E-ISSN: 2383-2126

IJMAE
International Journal of Management Accounting and Economics

Volume 10, Issue 2 – Serial Number 103

February 2023

International Journal of Management, Accounting and Economics (IJMAE)

Monthly Publication

OPEN ACCESS

Editorial Contact Information

Address: No. 26, Dadgar 15, Vakilabad 67, Mashhad, Iran / Postal code: 9189865456

Tel: +989151249564

Email: info@ijmae.com
ijmae.editor@gmail.com

Website: www.ijmae.com
www.ijmae.ir

Publication Authorization is certified by Ministry of Culture and Islamic Guidance of Iran; No.: 23560, February 17, 2014

Table of Contents

Volume 10, Issue 2 - Serial Number 103, February 2023

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Original Research

Rural Infrastructure and Its Impact on Agricultural Production in Bangladesh: A Case Study on Kushtia Sadar Upazila

Rimon Kumar[1]
MSS in Economics, Islamic University, Kushtia-7003, Bangladesh

Saikat Pande
Department of Economics, Dhaka International University, Satarkul, Badda, Dhaka, Bangladesh

Received 3 February 2023 Revised 3 March 2023 Accepted 15 March 2023

Abstract

Agriculture is one of the most important sectors and driving factors of the economy of Bangladesh, which plays a significant role in the prosperity of large rural communities by increasing productivity, income, and creating employment. Presently, this sector has faced a severe challenge in its production, due to the construction of unplanned infrastructure in rural areas. This study investigates the effect of rural infrastructure on agricultural production in Bangladesh. Using the purposive sampling technique, 50 respondents were interviewed through a structured questionnaire to collect primary data from six unions of Sadar Upazila in the Kushtia district. Statistical methods of multiple regression and paired-sample t-test have been utilized to analyze the collected data. The results of the multiple regression model show that the co-efficient of cultivable and infrastructural land size is statistically significant at 1 percent of level, which depicts cultivable land positively affects agricultural production, whereas infrastructural land negatively affects agricultural production in the study area. This means that infrastructure built on cultivable land has reduced agricultural production. Paired-sample t-test result also shows that the mean difference between agricultural production before and after constructing infrastructure is TK.134847.94 per year. The primary reasons for the construction of infrastructure in the study area are unanticipated population expansion, urbanization, unplanned human settlement, and a rise in nuclear families. Lastly, suitable policies have been offered to develop the infrastructure as well as agricultural production in rural areas.

Keywords: Infrastructure, Agriculture, Multiple Regression, Paired Sample, Bangladesh.

[1] *Corresponding author's Email: rimon.kumar@yahoo.com*

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Introduction

Bangladesh is a small country in South Asia where 93.51% of the total landed area is rural, and 81.27% of the country's total population lives in rural areas (BBS, 2020). About 80% of the people of rural Bangladesh are directly and indirectly dependent on agriculture, and 47.1% of employment is being created through this sector (BBS, 2020). Despite significant advances in the services and manufacturing sectors, the role of agriculture in the economy remains unchanged due to continued advances in food production and being one of the major sources of rural employment (dailystar.net). The agriculture sector's contribution to the GDP in the fiscal year 2020-21 is 13.46 percent (BER, 2021). According to the 2016-17 Labor Force Survey, 40.62 percent of the labor force is still engaged in agriculture, which means agriculture is still a significant field of employment.

Bangladesh Bank conducted a report that the figure of agricultural production and trade in Bangladesh has been increasing over time as well as also increases the total market size. This report find out the total agricultural production in the year 2016 was $30,424, and the total market size was $34,927. But in a short time, this figure is gradually increasing, and it is estimated in the year 2020, the total production and total market size are $40,899 and $44,728, respectively. So this sector generates remarkable benefits for Bangladesh's economy. Even the role of this sector in the country's macro-economy, such as job creation, poverty alleviation, human resource development, and food security, is undeniable (Rahman, 2013).

Table 1. Agricultural Production and Trade in Bangladesh (Units: $ millions)

Year	2016	2017	2018	2019	2020 (Estimated)
Total Local Production	$30,424	$33,374	$35,882	$38,095	$40,899
Total Exports	$1,488	$1,625	$1,418	$1,600	$1,342
Total Imports	$5,991	$9,470	$5,952	$8,000	$5,171
Total Market Size	$34,927	$41,219	$40,417	$44,495	$44,728

(Total market size = (total local production + imports) - exports)
Source: USDA, Bangladesh Bank

But the contribution of this potential sector has been steadily declining in GDP growth for more than a decade because of the rapidly declining cropland (Islam & Hassan, 2013). Researcher such as Islam, S. (2014) has said, Land is an important factor in agricultural production which sources of human food, shelter, and clothing. And in recent times, Bangladesh's land use pattern is changing very quickly because of changes in geography, social and economic conditions, climate, adaptation, and population growth. Ahmed & Marjuk, (2013) in their study find out that the country had a huge population and used its land and resources very intensively. Thus, this huge population creates the problem of establishing unplanned infrastructure on this land which has a particularly strong effect on agriculture. In every year, the cropland is declining to human settlement and other human-induced activities. Unplanned land usage is taking place and creating infrastructure here and there (Islam & Hassan, 2013). And this scenario is more acute in rural areas of Bangladesh. Various establishments are being constructed, including

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

housing, industrial establishments, roads, hospitals, educational institutions, hat-bazaar, shops, etc (Hasnat et al., 2018). As a result, the agricultural land in rural areas is rapidly going into the non-agricultural sector. And it is estimated that the rising population pressure will devour 50% of the country's arable land by 2025 (Islam, 2014).

According to a research report funded by the Food and Agriculture Organization of the United Nations, the European Union, and USAID, in 1976, our cultivable land was 96,71,450 hectares. By the year 2000, 3 lakh 21 thousand 909 hectares decreased to 94 lakh 39 thousand 541 hectares. But in the next 10 years alone, by 2010, the total amount of agricultural land has decreased from 6 lakh 8 thousand 604 hectares to 8 lakh 51 thousand 938 hectares. That is, in the last one decade, an average of 6,600 hectares of arable land has been reduced every year. Another report from the World Bank shows that the total land area of Bangladesh is 3 crore 56 lakh 63 thousand acres, of which only 70 lakh 30 thousand hectares are cultivable land. So each person only has access to 0.0526 ha of land, of which one-fourth is now under threat. The report shows that Bangladesh is losing 1 percent of its cultivable land or 82900 hectares of cropland every year and 221 hectares of cultivable land every day. One of the reasons for the decline in agricultural land in the country is unplanned housing, urbanization, and increasing industrialization (Bhuiyan, M. 2003a).

As a district of Bangladesh, its impact on Kushtia is also noticeable. According to the BBS District Statistics-2011, the land survey (a record) from 1966 to 1970, and the final RS Khatian in 1972, the total area of 14 unions and one municipality of Kushtia Sadar Upazila was 316.3. Square kilometers. The total amount of land was 78667 acres. The total amount of permanent agricultural land is 3560 acres, and the amount of temporary agricultural land was 55712 acres. Due to unplanned urbanization, industrialization, and housing in Kushtia Sadar Upazila, about 400 acres of permanent farmland have been reduced at a geometric rate. In that case, the total amount of current agricultural land in Upazila is 3160 acres (BBS, 2020).

Table 2. Land area on the basis of utilization 2008 (*acres)

Upazila	Total area	Permanent Cropped area	Temporary Cropped area	Permanent fallow area	Others
Kushtia Sadar	78667	3560	55712	450	18945

Source: BBS District Statistics-2011

If this continues, not only will the habitable environment be damaged, but in the near future, the entire population will be in a catastrophic state (Kolakar, 1993). At present, the amount of cultivable land per capita is very small. Even then, if agricultural land continues to decline at such a rapid rate, providing food for a large population will not be difficult at all, it will become virtually impossible (Mahbub, A. 2003b).

Under the above circumstance, this investigation was to find out the answers to the following questions:

- Whether the construction of infrastructure affects agricultural production?

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551

- What are the mean differences between agricultural production in the study area?
- What are the reasons for the construction of infrastructure in rural areas?
- What kind of actions are required to address the infrastructure issue and expand agricultural production?

The study is divided into six parts. The next section provides the objectives of this study. This is followed by a brief outline of the literature review. Section four presents data, model, and methodological framework. Then section five exhibits results and discussion. The final section deals conclusion and recommendations.

Objectives of the Study

The primary objective of this study is to explore the impact of rural infrastructure on agricultural production in Sadar Upazila of Kushtia District. To reach the main objective, this study sets out some specific objectives, which are as follows:

- To determine the mean difference between agricultural production before and after constructing infrastructure by applying paired samples t-test.
- To identify the factors responsible for constructing rural infrastructure in the study area.
- To suggest suitable policy measures and recommendations for developing the rural infrastructure and agricultural production.

Literature Review

In this section, a few works of literature were reviewed related to rural infrastructure and agricultural production in Bangladesh. This section also provides a summary of the findings from the previous research work. Notable analyses of Islam and Hassan (2013), Hasnat et al., (2018), Islam (2013), Shafiqul (2014), Rana et al., (2019), and Khan (2020) have been reviewed here.

(Islam & Hassn, 2013) investigated the factors that influence the loss of Agricultural Land, and they showed that due to Infrastructural Development, the agricultural land in Bangladesh is decreasing day by day. To analyze their study, they chose the Rajshahi district as the study area because it has seen a lot of growth in infrastructure development through different regional development programs. They used remotely sensed data (Landsat MSS-1977, TM-1990, and TM- 2010) and GIS techniques as their study methods to analyze the land use pattern and its changes. The secondary data of this study were collected from SPARRSO and various government sources. The data (spatial and characteristics) were evaluated using GIS, statistical tools, and several types of tables. They found that the land use pattern in the Rajshahi district is changing. Among the different causes of agricultural land loss, infrastructure development is one of the most significant. The agricultural land of the study area is losing 0.46% per year, whereas the area devoted to infrastructure is expanding by 5.86 percent annually. (Hasnat et al., 2018)

made a study about land use changing patterns and challenges for agricultural activities in Dumki Upazila, Patuakhali. The study was based on both primary and secondary data sources. In the selected Unions, a total of 70 households were purposely chosen to perform the questionnaire survey. After finding the sample households, a semi-structured qualitative questionnaire was used to collect primary data from the family representatives. The survey found that the pattern of land use of the studied households is slowly changing. In this study, they revealed that in the last 20 years, residential areas and water bodies have grown by about 3.56 acres and 1.37 acres, respectively. In contrast, approximately 4.13 acres of agricultural land have been declining from 1998 to 2018 due to new house construction, selling or mortgaging of land to meet financial needs, distributing land among successors, reducing soil fertility, wearing away land parts due to riverbank erosion, and government acquisition of land. As a result, these factors can be considered the main challenge for agricultural development in the study area. (Islam, 2013) carried out a survey of the causes and consequences of Agricultural land losses of Rajshahi District, Bangladesh. In this study, he predicted that just 0.0526 hectares of land are available per person in the Rajshahi district. He has also investigated two significant reasons for losing land: a) The rapid growth rate of the population consuming valuable land for settlement and b) the paucity of land to meet the growing demand for food. PRA techniques were used for the analyses to gather primary data, and both published and unpublished data about crops, populations, and other environmental factors, mostly from government sources, were used as secondary data. The findings of this study reveal that the causes of agricultural land losses are diverse, and their consequences are also multi-dimensional. (Islam, M. S. 2014) remains that land fragmentation is the most crucial factor in losing Bangladesh's land. For analysis, he conducted a clear picture of the status of land fragmentation in the Rajshahi district. Thus, he interviewed a total of 30 people to learn about the state of land fragmentation in Rajshahi, as well as the effects of land fragmentation on agriculture, the environment, the economy, and sustainable development. He found that Bangladesh's land use pattern is rapidly changing due to unplanned human settlement and industrialization. Consequently, agricultural land is rapidly diminishing. This study's findings revealed that the Rajshahi area's land fragmentation is changing, with agricultural land declining at an alarming pace and becoming more susceptible. Every year, the study area's agricultural land disappears. Agricultural productivity is also declining owing to a shortage of agricultural land, industrialization, a decrease in soil fertility, and the use of pesticides to make soils poisonous. If current trends continue, agricultural land will be depleted over the next several years. (Beckersa, V. et al., 2020) identified in their study urbanization is one of the major factor to a continuous loss of agricultural land, both directly under land acquisition and indirectly through the use of agricultural land for non-productive rural activities such as recreation, horse rearing or hobby farming. To implement their study, they are used agricultural agent-based model to explicit the urbanization scenerio of different city in Belgium. The study result find that farmers are under pressure from urbanization processes, which make farming more difficult due to decreased agricultural land, negative externalities, and competition for land. The findings also revealed that these decreases are predicted to be greater in the rural-urban periphery. (Fazal, S. 2000) conduct a survey in Saharanpur City to measure the urban expansion and loss of agricultural land. He applied in his study a remote sensing methodologies to enable extensive mapping of land use changes, including the location of agricultural land loss, changes in land use type, and the quality of lost agricultural land. The findings also

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

identifies the non-agricultural land uses that accounted for the majority of the lost agricultural land and explores the implications of these results for India and other countries where urbanization is limiting the availability of high-quality agricultural land. (Halim, M. A. et al., 2013) concluded a field survey how crop land converted every year into non- agricultural sector in the sub-urban area of Bangladesh. In this regard, they are purposively selected two villages (Narikel Baria and Baze Silinda) from ten surrounding sub-urban villages in the Pabna Upazila of the Rajshahi district. Both primary and secondary data are used to attain the objectives and various statistical tools like SPSS, EXCEL and GIS are used to process the data. The study result noted that more land has been converted from agriculture to non-agriculture associated uses in recent years than in the past due to steadily rising land demand for housing and related services, which has a negative impact on agricultural land and the people who depend on it. Finally they are provide better alternatives for meeting the land demand for the agricultural and housing sectors, integrated land-use planning is required. On a different angle (Rana et al., 2019) have used trend analysis to show the land utilization scenario in Bangladesh. To analyze the changes in land use patterns in Bangladesh they collected the data from secondary sources during the period of 1990 to 2015. The trend analysis and exponential growth rate indicated that the forest area considerably rose by 35.93 percent and 0.3 percent per year, whereas land not available for cultivation greatly declined by 4.49 percent and 0.04 percent per annum correspondingly. (Khan, 2020) published an article entitled "Worries over farmland depletion." In this article, he revealed that due to rapid industrialization, unplanned urbanization, and more rural settlements, over 69,000 hectares of farmland are being lost every year. He also showed that Bangladesh lost around 13,412 hectares of agricultural land between 1976 and 2000 and 30,000 hectares of land lost from 2000 to 2010. He said that rapid urbanization, including the building of new roads and highways and the increase in population, is consuming a significant area of farmland. If this situation continues, the country's food security will be at risk in the future.

