number of regional robotics companies were not significant, indicating that they are not related to regional employment competitiveness.

On the other hand, the ratio of the regional robotics industry negatively affects regional employment competitiveness, which is consistent with Atkinson's (2018) argument that many jobs are eliminated by increasing the productivity of other industries, as discussed in the introduction and theoretical background[4]. It is expected that as the proportion of the robotics industry increases, there will be a negative impact on employment, which is a measure of regional competitiveness, due to the effect of robots replacing existing human workers.

[Table 2] Regional Employment Competitiveness Panel Regression Results

Independent Variables	Model 1		Model 2		Model 3	
	B	SE	B	SE	B	SE
Regional Robotics Company Production Value	-2.43E-09	3.89E-09	4.55E-09	7.60E-01	4.51E-09	4.53E-09
Regional Robotics Company Workforce	-4.71E-07	6.43E-07	-9.16E-07	6.53E-07	1.84E-07	9.26E-07
Regional Robotics Industry Ratio			-8.66E-01**	3.72E-01	-8.30E-01	3.66E-01
Number of regional robotics companies					-1.32E-05	8.23E-06
Regional R&D Investment	1.60E-09	1.61E-07	6.08E-08	1.58E-07	8.72E-08	1.63E-07
Regional R&D Workforce	1.19E-10	4.79E-10	-8.35E-11	4.73E-10	-1.70E-10	4.82E-10
Regional Export Value	1.23E-07***	4.08E-08	1.21E-07***	3.95E-08	1.22E-07***	4.13E-08
Regional Population Density	-1.75E-09	1.57E-09	-2.37E-09	1.54E-09	-2.78E-09*	1.65E-09
Regional Area	3.26E-12	2.15E-12	3.50E-12*	2.07E-12	3.62E-12	2.30E-12
Constant	9.65E-01***	3.15E-03	9.67E-01***	3.16E-03	9.67E-01***	3.58E-03

*p<.05, **p<.01, ***p<0.01

4.2 Impact on Regional Productivity

The results of the panel regression analysis with regional productivity as the dependent variable are shown in [Table 3]. Before the analysis, a Hausman test was conducted to select a fixed-effect model and a random-effect model for the panel data. The statistical value of Hausman was 0.04 and the probability of significance was 0.842, which was not significant, so the null hypothesis (fixed-effect model) was rejected under the significance level and the random effect was utilized.

[Table 3] Regional Productivity Panel Regression Results

Independent Variables	Model 1		Model 2		Model 3	
	B	SE	B	SE	B	SE
Regional Robotics Company Production Value	0.003	0.004	-0.005	0.003	-0.006	0.004
Regional Robotics Company Workforce	0.018	0.536	0.381	0.428	0.262	0.656
Regional Robotics Industry Ratio			3868525***	843345	3966483***	948024
Number of regional robotics companies					1.81	7.509
Regional R&D Investment	-0.002**	0.001	-0.001	0.001	-0.001	0.001
Regional R&D Workforce	0.592***	0.184	0.351**	0.154	0.326*	0.186
Regional Export Value	0.119***	0.026	0.069***	0.023	0.072***	0.026
Regional Population Density	-0.005***	0.001	-0.003***	0.001	-0.003***	0.001
Regional Area	0	0.000	0	0.000	0	0.000
Constant	66831.58***	3193.857	63459.28***	2610.137	63293.97***	2738.042

*p<.05, **p<.01, ***p<0.01

According to the analysis results, regional productivity was not related to regional employment competitiveness as regional robotics company production value, regional robotics company workforce, and the number of regional robotics companies were not significant.

On the other hand, the regional robotics industry ratio was found to have a positive effect on regional productivity. This analysis results is due to the characteristics of the robotics industry, which is characterized by increasing productivity in other industries by utilizing robots, and the effect of industrial productivity is greater than the negative effect of job losses, so the productivity of the local economy is not reduced but increased.

4.3 Impact on Regional Competitiveness

The results of the panel regression analysis with regional competitiveness as the dependent variable are shown in [Table 4].

