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Returns to Major Agricultural R&D Sources in Thailand

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Abstract This paper aims at addressing the attribution issue among major agricultural R&D sources in Thailand. The public, private, university and foreign R&D are investigated as sources of agricultural productivity growth along with other economic and noneconomic factors using an econometric model. The model employs the error correction modeling technique using time-series data during 1980 to 2014. The estimated coefficients of the organized R&D variables are then used to compute the associated marginal internal rates of return on the local sources of R&D. The results show that all the major sources of agricultural R&D have statistically significant positive impacts on the productivity gain. However, the magnitude of the impacts and the associated rates of return are quite small. The university R&D payoff is shown to be slightly higher than those of the public and the private R&D, respectively. The findings also highlight the importance of the attribution among R&D sources and the systematic records of the R&D data.

Keywords Agricultural R&D, Rate of return, Research Attribution, Thai agriculture

1. Introduction

Agricultural research plays an important role in sustaining agricultural growth in many developing countries including Thailand. Previous studies show the public investment in agricultural research had contributed to the Thai agricultural productivity growth which has important implications on living standards, poverty alleviation, food security, and overall economic growth. The returns on public research investment have also shown to be high implying an underinvestment in agricultural research (Suphannachart and Warr, 2011, 2012).

However, the public sector is not the only research performer in Thailand and in fact its role in terms of research expenditure has recently declined. Among major research performers in Thailand, agricultural research activities have primarily been conducted by the government, followed by universities and private enterprises. The public R&D used to be the dominant source of agricultural R&D and so previous studies assumed it represents the entire agricultural R&D in the country but the situation has recently changed. The government share in total agricultural R&D spending has declined while that of universities increased, as shown in Table 1. The role of university research has become increasingly important in recent years; particularly in 2005 and 2007 when its R&D spending share slightly exceeded that of the government. The private sector also conducts research, well-known in seeds and livestock research but a systematic record of private R&D data still suffers from low surveyed responding rate and missing data from earlier years (Suphannachart, 2015, National Research Council of Thailand, 2007).

Moreover, the policies relating to agricultural research aim at encouraging more involvement from the private enterprises as well as strengthening research collaboration among major research performers (Suphannachart, 2015). The role of major sources of agricultural R&D has increasingly become important hence it is worth evaluating their payoffs to the society as a whole. It is also important to investigate which research has actually contributed most to the productivity change in Thai agriculture. However, there has never been any study providing empirical evidence on this attribution issue. The previous study by Suphannachart and Warr (2011) has only accounted for the contribution of public agricultural R&D and foreign research spillover ignoring the role of local university and private R&D.

The attribution issue among R&D sources has been recognized as the primary contributor to the observed productivity growth (Alston and Pardey, 2001) and the issue has gained more attention in the literature (Alston and Pardey, 2001, Pardey et al., 2004, Fuglie and Heisey, 2007, Alston, 2010). Failure to account for major sources of R&D in a productivity determinant model may lead to omitted variable bias and possibly over attribute observed gain in productivity to the included R&D, mostly public R&D. This study aims to fill this gap by addressing the attribution issue among R&D sources in Thailand during 1980-2014 which cover more recent period when the role of university and private of R&D has become more prominent. The study also makes first attempt in estimating the marginal internal rates of return on the public, university, and private agricultural

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R&D in Thailand. The empirical evidence from this study is expected to shed light on the attribution problem and guide future research policies.

2. Literature Review

Measuring the economic impact of research investment in the form of productivity growth has been a standard practice in evaluating an overall agricultural system in many countries (Agricultural Science and Technology Indicator, 2013). Total factor productivity (TFP) is often used as a measure of productivity that results from agricultural research. Research variables are regressed on the TFP to obtain the marginal research impact on productivity. The associated rates of return on research investment are then computed accordingly. Measuring returns on research investment is of particular importance to developing countries where agriculture plays a crucial role and a limited budget has to be allocated to various competing alternatives.

The attribution issue has become increasingly important when estimating the agricultural research impact on productivity and computing the associated rates of return on research investment. As many sectors are involved in conducting research, it is not clear which research has actually contributed most to productivity change. As a result, more recent studies have focused on the attribution problem ignored in the earlier literature. These studies try to determine who has conducted particular research that has led to productivity improvement (Alston and Pardey, 2001, Pardey et al., 2004). Nonetheless, estimation models distinguishing among types of research expenditure place a heavy burden on the data.

