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Finding Externalities: An Empirical Study on the US Agricultural Industry

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ABSTRACT

This paper searches for another empirical evidence supporting positive externalities from higher education. Using state-level US data on agriculture and IT industries, we find that there are positive spillover effects from more-knowledge intensive workers in the IT industry to less-knowledge intensive workers in the agricultural industry. According to our empiri- cal findings, one well-educated IT worker generates and contributes $11,000 to the agricultural industry, which implies that the benefits of higher education are diffused from education beneficiaries to the other member of society.

Keywords: Externality; Spillover Effects; Higher Education

1. Introduction

If we want America to lead in the 21*st century, nothing is more important than giving everyone the best education possible-from the day start preschool to the day they start their career*. (*Barack Obama*, *Weekly Presidential Address*, *Aug* 18, 2012).

Needless to say, many researchers and policy makers have emphasized the importance of higher education on economic outcomes. According to the White House, more than half of the 30 fastest growing occupations in the US require postsecondary education and the demand for the higher degree beyond a high school diploma will grow fast over this decade[1]. On average, according to a report from the US Census Bureau, a high school graduate expects to make $1.2 million over her/his lifetime while a college graduate expects to earn $2.1 million over her/his lifetime[2]. It is now commonly accepted that educational attainment is the most important factor of an individual economic success.

In addition to an individual economic success, there have been many academic research efforts focusing on the role of higher education in enhancing economic growth and development. As a result, it is commonly accepted that higher education leads economic growth through not only the *production of knowledge* but also the *diffusion of knowledge*[3]. Economists, following Lucas' seminal 1988 paper [2], generally consider that the *diffusion of knowledge* is the important contribution of education on economic growth and have tried to measure the economic size of this diffusion empirically. Empirical findings, however, have not found the consensus yet and the debate over empirical findings on educational externalities is by no means new. For example, Canton [3] and Yamarik [4] find no empirical evidence that education generates positive externalities while Moretti [5] and Kim and Lim [6] support the existence of positive externalities from college education.

In this paper, we search for another empirical evidence supporting positive externalities from higher education. Using state-level US data on agriculture and IT industries, we find that there are positive spillover effects from more-knowledge intensive workers in the IT industry to less-knowledge intensive workers in the agricultural industry.

In the following section, we will discuss our model. Section 3 will present our empirical results. Section 4 at last concludes.

2. The Model

To estimate externalities from higher education, we

[1]http://www.whitehouse.gov/issues/education/higher-education.
[2]*Current Population Reports*, the US Census Bureau, July 2002.
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[3]See Becker and Lewis [1].

choose two different industries in the United States, Agriculture and Information Technology (IT). According to the 2005-2009 American Community Survey data in **Table 1**, workers engaging in IT industry have the highest educational attainment, on average, while workers engaging in agriculture show the lowest educational attainment. In IT industry, 94.2% of workers have some college experience and 73.6% of them have at least a bachelor's degree. In contrast, 69.9% of workers engaging in agriculture do not have any college experiences and only 10.9% of workers have at least a bachelor's degree or higher. Therefore, we can conclude that workers engaging in IT industry are more-knowledge intensive workers while workers in agricultural industry are less-knowledge intensive workers.

Based on these statistics on educational attainment, we use the following constant returns agricultural production function to measure externalities[4]:

$$Y_{it} = AK_{it}^{\alpha} L_{it}^{\beta} N_{it}^{\gamma} E^{\delta}_{it}, \quad (1)$$

where Y_{it} is the total agricultural product for each US state in period t; A is a common intercept; K_{it}, L_{it}, and N_{it}, are capital, labor, and land used in the agricultural Industry for each US state in period t; E_{it} is the number of workers engaging in IT industry for each US state in period t.

Since we assume that workers in IT industry most likely have a bachelor's degree and least likely affect agricultural products directly, the statistical sign and significance of δ will decide the existence of positive externalities from higher education. In other words, if more-knowledge intensive workers engaging in IT industry increases the market value of agricultural products which are produced by less-knowledge intensive farmers, then that can be the evidence of positive externalities from higher education.

To estimate Equation (1) empirically, we take natural logs on both sides of Equation (1), which provides the following estimation equation:

$$\begin{aligned}\ln(Y_{it}) &= \ln(A) + \alpha \ln(K_{it}) + \beta \ln(L_{it}) \\ &\quad + \gamma \ln(N_{it}) + \delta \ln(E_{it}) + u_{it},\end{aligned} \quad (2)$$

Since E_{it} is the number of workers engaging in IT industry, a statistically significant and positive δ can be the evidence of positive externalities from higher education. We expect that all coefficients of Equation (2) are statistically positive and significant.

