



The Impacts of Spatial Interaction on Agricultural Productivity and Average Income: A Case of Vietnam

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Abstract

Agricultural productivity plays a crucial role in sustainable development while income is one of the most critical indicators that manifest the living standards; therefore, both of these aspects have attracted much attention from the national level to the provincial level. Yet, for various reasons, the importance of regional linkages, especially spatial interaction in the analysis of agricultural productivity and the average income, is not recognized and thus ignored in economic policies. Taking Vietnam as the study area, this paper examines the impact of spatial interaction between metropolises and provinces on agricultural productivity and income per capita of provinces. In order to evaluate the impacts, this paper uses a gravity model to estimate the spatial interaction then panel data analysis is employed to interpret the influences. The data used in this study is collected from the General Statistics Office of Vietnam in the period from 2015-2018. The results show a positive correlation between spatial interaction between metropolis and provinces to provincial change, including agricultural productivity and average income. As such, stronger linkages with metropolises through improving transportation systems could enhance agricultural productivity and income in the province.

Introduction

Agricultural productivity is a crucial component of food security, and its rapid growth underpins the development of the global food system (Mbow et al., 2019). In addition, increasing agricultural productivity through sustainable practices helps to decrease the amount of land needed for farming and slow environmental degradation and climate change (Hawken, 2017). As a development aspect, higher agricultural productivity increases overall rural employment and raises returns to capital and labor (Takeshima, Amare & Mavrotas, 2018). At the same time, higher income helps improve living conditions and respond to human needs better, such as healthcare, education, and food. Because of these reasons, agricultural productivity and income have also received a lot of attention both from scholars and policy-makers from the provincial level to the country level. However, most studies of agricultural productivity and income at the provincial level often focus on one or multiple factors related to a single province, with few considering the effects of outside relationships, especially linkages with the metropolis. This raises the question about the impact of regional linkages in agricultural productivity and income of provinces in the view of referring the spatial interaction.

From the spatial aspect, the interaction between metropolises and provinces is usually analyzed through flows of labor, remittances, goods and services, information, and knowledge (Tacoli, 2003). The changes in agricultural productivity and income in provinces are also based on these flows. The labor flow is known as migration, and the predominant direction of this flow is from

provinces to metropolises (Reddy, 2017). The losing labor in agricultural activities in provinces leads to decreased agricultural productivity (Shi, 2018; Taylor & Castelhana, 2016; Hussain et al., 2016). In places with labor shortages, households rely on family labor, so it may be difficult to replace the lost family labor with hired labor (Atamanov and Van den Berg, 2012). In particular, the labor flow is mainly the movement of young and skilled people leave provinces for metropolises this leaves behind older adults, women, and children that causes a so-called brain drain (Habitat, 2017; Woods & Heley, 2017), in this case, the lost-labor effect as a loss of human resources is a more negative impact on productivity (Shi, 2018). Besides that, the large number of household migrant laborers will significantly increase the probability of household farmland abandonment (Lu, 2020; Lorenzen et al., 2020; Xu et al., 2019), which reduces agricultural productivity.

Along with labor flow, there are remittances flow in opposite directions (Mobrand, 2012). Primarily, remittances are from migrators in metropolises to relatives and communities in the places they originate from (Adger et al., 2002), and this flow not only helps to diversify and increase the household's income in provinces (Samaratunge, Kumara & Abeysekera, 2020; Hatcher, 2017; Nguyen, Grote & Nguyen, 2017) but also enhance the agricultural productivity through abilities to use new technologies and more chemical fertilizers, pesticides (Caulfield et al., 2019). It is so clear that credit could bring about higher productivity and profit in agricultural production (Ashaolu et al., 2011; Baffoe et al., 2014); however, in the limited access to banking credit, the remittances serve as an important source of capital for migrant households in provinces (Zhang et al., 2006).

Another essential flow is the flow of goods and services. Through this flow, the provinces are supplied necessary agricultural inputs, even modern input, which helps to transform to higher agricultural productivity levels (Vandercasteelen et al., 2018), and reversely, the flow of goods and services also contains the agricultural products from provinces to metropolises that enhance the household's income and expand the market for agricultural output (Akkoyunlu, 2015).