Before the analysis, the Hausman test was conducted to select the fixed effect model and the random effect model of the panel data, and the Hausman statistic was 3.79 with a significance level of 0.05, so the null hypothesis (random effect model) was rejected under the significance level and the fixed effect was utilized.

According to the analysis results, regional competitiveness is positively affected by regional robotics company production value and regional robotics company workforce, while the regional robotics industry ratio and number of regional robotics companies negatively affect regional competitiveness. This analysis results could be interpreted as follows. First, the regional robotics company production value is judged to have a positive effect as it naturally contributes to the total productivity of the region, and in the case of the regional robotics company workforce, it is judged to have a positive effect as the labor input continuously contributes to the total regional output. On the other hand, the negative effect of a higher regional robotics industry ratio is judged to have a negative effect because the regional robotics industry itself should lead to productivity effects by affecting other industries rather than affecting the local economy, but a high regional robotics industry ratio is judged to have a negative effect because the productivity effects of other industries do not appear, and in the case of the number of regional robotics companies, it could be interpreted that the ripple effect on other industries is greater when medium and large robotics companies are concentrated rather than small and medium-sized companies.

[Table 4] Regional Competitiveness Panel Regression Results

Independent Variables	Model 1		Model 2		Model 3	
	B	SE	B	SE	B	SE
Regional Robotics Company Production Value	25.309**	11.234	27.699**	13.104	36.417**	15.545
Regional Robotics Company Workforce	592.53	1532.921	500.747	1575.849	2534.399	2511.677
Regional Robotics Industry Ratio			-1.53E+09	4.14E+09	-1.64E+09	4.13E+09
Number of regional robotics companies					-30960.27	29802.57
Regional R&D Investment	3.423	2.769	3.554	2.834	1.206	3.622
Regional R&D Workforce	1018.806	662.349	968.992	685.744	1610.7*	922.219
Regional Export Value	-54.994	170.740	-70.636	178.408	-57.492	178.605
Regional Population Density	47.521	31.309	48.853	31.988	39.725	33.129
Regional Area	-0.026	0.070	-0.017	0.075	-0.037	0.077
Constant	-2.8E+08	5.77E+08	-3.28E+08	6.00E+08	-1.68E+08	6.18E+08

*p<.05, **p<.01, ***p<0.01

5. Discussion

The results of the empirical analysis are as follows. First, the ratio of regional robotics industry has a negative impact on regional employment competitiveness, which is consistent with Atkinson's (2018) argument that when the use of robots in other industries increases the productivity of those industries, many jobs that occupy the majority of jobs in a firm are lost and few new jobs are created[4].

Second, the ratio of the regional robotics industry has a positive effect on regional productivity, which is consistent with Lee's (2021) argument that the robotics industry affects regional productivity[8] because it increases the productivity of other industries, while the effect of increasing industrial productivity by utilizing robots outweighs the negative effect of slowing regional productivity due to job losses.

Third, in terms of regional competitiveness, regional robotics company production value and regional robotics company workforce were found to have a positive effect on regional competitiveness, while the regional robotics industry ratio and the number of regional robotics companies were found to have a negative effect. This means that the increase in regional robotics company production value and the expansion of productivity due to the increase in the workforce naturally have a positive effect on the region's gross regional product (GRDP), while regions with a high ratio of the regional robotics industry have a negative effect on regional competitiveness because it means that the production value and productivity of other industries are lower, and regions with a high number of regional robotics companies contribute to regional competitiveness with a small number of medium and large companies rather than a large number of small and medium-sized companies.

Looking at the results of the analysis, these are the following implications. First, the robotics industry clearly reduces the number of jobs in local employment. However, the robotics industry has a role in increasing the productivity of other industries. This paradoxical result has implications for the development of the robotics industry in Korea. In order to secure the sustainable competitiveness of the country and local communities in a state where the number of working people is shrinking due to the low birthrate and aging population in Korea, it means that these problems must be solved through the development of the robotics industry and the utilization of robots. Second, while fostering small and medium-sized enterprises is important in fostering the robotics industry, it is also important to expand the competitiveness of Korea's robotics giants, which means that fostering a concentrated industry through SMEs and large enterprises can have a positive policy effect.

