DETERMINANT FACTORS OF VEGETABLE FARM PRODUCTIVITY IN PANGALENGAN, WEST JAVA, INDONESIA

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ABSTRACT. *Total-Factor Productivity (TFP) has a significant role to increase vegetable farming production. The objective of this research is to analyze factors affecting TPF in vegetable farming production. This research was conducted on farm level of vegetable production in Pangalengan, a sub district of Bandung, West Java. The samples in this research are 76 farms from six villages with different level of supporting infrastructure. TFP on those farms varies from 0.71 to 3.14, averaged at 1.43. These varieties are due to high response level to changes in diversification index. Farmers' education, cultivated area and access to inputs have significant and positive effect with low elasticity. Conservation technology and irrigation infrastructure have weak positive effect. Seed technology has significant and negative effect to TFP.*

Keywords: *Total-Factor Productivity, infrastructure, farm level*

JEL Codes:

Introduction

Vegetables are top commodities of horticulture, second to fruits in contribution to GDP. The numbers tend to decrease 2.14 percent annually in 2003 to 2008 (Table 1), due to low productivity and narrow cultivated area. Cultivated area is limit to change due to unavailability. It left productivity as the subject of change.

Productivity can be increased partially per inputs or totally with total-factor productivity. Studies of partial input productivity are considered not suitable to explain the whole. Total-Factor Productivity (TFP) is a concept to

measure productivity by explaining factors other than inputs that affect output. The study on farm level has not been done. Fuglie (2004) analyzed TFP of farms in macro level affect agriculture GDP using time series data. Fuglie (2010) found that TFP differs among periods, where it tends to increase during green revolution and liberalization and decrease during economic crisis using time series data. Juamo (2012) studied TFP in aggregate level to analyze productivity of prawn farming. Martinez-Cordero *et al* (1999) and Juamo (2012) analyzed TFP on farm level using cross sectional data to compare TFP variance on farm level to average TFP. By analyzing TFP on farm level, we can determine factors other than inputs that affect productivity.

Vegetable farming productivity varies on farm level, across location and time (Table 1). The productivity level shown here is partial productivity per cultivated area. This raises questions of why productivity greatly varies and what caused it. To answer those questions, we conduct a study of TFP on farm level. The study is conducted in Pangalengan, production center of vegetables, mostly potato and cabbage. Potato and cabbage productivity in 2009 are 19.80 tons/ha and 23 tons/ha covering 59 percent and 45 percent of West Java vegetable cultivated area respectively and both cover 88 percent of vegetable cultivated area of Bandung Regency. The objectives of the research are:

1. to analyze Total-factor Productivity of vegetable farms in Pengalengan
2. to analyze factors affecting Total-factor Productivity of vegetable farms in Pengalengan

Table 1 Farming productivities of potato and cabbage of West Java, 2009-2010 (in ton/ha)

District	2009		2010	
	Potato	Cabbage	Potato	Cabbage
Bogor	27.00	19.25	12.80	14.77
Sukabumi	12.38	12.14	20.91	12.68
Cianjur	26.38	18.95	26.31	11.61
Bandung	20.34	23.06	20.48	23.23
Garut	23.25	24.36	21.74	24.57
Tasikmalaya	12.50	14.77	na	16.33
Ciamis	Na	14.08	12.45	15.86
Kuningan	19.29	20.16	19.30	18.28
Majalengka	19.44	9.29	12.77	23.15
Sumedang	16.16	23.08	15.24	21.90
Subang	14.25	10.00	na	9.46
Purwakarta	Na	13.40	na	16.00
West Bandung	13.18	18.54	15.28	17.78
West Jawa Total	21.09	21.94	20.30	22.38

Note: na = no commodity produced on given area
Source: Statistical Bureau of West Java Province, 2011

Theoretical Framework

Increase in production can be obtained via increase on cultivated area and increase on productivity. Due to lack of cultivated area, increase in productivity is crucial. Productivity is the ratio of what is produced to what is required to produce. Partial input productivity, such as land productivity or labor productivity, cannot explain all the factors affecting productivity. Total-Factor Productivity (TFP) accounts of effects in total output not caused by traditionally measured inputs, such as labor and capital. TFP analysis can identify change in output that is not accounted to change in traditional inputs. TFP can be described mathematically as:

$$\text{TFP}_{\text{index}} = \frac{\text{OUTPUT index}}{\text{INPUT index}} \quad [01]$$

TFP can measure change in productivity or input efficiency due to technological change, either advancement or transformation. Technological change cause efficiency increase on input that later on increases overall productivity. Technology includes technology on input, mechanical, production system and output. It can affect productivity in sense of the same input yield greater output or lesser input yield same output.

