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Agricultural research raises productivity and reduces poverty: Evidence from Indonesia and Thailand

Peter Warr

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Australia's aid program is aimed at "promoting prosperity, **reducing poverty**, enhancing stability" and in agriculture this is achieved in part through actions to "invest in **agricultural research** to **increase productivity**, reduce post-harvest losses and make supply chains more efficient."

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But is there evidence for these statements?

Research questions

1. Does Indonesia's publicly-funded agricultural research contribute significantly to productivity growth?

2. If so, what is the rate of return to this public investment?

3. How much of the observed productivity growth is due to agricultural research?

4. Does research-induced productivity growth reduce poverty, and if so, how much?

Research strategy

Agric. research ⇒ Agric. productivity ⇒ Poverty reduction

– We study these links one at a time, using econometric methods

I. Agricultural research ➔ agricultural productivity

– using national level data

2. Agricultural productivity ➔ poverty reduction

– using provincial level data

Model I: ***Productivity determinants model***

- relates the rate of productivity growth in Indonesian agriculture to the level of agricultural research expenditure.

Model II: ***Poverty determinants model***

- relates the rate of reduction of poverty incidence to the rate of agricultural productivity growth.

Model III: ***Poverty projection model***

- combines models I and II to obtain the relationship between the rate of reduction of poverty incidence and the level of agricultural research expenditure.

Outline

1. Agricultural productivity growth in Indonesia

2. Econometric analysis of sources of productivity growth

3. Internal rate of return to expenditure on agricultural research

4. Decomposition of contribution of agricultural research

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Background data

	1975-2006
Average real GDP growth	6.0%
Average real agric VA growth	3.7%
Average share of agriculture in GDP	24%
Average contribution of agriculture growth to GDP growth	15%
Average agric factor growth rate	2.05%
Average agric TFP growth rate	1.63%
Average agric TFP contribution to agric VA growth	44%
Average agric TFP contribution to GDP growth	6.5%

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TFP and factor inputs

A = Output

B = TFP

C = Total factor input

(all at 1974 constant prices)

***Source*: Keith O. Fuglie *J Prod Anal (2010)*.**

	A	B	C
1975	20960.00	1.39	15079.14
1976	20960.00	1.38	15188.41
1977	22001.49	1.4	15715.35
1978	23173.17	1.44	16092.48
1979	24214.66	1.46	16585.38
1980	26427.83	1.57	16833.01
1981	28380.62	1.61	17627.71
1982	28250.43	1.57	17993.91
1983	30463.60	1.59	19159.50
1984	32937.14	1.65	19961.90
1985	34108.82	1.68	20302.87
1986	36582.36	1.73	21145.87
1987	37103.11	1.68	22085.18
1988	38925.71	1.73	22500.41
1989	40748.32	1.76	23152.46
1990	42440.75	1.77	23977.82
1991	43221.86	1.77	24419.13
1992	46736.89	1.86	25127.36
1993	47127.45	1.84	25612.75
1994	47387.83	1.79	26473.65
1995	51683.98	1.9	27202.09
1996	52204.72	1.88	27768.47
1997	50251.93	1.82	27610.95
1998	49861.37	1.86	26807.19
1999	51033.04	1.92	26579.71
2000	52595.28	1.96	26834.33
2001	53636.77	1.96	27365.70
2002	56631.06	2.02	28035.18
2003	60406.46	2.12	28493.61
2004	63270.56	2.22	28500.25
2005	64442.24	2.21	29159.38
2006	66395.03	2.26	29378.33

$$Q_t = h(X_t, Z_t)$$

$$h(X_t, Z_t) = f(X_t) g(Z_t)$$

$$TFP_t = Q_t / f(X_t) = g(Z_t)$$

$$TFPG_t = q_t - \sum_{i=1}^{I} \varepsilon_t^i x_t^i = \sum_{j=1}^{J} \eta_t^j z_t^j$$

Stylized model

$$TFP = g(GER, IER, GEE, TRA, RF, FS, D^c),$$

where TFP = total factor productivity in agriculture,

GER (+) = real government expenditure on agricultural research,

IER (+) = realinternational expenditure on agricultural research,

GEE (+) = real government expenditure on agricultural extension,

TRA (+) = total rate of government assistance to agriculture,

RF (+) =rainfall,

FS (–) =share of food crops in agricultural output,

D^c = case-specific dummy variables comprising:

D^1 (+) = the abnormally favorable climatic and pest control circumstances of 1980,

D^2 (–) = the disruptive effects of the Asian Financial Crisis of 1997 and 1998.