Table 1. R&D Expenditure in Agricultural Science Classified By Sector of Performance

	Government	Universities	Public Enterprise	Private Enterprise	Private Non-Profit	Total
1996	1,140.79	369.55	1.22	50.07	10.10	1,571.74
% in total	72.60%	23.50%	0.10%	3.20%	0.60%	100.00%
1997	1,127.45	270.30	12.77	47.57	0.67	1,458.77
% in total	77.30%	18.50%	0.90%	3.30%	0.00%	100.00%
1999	979.15	574.17	8.30	4.20	0.00	1,565.82
% in total	62.50%	36.70%	0.50%	0.30%	0.00%	100.00%
2001	2,529.01	387.53	21.28	251.17	0.00	3,189.00
% in total	79.30%	12.10%	0.70%	7.90%	0.00%	100.00%
2003	1,912.44	705.17	43.20	473.07	1.95	3,135.77
% in total	61.00%	22.50%	15.10%	0.10%	0.00%	100.00%
2005	1,323.26	1,424.76	48.08	766.34	8.34	3,570.86
% in total	37.10%	39.90%	1.30%	21.50%	0.20%	100.00%
2007	893.29	1,124.89	22.47	869.81	7.86	2,918.32
% in total	31.00%	38.50%	0.80%	29.80%	0.30%	100.00%
2009	4,382.07	770.78	43.60	817.00	19.33	6,032.79
% in total	72.63%	12.78%	0.73%	13.54%	0.32%	100.00%
2011	2,548.00	1,808.00	96.00	977.00	28.00	5,457.00
% in total	46.69%	33.13%	1.76%	17.90%	0.51%	100.00%

Source: National survey on R&D expenditure and personnel of Thailand, various issues, National Research Council of Thailand (NRCT). Note: Agricultural science includes crops, livestock, fisheries and forestry research.

Table 2. Summary of studies measuring rates of return on public agricultural R&D

Study	Period	Method	Scope	IRR
Setboonsarng & Evenson (1991)	1967-1980	Profit function/ SUR	Crops	42%
Pochanukul (1992)	1961-1987	Profit function/ SUR	Crops	44.95%
Suphannachart & Warr (2011)	1970-2006	TFP function/ ECM	Crops	29.50%
Suphannachart (2009)	1970-2006	TFP function/ ECM	All Agriculture	40.44%
			Crops	34.74%
			Livestock	130.84%

In a broader sense, the attribution issue not only accounts for different types of research expenditure but also addresses all important factors affecting productivity and specifies appropriate research lags in econometric models (Alston and Pardey, 2001). Failure to account for one source of innovation may overattribute observed gains in productivity to another source (Fuglie and Heisey, 2007). Agricultural productivity growth might be attributable to evolving weather patterns, institutional changes, or economies of size associated with changing structure of agriculture, however, in many cases it is likely that organized R&D has been the primary contributor to the observed growth. Thus, the important issue is the attribution among R&D sources (Alston, 2010).

At a country-level, economic impact of agricultural research is often measured as an internal rate of return (IRR), in which the research benefits are estimated based on agricultural productivity growth that is deem as a result of R&D and the research costs are annual R&D expenditure (Evenson, 2001). Agricultural Science and Technology Indicator (ASTI) (2013) and Flaherty et al. (2013) show that the accelerated growth of global agricultural R&D spending has yielded very high payoffs. The rate of return on R&D investment for developing countries as a whole is 82 percent and for countries that achieved remarkable growth in R&D spending like China and Brazil the returns are 136 percent and for is 176 percent, respectively. Numerous studies have provided evidence of high rates of return on agricultural R&D in various countries and commodities as reviewed by many studies (Alston et al., 2000, Hurley et al., 2014, Evenson, 2001).