Most of the research has only addressed infrastructural and agricultural development (Edeme, Nkalu, Idenyi, & Arazu., 2020, Andersen P. P., 2006, Patel. D. A., 1994). Furthermore, a few studies have revealed the causes of arable land losses and its consequence on agricultural production (Isalm R., 2013, Hasnat, Siddik, & Zaman 2018**,** Islam S., 2014). But there are no studies about infrastructure and its impact on agricultural production in rural areas in Bangladesh. Even no district-level study like Kushtia discussed the construction of unplanned infrastructure, which directly affects agricultural production. For that reason, a field research is required to determine the agricultural production difficulties and bring opportunities to Kushtia district as well as Bangladesh.

Data, Model and Methodological Framework

Study Area

The study is basically conducted on field-level data. Kushtia Districts in the Khulna Division of Bangladesh are purposively selected as the study area. Generally, rural areas under Kushtia Sadar Upazila are chosen for this study because of the rapidly growing rural infrastructure. A total of 6 unions namely Abdulpur, Ailchara, Alampur, Battail, Harinarayanpur, and Ujangram under Sadar Upazila of Kushtia District have been

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

purposively selected to get the real picture of the study areas. The following Table 3 represents the sampling area of the study.

Table 3. Sample Size and its Distribution (N=50)

Name of District	Name of Upazila	Name of Union	Number of Samples
Kushtia	Kushtia Sadar	Abdulpur	7
		Ailchara	5
		Alampur	10
		Boattail	16
		Harinarayanpur	6
		Ujangram	6
Total	1	6	50

Data Collection and Process

A total of 50 respondents have been randomly selected from the six unions under Sadar Upazila of kushtia District for interviews regarding rural infrastructure and its impact on agricultural production. A face-to-face interview method was used to give a structured questionnaire to acquire the primary data. The questions were both open-ended and closed. The data collection period was from January 2022 to March 2022. Secondary data sources (journals, govt. websites &reviews of literature) were also used to enhance the reliability of the outcome of this study. After data collection, it was processed with MS Excel and presented in tabular and graphical style for easy perception.

Descriptive Analysis

Descriptive statistics gives a comprehensive understanding of the study's variables with the use of Central tendency (Kaushik et al.,2016). In this study, the statistical terminology used to characterize them includes mean, standard deviation, maximum value, and minimum value. Descriptive analysis is used to delineate the information about age (Year), education (Year of Schooling), family size (members), and land size (Bigha). In addition, the causes of constructing infrastructure have been illustrated here. Furthermore, it has become used for categorizing, summarizing, and indicating the link between two or more variables. Besides Frequency, percentage, rank, and other metrics are also examined by using it.

Functional Analysis

Multiple Regression Model

The following model illustrates how the Multiple Regression Model was constructed and used to assess the impact of factors on the annual agricultural production. The following specification of the model has been applied:

$$\boldsymbol{Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \cup_i} \quad (1)$$

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

A multiple regression model has been utilized to estimate the effects of variables on agricultural production. In this instance, the influence of several factors on agricultural production is examined using the multiple regression model. As a consequence, there are two linear types of models have been used in this study. The first linear type multiple regression model is considered in this study, i.e.,

$$\boldsymbol{Ln\, Y_i = ln\, \beta_0 + \beta_1\, ln\, X_1 + \beta_2\, ln\, X_2 + \beta_3\, ln\, X_3 + \cup_i} \quad (2)$$

Where, Y_i = Agricultural Production, β_0= Intercept, $\beta_i = \beta_1$ to β_3 are coefficients, X_1= Cultivable Land Size, X_2= Infrastructure-building year, X_3= Family Size

The second linear type multiple regression model is considered in this study, i.e.,

$$\boldsymbol{Ln\, Y_i = ln\, \beta_0 + \beta_1\, ln\, X_1 + \beta_2\, ln\, X_2 + \beta_3\, ln\, X_3 + \beta_4\, ln\, X_4 + \cup_i} \quad (3)$$

Where, Y_i = Agricultural Production, β_0= Intercept, $\beta_i = \beta_1$ to β_4 are coefficients, X_1= Cultivable Land Size, X_2= Infrastructure Land Size, X_3= Infrastructure-building year, X_4= Family Size

Paired Sample t-test

In this study, paired sample t-test is used to show the mean difference between agricultural production before and after constructing infrastructure in the study area. This model is basically based on the differences between the values of a single pair, that is one deducted from the other. The test statistic for the Paired Sample t-Test, denoted t, follows by the following formula as the one-sample t-test:

$$\boldsymbol{t = \frac{\bar{x}_d - 0}{s_{\bar{x}}}}$$

Where,

$$\boldsymbol{s_{\bar{x}} = \frac{s_d}{\sqrt{n}}}$$

Where, $\bar{x}_d =$ sample mean of the differences, $n =$ sample size, $s_d =$ sample standard deviation of the differences, $s_{\bar{x}} =$ estimated standard error of the mean.

Results and Discussion

Results from Descriptive Statistics of the Variables

Descriptive statistics displays the estimation variables and associated sample data, including the respondents' maximum and minimum values, mean, and standard deviation about their Socio-Demographic variables (Age, Education, Family Size) along with economic variables (Establishing Year, Land Size, Agricultural Production). The results of the descriptive variables that are found in this study are shown in Table 4:

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Table 4. Descriptive Statistics of the Variables

Variables	Minimum	Maximum	Mean	Standard Deviation
Age of respondents (Years)	23	77	45.82	12.53841
Education of respondents (Years)	0	17	8.86	4.598181
Family Members of respondents	2	12	4.92	1.957090719
Year Of Establishing (Ago)	1	20	8.92	5.913803
Infrastructure Land Size (Bigha)	1	50	6.54	7.990326
Before yearly agricultural production (Per Bigha)	9000	69600	40490	11731.73
Current yearly agricultural production (Per Bigha)	8570	80000	39791.77	15226.17

From table 4, it is found that the average age of the respondent is 45.82 years, with a minimum age of 23 years and a maximum age of 77 years. The average level of education of the respondent is 8.86, which means most of the respondents are educated. The respondent's average member is 4.92, with a minimum member of 2 and a maximum of 12.

According to table 4, The average value of the year of establishing infrastructure is 8.92, with minimum and maximum years of 1 and 20, respectively. The average size of infrastructure land (Bigha) in the study area is 6.54, with a range of 1 to 50. Table 3 also shows, the average yearly agricultural production (Per Bigha) is TK. 40490 before constructing infrastructure, with the minimum and maximum production of TK. 9000 and TK. 69600 respectively. Finally, it is found that the average value of current yearly agricultural production (Per-Bigha) after constructing infrastructure is TK. 39791.77, with the minimum production value of TK. 8570 and the maximum value of TK. 80000. This result means that both the average yearly agricultural production are almost the same in the study area. The standard deviation of both yearly agricultural production (per bigha) before and after establishing infrastructure is TK. 11731.73 and TK. 15226.17 respectively. The standard deviation of age, education, family members, year of establishing, and infrastructure land size are 12.54, 4.60, 1.96, 5.91, and 7.99, respectively.

Results from Estimation of Multiple Regression Model

Using the Multiple Regression Model, the output of agricultural production and input are estimated here. Agricultural production is examined using different explanatory variables in this study. The results of the multiple regression model are divided into two sections. Table 4 shows the first section, and table 5 shows the second section. Both tables depict an interpretation of the variables' effects on agricultural production.

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Factors Affecting Agricultural Production before Constructing the Infrastructure

In this part, we show the effect of various factors on agricultural production before constructing the infrastructure in the study area. The three explanatory variables influencing agricultural production are listed in the table below:

Table 5. Estimation of Coefficient of Multiple Regression Model of Factors Affecting the Agricultural Production

Explanatory Variables	Coefficients	Std. Error	t-Statistic	P-value
Constant	1547.291	154015.5	0.010046	0.9920
Total Cultivable land size (X1)	28910.70	2199.028	13.14703	0.0000*
Infrastructure-building year (X2)	1034.198	9339.498	0.110734	0.9123
Number of family members (X3)	12547.02	28466.66	0.440762	0.6615
F-Value	59.38			
R-Squared	0.79			
Dependent Variable: Yearly Gross Agricultural Production (TK), Number of Observation (N)=50 *1% level of significant				

The estimated result shows that cultivable land size is significant at 1%, and the coefficient is 28910.70. This result indicates that as the cultivable land size increases by 1 unit, then the gross agricultural production increases by TK.28910.70. The coefficient of multiple determination R-squared is 0.79. That means the explanatory variable included in the model explains about 79% of the variation in the yearly agricultural production in the study area. It implies that the interpretation of the yearly agricultural production primarily depends on the explanatory variable considered in this model. Although the number of family members has a favorable effect on agricultural productivity, this effect is not statistically significant here. In addition, both the constant and year of building infrastructure are not statistically significant in this model.

Factors Affecting Agricultural Production after Constructing the Infrastructure

In this part, we show the effect of various factors on agricultural production after constructing the infrastructure. The four explanatory variables are used to examine agricultural production that is listed in the table below:

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Table 6. Estimation of Coefficient of Multiple Regression Model of Factors Affecting the Agricultural Production

Explanatory Variables	Coefficients	Std. Error	t-Statistic	P-value
Constant	-36397.65	63696.60	-0.571422	0.5706
Present cultivable land size (X1)	41680.10	1937.771	21.50930	0.0000*
Infrastructure land size (X2)	-24698.59	4041.603	-6.111087	0.0000*
Infrastructure-building year (X3)	-103.2390	3865.742	-0.026706	0.9788
Number of family members (X4)	16774.75	11809.71	1.420421	0.1624
F-Value	178.19			
R-Squared	0.94			
Dependent Variable: Yearly Gross Agricultural Production (TK), Number of Observation (N)=50 *1% level of significant				

The finding shows that both the current cultivable land and infrastructure land size are statistically significant at 1%, and the coefficient is 41680.10 and -103.2390 respectively. The coefficient of multiple determination R-squared is 0.94. That means the explanatory variable included in the model explains about 94% of the variation in the yearly agricultural production. This result indicates that the cultivable land size has positively impacted the gross agricultural production in the study area. On the other hand, infrastructure land size has negatively impacted the gross agricultural production and it depicts that if the other factors remained constant, a 1% increase in infrastructure land size would decrease the gross agricultural production by 103.2390 %. Although the other variables have a favorable effect on agricultural productivity, this effect is not statistically significant in this model. In addition, both the constant and year of establishing infrastructure have negatively impacted the gross agricultural production in the study area.

Results from Estimation of Paired sample t-test

The results of this test are classified into three parts: paired samples statistics, paired-samples correlation, and paired samples test. All these parts are the following:

Table 7: Paired Samples Statistics of Gross Production

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Gross Production TK (Per Year)	399050.00	50	803354.055	113611.420
	Present Gross Production TK (Per Year)	264202.06	50	613663.644	86785.145

Table 6 represents the paired sample statistics that give univariate descriptive statistics for a single variable, such as the mean, sample size, standard deviation, and standard error.

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Notice that the sample size here is 50; this is because the paired t-test can only use cases that have non-missing values for both variables. According to table 6, the average value of gross production before constructing infrastructure is TK. 399050.00, and the average value of current gross production is TK. 264202.06. That means when the infrastructure is built on the cultivable land then the average gross production is declined in the study area. The standard deviation of the two variables is TK. 803354.055 and TK. 613663.644 respectively. In addition, the standard error of the two variables is TK. 113611.420 and TK. 86785.145.

Table 8. Paired Samples Correlations of Gross production

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Gross Production TK (Per Year) & Present Gross Production TK (Per Year)	50	.974	.000

The paired sample correlation shows the bivariate Pearson correlation coefficient (including the significance of the two-tail test) for each pair of entered variables. The Paired Samples Correlation table 7 adds the information that gross production before constructing infrastructure and the current production scores are significantly positively correlated (r = .974). The correlation result depicts that the gross productions before constructing infrastructure are slightly varied when the infrastructure is built on the cultivable land in the study area.

Table 9. Paired Samples Test of Gross Production

Paired Samples Test									
		Paired Differences					t	df	Sig.(2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair1	Gross Production TK (Per Year) - Present Gross Production TK (Per Year)	134847.940	248033.436	35077.225	64357.617	205338.263	3.844	49	.000

In table 8, the first column shows the pair of variables being tested, and the sequence has been subtracted. The second column shows the mean difference between the two variables is TK.134847.94 which means the gross agricultural production declined every year because of construction infrastructure. The third and fourth columns in this table depict the standard deviation of different scores and the standard error in which both the scores are 248033.436 and 35077.225, respectively.