Estimation results (1975 to 2006)

	Model 1	Model 2	Model 3
Dependent variable: $\Delta \ln TFP_t$			
Independent variables:			
Constant	-1.4782	-1.1416***	-1.0555***
	(0.2616)	(0.0071)	(0.0007)
D^1	0.0438**	0.0533***	0.0531***
	(0.0473)	(0.0000)	(0.0000)
D^2	-0.0538**	-0441***	-0.0434***
	(0.0182)	(0.0084)	(0.0066)
$\ln TFP_{t-1}$	-0.5791***	-0.5086***	-0.4994***
	(0.0034)	(0.0009)	(0.0004)
$\ln GER_{t-1}$	0.1541**	0.1061***	0.0993***
	(0.0379)	(0.0038)	(0.0006)
$\Delta \ln GER_t$	0.0154		
	(0.8643)		
$\ln IER_{t-1}$	0.1646**	0.1176**	0.1122**
	(0.0304)	(0.0467)	(0.0365)
$\Delta \ln IER_t$	1.3384*	1.0069**	0.9353***
	(0.0759)	(0.0223)	(0.0082)
TRA_{t-1}	-0.0012*	-0.0001	
	(0.0973)	(0.7732)	
ΔTRA_t	-0.0004		
	(0.4705)		
$\ln GEE_{t-1}$	-0.0128		
	(0.9265)		
$\Delta \ln GEE_t$	0.2024		
	(0.4294)		
$\ln RF_{t-1}$	-0.0003		
	(0.8385)		
FS_{t-1}	0.2688		
	(0.5651)		
$\Delta \ln TFP_{t-1}$	0.0558		
	(0.7333)		
Long-run elasticities of *TFP* with respect to *GER* and *IER*			
GER	0.26**	0.20***	0.20***
IER	0.28**	0.23**	0.22**
Diagnostics			
R-squared	0.6216	0.5112	0.5099
Adjusted R-squared	0.31	0.3687	0.3923
F-statistic	1.9950	3.5865	4.3356
Prob. (F-statistic)	0.0885	0.0087	0.0039
Number of observations	32	32	32

Note: *p* values are reported in parentheses. Standard errors are corrected for heteroskedaticity. Statistical significance at the 1, 5 and 10% levels is indicated by ***, *** and *, respectively.
Source: Author's calculations.

Residual Unit root test :

Null Hypothesis: residuals have a unit root
Exogenous: Constant
Lag Length: Automatic

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.712	0.0000
	1% level	-3.662	
Test critical	5% level	-2.960	
values:	10% level	-2.619	

Serial correlation test:
Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.82315	Prob. F(1,24)	0.1895
		Prob. Chi-Square (1)	0.1328

Implications:

Government-sponsored domestic agricultural research significantly raises productivity

CGIAR-sponsored international agricultural research also significantly raises productivity