3. Empirical Results

First of all, we estimate the market value of agricultural products as a function of three factors of production using the state-level US data over two time periods of 2002 and 2007. Descriptive statistics are presented in **Table 2**. Since Lagrangian multiplier (LM) supports the random effects estimator, empirical results from the ordinary least squares (OLS) and the random effects model (REM) are both presented in **Table 3**. All coefficients from regression 3.1 and 3.2 are statistically positive and signifycant. The elasticities of capital, labor, and land in agricultural product are 0.54, 0.33, and 0.17 respectively and these results are not different from previous empirical findings[5].

Table 1. Educational attainment.

	Less than high school diploma	High school diploma or equivalent	Some college, no degree	Associate's degree	Bachelor's degree	Master's degree	Doctoral or professional degree
All occupations	9.9	26.8	21.4	8.8	20.8	8.4	3.9
IT industry	0.4	4.4	13.3	8.2	41.8	22.7	9.1
Agriculture	31.9	38.0	14.4	4.8	8.5	1.7	0.7

*Source: 2005-2009 American Community Survey, U.S. Census Bureau [7].

Table 2. Descriptive statistics.

	Variable	Obs	Mean	Min	Max
Y_{it}	Market value of agricultural products* (thousands of US$, 2002)	100	4,445,898	46,143	2.78e + 07
K_{it}	Machinery and equipment on operation* (thousands of US$, 2002)	100	3,314,083	41,853	1.59e + 07
L_{it}	Hired farm labor*	100	56,729	1330	535,256
N_{it}	Land in farms* (acres)	100	1.86e + 07	61,223	1.30e + 08
E_{it}	The Total number of workers in IT industry**	100	59,035	1860	394,840

Source: *2002-2007 Census of Agriculture, USDA. **2002-2007 Occupational Employment Statistics Survey, BLS.

[4]See E. Moretti [5] and C. Kim & G. Lim [6].
[5]See Martin and Mitra [8] and Echevarria [9].

Table 3. Empirical results.

Independent Variables	3.1 OLS	**3.2 Random**	3.3 OLS	**3.4 Random**	3.5 Canada[6]
$\ln(K_{it})$	0.628	**0.535**	0.618	**0.46**	0.427
	(9.79)**	**(11.31)****	(9.51)**	**(8.20)****	
$\ln(L_{it})$	0.357	**0.327**	0.311	**0.223**	0.419
	(6.19)**	**(5.22)****	(4.31)**	**(2.93)****	
$\ln(N_{it})$	0.092	**0.169**	0.117	**0.256**	0.159
	(2.36)*	**(3.15)****	(2.57)*	**(3.96)****	
$\ln(E_{it})$			0.048	**0.146**	
			(1.07)	**(2.29)***	
Constant	0.428		0.171	**0.106**	
	(1.11)		(0.38)	**(0.16)**	
R-squared	0.94		0.94		
Obs	100		100	**100**	
F-Statistics	486.70	**571.99^W**	365.87	**587.38^W**	
Prob. (F-Statistics)	0.0000	0.0000	0.0000	**0.0000**	

The numbers in the brackets are absolute value of *t*-statistics. **indicates significance at 1% level of significance. *indicates significance at 5% level of significance. ^{W}indicates Wald chi-squares statistics.

Second of all, we now include $\ln(E_{it})$, the total number of workers in IT industry, in our empirical model and estimates the Equation (2). According to the results from LM and Hausman tests, the REM is the most appropriate estimator in this case. Therefore, the results from regression 3.4 are our most preferred one. The share of capital, labor, and land in agricultural products are 46%, 22%, and 25% respectively and statistically significant. The coefficient on $\ln(E_{it})$ is 0.146 and statistically significant, too. Since this coefficient decides the existence of externalities, the positive coefficient supports that there are positive spillover effects from more-knowledge intensive IT workers to less-knowledge intensive workers in agricultural industry.

At last, since the coefficient of 0.146 represents the elasticity, 1% increase in the total number of IT workers will increase the market value of agricultural products by 0.146%. For example, on average, if the number of IT workers increases by 590 which is 1%, then the market value of agricultural products will increase by $6,491,000. In other words, one well-educated IT worker generates and contributes $11,000 to agricultural industry, which is an evidence of economically meaningful externalities.

4. Conclusion

Using data from US Agricultural and IT industries, we find that there are positive externalities from higher education. According to our empirical findings, 1% increase in the number of IT workers will increase the market value of agricultural products by 0.146%, which is not only statistically but also economically meaningful evidence of the existence of externalities from higher education.

[6]See Echevarria [9].

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