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

Causes of Constructing Infrastructure

In recent times, the construction of unplanned infrastructure is considered the main issue of agricultural land losses as well as decreasing agricultural production. In this study, the respondents of the study region give the various reasons that are responsible for constructing the unplanned infrastructure in rural areas of the kushtia district. In this section, we included all the factors in the table below and then analyzed all of these factors.

Table 10. Causes of Constructing Infrastructure in the Study Area

No.	Factors Responsible	Frequency	Percentage	Rank
1	Population Growth	45	90	1
2	Urbanization	39	78	2
3	Family Separation	27	54	3
4	Family Conflict	22	44	4
5	Advantages of Employment	12	24	5
6	River Erosion	9	18	6
7	To promote the educational expansion	4	8	7
8	Industrialization	2	4	8

From table 9, around 90% of respondents agree that population growth is the main reason for establishing infrastructure in the study area. With this high population growth, people are looking for new places to live. As a result, they are constructing new buildings on agricultural land in rural areas. Secondly, 78% of respondents consider urbanization as another factor in construction infrastructure in rural areas. At present, the trend of urbanization in Bangladesh is increasing day by day. Mainly people in rural areas are choosing the non-agricultural sector as their profession more than the agricultural sector. As a result, they are building new infrastructure on their agricultural land that results in rural areas rapidly turning into urban areas and the amount of arable land gradually decreasing. About 54% of respondents answered in favor of family separation. They believe that family separation creates a high rate of nuclear families in rural areas and every family constructs new houses on their arable land which brings extra pressure on agricultural production. In addition, about 44% of respondents further think that family conflict is another reason for building infrastructure in the study area. At present, most joint families are being divided into nuclear families due to family conflicts. Besides, because of the employment opportunities, many people have built new houses, shops, markets, and industrial institutions in rural areas and 24% of the people in the study area have expressed their opinion in favor of it. They remain that these infrastructures are more profitable institutions than agricultural production and they can get more money from these institutions.

Due to river erosion, rural infrastructure has grown dramatically in recent years. According to 18% of respondents, agricultural land in the study region is declining every year because of river erosion. Consequently, the residents of the region have built new infrastructure and put further strain on agricultural land. Educational development and

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7749551
www.ijmae.com

industrialization are also cited as the reasons for building infrastructure in rural areas, supported by 8% and 4% of the people in the study area.

Conclusion and Recommendations

The study was carried out to investigate the influence of rural infrastructure on agricultural production in Sadar Upazila of Kushtia district in Bangladesh. Primary data were collected from 50 respondents randomly in the rural areas of Kushtia Sadar Upazila. Both descriptive and econometric tools were used to analyze the data. The findings of the study depict that the average age of the respondent was 45.82 years and the average year of schooling was 8.86, which shows that most of the respondents are educated and experienced. Most of the respondents' families in the study area were laid in the medium size whose members were 4.92 on average. In this study, the coefficient of agricultural land size is positively significant at 1 percent on agricultural production. That means if the infrastructure is not built on cultivable land, each unit of cultivable land increases the agricultural production in the study area. On the other hand, the coefficient of infrastructural land size is negatively significant at 1 percent on agricultural production and it reduces agricultural production. Family members and the year of establishing infrastructure are not statistically significant in this study. Besides, the result of the paired-sample t-test shows that the mean difference between agricultural production before constructing infrastructure and current agricultural production is TK.134847.94 per year. In this study, we see that several factors are affecting the demand for infrastructure and its uses in the rural areas under Kushtia districts. Increasing numbers of nuclear families and unplanned urbanization are among them, which are also restricting agricultural production day by day. Besides, the studied area's land use pattern is fast changing due to uncontrolled population expansion and economic development. As a result, it is observed that the study areas' agricultural land is losing every year, which is putting extra pressure on agricultural production. And this tendency will face a big challenge if a proper plan of agricultural land in the study area is not adopted and implemented.

In this situation, the following recommendations have been proposed for future planning: Vertical infrastructural development is necessary; accumulation of zonal growth planning; taxes can be imposed for new infrastructures; rate of population growth must be controlled; and most importantly, awareness should be raised among people. In addition, the following recommendations for further measures were made:

District and Upazila-based satellite towns should be developed to protect agricultural land from unplanned housing.

Villages must be turned into small towns without building houses in isolation. In that case, multi-storied buildings can be built.

'Land banks' can be created based on the nature of the land and the use of the land and can be used appropriately in development issues.

Creation of a 'Combined Data Bank' to clearly capture data on land use and agricultural production from the Union level to the State level in chronological order.

To encourage living in the extended family so that the rate of creating a nuclear family will decline.

Necessary legal actions should be taken to ensure proper utilization of agricultural land.

References

Ahmed, Z., & Marjuk, O. A. (2013). Horizontal Expansion of Housing in Rural Areas of Bangladesh: Does Population Growth Matter? *Developing Country Studies*, *3*(10), 66–77.

Bangladesh Economic Review. (2021). Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh.

BBS. (2011a). *Population & Housing Census, Zila Report: Kushtia*. Bangladesh Bureau of Statistics, Statistics & Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

BBS. (2013). *Economic Census 2013 District Report*. Bangladesh Bureau of Statistics, Statistics & Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Beckers, V., Poelmans, L., Van Rompaey, A., & Dendoncker, N. (2020). The impact of urbanization on agricultural dynamics: A case study in Belgium. *Journal of Land Use Science*, *15*(5), 626–643. https://doi.org/10.1080/1747423X.2020.1769211

Bhuiyan, M. (2003a). Has urbanization caused the agricultural land loss? *The Daily Star*.

Islam, R. (2013). Causes and consequences of Agricultural land losses of Rajshahi District, Bangladesh. *IOSR Journal Of Environmental Science, Toxicology And Food Technology*, *5*(6), 58–65. https://doi.org/10.9790/2402-0565865

Fazal, S. (2000). Urban expansion and loss of agricultural land—A GIS based study of Saharanpur City, India. *Environment & Urbanization*, *12*, 133–149.

Halim, M. A., Rahman, M. M., & Hassan, M. Z. (2014). Agricultural Land Conversion in the Sub-Urban Area: A Case Study of Rajshahi Metropolitan City. *Journal of Life and Earth Science*, *8*, 21–30. https://doi.org/10.3329/jles.v8i0.20136

Hasnat, G. N. T., & Siddik, A. (2018). Land Use Changing Pattern and Challenges for Agricultural Activities: A Study on Dumki Upazila, Patuakhali. *J. Patuakhali Sci. and Tech. Uni*, *1*(2), 67–76.

Https://thefinancialexpress.com.bd/views/worries-over-farmland-depletion-1605105883. (n.d.).

Islam, R., & Hassn, D. Z. (2013). Losses of Agricultural Land due to Infrastructural Development: A Study on Rajshahi District. *International Journal of Scientific & Engineering Research*, *4*(11), 391–397.

Islam, S. (2014). Study on Impact of Land Fragmentation in Agriculture-A Case of Rajshahi District, Bangladesh. *International Journal of Recent Research in Social Sciences and Humanities (IJRRSSH)*, *1*(1), 54–61.

Kolakar, S., R., R. (1993). *The Future of Our Land: Facing the Challenge. Hall of India Pvt. Ltd., New Delhi*.

Mahbub, A. (2003b). *Agricultural land loss and food security: An assessment. IRRI, Manila, The Philippines*.

Rahman, M.T, H., M. N. (2013). *Assessment of shifting of agricultural land to nonagricultural land in Bangladesh*. SRDI, Ministry of Agriculture, Government of Bangladesh.

Rana, S., Faruk, O., Begum, N., & Tabassum, M. (2020). Trend Analysis of Land Utilization in Bangladesh. *International Journal of Engineering Technologies and Management Research*, *6*(2), 39–46. https://doi.org/10.29121/ijetmr.v6.i2.2019.354

World Bank Report. (2018). *Food and Agriculture Organization, Electronic Files and Website*.

HOW TO CITE THIS ARTICLE

Kumar, R., & Pande, S. (2023). Rural Infrastructure and Its Impact on Agricultural Production in Bangladesh: A Case Study on Kushtia Sadar Upazila. *International Journal of Management, Accounting and Economics*, *10*(2), 106-121.

DOI: 10.5281/zenodo.7749541

DOR: 20.1001.1.23832126.2023.10.2.1.6

URL: https://www.ijmae.com/article_168683.html

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

Original Research

Investigating the Long-run Influences of Human Capital on Innovation and Economic Growth in MENA Countries

Seyed Valiallah Mirhoseyni[1], Seyed Hossein Izadi
Leila Mohammad Ghader
Department of Economics, Payam Noor University (PNU), P.O. Box 19395-4697, Tehran, Iran

Received 17 January 2023 Revised 31 January 2023 Accepted 3 February 2023

Abstract

Human capital is supposed to be an important factor in innovation and economic development. However, the long-run influence of human capital on current innovation and economic development is still unclear, in particular in the MENA region. Therefore, the present study is to investigate the long-run influence of human capital on innovation and economic growth in MENA countries for the years 2010-2012. The data were collected using the library method from the World Bank database and were analyzed using statistical and econometric methods for panel data. The results obtained from this study showed that human capital had a positive, significant influence on innovation and economic growth in MENA countries. The same influence was observed for the population density in some age groups (more educated people) on the patents in MENA countries.

Keywords: Human capital, Innovation, Economic growth, MENA region.

[1] *Corresponding author's Email: svmir@pnu.ac.ir*

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

Introduction

Innovation as one of the key drivers of economic growth is needed by any society to achieve its goals related to the knowledge-based economy in moving towards sustainable economic growth and development. In developed countries, innovation plays a bold role in the infrastructural changes in economic growth. In the present era, known as the age of knowledge and information, human power can be considered an economic privilege when it is of high knowledge and intellectual ability. Because the economists, it is one of the factors that can make difference in the economic growth of developed and developing countries (Kazeroni et al., 2014). Human capital is a complement of physical capital in this way that the first can lead to better use of the later. The experiences of the developed countries and various studies on the economic growth of the countries over time or among the countries have demonstrated that the rate of economic growth is not explainable only by conventional factors such as capital and workforce. Human capital, as a main variable, should be included in the growth models. The studies investigating the effective factors on economic growth have attributed less than half of the percentage of growth to the main factors of production (labor, capital, and land) and the rest to the unknown factors like technology, increase in productivity, etc. Human capital is an effective qualitative factor in the production process, which is not explainable by labor. It appears that it has only one source: education (Emadzadeh et al, 2008).

Although many thinkers believe that human capital has a considerable role in innovation and economic growth, the way human capital influences innovation and economic growth, its influence mechanisms, and the short-run and long-run influences brought about by it has not completely been known. Thus, such factors are necessary to investigate to unveil how and how much human capital influences innovation and economic growth. In many countries, realizing sustainable development goals has strongly to do with economic and financial sector development and innovation and many thinkers believe that human capital has a bold role in innovation and economic growth and development of different societies (Niknami et al., 2014). Nevertheless, the way human capital influences innovation and economic growth, its influence mechanisms, and its short-run and long-run effects on economic growth and development are not completely known. Thus, it is necessary to investigate this variable (human capital) and its effects in various societies including MENA countries, regarding their economic characteristics.

MNEA refers to a group of countries situated in and around the Middle East and North Africa, which are the main producers of oil. The economy of these countries has a close relationship with the global oil price changes. This region is one of the oldest oil fields and for this reason, the oil reserves of the countries of this region have experienced more decrease compared to the other regions and the wear and tear of oil drilling and extraction tools are more evident. During the past few decades, many of these countries have turned to physical and human investments in various sectors to reduce dependence on the oil industry, one of which is human capital. However, the unemployment rate is high in these countries despite abundant oil and physical resources. Thus, the present study investigates the role of human capital in innovation and economic growth to show how these capabilities (oil and physical resources) can be used properly for regulating the economic

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

relations among MENA countries and increasing innovation and economic growth. In this respect, the question is what are the long-run influences of human capital on innovation and economic growth in MENA countries?

Literature Review

The global market is always a challenging field for countries in the world. These countries are facing conditions like increasing complexity and change, globalization, customer needs, and intense competition. Therefore, product development and innovation are vital to survive. Countries are always seeking ways to avoid uncertainty and to find conditions to give them the ability to predict the future and make the necessary arrangements for it. We call a country successful if it moves toward innovation and creativity (Delmas and Pekovic, 2013). Innovation as one of the key drivers of economic growth is needed by any society to achieve its goals related to the knowledge-based economy in moving towards sustainable economic growth and development. In developed countries, innovation plays a bold role in the infrastructural changes in economic growth. In the present era, known as the age of knowledge and information, human power can be considered an economic privilege when it is of high knowledge and intellectual ability. Because the economists, it is one of the factors that can make difference in the economic growth of developed and developing countries (Kazeroni et al., 2014).

Innovation means a meaningful change for improving the services and the routine processes and for creating new values for the beneficiaries and it focuses on the leadership to achieve new dimensions (Vahnani, 2015). Innovation is formed in a social, political, and institutional context strongly tied to the economic features of each region (Deloreux and Parto, 2005). Interactions among different sectors of the region, including technical, commercial, legal, social, and financial ones, can contribute to the development, protection, funding, and legislation of innovation and technology. Innovation is a process dependent on geography and region where local capabilities like resources, institutions, and public and cultural values are the key drivers. Generally, various regions and countries can ensure a mid-run and long-run development by making changes in the type of innovation management (Ferrara et al., 2012).

In this respect, by time, experience, goal, and capabilities, human capital can play a bold role in the performance of innovation. Innovation by human capital, as mainstream in the economic literature, came into being in the early 1960s, when economists attempted to provide a convincing explanation for a significant unexplained portion of economic growth (Sultani Firouz & Isapour, 2012). However, in the late 1980s, human capital was included in economic growth patterns as a factor of production. The lack of innovation is one of the main reasons for the low economic growth rate in developing countries. This and the efficiency and proficiency of the workforce and capital do not increase until these countries promote the innovation and necessary training on how to use science and knowledge and increase the level of professional skills(Shahabadi et al., 2014). Therefore, human power, or in other words, human capital is considered the most important factor in gaining competitive privilege among countries and is the main intangible asset. It also can be considered as a basis for improving the quality and productivity of all economic processes (Alexandru & Hudson, 2005).