Government assistance directly to agriculture has no impact on productivity

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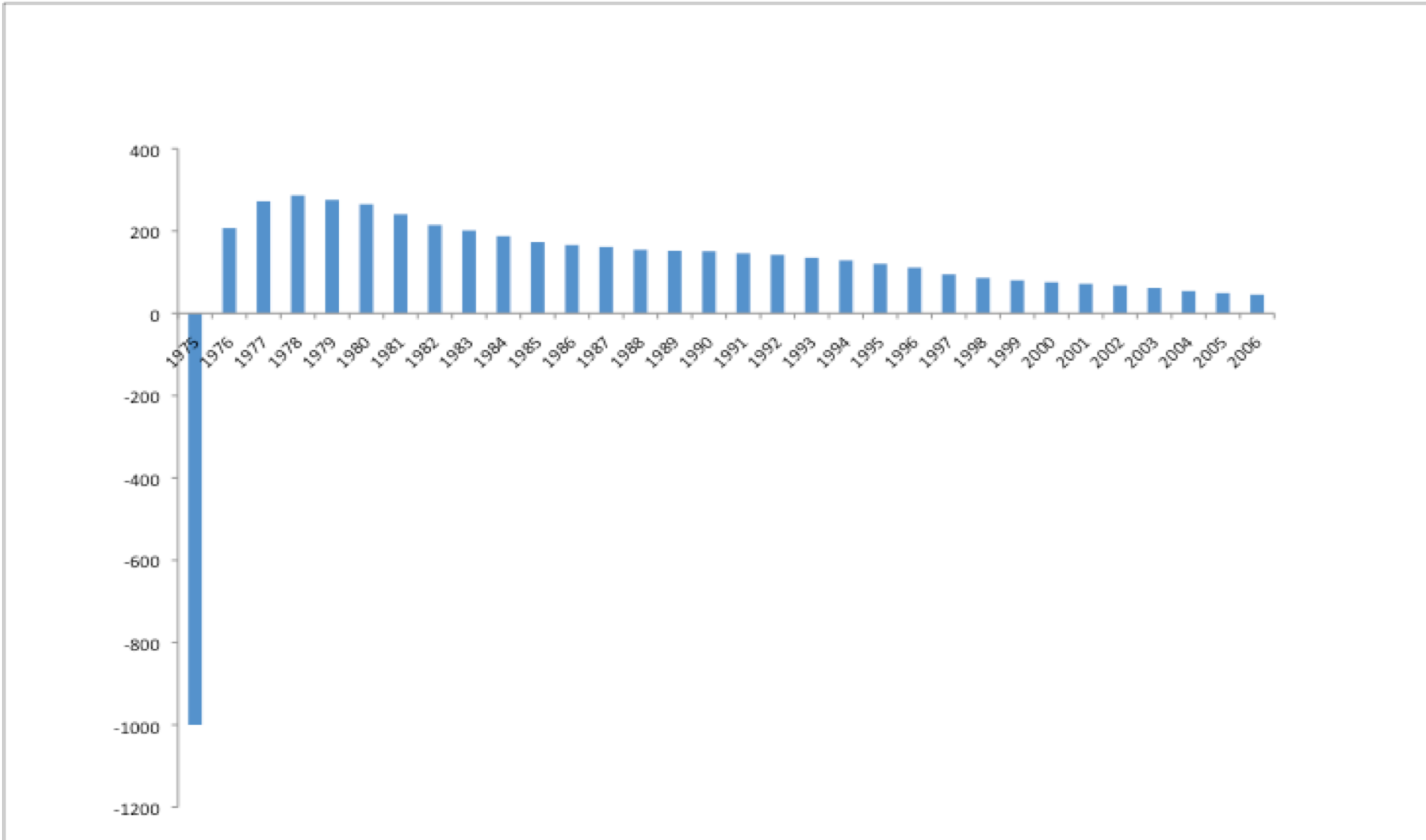
Projected streams of net economic benefits arising from a 1 billion Rupiah increase in research expenditure in 1975

(units: millions of Indonesian Rupiah, constant 1974 prices



Calculation of IRR

$$\sum_{t=1976}^{2006}\left[(\hat{V}_t^1 - \hat{V}_t^0)/(1+r)^{t-1975}\right] - 1 = 0$$

Calculation of IRR

$$\sum_{t=1976}^{2006}\left[(\hat{V}_t^1 - \hat{V}_t^0)/(1+r)^{t-1975}\right] - 1 = 0$$

r = 27%

The findings for Thailand are similar:

Waleerat Suphannachart and Peter Warr, 'Research and Productivity in Thai Agriculture', *Australian Journal of Agricultural and Resource Economics*, vol. 55, no. 1 (March 2011), 35-52.

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Waleerat Suphannachart and Peter Warr, ‘Research and Productivity in Thai Agriculture’, *Australian Journal of Agricultural and Resource Economics*, vol. 55, no. 1 (March 2011), 35-52.