In addition to technological advancement, productivity can be affected by several internal and external factor of the farm. Main internal factor is farmer ability to manage the farm, which determined by factors such as education, experience, knowledge and skill. Those factors called human capital. Farmer role as manager is important due to one's role as decision maker. Other internal factor is business capacity measured by cultivated area and assets availability. Wider area and more suitable assets available can boost farm productivity.

The external factor is supporting infrastructure- physical and non physical (Fuglie, 2010; Kumar *et al*, 2008; Weiping and Ying, 2007; Anderson and Situmorang, 2006; Ashok and Balasubramanian, 2006; Kalyvitis, 2002; Nayak, 1999, dan Looney, 1994). It includes roads, irrigation, markets, research centers, consulting agencies, credit and financial institutions and agrarian system and policies

Change in infrastructure influence cultivated area and productivity. Increase of supporting infrastructure -given fixed output price- will increase cultivated area and productivity that eventually will increase production and profit. Infrastructure in this research includes physical infrastructure (road and irrigation), financial (credit availability) and technology (land conservation, seed technology and planting diversification).

We can conclude that TFP is influenced by several important factors such as human capital, infrastructure, quality and capacity of assets (vintage of capital) and research and development. TFP can be measured by index of Laspeyres, Paaschem Fisher and Tomqvist. Based on economic theory and functional test approach, Fisher and Tomqvist index are considered the best[1]. This research use Tomqvist index, formulated as:

$$\ln \text{TFP index}_{\text{st}} = \ln \frac{\text{Output index}_{\text{st}}}{\text{Input index}_{\text{st}}} = \ln \text{Output index}_{\text{st}} - \ln \text{Input index}_{\text{st}}$$

[1] Efficiency and Productivity Analysis: Deterministic Approach (Lissitsa,)

$$= \tfrac{1}{2}\sum_{i=1}^{m}(W_{is} + W_{it})\,[\ln Y_{it} - \ln Y_{is}] - \tfrac{1}{2}\sum_{j=1}^{k}(V_{js} - V_{jt})\left[\ln X_{jt} - \ln X_{js}\right] \quad [02]$$

Tomqvist index can be used to measure TFP for time series data, panel data and cross sectional data (across locations or enterprises at certain time). This research measured farms TFP certain year.

Reseach Method

Location and data collection

This research is an empirical study in farm level. The location selected is vegetable production center (potato and cabbage), Pangalengan Sub District, Bandung Regency, West Java. The sample villages are determined by two criteria: vegetable (potato and cabbage) production center and has access to road. The sample villages are Margamulya, Margamekar, Pulosari, Margamukti, Margaluyu and Sukaluyu (Table 2). The sampling method is stratified random sampling. Strata are based on cultivated area: narrow (<0.5 ha), medium (0.5-1.0 ha) and wide (>1 ha).

Primary data collected are farm input and output volume and price, planting area to economic center distance, road condition, irrigation, cultivation technology, conservation technology, land slope, number of input and output market, credit, fixed assets and farmer characteristics during planting season of 2010/2011. Data collected limited to potato and cabbage as main commodities of vegetable farmers. Data gained by questionnaire for sample farmers. Besides that, key people in vegetable farming industry, such as counselor, chairman and member of farmers group, village and sub district authorities, vegetable whole sellers, input and output vendors and financiers, are also interviewed.

Table 2 Sample distribution in Pangalengan Sub District, 2010/2011

No	Village	Number of sample (people)	Distance to district center (km)[a]	Time needed to travel to regency center (minute)[a]	Altitude (mamsl)[a]	Slope (%)[a]
1.	Margamulya	9	0,7	12	1200	40,0
2.	Pulosari	16	2,5	25	1446	32,0
3.	Margamekar	15	3,2	15	1440	30,0
4.	Margamukti	15	1,7	9	1485	36,0
5.	Margaluyu	18	13,0	60	1550	2,5
6.	Sukaluyu	3	10,0	40	1522	31,0

Source : [a]Pengalengan Sub District Profiles, 2011

Method of Analysis

Productivity measured in this research is Total-Factor Productivity (TFP) using index Tomqvist-Theil (Cordero et al, 1999; Juarno, 2012). This index measure TFP of each farm compared to average TFP. The formula for cross sectional data is

$$TFP_{iavg} = \tfrac{1}{2}\sum m\,(\log Q_{mi} - \log Q_{mavg})(S_{mi} + S_{mavg}) - \tfrac{1}{2}\sum k\,(\log X_{ki} - \log X_{kavg})(S_{ki} + S_{kavg}) \quad \ldots\ldots[03]$$