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

On the other hand, economic growth is a common goal of every economy. The reason is achieving many privileges and interests, which can be realized through economic growth. Economic growth means a steady increase in GDP. In this regard, training is the main axis for economic growth. The experiences of the developed countries show that physical capital and working population are not enough for explaining the economic growth rate. Some other factors can be mentioned. Such factors, called residual factors, are the main reasons for increasing the productivity of capital and human power (Emadzadeh et al, 2011). Until now, capital has been the first concept and effective factor in economic growth in growth patterns. Changes in production or economic growth were explained by changes in the physical capital accumulation in this way that it was expected that higher physical capital accumulation in a country would lead to more increase in its economic growth. However, the experiences of the developed countries in the economic growth during the time or among countries indicated that the economic growth rate, which is only explainable by conventional factors such as capital and labor, would not be fruitful and the human capital, as a main variable, should be included in the growth models. Thus, the fact is that not all economic changes can be explained by physical capital accumulation (Paseban, 2013). Therefore, it is very important to pay attention to all capital, especially human capital. In fact, from an economic theories perspective, the role of human capital in the process of economic growth has undertaken remarkable changes. These changes have a diverse range where a concept called workforce or labor on one end and it is only evaluated through physical capabilities and human capital is on the other end which is the result of the accumulation of knowledge, skills as well as experience(Mahdavi & Barkhordari, 2013). Thus, to achieve the main goals of this research, the following hypotheses were addressed and tested:

H_1: Human capital has a significant effect on the number of patents in MENA countries

H_2: Population density in some age groups has a significant effect on the number of patents in MENA countries

H_3: Human capital has a significant effect on GNP in MENA countries

In today's economy, knowledge and expertise is the basis of wealth creation. Using elements of innovation (knowledge and information), the countries can create wealth. Thus, economic experts have directed their attention toward innovation as a necessary component to improve the life level and well-being of people and societies. In general, Innovation means changing an idea to a product or a new service to achieve economic privilege. Human capital is one of the variables, which is highly effective in innovation in a region. This paper is to investigate the long-run influences of human capital on innovation and economic growth in MENA countries. In the rest of the paper, some studies in this field have been noticed. Paseban (2013) investigated the effect of human capital on the economic growth of MENA countries. The results showed that there was a positive, significant relationship between the human capital index and the economic growth of MENA countries. Shahabadi and colleagues (2013) investigated the determinants of innovation, emphasizing the human capital in the countries of the Organization of Islamic Cooperation. Their results showed that human capital, as a

variable did not influence innovation whether in general to in particular (basic education, university education, and research and development sector) manner.

Vahnani (2015) researched the effect of human capital on the performance of innovation, considering the mediating role of dynamic capabilities. Their findings showed that human capital and dynamic capabilities had a positive, significant influence on the performance of innovation and human capital had the same influence on dynamic capabilities. However, in external variable indicators, the effect of quantity, appropriateness, and complementarity on the ability to use opportunities was not significant. In their study, Besharati Kalaye et al. (2017) focused on the effect of human capital on innovation in developing and developed countries. They analyzed 113 countries in four income categories using data from the World Bank and the Global Innovation Index. The results obtained from each category showed that in (down top) moving towards development, attention should be paid to the skills and training of human resources according to the situations in each country. Kazerooni and others (2014) studied the influence of intellectual property rights and human capital on innovation in MENA countries. The results obtained from the estimation of the model indicated that human capital accumulation has a significant, positive influence on innovation, that is, the higher the level of an individual's education, the more innovation. Van Uden and colleagues (2014) investigated the relationship between human capital and innovation. They collected the data related to the selected countries (Kenya, Tanzania, and Uganda) obtained from a survey from the World Bank and concluded that there was a positive relationship between human capital and innovation.

McGuirk and others (2015) measured a concept called "innovative human capital" and its impact on small firms' propensity to innovate. There was evidence from the results that Innovative Human Capital may be more valuable to small firms (i.e. less than 50 employees) than larger-sized firms (i.e. more than 50 employees). The research expands innovation theory to include the concept of Innovative Human Capital as a competitive advantage and determinant of small firm innovation. Plinoskova (2015) analyzed the impact of human capital on the economic growth of EU countries. In that paper, the importance of human capital in ensuring (gross) economic growth was highlighted. The results showed there was a positive relationship between GDP per capita, the innovative capacity of human capital (confirmed by the number of patents), and employee conditions (secondary education). Chindo et al. (2015) conducted a research entitled "Human Capital, Technology, and Economic Growth: Evidence from Nigeria". The cointegration result revealed that all the variables in the two separate models were cointegrated. Furthermore, the results of the two estimated models showed that human capital had a significant positive impact on economic growth. Diebolt and Hippe (2019) investigated the long-run impact of human capital on innovation and economic development in the regions of Europe. This article made a connection between the past and the present. Using a large new dataset on regional human capital and other factors in the 19th and 20th centuries, they found that past regional human capital was the main factor, which explained present regional differences in innovation and economic development.

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

Methodology

By goal, this research is applied and by method, it is descriptive-analytical. The period is 2010-2012 and the geographical area is the countries of the MENA region. Therefore, the present study is to investigate the long-run influence of human capital on innovation and economic growth in MENA countries for the years 2010-2012. The data were collected using the library method from the World Bank database. The data were analyzed using statistical and econometric methods for panel data. The results obtained from this study showed that human capital had a positive, significant influence on innovation and economic growth in MENA countries. The same influence was observed for the population density in some age groups (more educated people) on the patents in MENA countries. For the contents related to the subject, the library method was used. For this purpose, books, magazines, articles, theses, etc. were referred to. The statistical data were analyzed using the panel data econometric method. Required statistics and information were extracted from the database of the World Bank website. In Table 1, the variables used in the models, their abbreviations, and the sources of the collection have been presented.

Table 1. Variables investigated in the research

Variable	Abbreviation	Source of data collection
Human capital	ABBC	World Bank website
population density	Population density	World Bank website
Number of patents	Patents/c	World Bank website
National production per capita	GDP/c	World Bank website
Literacy	Literacy	World Bank website
Death rate	Mortality	World Bank website
Birth rate	Fertility	World Bank website

In this study, the following model was used to investigate the long-run influence of human capital on innovation and economic growth (Diebolt and Hippe, 2019):

$$\text{In}(\text{Patents}/C_j) = \beta_0 + \beta_1 H_j + X_j + \varepsilon_j$$
$$\text{In}(\text{GDP}/C_j) = \beta_0 + \beta_1 H_j + X_j + \varepsilon_j \quad (1)$$

Where,

(Patents/c): number of patents per million

(GDP/c): GDP per capita

H: human capital index

X: control variables

Given the characteristics of the data including time series information and cross-sectional data, the panel data was used. Panel data analysis is very similar to variance analysis, which is mixed with a time series analysis as a multivariate, and then the effect of random or fixed factors in the model is examined. At times, the data we are dealing

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

with are both time series and cross-sectional. Both modes are identified using the F-Limer test. Thus, this test can be applied for selecting between pooled data regression methods (combined) and regression with fixed effects. Hausman test was also used to show the compatibility of a model with data, especially in econometrics. This test is based on the existence or non-existence of a relationship between the estimated regression error and the independent variables of the model.

Findings

First, the stationarity of the variables in the models was examined using Levin- The lin-Chu test. It is designed to test the null hypothesis of a common unit root in the panel versus the alternative of stationarity. It was performed for all the variables in the model and the results have been presented in Table 2, briefly. As the results show, the variables are static at the data level and their stationarity has no problem.

Table 2. Levin- Lin-Chu test to estimate the stationarity of the time series data

Series	Levin statistic	The level of significance	Obs
Human capital	-2.33	0.0097	170
population density	-2.06	0.0192	7
Number of patents	-6.20	0.0000	153
National production per capita	-3.03	-0.0088	170
Literacy	-4.06	0.0046	59
Death rate	-3.47	-0.0113	127
Birth rate			

The first model of the research examines the influence of human capital on innovation. It is at below:

$$\mathrm{In}(\mathrm{Patents}/\,C_j) = \beta_0 + \beta_1 H_j + X_j + \varepsilon_j \qquad (2)$$

In this section, the tests needed for estimating the model and the results are presented. The method of data estimation should be determined to use the proper research model for MENA countries. First, the F-Limer test is used to determine the existence or non-existence of the y-intercept for each country. As Table 3 shows, the F-Limer test with 5 and 24 degrees of freedom is statistically significant at the 95% confidence level, thus the group effects are accepted and various y-intercepts should be included in the estimation. Once it is confirmed that the y-intercept is different for each country, this hypothesis should be tested whether the fixed effects method or the random effects method can be used for determining the model. For this purpose, the Hausman test is used.

Table 3. The results of the F-Limer test to identify the pattern

F statistic	Degree of freedom	Probability
9.452	5, 24	0.0056

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

To test the possibility of determining the model using fixed effects or random effects, the Hausman test was used as follows. The results in Table 4 show that the 2-tailed test statistic is statistically significant at 95%. Thus, the null hypothesis is rejected. As a result, the random effects method is not appropriate and we should use the fixed effects method.

Table 4. the results of the Hausman test for selecting fixed effects or random effects

Chi-squared statistic	Degree of freedom	Probability
23.651019	3	0.0000

The first model of the research designed for estimating the influence of human capital on innovation is as follows:

$$\text{In}(\text{Patents}/\, C_j) = \beta_0 + \beta_1 H_j + X_j + \varepsilon_j \qquad (3)$$

In this model, the control variables are population density, death rate, and birth rate. In Table 5, the results of the model have been presented. As the results show, the coefficient of human capital is statistically at the significance level of 95%. It indicates that human capital in MENA countries contributes to the increase in the number of patents during the period of study. Moreover, in the case of the effect of the population density in age groups on the number of patents, it was highlighted that the results are statistically significant at the 95% confidence level. It indicated that human capital in MENA countries contributes to the increase in the number of patents during the period of study.

Table 5. the results of estimating the influence of human capital on the number of patents in MENA countries

	The estimation of the model using the fixed effect method		
	Coefficients	t statistic	Probability
Fixed Coefficient	0.331452	5.36524	0.0120
Human capital	0.023654	8.5201	0.008
Population density	0.23410	4.2354	0.007
Death rate	0.08941	2.3827	0.026
birth rate	0.017029	2.4849	0.021
Degree of freedom	1.4120	4.3301	0.000
R^2	0.602144		
Adjusted R^2	0.601362		
F statistic	7.62415		0.000321

The results reported for the death rate and birth rate are not statistically significant at the 95% significance level. It shows that these two variables in MENA countries have not led to an increase in the number of patents in these countries. The second model investigates the influence of human capital on economic growth. It is written as follows:

$$\text{In}(\text{GDP}/\, C_j) = \beta_0 + \beta_1 H_j + X_j + \varepsilon_j \qquad (4)$$

In this section, the tests needed for the estimation of the model and the results are presented. The existence or non-existence of the y-intercept was determined using the F-

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

Limer test. The results of the second model can be seen in Table 6. As the Table shows, because the F-Limer test with 5 and 24 DF is statistically significant at the 95% confidence level, group effects are accepted and the different y-intercepts are considered. Then, this hypothesis is tested that whether fixed effects or random effects should be used to estimate the model. For this purpose, the Hausman test is used.

Table 6. The results of the F-Limer test in the second model

F statistic	DF	Probability
6.406	5, 24	0.0037

To test whether fixed effects or random effects can be used to estimate the model, the Hausman test can be used as follows. As the results in Table 7 show, the chi-square test statistic is statistically significant at the 95% confidence level. Thus, the null hypothesis is rejected and the fixed effect method is better to use.

Table 7. The results of the Hausman test to select the fixed effect or random effects

$\chi 2$ statistic	DF	Probability
21.3245	3	0.0142

The second model for investigating the influence of human capital on economic growth is written below:

$$\text{In}(\text{GDP}/C_j) = \beta_0 + \beta_1 H_j + X_j + \varepsilon_j \qquad (5)$$

The results of estimating the model are presented in Table 8. As the Table shows, the variable coefficient of human capital is statistically significant at the 95% confidence level. This indicates that human capital in MENA countries has led to an increase in GNP in these countries during the studied period. In the cases of population density and birth rate, the results are statistically significant at the 95% confidence level, which shows these two variables in the region have led to the increase of GNP in the countries during the studied period. However, in the case of the death rate, the results are insignificant and this variable has been shown to not affect GNP.

Table 8: The results of the influence of human capital on GNP in MENA countries

The estimation of the model using the fixed effect method			
Explanatory variables	Coefficients t statistic	t statistic	Probability
Fixed Coefficient	0.062513	4.32014	0.000
Human capital	0.033145	5.66321	0.00236
Population density	0.18742	0.22145	0.002
Death rate	-0.02791	-0.21590	0.8293
birth rate	0.15304	6.16847	0.000
Degree of freedom	3.6254	4.2301	0.00142
R^2	0.640031		
Adjusted R^2	0.631523		
F statistic	9.6852		0.0000237

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603

Discussion and Conclusion

As it was shown in the findings section, three main hypotheses are confirmed. It means human capital has a positive, significant influence on the number of patents and the amount of GNP. In addition, the population density in some age groups has the same influence on the number of patents in MENA countries. Patents are often the output of R&D and the most important performance indicators of science and technology, which can indicate the effectiveness of R&D costs. Therefore, it can be considered as a main complement for other information sources to measure scientific and technological information of the countries. Inventions in MENA countries are of more importance because of the dependency of these countries on the source of oil income and it can help them exit from a one-product economy and improve growth and development. To achieve this aim, they need skillful and trained human resources. In today's competitive world, human capital has changed into a fundamental concept for companies and organizations and has strongly impacted their survival. Human capital is the most effective factor in organizational growth and survival. All organizations want to attract and, even more importantly, retain and develop the most competent individuals to do their current and future activities so that they can realize their predetermined goals and strategies. GNP is the most important variable used in the analysis and evaluation of the macroeconomy. It is a flow variable, which is defined as the annual Iranian Rial value of all final goods and services produced at current (market) prices in the national economy. In this respect, a country with efficient human capital can supply the final goods and services with the highest quality in the market and lead to an increase in GNP.