r = 29%

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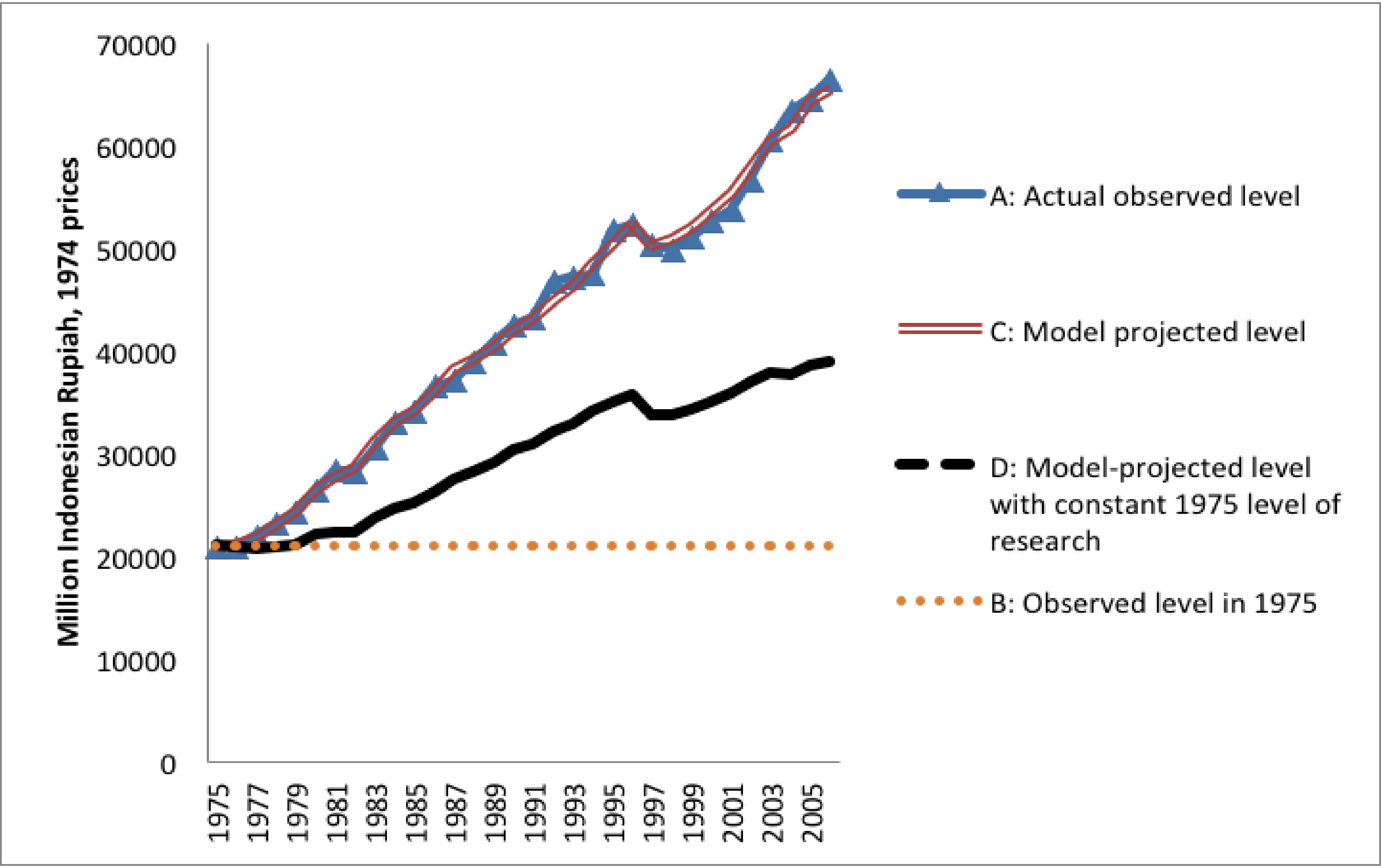
Indonesia: Projected streams of real value-added in agriculture



Indonesia: Contributors to real agricultural value-added growth, 1975 to 2006

(units: millions of Rupiah, 1974 prices)

Projected contribution to growth, 1975 to 2006:	Increase in level of value-added	Per cent of increase in value-added
Factor growth only	16,644	36.6
Government research	25,387	55.9
All explanatory factors	44,366	97.6
Actual increase	45,436	100