6. Conclusion

Automation and robots are having an arguably transformative effects on labor markets and the economy in Korea, as well as in many other advanced countries. Robots, in particular industrial robots, are anticipated to spread rapidly in the next several decades and assume tasks previously performed by labor. These momentous changes are accompanied by concerns about the future of local jobs and the economy. Nevertheless, there is relatively little work on the impact of the robotics industry on local employment and economy from a microscopic perspective. No substantive studies have been conducted to evaluate this impact. In this paper, the impact of industrial robots on employment and wages in Korea between 2011 and 2017 on the labor markets and economy of metropolitan local governments was estimated.

As a result of the analysis, the robotics industry has led to a decrease in local jobs but an increase in productivity. These results clearly demonstrate the contrast within the robotics industry. The concern still remains on the possibility of a decrease in job opportunities in the immediate future, leading to a society that competes with robots. However, with the current Korean economy facing an aging population and labor shortage, fostering the robotics industry will serve as a foundation for overcoming these challenges.

The significance of this study is that it empirically analyzes the effects of the robotics industry at the regional level in terms of productivity and jobs. While previous studies have focused on the national robotics industry, this study is differentiated by the fact that it was conducted from a regional perspective, and not simply in terms of the size of the industry, but in terms of jobs and productivity, which are priorities for the region. This study could also serve as a basis for policies to foster the robotics industry in the current situation of the country.

Meanwhile, the limitation of this study are as follows. The dependent variables of jobs, production value, and gross regional production value used in this study were influential factors, but there are many other factors. This study attempted to consider major factors such as industrial economy, employment, industry, and R&D but failed to consider various factors such as infrastructure, cultural facilities, and welfare. In addition, despite the fact that this study attempted to conduct a panel analysis, there is a limitation in that the analysis was conducted by utilizing historical data (data released in 2019) before 2017 due to the lack of data after 2018 because of the policy of the statistical release agency. In future studies, it is necessary to consider these limitations and overcome the limitations of this study.

References

[1] D. Acemoglu, P. Restrepo, Automation and new tasks: The implications of the task content of production for labor demand, Journal of Economic Perspectives, (2018), Vol.33, No.2, pp.3-30.
DOI: http://dx.doi.org/10.3386/w25684

[2] J. S. Lee, J. T. Min, Y. S. Choi, M. J. Park, D. S. Sohn, A Study on the Hardware Cost Estimation Equation of Professional Service Robot, Journal of Digital Convergence, (2018), Vol.16, No.7, pp.89-96.
DOI: http://doi.org/10.14400/JDC.2018.16.7.089

[3] International Federation of Robotics, World Robotics R&D Program. IFR, (2021)
Available from: https://ifr.org/r-and-d

[4] R. D. Atkinson, Which Nations Really Lead in Industrial Robot Adoption?, Information Technology & Innovation Foundation, (2018)
Available from: https://www2.itif.org/2018-industrial-robot-adoption.pdf

[5] OECD, Technology, Productivity and Job Creation. Organisation for Economic Co-operation and Development, (1998)
Available from: https://www.oecd-ilibrary.org/technology-productivity-and-job-creation_5lmqcr2k9kwc.pdf?itemId=%2Fcontent%2Fpublication%2F9789264163416-en&mimeType=pdf

[6] ILO, World Employment Report 2004–05: Employment, Productivity and Poverty Reduction. International Labour Organization Geneva, (2005)
Available from: https://www.ilo.org/public/libdoc/ilo/P/09465/09465%282004-2005%29272.pdf

[7] B. Van Ark, E. Frankema, H. Duteweerd, Productivity and employment growth: An empirical review of long and medium run evidence, Research Memorandum GD, Vol.71, (2004)
Available from: https://hdl.handle.net/11370/99b74a2b-f94b-4ca6-9a82-a4f5240447ed