Education builds human capital, which includes the skills needed for the traditional and modern sectors of the economy. It also boosts the productive power of individuals. It increases financial income by creating the ability of productive power, particularly, in the labor force. The thesis of human capital theory is that education renders people more productive, which, in turn, increases economic growth. It has been confirmed in most domestic and foreign studies that human capital is the main dimension and capacity of economic growth and development. The difference in the growth rate among countries and its stability or instability is a phenomenon explained in various ways by growth theories. These theories attribute this difference to several factors. Most economists agree on this point that human capital is what ultimately determines the process of economic and social development of a country and the role and importance of human capital, in this case, is as much as physical capital. Such a role can be more understood if the prominent records of countries such as Japan, Taiwan, Hong Kong, South Korea, and other rapidly growing economies in Southeast Asia are considered. These countries most of which have fewer natural resources have been successful to experience rapid growth because of having experienced, skillful, trained, and hard-working workforce. Increasing and improving the indices related to human capital like level of literacy, the skills of employees, health and life expectancy, per capita income, and other ones in a country can both contribute to gaining economic benefits such as increasing productivity and realizing the goals of economic development and increase in efficiency. Thus, all countries should give importance to human capital and attempt to improve the indices related to it.

According to the results, countries that invest more in human resources and the fact their workforce has a higher level of technical and educational knowledge can invent

more products and supply them to global markets. To put it differently, developing international trade can be achieved by training the human force, which plays a very bold role in improving the productivity of all production factors and achieving higher economic growth. In this regard, it is recommended that MENA countries pay heed to this matter and have short-run and long-run plans to improve it. It is also recommended that countries pay heed to individual structures since human capital influences the number of patents. Because individual structures can lead to creating new ideas and aligning thoughts with the culture, they should not be neglected. Finally, MENA courtiers should support, financially and non-financially, research on basic sciences and academic research, which has public benefits and less private return. In this way, the motivation of research and development in the country can pave the way for economic growth and development in the long -run. For this aim, MENA countries should provide attractive educational and financial opportunities for intelligent and elite people so that they can contribute to the improvement of research, production of science, and development of knowledge and use their skills to realize the potential abilities of their countries. Moreover, different production institutions should be encouraged to invest in research and the use of effective human power and open the doors towards creating new ideas and desirable technologies.

References

Besharati Kalaye, F.; Moradi, M. A. and Akbari, M. (2017). The impact of human capital on innovation: a comparative study of developing and developed countries. *Quarterly magazine of strategic and macro policies*. Sixth year, twenty-second issue, 23-46.

Chindo, S,. Umar, Bala,. Bulama, Abiso, T,. Salisu, I,. W and Kabiru Maji, I. (2015). Human Capital, Technology, and Economic Growth: Evidence From Nigeria. SAGE Open.1-10.

Delmas, M., Pekovic, S. (2013). The engaged organization: Human Capital, Social Capital, Green Capital and Labor Productivity. ACAD MANAGE PROC, 1-31.

Diebolt, C & Hippe, R,. (2019) The long-run impact of human capital on innovation and economic development in the regions of Europe, Applied Economics, 51:5, 542-563.

Emadzadeh, M., Khosh Akhlaq, R., Sadeghi, M. (2011). The role of human capital in growth. Tehran: *Program and Budget Magazine*, No. 49, 50

Emadzadeh, M.; Dalali Esfahani, R.; Samadi, S. and Mohammadi, F. (2008). The effect of workforce quality on economic growth in selected countries. Quarterly scientific research *journal of quantitative economics* (former economic surveys), sixth period, 26-1

Hudson, J. and Alexandru, M. (2013), Innovation, Intellectual Property Rights, and EconomicDevelopment: A Unified Empirical Investigation, World Development Vol. 46, pp. 66-78.

Kazeroni, A.; Akbari, A. and Ashrafi, M. (2014). Investigating the impact of intellectual property rights and human capital on innovation in MENA countries. The second scientific research conference on new findings of management, entrepreneurship and education in Iran

Mahdavi, A., Barkhordari, S. (2013). Intellectual property rights and foreign direct investment flow. *Tehran: Knowledge and Development Magazine*, 15, 21, 11-31

McGuirk, H., Lenihan. H. & Hart, M. (2015). Measuring the impact of innovative human capital on small firms' propensity to innovate, Research Policy, 44, 965–976.

Niknami, M., Taqipour Zahir, A., Delawar, A., Ghafari Majalaj, M. (2014). Designing and evaluating the excellent model of creativity and innovation of educational managers in Tehran. Scientific-Research Quarterly New Approach in Educational Management, 2, 28, 5-1

Paseban, F. (2013). Investigating the impact of human capital on the economic growth of MENA countries. Master's thesis in economic sciences. Payame Noor university of Tehran

Shahabadi, A.; Sadeghi, H. and Amiri, B. (2013). The impact of human capital on the innovation of selected countries of the Organization of Islamic Cooperation. *Business Journal*, year 18, number 70

Soltani Firouz, N. and Isazadeh, S. (2011). Investigating the effect of social capital on innovation, a case study (comparison of selected MENA countries and the OECD group). The second student entrepreneurship conference of the country, Tehran

Vahnani, R. (2015). Investigating the human impact on innovation performance considering the mediating role of dynamic capabilities. Thesis of Master of Business Administration, Marketing major. Khatam non-governmental non-profit university

Van Uden, A., Knoben, J. & Vermeulen, P. (2014). Human Capital and Innovation in Developing Countries: A Firm Level Study, working paper for Institute for Management Research (Radboud University)

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7760603
www.ijmae.com

HOW TO CITE THIS ARTICLE

Mirhoseyni, S. V., Izadi, S. H., & Mohammad Ghader, L. (2023). Investigating the Long-run Influences of Human Capital on Innovation and Economic Growth in MENA Countries. *International Journal of Management, Accounting and Economics*, *10*(2), 122-134.

DOI: 10.5281/zenodo.7760603

DOR: 20.1001.1.23832126.2023.10.2.2.7

URL: https://www.ijmae.com/article_168682.html

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

Original Research

Evolutionary Path of Responsible Research and Innovation: Opening the Black Box of RRI

Akbar Mohammadi[1]
Faculty of Management, University of Tehran, Tehran, Iran

Sahar Babaei
Faculty of Accounting, Allameh Tabatabaei University, Tehran, Iran

Received 8 July 2022 Revised 2 March 2023 Accepted 25 March 2023

Abstract

In the new generation of entrepreneurial and community-based universities, their role in solving social issues and socializing has become much more essential. If universities and scientific institutions want to take action in this direction more than before, it is necessary to gain an accurate understanding of the insights and dimensions of social responsibility in research and innovation. In this study, we seek the main concepts in the field of Responsible Research and Innovation (RRI). We have opened the black box of it through systematic literature review(SLR) and Scientometrics Analysis(SA). This study shows that the Responsible Research and Innovation concept has been evolving in recent years with the development of scientific concepts such as social innovation, corporate social responsibility, and university social responsibility. In this study, the selected articles identified by the SLR method from different textual dimensions and the emergence of new concepts are analyzed. In this study, 33 concepts in 8 different themes in the black box of RRI were identified based on the SLR method. Also, based on the Scientometric analysis and word occurrences analysis, the 10 most used words were identified. Finally, through a collaborative review, 5 key concepts for this area have been identified. These concepts are public engagement, sustainability, ethics, governance, and RRI. Breaking the black box of this concept in this article can shed some light on the literature in this field and reduce its complexity.

Keywords: Responsible Research and Innovation (RRI), Black Box, Systematic Literature Review (SLR), Scientometric Analysis (SA), Public Engagement, Sustainability.

[1] *Corresponding author's Email: imohammadi@ut.ac.ir*

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

Introduction

One of the most important issues in different societies is to determine the appropriate way of governing science and technology to realize the concept of responsible research and innovation. Accountability of universities and research institutes in developing countries, which are mostly government-oriented structures, is one of the challenges. The integration of this concept in the science and technology policy structures of these countries can lead to appropriate paths of development and reduction of society and industry issues.

Responsible research and innovation is a transparent and interactive process in which actors and innovators of society are held accountable based on acceptance (ethical), sustainability and social desirability, based on the process of innovation and marketable products. (In order to institutionalize scientific and technological advances in society) (René Von Schomberg, 2012; Rene Von Schomberg, 2013). While the origins of RRI date back to the early 1990s, the concept has received a great deal of attention since 2011 in the European Union (EU)'s policy and research communities (Owen, Macnaghten, & Stilgoe, 2012). The concept of RRI has been challenged by discourses on emerging technologies and research ethics in innovative fields(Owen & Goldberg, 2010). It has been driven by EU's research and innovation policy over the past few years(Auer & Jarmai, 2018). RRI can be considered as a concept that has been developed to expand the scope of policy-making, to show the path of innovation and to determine the role of actors in society (Burget, Bardone, & Pedaste, 2017; Levidow & Neubauer, 2014). The concept of RRI is an attempt to promote a new method of governance in the direction of research and innovation. This method has been described as "a way to think more systematically about the general benefits of scientific and technological research."(Baldwin et al., 2013; Timmermans, Yaghmaei, Stahl, & Brem, 2017).

There are several definitions of the main factors of RRI discourse. Von Schomberg defined RRI as "a design strategy that drives innovation and achieves the desired goals of society" (Rene Von Schomberg, 2013). Most researchers in the definition of RRI have emphasized von Schomberg's definition(Bremer, Millar, Wright, & Kaiser, 2015; Mohammadi & Babaei, 2022; Mohammadi & Mohammadi, 2021). Stahl (2013) considers RRI as a trans-responsibility that defines the concept as follows (Bisheh, 2022; Stahl, 2013):

"RRI is a macro-level responsibility or trans-responsibility that aims to shape, maintain, develop, coordinate and align existing and new processes related to research and innovation, actors and responsibilities in order to ensure desirable and acceptable research results "

RRI explicitly addresses issues of social development, social justice, and the extension of STI benefits. However, it is rarely articulated about this concepts in the subject literature (Ribeiro et al., 2018). RRI emphasize the importance of governance in innovation process (especially in the field of key stakeholders interaction and the need for inclusive and sustainable development) in the field of regional development (Thapa, Iakovleva, & Foss, 2019). Another important definition stems from another policy

document issued in 2013 (p. 3) by the European Commission (EC) entitled " Options for strengthening responsible research and innovation". In recent years, another comprehensive definition has been provided as follows:

RRI is a policy-driven discourse that has been grounded in the EC since 2011. At the macro level, its goal is to foster a comprehensive and sustainable research and innovation plan, with an emphasis on co-creation with society ("Science with society and for society") (Owen & Pansera, 2019).

Based on the EU's RRI Framework for Horizon 2020, RRI became a formal issue, and project funding began in the Science for Society program (now known as Science with and for Society). Therefore, in 2014, the mainstream RRI was introduced throughout the EU region through the "Rome Declaration on RRI" project (Thapa et al., 2019).

In this study, based on a systematic literature review(SLR) and scientometric methods, the growing path of the Responsible research and Responsible innovation in the literature is investigated. In this paper, new concepts in the field of responsible innovation and responsible research are analyzed by SLR and Sientometric analysis.

If the concept of RRI is to be considered as a concept recognized in other countries and other research initiatives and fields, it must be able to take significant relevant action. Participating and interacting with global science and technology actors and their distinct needs can work for nations where the RRI discourse is underdeveloped and not considered a priority. To be able to make innovation and research transparent and responsible (Macnaghten et al., 2014).

The EC described six distinct dimensions termed as follows: engagement, gender equality, science education, ethics, open access and governance (‘‘Regulation (EU) No 1291/2013,’’ 2013). Of course, the concept of ethics and some other related issues in science, technology, research and innovation is not a new topic in general, but the concept of RRI has recently been introduced to include responsibility in research and innovation policies and methods (Flick, 2016; Stilgoe, Owen, & Macnaghten, 2013).

Stahl (2013) focused his research on the practical implementation of the dimensions that arise for actors, norms, and activities. Various authors have referred to previous dimensions that were not originally associated with RRI (Stahl, 2013). Stilgoe et al. (2013) mentioned four dimensions that were raised during the general debates: anticipation, inclusion, reflexivity, and responsiveness. This framework for RRI focuses on four integrated dimensions(Stilgoe et al., 2013). This classification was adapted and adopted by the UK Engineering and Physical Sciences Research Council to form the AREA (anticipation, reflection, engagement and action) framework(Owen, 2014). Stilgoe et al, proposed a broader definition of RRI ‘taking care of the future through collective stewardship of science and innovation in the present’ in 2013 (Stilgoe et al., 2013).

Despite various studies conducted in the field of responsible innovations and researches, there has not been an appropriate study on the process of manuscripts production in this regard. The identification and scientometric analysis in this regard can

raise new insights on the research process of this field and the emergence of new concepts. These issues need further investigation and trying to be addressed in this study.