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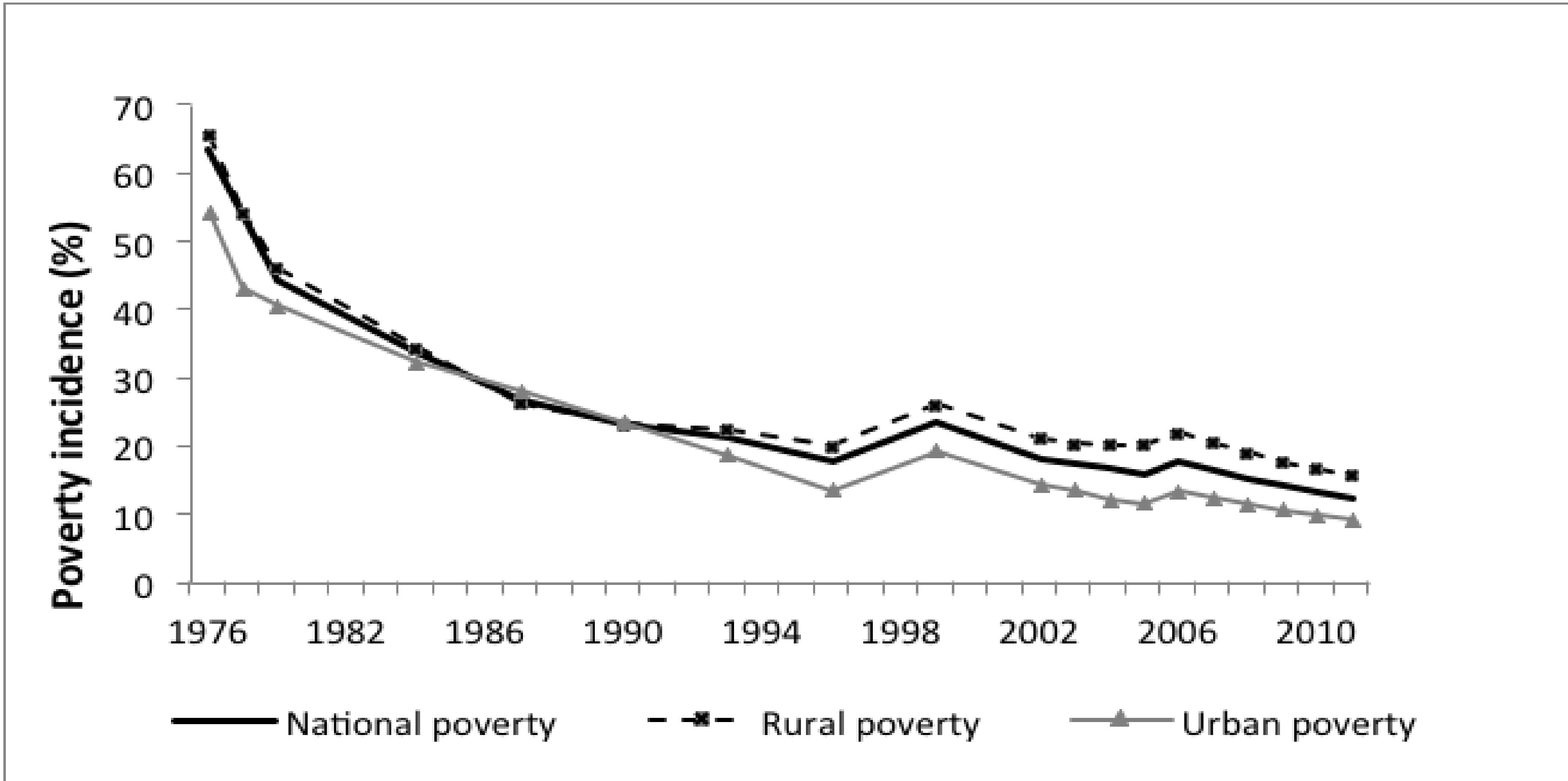
Indonesia: Poverty incidence, 1976 to 2012