TFP_{iavg} = Total-factor Production of farm i
Q_{mi} = output m of farm i
Q_{mavg} = average output m of all farms
S_{mi} = income proportion of output m for farm i
S_{mavg} = average income proportion of output m of all farms
m = number of farm output (m= 1,2,…,n)
k = number of farm input (k = 1,2,…, n)
X_{ki} = input k of farm i
X_{kavg} = average input k of all farms
S_{ki} = cost proportion of input k of farm i
S_{kavg} = average cost proportion of input k of all farms

Regression analysis is used to determine factors affecting TFP with Ordinary Least Square approach using SAS 9.2 computer program. The model of factors affecting TFP is:

$$TFP_{iavg} = \beta_0 + \beta_1 SID + \beta_2 EDF + \beta_3 ITEKB + \beta_4 IKONS + \beta_5 IRIG1 + \beta_6 LHN + \beta_7 AKSII + u \quad [04]$$

SID = Simpson diversification index
EDF = formal education
ITEKB= seed technology index
IKONS= land conservation index
IRIG1 = irrigation infrastructure index
LHNS = size of cultivated area
AKSII = access to input market index
βi = predicted parameter
i = number of observation (sample)

Simpson Diversification Index is:

$$SID = 1-\sum(a_i/A)^2 \quad \ldots\ldots [05]$$

ai = planting area of vegetation i
A = total area of plantation

Index of seed technology irrigation and access to input market is measured index used by Iyengar and Sudarshan (1982) and Ashok and Balasubramanian (2006) as follows:

$$Y_{id} = (X_{id} - MinX_{id})/\,(MaxX_{id} - MinX_{id}) \quad \ldots\ldots [06]$$

Y_{id} = infrastructure index i of farm d
X_{id} = weight of infrastructure i of farm d
$MinX_{id}$= minimum weighted infrastructure of farm d
$MinX_{id}$= maximum weighted infrastructure of farm d

Result and Discussion

Research Location and Farm Description

Pangalengan is located on the south of Bandung Regency, approximately 36km from the regency central, one hour ride on public transport. Pangalengan covers 27294.72 hectares, consists of 13 villages, the biggest sub district of the regency, 1000-1500 meters above sea level. Almost all villages are located at the edge or near forest, where forest area is 45 percent of total area of the sub district. Plantation area is 25 percent of the total area, where 80 percent of it is state-owned -plantation. In 2009, the population is 136 678 people with average of 3.7 people per family. Although Pangalengan is relatively far from regency center, the area flourished because regency and provincial roads run through it. Most resident (48 percent) works in farms, where 38 percent works as farm worker/peasant farmer and only 10 percent own land.

Vegetable farm is the main agriculture business for most of the resident. Seventy percent of agriculture land is used of planting vegetable. The vegetables planted are high and dry land vegetables. Seventy one percent of Pangalengan land is dry land and only for percent of it is wet land/paddy field (Table 3).

Table 3 Land usage in Pangalengan Sub District, 2010/2011

Land Usage	Area (Ha)	%
Wet land	1.131,84	4,15
Dry land	19.334,18	70,83
Other usage	6.828,70	25,02
Total	**27.294,72**	**100,00**

Source: Statistical Bureau of Bandung Regency, 2011

Main vegetables planted are potato and cabbage, using 37 percent of agriculture area. Other commodities include carrot, tomato, scallion, radish, chicory, cauliflower, squash and red chili. Farmers start planting potato and cabbage on rainy season (MH), September to January and first dry season (MKI), February to May. On the second dry season (MKII), farmers plant other vegetables or legumes. About 20 percent of farmers fallow their land during MKII (Table 4).

Table 4 Vegetable Planting Pattern in Pangalengan Sub District, 2010/2011

Commodity	MH (N=76)	MKI (N=76)	MKII (N=76)
Potato + Cabbage	63,16	67,11	31,58
Other vegetable	32,89	32,89	48,68
Fallow (uncultivated)	3,95	0,00	19,74
Total	100,00	100,00	100,00

The cultivated land area is varied, averaged at 1.41 hectares. Average cultivated land on first stratum is 0.3, second is 0.75 and third is 3.65 hectares (Table 5). On second and third stratum, land cultivated by farm worker/peasant

farmer proportionally bigger than one that cultivated by its owner; which is not the case for first strata. The farm worker/peasant farmers are either rented or only worked on the land. Rent cost is 1.5 to 5 million rupiahs per hectare per season. Rent cost is determined by land location, land slope, land fertility and access to irrigation. Farm workers, who only work on the land, usually cultivate uncultivated area of plantation or forest without interfering with the main crops such as tea, quinine or cajuput.