Methodology

In this paper, a comprehensive scientometric study in the field of responsible research and responsible innovation has been conducted. In the first step, ISI papers in related fields were extracted from the WOS database. In the next step, after initial screening and identification of related articles in terms of title, abstract and content, the final articles were analyzed based on an analytical-process package called "Bibliometrix" in R software. This analytical-process package is a tool for quantitative research in the field of scientometrics that is used for statistical analysis of articles extracted from citation databases. These statistical analyzes that have been used in this study have been in the fields of analysis of scientific collaborations of researchers, co-citation and synergies between scientific activities. These statistical analyzes have been performed on scientific collaborations of researchers, co-citations and synergies between scientific activities(Aria & Cuccurullo, 2017).

In the first search on the Web of Science citation database, the keywords "Responsible Research" and "Responsible Innovation" were searched. 861 articles were identified in English between 1990 and 2021. Then, in the first screening step, 648 articles were selected based on the subject area and journals. In this step, only articles related to management and social sciences were selected. duplicates were eliminated. Also, in the next screening, from the perspective of reviewing the title and abstract, 572 articles were finally selected for scientometric analysis in the field of responsible research and responsible innovation.

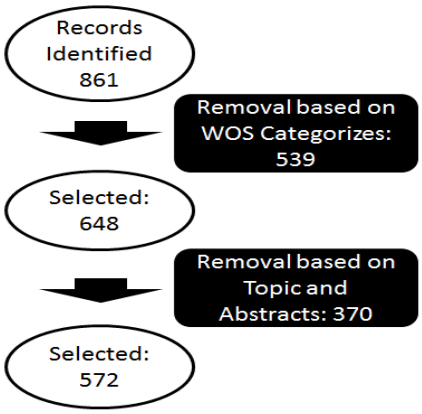

Figure 1. Flow diagram of article selection

Scientometrics is a tool for quantitative analysis and statistical evaluation of documents such as journal papers and the number of citations. Today, these analytical methods are used to assess the growth rate of concepts, leading authors, and the mind and concept maps of research. These tools can also be used to identify the evolution of scientific societies and evaluate research performance in various fields. The existence of effective statistical algorithms, access to quality numerical routines as well as integrated information imaging tools are the most important qualitative features that make

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

researchers prefer R programming language to other languages for scientific computing (Aria & Cuccurullo, 2017).

A. Descriptive statistics of selected articles

Based on the results of scientific search and screenings, the descriptive statistical information of the selected papers is presented in Table 1.

Table 1. The descriptive statistical information of the selected papers

Description	Value
Articles	572
Period	1990:2021
Average citations per documents	11.22
Authors	2037
Author Appearances	2411
Authors of single authored documents	121
Authors of multi authored documents	1916
Documents per Author	0.28
Authors per Document	3.52
Co-Authors per Documents	4.17

As shown in Table 1, based on scientometric analysis, 572 selected articles of this research were analyzed. Indicators of mean citation and co-authorship are also expressed. Out of 572 selected articles, 94 are related to the journal entitled: "Journal of Responsible Innovation". The 10 journals with the most selected articles in the field of social innovation and social responsibility are listed in Table 2 along with the number of articles included.

Table 2. The 10 journals with the most selected articles in the field of social innovation and social responsibility

Sources	Articles
Journal of Responsible Innovation	94
Science and Engineering Ethics	38
Sustainability	33
Nanoethics	29
Science and Public Policy	12
Technological Forecasting and Social Change	10
Research Policy	9
Ethics And Information Technology	8
Journal of Agricultural & Environmental Ethics	8
Science Technology and Society	8

The results of reviewing the references of 572 selected articles showed that 724 referenced articles were from the journal entitled: "Journal of Responsible Innovation".

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

There are also 619 articles cited in the journal entitled: "Research Policy". Table 3. shows the journals with the most citations.

Table 3. The summary of the most cited journals

Sources	Articles
Journal of Responsible Innovation	724
Responsible Iinovati	640
Research Policy	619
Science and Engineering Ethics	450
Science And Public Policy	409
Nature	313
Science, Technology, & Human Values	312
Sustainability	264
Public Understanding of Science	262
Technological Forecasting and Social Change	256

There are various software tools that help researchers analyze scientometrics, but some of them are much more widely used. Among them can be software tools are Biblioshiny (Mohammadi & Babaei, 2022).

Findings

In this section, with the help of scientometric tools, the growing trend of attention in the development of scientific manuscripts in the responsible research and responsible innovation fields is described. The interactions of different authors and their scientific achievements in this area in various journals leads us to identifying the new impression of emerging concepts in this area.

Based on the Co-Citation Network, researchers' citation network can be observed in the field of scientific production of responsible innovation and responsible research. Scientific articles of researchers such as Stilgoe, 2013, Owen, 2012 and Von schomberg, 2013 have the highest density in the rate of co-citation in the network. These articles promote strong networks around themselves by presenting the basis of scientific discussions on innovation and responsible research.

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

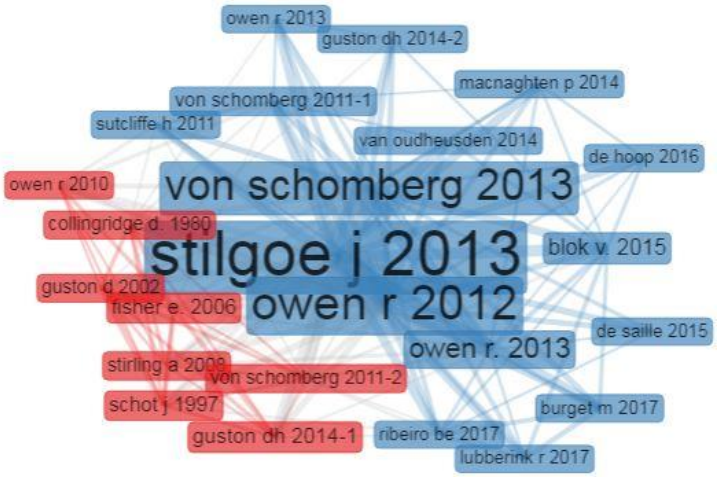

Figure 2. Co-Citation Network

Based on the keyword analysis of 572 selected articles, the results in terms of words occurrence are shown in Table 4. The new concept of "Responsible research and innovation" ranks first with 160 repetitions in articles. The keyword "Responsible innovation" has since been repeated 120 times. The keywords "Ethics" and "Governance" are also in the next categories.

Table 4. Words Occurrence in Selected Papers

Words	Occurrences
Responsible Research and Innovation	160
Responsible Innovation	120
Ethics	44
Governance	37
Nanotechnology	26
RRI	26
Innovation	25
Synthetic Biology	24
Sustainability	23
Public Engagement	22

Figure 4. obtained with the help of R software tools, shows well that in the scientific literature in the field of responsible innovation and responsible research, new concepts such as sustainability, ethics, public engagement, governance and innovation have been able to play more prominent roles. These issues can be very significant for relevant stakeholders at the relevant academic and executive levels.

Various concepts in recent research of universities and scientific centers are about sustainability proposed. Environmental innovation, sustainability innovation (Auer & Jamai, 2018) and regional sustainable development (Thapa et al, 2019) have been proposed by researchers in this field. Nowadays, considering ethics in research and the effectiveness of research ethics in solving social problems is very necessary (Decker et

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

al, 2018, Flick et al, 2015, Stahl, 2013, Van den Hoven et al, 2012, Decker et al , 2018). It has been suggested that communities (Ribeiro et al, 2018), different stakeholders (Timmermans et al, 2017) and finally the society (Levidow & Neubauer, 2014) participate in various studies. Table 5 shows the set of concepts identified from the systematic literature review and their classification into 8 themes.

Table 5. Identified Themes and Concepts based on SLR

Themes	Concepts	Refrences
Sustainability	Eco-Innovation	Auer & Jamai, 2018
	Sustainability Innovation	Auer & Jamai, 2018
	Sustainable Regional Development	Thapa et al, 2019
Ethics	Dynamics of Ethics	Decker et al, 2018
	Sufficient Ethical	Flick et al, 2015
	Ethics	Stahl, 2013
	Integration of Ethical	Van den Hoven et al, 2012
	Global Ethics	Decker et al, 2018
Engagement	Society Engagement	Ribeiro et al, 2018
	Stakeholder Engagement	Timmermans et al, 2017
	Public Engagement	Levidow & Neubauer, 2014
Social Integration	Societal Alignment	Ribeiro et al, 2018
	Mutual Respect	Decker et al, 2018
	Mutual Understanding	Decker et al, 2018
Stakeholders Commitment	Overarching Commitment	Macnaghten et al, 2014
	Pledges to Broader Concerns	Stahl, 2013
	Higher Level Responsibility	Stahl, 2013
Governance in STI Transition	Socioeconomic Transformation	Thapa et al, 2019
	Governance of STI	Ribeiro et al, 2018
	Governance of Socially Controversial Technologies	Macnaghten et al, 2014
	The Sociotechnical Nature of Innovation	Wiarda et al, 2021
	Responsible Governance	Fosberg et al, 2015
	Work Packages on Ethical, Social & Legal Issues	Stahl, 2013
	Anticipant Governance	Sutcliffel, 2011
Synergy and Convergence	Community's Collective Productivity	Wiarda et al, 2021
	Science in Society	Decker et al, 2018
	Integrating in Organizational Routines	Timmermans et al, 2017
New Research Natures	Research Integrity	Stahl, 2013
	Awareness Structure	Stahl, 2013
	Professionalism	Stahl, 2013
	Social Goods	De Saille, 2014
	Networks of Responsibility	Timmermans et al, 2017
	Desirable Research Outcomes	Stahl, 2013

The degree of ability to develop social interactions is essential in conducting purposeful and effective research. Social alignment(Ribeiro et al., 2018). towards the relevant research, the existence of mutual respect (Mohammadi, 2021) in such research and finally the creation of mutual understanding (Forsberg, Shelley-Egan, Ladikas, & Owen, 2018) in these studies is very important. Also, the existence of commitment in various stakeholders, especially researchers, can significantly help the research to be more effective in solving social problems. Creating a comprehensive commitment(Macnaghten & Owen, 2011), the commitment to create more concerns about existing issues and having more responsibilities in relation to the situation (Stahl, 2013), fall within the scope of these commitments.

The transition in science, technology and innovation will require more complex governance in the new context. In this regard, various researchers have proposed various concepts and discussed their characteristics and different conditions. Socioeconomic Transformation (Tavakoli, Babaei, & Sajadieh, 2020; Thapa et al., 2019), Governance of STI (Babaei & Tavakoli, 2017), Governance of Socially Controversial Technologies (Macnaghten & Owen, 2011), The Sociotechnical Nature of Innovation(Liang & Wang, 2021), Responsible Governance (Forsberg et al., 2015), Work Packages on Ethical, Social & Legal Issues(Stahl, 2013), and Anticipant Governance (Rene Von Schomberg, 2011) are among them.

Convergence and synergy in research are also necessary to enhance the role of science in society and increase collective productivity (Forsberg et al., 2018). Of course, this requires that research results be integrated at different organizational levels in society (Timmermans et al., 2017). To succeed in increasing the effectiveness of research in solving social issues, it is necessary to pay attention to the different nature of science and responsible research (Davies & Horst, 2015).

Conclusion

This study has generally been done on the emergence of new concepts and evolution of concepts related to responsible research and innovation. In this article, we have also stated the managerial implications for implementing these concepts in scientific institutions. Examining the challenges of implementing innovation models and responsible research in educational and research institutions and policy making related to them can be considered as complementary axes in future studies. Identifying the mechanisms and processes of implementing RRI and designing appropriate managerial functions is also suggested as future research in this field.

One of the most important aspects of RRI is to create a new model for the Science and technology governance. The main question of the present article is what are the new scientific concepts and paths for the realization of RRI? What are the practical and managerial conditions for the rule of science in the framework of RRI? And with what changes can these conditions be met in the governing system of universities? Our research on responsible innovation and responsible research outlines their overall approach to how science's responsibilities take precedence over social, moral, and environmental values. The ultimate goal of the development of this field of literature is to create a common responsible paradigm between science, policy-making and society in all elements of

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7783496
www.ijmae.com

society so that all people can enjoy the benefits of science and technology in a balanced way (EU, 2020). One of the most important issues that researchers and policy makers now face is the development of theoretical and creative ideas of RRI into practice and the responsibility implementation in the field of research and innovation. This study is also designed to help these researchers and policy makers in clarifying the path of operationalization of ideas to operationalize the responsibility of science and technology. Achieving this goal has been done by reviewing the results presented in recent years in this regard based on scientometric analyzes. Therefore, in order to research and policy in the field of research and responsible innovations, emerging scientific paths have been identified and introduced based on paper analysis. Understanding emerging concepts in the literature can design different and new paths for researchers and policy makers to design patterns and processes for research responsibility. The EC has also emphasized the need for new structural, executive and operational perspectives in this regard by introducing the concept of new patterns of scientific governance based on RRI. Accountability of educational and research centers, including universities and research institutes, along with the need for the participation of different sections of society, are general principles that emphasize the creation of new models of governance in RRI.