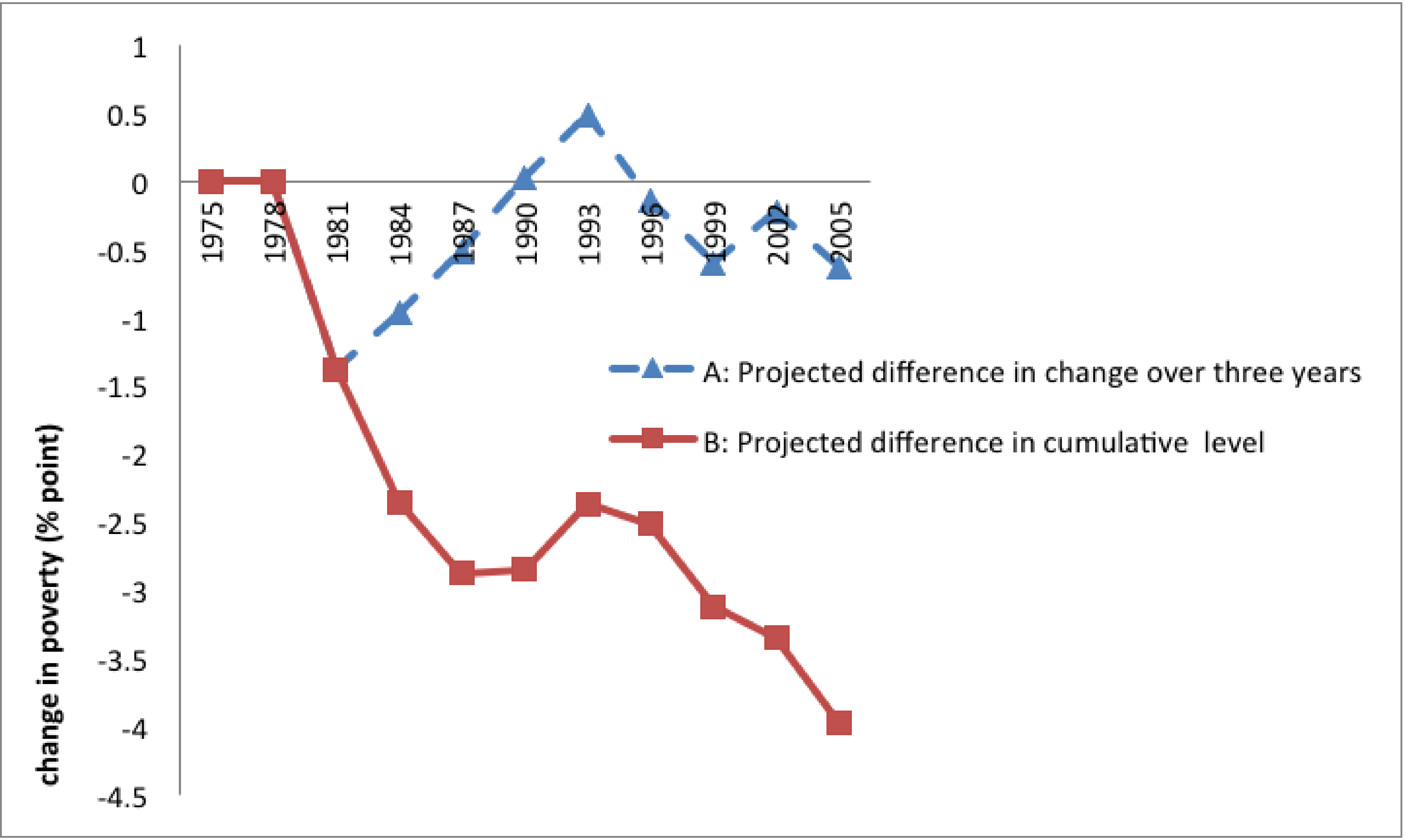
Effects of agricultural incomes, non-agricultural incomes and food prices on rural poverty incidence

Dependent variable: annual change in rural poverty incidence		
Independent variables	**Rural 1**	**Rural 2**
Annual change in agricultural income per capita	-0.01820***	-0.02680***
	(0.00673)	(0.00650)
Annual change in non-agricultural income per capita	-0.00106	-0.00268***
	(0.00097)	(0.00088)
Annual change in real price of food	9.85929***	
	(2.99297)	
Time dummy 1990-93	-0.87920**	-0.83765**
	(0.40605)	(0.42557)
Time dummy 1993-96	-1.53068***	-1.10214**
	(0.44290)	(0.44393)
Time dummy 1999-02	-1.28819***	-1.38525***
	(0.38689)	(0.40451)
Constant	0.54888**	0.50645**
	(0.21909)	(0.22934)
R^2	0.434	0.371
F-value	12.53	11.70
p-value	0.0000	0.0000
Number of observations	105	105