Table 5 Cultivated area cultivation state, numbers of partials and slope for vegetable farming in Pangalengan 2010/2011

Status	Unit	Stratum 1 (N=30)	Stratum 2 (N=24)	Stratum 3 (N=22)	Total (N=76)
Cultivated area	Ha	0,30	0.75	3.65	1.41
Owned	Ha	0,19	0.37	1.50	0.63
Non-owned :	Ha	0,11	0.38	2.15	0.79
a. Rented	Ha	0,05	0.29	2.03	0.70
b. Worked on	Ha	0,07	0.09	0.12	0.09
Number of partials	unit	1,90	2,92	3,41	2,66
Slope	%	18,00	21,49	19,32	19,48

The location of sample farms from regency center is varied from 0.5 to 20 km. The slope is varied from nine to 80 percent, averaged at 19.5 percent. Most farms are fragmented up to eight partials, averaged at three. Stratum 3 (wide) farms are fragmented more than the other strata (narrow and medium) due to gradual increase of cultivated area on dispersed locations. The increase and dispersion are caused by purchase, inheritance, grant, rent or uncultivated area usage. Land fragmentation in a way can add accessibility of land, but in other hand prevent higher productivity. It can lead to inverse farm productivity (Kusnadi, 2005). In this research, there is no inverse land productivity where TFP is bigger on wider land (Table 6).

Vegetable Farm Productivity

TFP of vegetable farm in Pangalengan is varied from 0.71 to 3.14, averaged at 1.43. Index of 0.71 means that productivity of certain farm is 29 percent lower than the average, meanwhile 3.14 means the productivity is 314 percent higher than the average. Most farms (43.42 percent) have TPF index less than 1 that means lower than average. Most of these farms are stratum 1. Percentage of farms with TFP index 1 to 2 is 32.58 percent, mostly on stratum 2. Percentage of farms with TFP index more than 2 is 25 percent, mostly on stratum 3. Percentage of farms with TFP index less than one is shown in Table 6.

Table 6 Index of productivity vegetable farms based on land strata on Pandeglang, 2010/ 2011

TFP	Stratum 1		Stratum 2		Stratum 3		Total	
	n	%	n	%	n	%	n	%
< 1	17	22.37	7	9.21	8	10.53	33	43.42
1 – 2	6	7.89	11	14.47	7	9.21	24	31.58
> 2	7	9.21	6	7.89	7	9.21	19	25.00
Total	30	39.47	24	31.58	22	28.95	76	100.00

Productivity of vegetable farms increase with the increase of cultivated area (Table 7). Nevertheless, the productivity increase is small compared to increase in cultivated area. This is shown by big difference in area of cultivated land among strata (0.29, 0.46 and 1.99 hectares) while the difference of productivity is small (1.37, 1.45 and 1.51). The cultivated area of stratum 3 is nearly 7 times as wide as stratum 1 and 4 times of stratum 2, but the productivity only 1 and 1.1 times of stratum 1 and 2 respectively. We can see that productivity of stratum 3 farms is low weigh against its area, although there is no of inverse farm size productivity (IP) indicated.

Table 7 Estimated variable average of productivity model of vegetable farms in Pandegelang 2010/2011

Description	Strata 1 n=30	Strata 2 n=24	Strata 3 n=22	Total n=76
Productivity (TFP)	1.3667	1.4486	1.5050	1.4326
Plant diversification index	0.5111	0.5093	0.4949	0.5058
Farmer' formal education	2.4667	2.6667	2.6364	2.5789
Seed technology index	0.4074	0.3895	0.3399	0.3822
Land conservation index	0.1700	0.2267	0.2227	0.2032
Irrigation index	0.1600	0.1333	0.2091	0.1658
Cultivated area index	0.2926	0.4608	1.9871	0.8363
Access to market index	0.0911	0.0246	0.0622	0.0618

Factors affecting productivity

Determination coefficient (R2) shows that 59.20 percent of productivity index can be explained by the independent variables. The variance inflation factor (VIF) of the model is less than 1.5 that shows no multi co-linear problems among the independent variables. F-test shows that the model can properly explain the actual phenomenon. The statistical description is shown in Table 8.

Variables that significantly and positively affecting TFP ($\alpha < 0.15$) are plant diversification, farmer' education, irrigation, cultivated area and access to input market. Seed technology and land conservation are not significantly affect TFP (Table 9).