In Thailand, there are few studies measuring returns on the public agricultural R&D but there are none for other types of research performers, mainly due to data constraint. Existing studies that measured IRR on the public investment in agricultural research are summarized in Table 2. The first two studies by Setboonsarng and Evenson (1991) and Pochanukul (1992) employed similar methods using profit function and seemingly unrelated regression (SUR) and found IRR on the public crop research around 42 percent and 44.95 percent, respectively. Suphannachart and Warr (2011) also measured IRR on the public crop research using total factor productivity (TFP) function and error correction modeling (ECM) technique and found the IRR equal to 29.5 percent. Suphannachart (2009) estimated IRRs, using similar method but controls for different explanatory variables, for overall agricultural R&D and crops and livestock R&D separately. The IRRs for the overall agriculture is 40.44 percent, for crops is 34.74 percent and for livestock is 130.84 percent. Despite different methodologies and study period previous studies have confirmed the returns on agricultural R&D are higher than the opportunity cost of public funds and high enough to justify continued public investment in agricultural research.

3. Methodologies and Data

This study follows the same methodologies used in Suphannachart and Warr (2011). They consist of two stages. First is estimating the agricultural productivity determinant model using the error correction modeling (ECM) technique, developed by Hendry and his co-researchers (Davidson et al., 1978, Hendry et al., 1984, Hendry, 1995), to obtain each source of research impact on the productivity. Under the ECM, the long-run relationship is embedded within a detailed dynamic specification, including both lagged dependent and independent variables, which helps minimize the possibility of estimating a spurious regression. Second is computing the associated marginal internal rates of return (MIRR) using the typical IRR formula but replacing the cost streams with unit research cost and the benefit streams with marginal benefits obtained from the regression analysis.

The agricultural total factor productivity (TFP) determinant model include major sources of local R&D; namely public, university, and private-sector R&D, foreign research spillovers, agricultural extension, and weather factor. It is expressed in stylized form as in equation (1).

$$TFP = f(R^{pub}, R^{uni}, R^{pri}, R^{f}, E, I, W) \qquad (1)$$

where TFP = total factor productivity in the agricultural sector,

R^{pub} = real public agricultural research expenditure,

R^{uni} = real university agricultural research expenditure,

R^{pri} = real private agricultural research expenditure,

R^{f} = real foreign agricultural research expenditure,

E = real public agricultural extension expenditure,

I = infrastructure factor (irrigation and rural roads),

W = weather or climate factor (rainfalls).

The formula for computing the MIRR is shown in equation (2). It is computed based on the estimated coefficients of the level terms of the local research variables or the long-term TFP elasticities with respect to the public, university, and private R&D variables. This regression-based rate of return is calculated as the discount rate *r*, such that:

$$\sum_{t=1}^{\infty}\left[VMP_t / (1+r)^t\right] - 1 = 0 \qquad (2)$$

The *MIRR* is the discount rate that equates a stream of discounted benefits from an initial investment of 1 baht, to exactly 1 baht. The research cost of 1 baht occurs in year 0 while the research benefit begins from year 1 and extends to infinity. Under the ECM, the annual research benefit or value marginal product (VMP) may vary for a certain number of years until it reaches the long-run equilibrium, after which it remains constant and lasts into perpetuity (see Suphannachart and Warr, 2011 and Suphannachart, 2009 for full details). The criterion for evaluating research impact is that an investment is worthwhile if it yields positive returns and has an IRR greater than the social interest rate or the opportunity cost of funds. The high rate of return implies there had been underinvestment making additional investment in agricultural research is worthwhile (Fuglie et al., 1996).

The data employed in this study also follow the same official data sources, definitions, and measurement as in the previous studies by Suphannachart and Warr (2011, 2012) and Suphannachart (2009). TFP is measured using the growth accounting method, which means that it is a residual of output growth that cannot be explained by land, labor, and capital growth, weighted by their respective income shares, as explained in Suphannachart and Warr (2012). Some departures from the previous studies are that this study covers the overall agricultural sector while Suphannachart and Warr (2011) covers only crops, the period of this study is 1980-2014; beginning at later year (as data on university and private agricultural R&D spending are not available before 1980) and the series are updated to cover more ending periods, the domestic research variables was extended from the previous study (that includes only public agricultural R&D) to cover the university and private-sector R&D. Note that due to data constraint the university and private R&D data series was constructed by combining the 1980-1996 data set from Suphannachart (2009) with the National Research Council of Thailand surveyed data (available from 1996 onwards) using the splicing technique.