Effects of agricultural productivity, non-agricultural incomes and food prices on rural poverty incidence

Dependent variable: annual change in rural poverty incidence		
Independent variables	**Rural 3**	**Rural 4**
Annual change in agricultural TFP	-0.11956***	-0.08883*
	(0.04533)	(0.05179)
Annual change in agricultural inputs per capita	0.00001	0.00001
	(0.00003)	(0.00004)
Annual change in real price of food	15.17528***	
	(2.94246)	
Annual change in non-agric. income	-0.00078	0.00025
	(0.00064)	(0.00071)
Time dummy 1993-96	-1.95726***	-2.01243***
	(0.41627)	(0.47958)
Time dummy 1999-02	-1.38524***	-1.89458***
	(0.41803)	(0.46813)
Constant	0.91153***	0.93172***
	(0.26979)	(0.31090)
R^2	0.461	0.275
F-value	10.98	5.92
p-value	0.0000	0.0001
Observations	84	84

Indonesia: Projected streams of rural poverty reduction



Indonesia: Projected changes in rural poverty incidence, 1978 to 2005

Year ending	A: Projected difference in change over three years	B: Projected difference in cumulative level
1978	0	0
1981	-1.382	-1.382
1984	-0.972	-2.354
1987	-0.523	-2.877
1990	0.026	-2.852
1993	0.483	-2.368
1996	-0.149	-2.517
1999	-0.605	-3.123
2002	-0.225	-3.348
2005	-0.627	-3.975

Conclusions: Indonesia

- Between 1975 and 2006 the level of agricultural research in Indonesia increased by a factor of 8.2. Suppose that instead its real value had remained permanently at its 1975 level. Then by 2006 the level of rural poverty incidence would have been 26 percent of the rural population and not the 22 percent actually observed.

- That is, of the 32 percentage point decline in rural poverty incidence that actually occurred (from 54 percent to 22 percent of the rural population), four percentage points, one eighth of the observed decline, is attributable to government-sponsored agricultural research.

- **Out of a rural population of 121 million in 2006, 4.8 million people were non-poor because of the increased real level of agricultural research that had occurred since 1975.**

- **It is not suggested that Indonesia's agricultural research establishment is world class. Casual inspection of the research facilities in place suggests otherwise.**

- **But the activity of taking the output of the international agricultural research community and adapting it to local circumstances is so productive that even a modest commitment of skilled professionals and research facilities can generate a high payoff.**

Conclusions: Thailand

Suppose real domestic research expenditure had remained at its 1975 level. Then three decades later rural poverty incidence would have been higher by 0.5 per cent of the rural population (roughly 200,000 people) than it actually was.

Urban poverty incidence would have been higher by 0.35 per cent of the urban population (roughly 70,000 people).

That is, it is estimated that roughly 270,000 Thai people are non-poor now, but would have remained poor if the real value of research expenditure had remained constant since 1975.

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6. Comparison with Rada, Buccola and Fuglie (2011)

Rada *et al.* (2011):

"We find that agriculturally focused liberalization efforts and massive depreciation succeeded in lifting Indonesian farm technology growth. Yet government-sponsored research can take little credit for the improvement.

Most of Indonesia's productivity growth is explained by informal technological diffusion unaccounted for by these government initiatives." (p. 867)