As for the flow of information, the metropolises play a role as the center of development and information (EC, 2010; Wattenbach, Bishop-Sambrook & Dixon, 2005), so this flow mainly contains information from metropolises to provinces that relates to markets of goods and employment (Sietchiping, 2014) and knowledge of technologies (Srivastava & Shaw, 2016). Base on the timely and necessary information about markets, households in provinces can improve income by predicting the suitable time to harvest and sell products at a high price, restricts effects of fluctuation of the market, selling below fair value (Miller, Saroja & Linder, 2013) while the weather updates help people in provinces increase the agricultural productivity by protecting crops and reducing the harmful impacts from the natural hazard (Ajani, 2014). Besides the information about markets, the information flow supports knowledge diffusion and technology transfer. Agricultural research and development can lead to technological breakthroughs that enable significant improvement in agricultural productivity (Braun, 2007). The advanced technology requires less labor to harvest crops (Mellor, 2017) or create more crop yields by using genetically engineered plants (Bustos, Caprettini & Ponticelli, 2016). Although it is not the direct effect on change in agricultural productivity or income, the distance, which is a component of spatial interaction, has an indirect impact on each flow. Base on empirical research of some countries such as China, India, and SubSaharan Africa, there is substantial evidence that proximity to metropolises positively affects agricultural productivity and output (Fan and Hazell, 2001; Dorosh et al., 2010).

From above explanation, this study investigates the impact of spatial interaction in agricultural productivity and income of provinces. The results of the investigation not only implement groundwork for researchers but also support policy-makers in assessing and planning the policies for regions.

Methods

Spatial Interaction Measurement

To quantify the spatial interaction between metropolis and provinces, this study relies a modified gravity model because of the similarity between the interaction strength and universal gravitation rules (Yang, 1989). This model was first used in economics by Reilly (1931) then Zipf (1942) adopted the gravitation model to city-system spatial-interaction analysis. After that, the gravitation model has been widely adopted by researchers measuring bilateral relations. The basic model of gravitation is:

$$F_{ij} = k \frac{M_i M_j}{d_{ij}^b} \quad (1)$$

Where: F_{ij} is the spatial interaction between two areas i and j; $M_i; M_j$ are the mass of area i and j; d_{ij} the distance between area i and j; b is the distance decay coefficient; k is the constant. Referring to previous studies, the mass of areas will be modified (Anderson, 2011; Egger & Pfaffermayr 2003) and measured base on three components (Sun et al., 2015): Gross Regional Domestic Product (Wang and Zhuang, 1996); population (Taaffe, 1962). As for distance between areas, the improvement and development of transportation system help the movement becomes easily therefore travel time can be more accurate for depicting the changes in spatial interaction between cities. The minimum travel time by car between two areas will be used to measure the distance. The spatial interaction is demonstrated to be inversely proportional to the square of distance between two areas (Taaffe, 1962) therefore the distance decay coefficient will be “2”.

Therefore, the spatial interaction can be calculated as the following equation:

$$F_{ij} = k_{ij} \frac{\sqrt{GRDP_i \times Pop_i} \times \sqrt{GRDP_j \times Pop_j}}{d_{ij}^2}; \quad k_{ij} = \frac{GRDP_i}{GRDP_i + GRDP_j} \quad (2)$$

Where: F_{ij} is the spatial interaction of area i to area j; $GRDP_i; GRDP_j$ are the gross regional domestic product values of area i and j; $Pop_i; Pop_j$ are the populations of area i and j; d_{ij} The minimum travel time by car between area i and j.

Panel data models

Panel data models are used to analyze the data in both cross-sectional and time-series dimensions. A common panel data regression model is given in the simplest form in Equation (3):

$$Y_{it} = \alpha + X_{it}\beta + v_{it} \quad (3)$$

Where: Y_{it} is the dependet variable of the province i in year t. X is the independent variable. α and β are coefficients to be estimated. v is the random disturbance term with a mean of 0. If there is unobserved heterogeneity across provinces, two other types of models will be employed: Random effects model and fixed effects model (Hausman, 1978; Croissant and

Millo, 2008). The common form of model which accounts for characteristics of individual provinces is in Equation (4):

$$Y_{it} = X_{it}\beta + \alpha_i + \varepsilon_{it} \quad (4)$$

Where: α_i is the provincial specific effects, ε is the idiosyncratic error. The F test and Lagrange multiplier test help identify the existence of heterogeneity across provinces (Breusch and Pagan, 1980), while choosing between fixed and random effects is based on the Hausman test (Hausman, 1978).

Results and Discussion

The Spatial Interaction

Table 1 shows the components and measurement of spatial interaction between metropolises and provinces. As for components, the GRDP of areas have a considerable difference in which the mean of metropolises' GRDP is 465092 billion VND, nearly ten times of provinces' GRDP and the range of GRDP of areas are also large, from 465092 to 907059 in GRDP of metropolises; from 47480 to 276517 in GRDP of provinces. The population of metropolises fluctuates from 1026 to 8598 thousand people, while this index in provinces is from 313 to 3558. The mean distance from provinces to metropolises is 194 minutes, and the nearest place to metropolis takes 44 minutes by car while the longest place takes 611 minutes. From the detailed data of components and the modified gravity model, the spatial interaction measurement is established, and the results indicate that the mean of spatial interaction is 46661 while the range between minimum and maximum value is huge.