4. Results and Discussion

From the estimation of the productivity determinant model using the ECM method, the TFP determinant equations are statistically significant at the 1% level in terms of the standard F test and perform well in terms of standard diagnostic tests for serial correlation, functional form specification, heteroskedasticity and stationarity of the residuals. The final parsimonious equations are shown in Table 3. The choice of dropping or keeping variables in the final models was statistical acceptance in terms of the joint variable deletion tests against the maintained hypothesis. The interaction terms among major sources of R&D was also tested. Since all variables are measured in logarithms, the regression coefficients can be interpreted as elasticities and the size of the coefficients also indicate the magnitude of their relative influence.

The regression results shown in Table 3 confirm that the agricultural research impacts on productivity measured as the long-run elasticities for all the major sources of agricultural R&D are statistically significant though their magnitude are quite small. This conforms to theory and previous studies (Suphannachart and Warr, 2011) that the agricultural research investment has a positive and significant impact on the agricultural productivity. For the domestic sources of R&D, a 1 percent increase in the public, university, and private agricultural R&D expenditure lead to 0.018 percent, 0.022 percent, and 0.012 percent increase in agricultural productivity, respectively. The attribution among the local sources of agricultural R&D can be ranked as the universities, followed by the public-sector, and the private enterprises, respectively. The slightly higher contribution from the university research is consistent with its increasing shares in total agricultural R&D expenditure during recent periods as shown in Table 1. Moreover, the public agricultural research impact is relatively smaller than those found in the previous studies that ignored the role of university and private R&D. This suggests the previous public R&D impact could be overestimated when omitting other sources of R&D. Thus, the attribution among R&D sources is an important issue to be considered when the estimating the benefits from agricultural R&D.

Table 3. TFP Determinants in the Agricultural Sector of Thailand, 1980-2014

Dependent variables = $\Delta \ln TFP_t$	Coefficient (t-statistics)	Long-run elasticity
constant	-0.799 (-3.546)***	
$\Delta \ln P_{t-1}^{pub}$	0.013 (1.703)	
$\Delta \ln P_{t-1}^{uni}$	0.002 (0.148)	
$\Delta \ln P_{t-1}^{pri}$	0.005 (0.887)	
$\Delta \ln P_t^f$	0.117 (1.959)	
$\Delta \ln E_t$	-0.042 (-2.81)***	
$\ln P_{t-2}^{pub}$	0.015 (2.327)**	**0.018****
$\ln P_{t-1}^{uni}$	0.018 (1.856)*	**0.022***
$\ln P_{t-1}^{pri}$	0.010 (1.978)*	**0.012***
$\ln P_{t-1}^f$	0.212 (3.571)***	
$\ln TFP_{t-1}$	-0.838 (-4.047)***	
No. of observation	32	
Adjusted R-squared	0.508	
F-statistics	5.369 (p-value = 0.000)***	

Notes: ***, **, * significant at the levels of 1%, 5% and 10%, respectively. The models pass standard diagnostic tests: Breusch-Godfrey serial correlation LM test, Ramsey test for functional form misspecification, Breusch-Pagan-Godfrey Heteroskedasticity test, and Augmented Dickey Fuller test for residual stationarity. All variables are expressed in natural logarithm. Variables expressed in delta terms represent short-term impact. Long-run elasticity is computed by dividing the estimated coefficients of the level term with the positive value of the lagged dependent variable (TFP_{t-1}).

The rates of return on the major sources of agricultural R&D are then computed based on the estimated coefficients of the level terms of the public, private and university research variables or the long-term TFP elasticities with respect to the local research variables. These regression-based marginal internal rates of return (MIRRs) are estimated at 0.37 percent for the public agricultural R&D, 3.81 percent for the university R&D, and 0.14 percent for the private-sector R&D. These rates of return are quite small and not high enough to cover the opportunity costs of their research funds and so not justified for addition investment, which is contradict with priori expectation and the majority of previous international studies. There could be some problems with the R&D data that are not kept systematically as discussed in Suphannachart (2015). However, this study makes the first attempt in calculating the returns on agricultural R&D classified by sector of performance in Thailand. Further investigation is encouraged as well as a systematic record of the agricultural R&D data is required. At the very least this study found statistical evidence that all the major sources of agricultural R&D investment have significant impacts on the agricultural total factor productivity highlighting the important role of research-induced technology and innovation that can help improve productivity and sustain log-term growth of the agricultural sector of Thailand.

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