Vegetable farm productivity is responsive to change in plant diversification index (elasticity index 1.72). Most farmers cultivate two or three plants on the same area in a year according with certain cultivation pattern. Average plant diversification index is 0.51 within the variance of 0.44 to 0.67. In technical aspect, plant diversification can preserve land fertility, reduce pest and disease, prevents land erosion and cause better usage of limiter water. In research location, plant diversification tends to be based on technical aspect and farmers' habit rather than market demand due to untimely access to information and long gestation period. Most of the time the information gained to decide the commodity to cultivate is obsolete when it is the time to harvest.

Table 8 Estimated variables of productivity model of vegetable farms in Pangalengan, 2010/2011

Variabel	Label	n	Average	Std Dev	Minimum	Maximum
Productivity (TFP)	TFP	76	1.4326	0.6727	0.7061	3.1393
Plant diversification	SID	76	0.5058	0.1000	0.4444	0.6667
Farmer' formal education	EDF	76	2.5789	1.1345	1.0000	6.0000
Seed technology	ITEKB	76	0.3822	0.2764	0.0217	1.0000
Land conservation	IKON	76	0.2032	0.2304	0.0000	1.0000
Irrigation	IRIG1	76	0.1658	0.2517	0.0000	1.0000
Cultivated area	LHNS	76	0.8363	1.2540	0.0400	6.0000
Access to market	AKSII	76	0.0618	0.1539	0.0000	1.0000

The education level of the farmers, access to input market and irrigation infrastructure are significant with small elasticity. This shows that productivity is less responsive to these variables. Meanwhile, seed technology has negative but not significant effect. Education is important to influence farmer skill in managing farm. This research finds that farmers' formal education is considered good enough (equal to grade 9).

Table 9 Parameter estimate of factors affecting vegetable farm productivity in Pangalengan 2010/2012

Variabel	Parameter Dugaan	Std. Err	t Value	Pr >|t|	Elastisitas
Constant	-1.3821	0.3112	-4.4400	<.0001	
Plant diversification	4.8703***	0.5071	9.6000	<.0001	1.7197
Farmer' formal education	0.0978**	0.0454	2.1500	0.0174	0.1761
Seed technology	-0.1432	0.1821	-0.7900	0.2172	-0.0382
Land conservation	0.0586	0.2293	0.2600	0.3996	0.0083
Irrigation	0.2187*	0.2000	1.0900	0.1390	0.0253
Cultivated area	0.0954**	0.0421	2.2700	0.0133	0.0557
Access to market	0.4150*	0.3295	1.2600	0.1062	0.0179

Note: *** $\alpha < 1\%$; ** $\alpha = 2{,}5\%$; * $\alpha = 15\%$

Cultivated area has weak but significant effect on productivity. Average area difference among strata is great but productivity difference is small (Table 6). It is assumed that the land quality is not good. Average area is 0.83 hectares, varied greatly from 0.04 to 6 hectares. Area with grater slope is less productive than the smaller one. Irrigation has weak but significant effect. Limited access to

irrigation is assumed to be the cause of this. Average irrigation index is relatively low 0.17 but varied greatly from 0 to 1. Access to input market is also weak but significant, shown by elasticity index of 0.02. Access to input market index is a ratio of accessible input market to available input market. Low number of this index shows that farmers have less market choice. Store credit availability in certain market is likely to be the cause of it.

Land conservation shows non-significant positive effect, which means that it has small effect to productivity. Most farmers are not aware of land conservation by planting in the same direction as the hill with plenty enough manure. Seed technology shows non-significant negative effect, which means that it has small effect to productivity. Qualified seed supply is small and the price is high. Although Pandegelang are known as potato seed center, the available amount is not enough to fulfill demand from all over Indonesia. Low number of G2 seed is likely to be the cause. Seed Central Bureau of Pandegelang has not produced enough G2 seed to fulfill the demand of seed producer. Cabbage seed and other vegetable seed are fulfilled by import.

Conclusion and Recommendation

Conclusion

1. Vegetable farm productivity in Pangalengan is low, where most (43.4 percent) has lower productivity than average.
2. Total-Factor Productivity is significantly affected by vegetation diversification, farmer' formal education, cultivated area, irrigation and access to input market. Productivity is responsive to vegetation diversification and less responsive to farmer' formal education, cultivated area, irrigation and access to input market.

Recommendation

1. Vegetation diversification is significant factor to vegetable farm productivity. Farmers should be encouraged to diversify vegetation by communication and counseling.
2. Government should provide better public facility such as irrigation and education institution. Cooperative irrigation management is recommended.
3. Institutional arrangement of seed producers and Seed Central Bureau effort for G2 seed continuous availability are recommended.

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