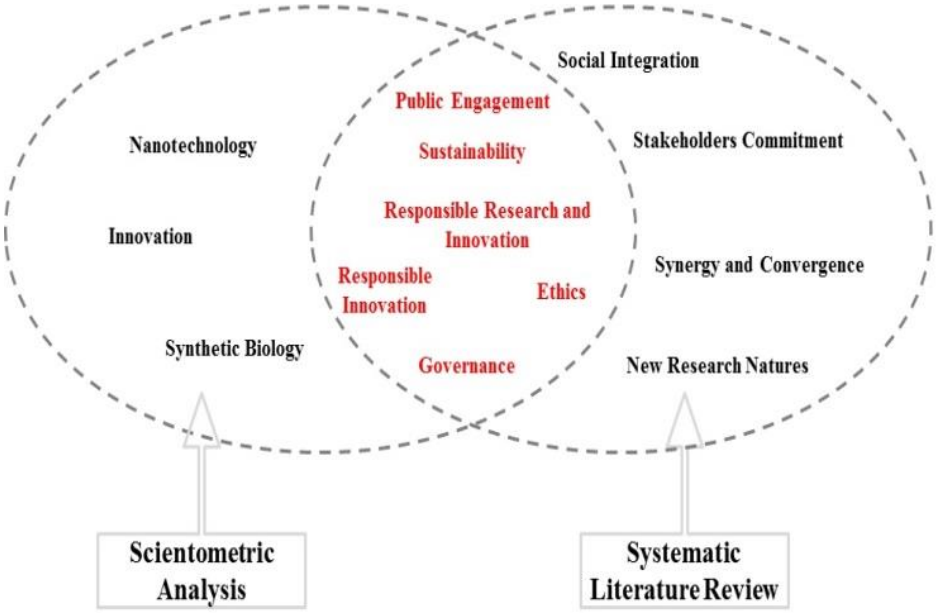

Figure 5. Concepts identified through SLR and Scientometric Analysis

Figure 5 shows the results of the study of concepts in the field of responsible research and responsible innovation in universities and scientific centers. The concepts shown in red have been identified as key concepts in the field of responsible research and responsible innovation, both in terms of Biblioshiny analysis and in terms of systematic literature review and duplicate code extraction. These include social participation, research ethics, and the various dimensions of the governance of science, technology, and innovation, sustainability, and responsible research and innovation (RRI).

This study has generally been done on the emergence of new concepts related to RRI. In this article, we gain insights to better conduct RRI in our societies for implementing

these concepts in scientific institutions. Examining the challenges of implementing innovation models and responsible research in educational and research institutions and policy making related to them can be considered as complementary axes in future studies. Identifying the mechanisms and processes of implementing RRI and designing appropriate managerial functions is also suggested as future research in this field. first of all, based on the SLR method, identified scientific articles in the field of responsible innovation and responsible research from the WOS database. Then, with screenings and selection of 572 articles, the second step was performed based on the steps of analysis using scientometric tools. With the introduction of the above concepts from the EU in recent years, today, the field of RRI has expanded rapidly in developing Asian countries as a growing necessity. This issue should be considered at the academic level as well as the relevant executive levels in different countries. RRI is one of the newest areas that is now widely discussed by researchers in the field of science, technology and innovation (STI) studies. Some researchers have introduced this concept as a new paradigm shift in the field of science, technology and innovation studies (Roco, Harthorn, Guston, & Shapira, 2011). Our research on responsible innovation and responsible research outlines their overall approach to how science's responsibilities take precedence over social, moral, and environmental values. The ultimate goal of the development of this field of literature is to create a common responsible paradigm between science, policy-making and society in all elements of society so that all people can enjoy the benefits of science and technology in a balanced way (Parliament & Union, 2013).

In this study, based on the SLR method, 33 concepts in 8 different themes for responsible research and responsible innovation were identified. Also, based on the scientometric analysis and word occurrences analysis, the 10 most used words were identified. Finally, through a collaborative review, 5 key concepts for this area have been identified and introduced. These 5 concepts include public engagement, sustainability, ethics, governance and RRI.

The results of this study show that significant changes in the exploration of research are underway. The emergence of the RRI concept also emphasizes the same. Of course, these concepts are interacting with each other and has many shares. But what is clear is the growing process of attention to these concepts. This issue is also growing in developing countries. New concepts in different areas of social engagement, citizen sciences, ethics and social responsibility are growing more than other areas. Therefore, the result of this study shows that scientific production based on this social need is grow.

References

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of informetrics, 11*(4), 959-975.

Auer, A., & Jarmai, K. (2018). Implementing responsible research and innovation practices in SMEs: Insights into drivers and barriers from the Austrian medical device sector. *Sustainability, 10*(1), 17.

Babaei, S., & Tavakoli, G. (2017). Deriving basic rationalities in public policy making process. *Iranian Journal of Public Policy, 3*(1), 63-82.

Baldwin, T., Fitzgerald, M., Kitzinger, J., Laurie, G., Price, J., Rose, N., . . . Warwick, K. (2013). Novel neurotechnologies: Intervening in the brain. *Nuffield Council on Bioethics: London, UK*.

Bisheh, M. N. (2022). *Machine learning modeling for image segmentation in manufacturing and agriculture applications.* Kansas State University.

Bremer, S., Millar, K., Wright, N., & Kaiser, M. (2015). Responsible techno-innovation in aquaculture: Employing ethical engagement to explore attitudes to GM salmon in Northern Europe. *Aquaculture, 437*, 370-381.

Burget, M., Bardone, E., & Pedaste, M. (2017). Definitions and conceptual dimensions of responsible research and innovation: A literature review. *Science and engineering ethics, 23*(1), 1-19.

Davies, S. R., & Horst, M. (2015). Responsible innovation in the US, UK and Denmark: Governance landscapes *Responsible Innovation 2* (pp. 37-56): Springer.

Flick, C. (2016). Informed consent and the Facebook emotional manipulation study. *Research Ethics, 12*(1), 14-28.

Forsberg, E.-M., Quaglio, G., O'Kane, H., Karapiperis, T., Van Woensel, L., & Arnaldi, S. (2015). Assessment of science and technologies: Advising for and with responsibility. *Technology in Society, 42*, 21-27.

Forsberg, E.-M., Shelley-Egan, C., Ladikas, M., & Owen, R. (2018). Implementing responsible research and innovation in research funding and research conducting organisations—What Have we learned so far? *Governance and sustainability of responsible research and innovation processes* (pp. 3-11): Springer.

Levidow, L., & Neubauer, C. (2014). EU research agendas: Embedding what future? *Science as Culture, 23*(3), 397-412.

Liang, T., & Wang, H. (2021). Consumer decision-making and smart logistics planning based on FPGA and convolutional neural network. *Microprocessors and Microsystems, 80*, 103628.

Macnaghten, P., & Owen, R. (2011). Good governance for geoengineering. *Nature, 479*(7373), 293-293.

Macnaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., de Campos, A., . . . Frow, E. (2014). Responsible innovation across borders: tensions, paradoxes and possibilities. *Journal of responsible innovation, 1*(2), 191-199.

Mohammadi, A. (2021). Responsible Research and Innovation (RRI): Scientometric Analysis. *European Public & Social Innovation Review, 6*(2), 64-77.

Mohammadi, A., & Babaei, S. (2022). *Responsible Research and Responsible Innovation: Have new concepts emerged?* Paper presented at the 2022 IEEE 28th

International Conference on Engineering, Technology and Innovation (ICE/ITMC) & 31st International Association For Management of Technology (IAMOT) Joint Conference.

Mohammadi, A., & Mohammadi, S. (2021). Providing a conceptual model for the innovation strategy by using scenariobased technology roadmap in context of smart logistic system. *Journal of Organizational Culture, Communications and Conflict, 25*, 1-12.

Owen, R. (2014). The UK Engineering and Physical Sciences Research Council's commitment to a framework for responsible innovation. *Journal of responsible innovation, 1*(1), 113-117.

Owen, R., & Goldberg, N. (2010). Responsible innovation: a pilot study with the UK Engineering and Physical Sciences Research Council. *Risk analysis: An international journal, 30*(11), 1699-1707.

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. *Science and public policy, 39*(6), 751-760.

Owen, R., & Pansera, M. (2019). Responsible innovation and responsible research and innovation *Handbook on science and public policy*: Edward Elgar Publishing.

Parliament, E., & Union, t. C. o. t. E. (2013). Regulation (EU) No 1291/2013 of The European Parliament and of The Council of 11 December 2013 establishing Horizon 2020—the Framework Programme for Research and Innovation (2014–2020) and repealing Decision No 1982/2006/EC. Off J Eur Union; L 347/104–173. *Official Journal of the European Union, 20*(12), 2013.

Ribeiro, B., Bengtsson, L., Benneworth, P., Bührer, S., Castro-Martínez, E., Hansen, M., . . . Ott, C. (2018). Introducing the dilemma of societal alignment for inclusive and responsible research and innovation. *Journal of responsible innovation, 5*(3), 316-331.

Roco, M. C., Harthorn, B., Guston, D., & Shapira, P. (2011). Innovative and responsible governance of nanotechnology for societal development *Nanotechnology research directions for societal needs in 2020* (pp. 561-617): Springer.

Stahl, B. C. (2013). Responsible research and innovation: The role of privacy in an emerging framework. *Science and public policy, 40*(6), 708-716.

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research policy, 42*(9), 1568-1580.

Tavakoli, G., Babaei, S., & Sajadieh, A. (2020). An Explanation and Analysis of the Indicators of Good Governance in the Ministry of Defense and Iranian Armed Forces Logistics. *Defensive Researches and Management, 19*(87), 73-102.

Thapa, R. K., Iakovleva, T., & Foss, L. (2019). Responsible research and innovation: a systematic review of the literature and its applications to regional studies. *European Planning Studies, 27*(12), 2470-2490.

Timmermans, J., Yaghmaei, E., Stahl, B. C., & Brem, A. (2017). Research and innovation processes revisited–networked responsibility in industry. *Sustainability Accounting, Management and Policy Journal*.

Von Schomberg, R. (2011). Towards responsible research and innovation in the information and communication technologies and security technologies fields. *Available at SSRN 2436399.*

Von Schomberg, R. (2012). Prospects for technology assessment in a framework of responsible research and innovation *Technikfolgen abschätzen lehren* (pp. 39-61): Springer.

Von Schomberg, R. (2013). A vision of responsible research and innovation. *Responsible innovation: Managing the responsible emergence of science and innovation in society*, 51-74.

HOW TO CITE THIS ARTICLE

Mohammadi, A., & Babaei, S. (2023). Evolutionary Path of Responsible Research and Innovation: Opening the Black Box of RRI. *International Journal of Management, Accounting and Economics*, *10*(2), 135-148.

DOI: 10.5281/zenodo.7783496

DOR: 20.1001.1.23832126.2023.10.2.5.0

URL: https://www.ijmae.com/article_168950.html

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7790265
www.ijmae.com

Research Note

Mixed Duopoly, Privatization and Subsidization: Complementary Goods

Kazuhiro Ohnishi[1]
Department of Economics, Institute for Economic Sciences, Kobe, Japan

Received 7 February 2023 Revised 10 March 2023 Accepted 17 March 2023

Abstract

This paper uses a mixed market model in which a state-owned public firm and a private firm produce complementary goods and reassesses the welfare effects of production subsidies. The paper examines four regimes: mixed and private duopoly, each with and without subsidies. In the regimes without subsidies, a one-shot Cournot-Nash game is considered. In the regimes with subsidies, the following two-stage game is considered: At the first stage the government chooses the subsidy level to maximize social welfare, and at the second stage each firm observes the subsidy and simultaneously chooses its output level. The paper presents the following two main results. First, if production subsidies are used only before privatization, then there is a reduction in social welfare. Second, if production subsidies are used before and after privatization, then social welfare is not changed by privatization. The paper finds that the results are the same as those obtained by White (1996) that examines the welfare effects of production subsidies in a Cournot mixed market with homogeneous goods.

Keywords: Complementary goods, mixed market, privatization, subsidy.

[1] *Corresponding author's Email: ohnishi@e.people.or.jp*

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7790265

Introduction

As is very well known, the trend of privatization of public firms has been increasing worldwide since the nineteen-eighties. Therefore, the theoretical research on privatization is often done in the context of mixed oligopoly models where private firms compete with state-owned public firms (for example, see Anderson, de Palma, & Thisse, 1997; Bárcena-Ruiz & Garzón, 2005; Bosi, Girmens, & Guillard, 2005; Chang, 2005; Chao & Yu, 2006; Dadpay, 2014; Fjell & Pal, 1996; George & La Manna, 1996; Gronberg & Hwang, 1992; Han & Ogawa, 2008; Kato & Tomaru, 2007; Kim, Lee, & Matsumura, 2019; Mujumdar & Pal, 1998; Myles, 2002; Ohnishi, 2012, 2021; Pal & White, 1998; Poyago-Theotoky, 2001; Sasaki & Wen, 2003; Wang, Wang, & Zhao, 2009; White, 1996). For instance, White (1996) presents three effects of production subsidies in a quantity-setting mixed oligopoly market. First, if production subsidies are utilized before and after privatization of a state-owned public firm, then privatization does not change social welfare. Second, if production subsidies are used before but not after privatization, then there is a reduction in social welfare. Third, the production subsidy contributes to overall efficiency in a mixed market because of cost distribution effects. Poyago-Theotoky (2001) and Myles (2002) show that the optimal production subsidy is identical irrespective of whether (i) a state-owned public firm moves simultaneously with n private firms, (ii) it acts as a Stackelberg leader, or (iii) all firms behave as profit-maximizers. In addition, Ohnishi (2012) studies the welfare effects of production subsidies in a price-setting mixed duopoly market by extending the analysis by White (1996), and finds that the introduction of production subsidies into the analyses of Cournot and Bertrand mixed markets can improve social welfare. However, most studies examine privatization in mixed markets where public and private firms produce homogeneous or substitute products.

In this paper, we consider a Cournot mixed market in which a state-owned public firm and a private firm produce complementary products, and reassess the welfare effects of production subsidies regarding privatization. We examine four regimes: mixed and private duopoly, each with and without subsidies. In the regimes without subsidies, a one-shot Cournot-Nash game is constructed. In the regimes with subsidies, the following two-stage game is examined: At the first stage the government chooses the subsidy to maximize social welfare, and at the second stage each firm observes the subsidy and non-cooperatively chooses its quantity level. We solve and compare the four regimes. The main purpose is to examine the welfare effects of production subsidies in a mixed market with complementary goods regarding privatization.