Table 1. Descriptive statistics of spatial interaction components and measurement

Spatial interaction components	Mean	SD	Min	Max
GRDP (billion VND)				
GRDP of metropolis	465092	317131	49182	907059
GRDP of province	47480	46101	5518	276517
Population (thousand persons)				
Population of metropolis	5494	3121	1026	8598
Population of province	1261	623	313	3558
Distance to metropolis (minutes)	194	139	44	611
Spatial interaction measurement				
Spatial Interaction (SI)	46661	105585	97	768180
Characteristics of provinces (Thousand VND)				
Agricultural productivity (AP)	23,327	17038	6907	175537
Average income (AI)	32,868	10004	13086	70680

Source: Author's calculate

The Impacts of Spatial Interaction

Table 2 shows that the coefficients in Pooled OLS model and Random-effects model are significant and positive, while the coefficient in the fixed effects model is negative. The F test for individual effects gets the value of 3.477, and Breusch-Pagan Lagrange Multiplier Test gets the value of 46.886 (both p-value < 0.05) which means there is the existence of unobserved heterogeneity across provinces, in other words, the Pooled OLS model is unsuitable for analyzing the estimation results. Besides that, the p-value of the Hausman Test is 0.07695 (p-

value < 0.05), so the random effects estimator is more efficient, and the results of the random-effects model are used to analyze. The coefficient of SI is positive, which means the increase of spatial interaction between metropolis and province leads to an increase in agricultural productivity in provinces. Although the R square is low (0.017), the previous theories mentioned supporting the existence of the relationship between spatial interaction and agricultural productivity, only the spatial interaction used is not really good in explaining changes in agricultural productivity.

Table 2. Regression results of Panel data models for Agricultural productivity

Dependent Variable: Agricultural productivity (AP)			
	Pooled OLS model	Fixed effects model	Random effects model
Intercept	2.17e+04*** (18.13)		2.19e+04*** (12.48)
Spatial interaction (SI)	3.48e-02*** (3.35)	-0.063 (-1.1576)	2.97e-02** (1.99)
R-Squared:	0.047	0.008	0.017
Breusch-Pagan Lagrange Multiplier Test	46.886***		
F test for individual effects	3.478***		
Hausman Test	3.128		
Note: t statistics in parentheses; *** p < 0.01; **p < 0.05; * p < 0.1			

Source: Author's calculate

As for average income, table 3 indicates that spatial interaction has significant effects on the average income in all three models (p-value < 0.05). The unobserved heterogeneity across provinces also existed in analyzing average income in provinces when The F test for individual effects and Breusch-Pagan Lagrange Multiplier Test have a p-value of less than 0.05. However, in this analysis, the Hausman Test gets a value of 12.156 with a p-value less than 0.05, so the fixed effects estimator is more efficient. The results of SI coefficient in the fixed effects model are positive that expresses the positive correlation between spatial interaction and province; in other words, as the value of the spatial interaction between metropolis and province increases, the mean of the average income in the province also tends to increase.

Table 3. Regression results of Panel data models for Average income

Dependent Variable: Average income (AI)			
	Pooled OLS model	Fixed effects model	Random effects model
Intercept	2.98e+04*** (57.48)		2.93e+04*** (32.03)
Spatial interaction (SI)	6.57e-02*** (14.611)	0.129*** (7.66)	7.61e-02*** (10.335)
R-Squared:	0.481	0.253	0.317
Breusch-Pagan Lagrange Multiplier Test	151.46***		
F test for individual effects	9.824***		
Hausman Test	12.156***		
Note: t statistics in parentheses; *** p < 0.01; **p < 0.05; * p < 0.1			

Source: Author's calculate

Base on the above results, it can be seen that metropolises play crucial roles in provincial development. Through the regional linkages, which are represented by spatial interaction, metropolises help enhance agricultural productivity and income. The results are also appropriate to previous research that support the uneven development theory. In addition, this discovery not only demonstrates the importance of geographical factors in the study of specific areas but also opens a new direction in further research about the regional linkages or role of metropolises in changes in provinces generally. From the viewpoint of policy, these results help policy-makers have a deep understanding of a way to promote agricultural productivity and income in provinces efficiently by affecting spatial interaction.

Conclusion

This study analyzes the impacts of spatial interaction between metropolises on agricultural productivity and income in provinces. The results extend the understanding of the change in agricultural productivity and income of provinces which is usually studied through inside factors. The positive correlation with spatial interaction shows the stronger spatial interaction with metropolises through improving transportation systems could also increase agricultural productivity and average income in provinces. Furthermore, it also suggests that the policies which are used to enhance agricultural productivity or income should be put in general relationship with considering the outside factors.

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