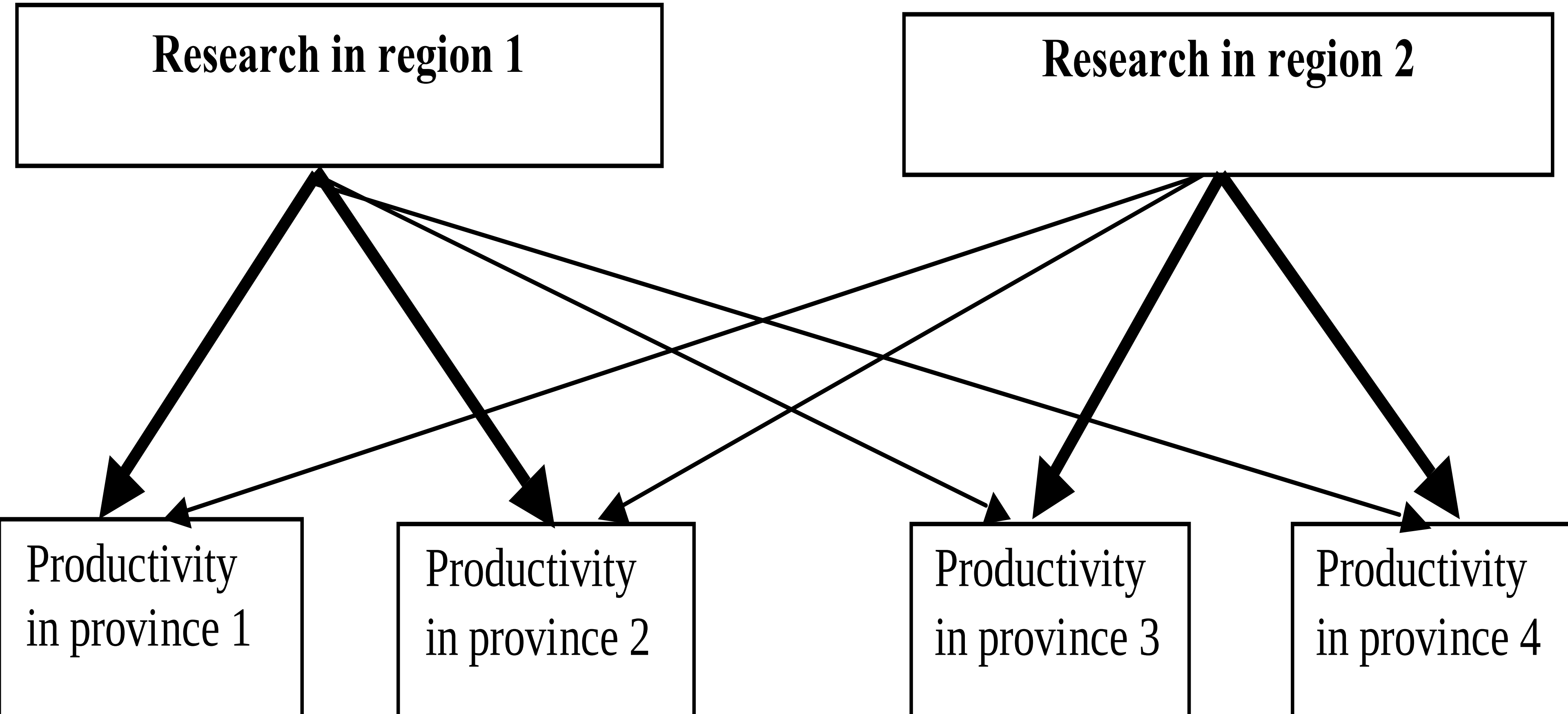
"Among the range of interventions at government's disposal – trade restrictions, subsidies, price supports and taxes, and public research – the latter appears to have been the least effective in boosting productivity growth." (p. 878)

Rada *et al.* (2011, p. 873):

Data on 22 provinces in 5 regions

"Although regionally located institutes may, regardless of their location, have some national research mandate, we assume their programs are oriented toward local or at least regional agronomic conditions (Evenson *et al.* 1994)".

Regional research and productivity assumptions: Rada *et al.*



Thanks for listening

Data decomposition: Mean annual changes in poverty incidence

	Actual							
	Indonesia	Laos	Malaysia	Myanmar	Philippines	Cambodia	Thailand	Vietnam
National [a]	-1.281	-1.227	-0.932	-1.300	-0.695	-1.760	-1.301	-2.174
Urban [b]	-0.313	-0.129	-0.150	-0.305	-0.177	0.131	-0.191	-0.188
Rural [c]	-0.911	-1.051	-0.524	-0.973	-0.401	-1.357	-1.107	-1.887
Migration [d]	-0.057	-0.046	-0.259	-0.022	-0.117	-0.534	-0.003	-0.099
	Normalized (National = 100)							
National [a]	100	100	100	100	100	100	100	100
Urban [b]	24.43	10.54	16.05	23.44	25.41	-7.47	14.67	8.65
Rural [c]	71.10	85.70	56.22	74.86	57.72	77.11	85.11	86.80
Migration [d]	4.46	3.77	27.73	1.69	16.87	30.36	0.22	4.55