[8] J. S. Lee, M. J. Park, J. T. Min, M. J. Park, D. S. Sohn, The Impact of the Domestic Robot Industry on the Regional Economy in the cases of South Korea, Journal of Korea Academia-Industrial cooperation Society, (2021), Vol.22, No.10, pp.174-186.
DOI: http://doi.org/10.5762/KAIS.2021.22.10.174

[9] J. S. Lee, D. S. Sohn, Y. S. Choi, M. J. Park, J. T. Min, A Study on the Factors of the Hardware Cost Estimation for Service Robot Development, Journal of the Korea Academia-Industrial Cooperation Society, (2018), Vol.19, No.5, pp.35-44.
DOI: http://doi.org/10.5762/KAIS.2018.19.5.35

[10] ISO 8373, Robots and Robotic Devices—Vocabulary, International Organization for Standardization (ISO), (2012)
Available from: https://www.iso.org/standard/55890.html

[11] Statistics Korea, the result of the third revision of the special classification of the robot industry, (2019)
Available from: http://kssc.kostat.go.kr/ksscNew_web/kssc/common/selectIntroduce.do?gubun=2&bbsId=rob_ug#

[12] G. Graetz, G. Michaels, Robots at work: the impact on productivity and jobs, Centre for Economic Performance, LSE, (2015)
Available from: https://cep.lse.ac.uk/pubs/download/cp447.pdf

[13] R. D. Atkinson, J. J. Wu, False alarmism: Technological disruption and the US labor market, 1850–2015, Information Technology & Innovation Foundation ITIF, May, (2017)
Available from: https://itif.org/publications/2017/05/08/false-alarmism-technological-disruption-and-us-labor-market-1850-2015/

[14] K. Grace, J. Salvatier, A. Dafoe, B. Zhang, O. Evans, When will AI exceed human performance? Evidence from AI experts, Journal of Artificial Intelligence Research, (2018), Vol.62, pp.729-754.
DOI: http://dx.doi.org/10.1613/jair.1.11222

[15] P. Aghion, C. Antonin, S. Bunel, Artificial intelligence, growth and employment: The role of policy, Economie et Statistique, (2019), Vol.510, No.1, pp.149-164.
DOI: http://dx.doi.org/10.24187/ecostat.2019.510t.1994

[16] W. Dauth, Job polarization on local labor markets, IAB-Discussion Paper, (2014)
Available from: https://doku.iab.de/discussionpapers/2014/dp1814.pdf

[17] H. David, D. Dorn, The growth of low-skill service jobs and the polarization of the US labor market, American Economic Review, (2013), Vol.103, No.5, pp.1553-1597.
DOI: http://dx.doi.org/10.3386/w15150

[18] M. Goos, A. Manning, A. Salomons, Job polarization in Europe, American economic review, (2009), Vol.99, No.2, pp.58-63.
DOI: http://dx.doi.org/10.1257/aer.99.2.58

[19] N. Jaimovich, H. E. Siu, Job polarization and jobless recoveries, National Bureau of Economic Research, (2012)
Available from: https://www.nber.org/system/files/working_papers/w18334/w18334.pdf

[20] F. Mazzolari, G. Ragusa, Spillovers from high-skill consumption to low-skill labor markets, Review of Economics and Statistics, (2013), vol.95, no.1, pp.74–86.
DOI: http://dx.doi.org/10.2139/ssrn.1022931

[21] https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1DA7002S&conn_path=I2, May 2 (2023)

[22]https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1C81&vw_cd=MT_ZTITLE&list_id=Q_7&seqNo=&lang_mode=ko&language=kor&obj_var_id=&itm_id=&conn_path=MT_ZTITLE, May 2 (2023)

[23] https://kiria.org/portal/policysut/portalPlcyReports.do, May 2 (2023)

[24] https://www.ntis.go.kr/ThDataList.do?ctgrCd=04, May 2 (2023)

[25] https://stat.kita.net/, May 2 (2023)

[26] https://jumin.mois.go.kr/, May 2 (2023)

[27] https://www.eum.go.kr/web/cp/st/stUpisStatDet.jsp, May 2 (2023)