Basic Setting

We consider an industry in which there are one state-owned welfare-maximizing public firm (firm 0) and one profit-maximizing private firm (firm 1). In the remainder of this paper, subscripts 0 and 1 denote firm 0 and the firm 1, respectively. In addition, when i and j are used to refer to firms in an expression, they should be understood to refer to 0 and 1 with $i \neq j$. There is no possibility of entry or exit. Both firms produce complementary goods. There is a continuum of consumers of the same type, and the representative consumer maximizes consumer surplus: $CS = U(q_0, q_1) - p_0 q_0 - p_1 q_1$,

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7790265
www.ijmae.com

where q_i is the amount of good i and p_i is its price. The function $U(q_0, q_1)$ is quadratic and symmetric in q_0 and q_1: $U(q_0, q_1) = a(q_0 + q_1) - (q_0^2 - 2bq_0q_1 + q_1^2)/2$, where $a \in (0, \infty)$ is a constant and $b \in (0, 1)$ is a measure of the degree of complementarity among products.

The inverse demand function is given by

$$p_i = a - q_i + bq_j . \quad (1)$$

For the sake of simplicity, we assume $b = 0.5$. Both firms have the same production function represented by a quadratic cost function: $C(q_i) = c + q_i^2/2$. We assume $c = 0$, since entry decisions are not considered.

Therefore, each firm's profit is given by

$$\pi_i = p_i q_i - \frac{1}{2} q_i^2 + sq_i , \quad (2)$$

where $s \in (0, \infty)$ denotes the subsidy for each unit of output.

Social welfare, defined as the sum of consumer surplus and producer surplus, is given by

$$W = CS + \pi_0 + \pi_1 - s(q_0 + q_1) . \quad (3)$$

We examine four regimes: mixed and private duopoly, each with and without subsidies. In the regimes without subsidies, a one-shot Cournot-Nash game is considered and solved. In the regimes with subsidies, a two-stage Cournot game is considered: At the first stage the government chooses the subsidy level to maximize social welfare, and at the second stage each firm observes the subsidy and non-cooperatively determines its output level.

Results

In this section, we discuss the following four games: unsubsidized mixed duopoly, subsidized mixed duopoly, unsubsidized private duopoly, and subsidized private duopoly.

Unsubsidized Mixed Duopoly

We present the Cournot equilibrium values of outputs, profits, consumer surplus and social welfare when there is no subsidy:

$$q_1^{\mathrm{M}}(0) = \frac{10}{23} a , \quad q_0^{\mathrm{M}}(0) = \frac{14}{23} a , \quad (4)$$

$$Q^{\mathrm{M}}(0) = \frac{24}{23} a , \quad (5)$$

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7790265
www.ijmae.com

$$\pi_1^{\mathrm{M}}(0)=\frac{150}{529}a^2,\quad \pi_0^{\mathrm{M}}(0)=\frac{98}{529}a^2, \tag{6}$$

$$CS^{\mathrm{M}}(0)=\frac{78}{529}a^2, \tag{7}$$

$$W^{\mathrm{M}}(0)=\frac{326}{529}a^2. \tag{8}$$

Notice that firm 0 makes a strictly positive profit.

Subsidized Mixed Duopoly

In this subsection, we examine the mixed duopoly game when the government considers setting a production subsidy. The timing of the game is as follows. At stage one, the government chooses the subsidy level to maximize social welfare. At stage two, each firm simultaneously and independently chooses its output level conditional on the subsidy. We discuss the subgame perfect Nash equilibrium by backward induction. Maximizing (2) and (3) simultaneously, we obtain the second-stage Cournot equilibrium outputs for a given subsidy:

$$q_1^{\mathrm{M}}(s)=\frac{10a+8s}{23},\quad q_0^{\mathrm{M}}(s)=\frac{14a+2s}{23}, \tag{9}$$

We now consider the first stage of the game. At the first stage, the government takes into account how firms will react to the subsidy and sets the subsidy level to maximize (3). We can obtain the welfare-maximizing subsidy as follows:

$$s^{\mathrm{M}}=\frac{2}{3}a. \tag{10}$$

Notice that s^{M} is strictly positive. From (9) and (10), we obtain the following subgame perfect Nash equilibrium values:

$$q_1^{\mathrm{M}}(s^{\mathrm{M}})=q_0^{\mathrm{M}}(s^{\mathrm{M}})=\frac{2}{3}a, \tag{11}$$

$$Q^{\mathrm{M}}(s^{\mathrm{M}})=\frac{4}{3}a, \tag{12}$$

$$\pi_1^{\mathrm{M}}(s^{\mathrm{M}})=\pi_0^{\mathrm{M}}(s^{\mathrm{M}})=\frac{2}{3}a^2, \tag{13}$$

$$CS^{\mathrm{M}}(s^{\mathrm{M}})=\frac{2}{9}a^2, \tag{14}$$

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7790265
www.ijmae.com

$$W^{\mathrm{M}}(s^{\mathrm{M}}) = \frac{2}{3}a^2 . \quad (15)$$

From the preceding results, we can have the following proposition.

Proposition 1: If optimal production subsidies are used in a mixed duopoly, then $q_1^{\mathrm{M}}(s^{\mathrm{M}}) = q_0^{\mathrm{M}}(s^{\mathrm{M}})$, $Q^{\mathrm{M}}(0) < Q^{\mathrm{M}}(s^{\mathrm{M}})$, and $W^{\mathrm{M}}(0) < W^{\mathrm{M}}(s^{\mathrm{M}})$.

Unsubsidized Private Duopoly

In the subsection, we present the one-shot Cournot equilibrium outcomes of the unsubsidized private duopoly game. Each duopolist maximizes its own profit. Therefore, we can obtain the following equilibrium values:

$$q_0^{\mathrm{P}}(0) = q_1^{\mathrm{P}}(0) = \frac{2}{5}a , \quad (16)$$

$$Q^{\mathrm{P}}(0) = \frac{4}{5}a , \quad (17)$$

$$\pi_1^{\mathrm{P}}(0) = \pi_0^{\mathrm{P}}(0) = \frac{6}{25}a^2 , \quad (18)$$

$$CS^{\mathrm{P}}(0) = \frac{2}{25}a^2 , \quad (19)$$

$$W^{\mathrm{P}}(0) = \frac{14}{25}a^2 . \quad (20)$$

We compare the subsidized mixed duopoly outcomes with those of the unsubsidized private duopoly. We see that social welfare is higher in the subsidized mixed market than in the unsubsidized private market. We now present the following proposition.

Proposition 2: If optimal production subsidies are used only before privatization of firm 0 in a mixed market, then $W^{\mathrm{M}}(s^{\mathrm{M}}) > W^{\mathrm{P}}(0)$.

Subsidized Private Duopoly

In this subsection, we consider the following two stage game. At stage one, the government chooses the output subsidy level to maximize social welfare. At stage two, each profit-maximizing firm simultaneously and independently chooses its output level conditional on the subsidy. The game is solved by backward induction to obtain a subgame perfect Nash equilibrium. Starting from the second stage, we obtain the Cournot equilibrium outputs for a given subsidy:

$$q_1^{\mathrm{P}}(s) = q_0^{\mathrm{P}}(s) = \frac{14(a+s)}{35} . \quad (21)$$

International Journal of Management, Accounting and Economics
Volume 10, Issue 2, February, 2023
ISSN 2383-2126 (Online)
DOI: 10.5281/zenodo.7790265
www.ijmae.com

We consider the first stage of the game. In the first stage, the government takes into account how firms will react to the subsidy and determines the subsidy level to maximize (3). It happens that the optimal subsidy, outputs, profits, consumer surplus and social welfare in this game are the same as those in the subsidized mixed duopoly: $s^{\mathrm{P}} = s^{\mathrm{M}}$, $q_1^{\mathrm{P}}(s^{\mathrm{P}}) = q_0^{\mathrm{P}}(s^{\mathrm{P}}) = q_1^{\mathrm{M}}(s^{\mathrm{M}}) = q_0^{\mathrm{M}}(s^{\mathrm{M}})$, $Q^{\mathrm{P}}(s^{\mathrm{P}}) = Q^{\mathrm{M}}(s^{\mathrm{M}})$, $\pi_1^{\mathrm{P}}(s^{\mathrm{P}}) = \pi_0^{\mathrm{P}}(s^{\mathrm{P}}) = \pi_1^{\mathrm{M}}(s^{\mathrm{M}}) = \pi_0^{\mathrm{M}}(s^{\mathrm{M}})$, $CS^{\mathrm{P}}(s^{\mathrm{P}}) = CS^{\mathrm{M}}(s^{\mathrm{M}})$, and $W^{\mathrm{P}}(s^{\mathrm{P}}) = W^{\mathrm{M}}(s^{\mathrm{M}})$.

Therefore, the effects of the subsidy on the private duopoly results are stated by the following proposition.

Proposition 3: If optimal production subsidies are used in a Cournot private market, then $Q^{\mathrm{P}}(0) < Q^{\mathrm{P}}(s^{\mathrm{P}})$, and $W^{\mathrm{P}}(0) < W^{\mathrm{P}}(s^{\mathrm{P}})$.

Finally, we compare the two subsidized games. The optimal subsidy, outputs, profits, consumer surplus and social welfare in the subsidized mixed market are identical with those in the subsidized private market. This comparative result is summarized in the following proposition.

Proposition 4: If optimal production subsidies are used before and after privatization of firm 0 in a quantity-setting mixed market, then $s^{\mathrm{M}} = s^{\mathrm{P}}$, and $W^{\mathrm{M}}(s^{\mathrm{M}}) = W^{\mathrm{P}}(s^{\mathrm{P}})$.

Conclusion

We have examined the welfare effects of production subsidies in a mixed market where a state-owned public firm and a private firm produce complementary goods, and have considered the following four regimes: unsubsidized mixed duopoly, subsidized mixed duopoly, unsubsidized private duopoly, and subsidized private duopoly. We have found that our results are the same as those obtained by the existing Cournot mixed market model with homogeneous goods.

References

Anderson, S. P., de Palma, A., & Thisse, J.-F. (1997). Privatization and efficiency in a differentiated industry. *European Economic Review 41 (9),* 1635-1654.

Bárcena-Ruiz, J. C., & Garzón, M. B. (2005). Economic integration and privatisation under diseconomies of scale. *European Journal of Political Economy 21 (1)*, 247-267.

Bosi, S., Girmens, G., & Guillard, M. (2005). Optimal privatization design and financial markets. *Journal of Public Economic Theory 7 (5)*, 799-826.

Chang, W. W. (2005). Optimal trade and privatization policies in an international duopoly with cost asymmetry. *Journal of International Trade and Economic Development 14 (1),* 19-42.

Chao, C.-C., & Yu, E. S.-H. (2006). Partial privatization, foreign competition, and optimum tariff. *Review of International Economics 14 (1)*, 87-92.

Dadpay, A. (2014). Subsidization and privatization: in a multinational mixed oligopoly. *Eastern Economic Journal 40 (1)*, 5-25.

Fjell, K., & Pal, D. (1996). A mixed oligopoly in the presence of foreign private firms. *Canadian Journal of Economics 29 (3)*, 737-743.

George, K., & La Manna, M. (1996). Mixed duopoly, inefficiency, and public ownership. *Review of Industrial Organization 11 (6)*, 853-860.

Gronberg, T. J., & Hwang, H. (1992). On the privatization of excludable public goods. *Southern Economic Journal 58 (4)*, 904-921.

Han, L., & Ogawa, H. (2008). Economic integration and strategic privatization in an international mixed oligopoly. *FinanzArchiv 64 (3)*, 352-363.

Kato, K., & Tomaru, Y. (2007). Mixed oligopoly, privatization, subsidization and the order of firms' moves: several types of objectives. *Economics Letters 96 (2)*, 287-292.

Kim, S.-L., Lee, S.-H., & Matsumura, T. (2019). Corporate social responsibility and privatization policy in a mixed oligopoly. *Journal of Economics 128 (1)*, 67-89.

Mujumdar, S., & Pal, D. (1998). Effects of indirect taxation in a mixed oligopoly. *Economics Letters 58 (2)*, 199-204.

Myles, G. (2002). Mixed oligopoly, subsidization and the order of firms' moves: an irrelevance result for the general case. *Economics Bulletin 12 (1)*, 1-6.

Ohnishi, K. (2012). Price-setting mixed duopoly, privatization and subsidization. *Microeconomics and Macroeconomics 1 (1)*, 20-23.

Ohnishi, K. (2021). Mixed duopoly, privatization, subsidization and partial foreign ownership. *International Journal of Management, Accounting and Economics 8 (9)*, 707-714.

Pal, D., & White, M. D. (1998). Mixed oligopoly, privatization, and strategic trade policy. *Southern Economic Journal 65 (2)*, 264-281.

Poyago-Theotoky, J. (2001). Mixed oligopoly, subsidization and the order of firms' moves: an irrelevance result. *Economics Bulletin 12 (3)*, 1-5.

Sasaki, D., & Wen, M. (2003). On optimal privatization. In M. Baldassarri, & L. Lambertini, *Antitrust, Regulation and Competition* (pp. 193-216). New York: Palgrave Macmillan.

Wang, L. F.-S., Wang, Y., & Zhao, L. (2009). Privatization and efficiency gain in an international mixed oligopoly with asymmetric costs. *Japanese Economic Review 60 (4)*, 539-559.

White, M. D. (1996). Mixed oligopoly, privatization and subsidization. *Economics Letters 53 (2)*, 189-195.

HOW TO CITE THIS ARTICLE

Ohnishi, K. (2023). Mixed Duopoly, Privatization and Subsidization: Complementary Goods. *International Journal of Management, Accounting and Economics*, *10*(2), 149-156.

DOI: 10.5281/zenodo.7790265

DOR: 20.1001.1.23832126.2023.10.2.4.9

URL: https://www.ijmae.com/article_168684.html