Crop Price Variation and Water Saving Technologies

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Abstract. *Considering the importance and scarcity of water resources, the efficient management of water resources is of great importance. Adoption of modern irrigation technology is considered to be a key of increasing the efficiency of water used in agriculture. Policy makers have implemented several ways to induce the adoption of new irrigation technology. The empirical studies show that farmers are reluctant to utilize the use of new irrigation methods. This study aims to assess factors affecting on farmer's decision on application of water saving technologies with emphasize on crop price variation and water sources. A Logit model was employed to examine the impact of different variables on use of water saving technology. The required data gathered from a sample of 204 farmers in year 2016. The results indicate that different variables such as crop price variability, water supply source, high value crops, farm size, income, education, membership in cooperatives have positive effect and variables such as age and number of plots have negative impact on the probability of adopting modern water saving technologies.*

Keywords*: water, irrigation, water saving technologies, scarcity,*
Classification ***JEL****: Q25,Q15 ,Q55, C21*

Introduction

Water scarcity and its undesirable quality have turned the water issue into a global significant challenge. With the rapid growth of urbanization and industrialization, the demand for various water usages is gradually increasing.

Considering the rapid increase of population resulting increase in demand of foods, agriculture sector plays a key role in food security as well as economic cycle. However, focusing on the managerial and economical aspects of production in agriculture sector along with technical and productive factors can be a support for agricultural sector to play an imperative role in economic cycle of the country.

Irrigated agriculture is the main factors of food production in Iran thus water plays a very importance role in agricultural production inputs. Iran is vastly dominated by deserts and dry lands, therefore in this case, climate effects emerged by drought and wet phenomenon can cause many negative and positive effects on agricultural production and food security in Iran. Apart from population increase, some predicaments such as high evapotranspiration, low efficiency of water use, shortage and reducing of water resources, increased cost of expanding new water resources, degradation soil in agricultural farms, lowered aquifers, pollution, degradation water ecological and irregular water consuming from existing sources in most part of Iran are important causes of water scarcity. Iran is facing a serious water scarcity and the government of Iran is trying to implement technical and institutional measures to meet the challenge.

Based on data gathered from Alborz Province Agriculture Organization, the water consumption in agriculture sector amounts to about 630.5 million cubic meters, and agriculture sector consumes 89 percent of water from total consumption in Alborz province which indicates a considerable chunk of the whole province consumption. Irrigated agriculture is the main factors of food production in the study area thus water plays a very importance role among the agricultural production inputs. Irrigation productivity is about 46 percent and this low percentage indicates the limitations for sustainable development in this sector. Studying on underground water resources in Alborz's plains indicate more pressure on underground and as a result an annual decline of water levels in the region.

Considering the population increase in the province in one hand and the downward trend of water level resources in the other hand, farmers need to reduce water consumption, therefore any sort of reduction in consuming trends shall be a greatly facilitate water saving in its resources. Investing on methods of water consumption efficiency and development of water irrigation systems is an important factor in increasing agricultural production (Hosseinzadeh, 2001; Karbassi, 2001; Karbassi & et al, 2000؛ Radha & et al, 2010 ؛Mallawaarachchi & et al, 1992). Furthermore, investment in water saving technologies shall lead to higher water use efficiency and reduction of uncertainty (Koundouri & et al, 2006؛ Khalilian& et al 2005).Moreover, modern irrigation technology could lessen the scarcity of water in times of problems and financial limitation (Bjornlund& et al, 2009). The upward trend of irrigation cost is another reason to further employ water saving technologies (Giannoccaro & et al, 2008؛ Burke & et al, 1999؛ Shresta & et al, 1998).

Iran's history shows that ancient Persians engaged various innovations to counter the scarcity of water resources through management of surface and underground water sources. Various water management methods such as indigenous water using techniques in farm, covering water distribution networks and transmission, use of low-pressure pipes for water transmission, accurate land leveling, surge irrigation, building of water depots, construction of "Qanats[1]" and dams, laws for water system rights, application of modern irrigation systems such as drip and sprinkler irrigation system and center pivot systems have been used (Norouz& et al 2006؛Jahan Name, 2001). Use of plastic and organic coverings, drought resistant crops, collecting rainwater in big and small reservoirs, irrigation planning based on soil, plants and climatology relations, land integration during optimal management of water consumption are also used to further manage the leveling of water consumption and water resources(Kohansal& et al, 2009؛ Karami & et al, 2002 ؛Skaggs, 2001).The limited water resources and the widespread use of unscientific and traditional irrigation systems which result in up to three times higher water consumption than actually needed for production of crops, are the major constraints facing agriculture in Iran. To overcome this problem new irrigation improvement program is being implemented throughout the country. It is argued that modern irrigation system can reduce the consumption of water and improve water efficiency to cope with population growth and poverty. It is also argued that adoption of new irrigation technology would lead toward a more environmental sustainable development (Foltz, 2003). Despite of government policy to induce farmers to utilize more new irrigation technologies and also economics and social benefits of modern technology, some empirical studies have shown that the rate of adoption of modern technologies is not significant (Kohansal & et al, 2009؛ Karami & et al, 2002, Feder and et al 1985,Zhou et al 2008, Awudu 2011, Perret et al 2006).

Factors affecting on farmers decision to adopt new irrigation technology has been examined in several studies (Hellegers, Zeng&Zilberman, 2011, Caswell & Zilberman, 1985, Lopez-Morales, Carlos; Duchin, Faye 2011, Schaible et al 2010, Alcon et al 2008, Chokri2005, Binet et al(2011) 2008, Sylvain et al 2006, Arabiyat 1999, Zhou,2008,Awudu et al 2011, Lichtenberg 1989,Bjornlund et al 2009, Foltz 2003, Isik, 2004, Sangtaek et al 2008, Dinar, 2002). The most of the empirical studies on the adoption of water saving technologies have tried to indicate the main factors affecting on slow adoption behavior of farmers ((Perret et al 2006).A number of empirical studies have shown that the adoption rate has been affected by farmers' socio-economics characteristics such as age, income, farm size and education, etc. (Awudu, 2011, Perret& Stevens 2006). Some other studies focused more on the physical and exogenous factors. Foltz (2003) investigated the impact of natural resource prices and quality along with farm and farmer characteristics in Tunesia. Other factors such as land quality, water price, production risk and cropping pattern on diffusion of new irrigation system were examined by some other researchers (Awudu 2011, Green et al 1997, Lichtenberg 1989, Carey and Zilberman 2002).Gree et al.(1996) also assessed the effect of economic variables, environmental characteristics, and institutional variables on irrigation technology adoption. The variability of product price has not been addressed in these studies. The basic problem facing farmers where it comes to adoption is the financial constraints. Since new irrigation technology needs immediate considerable investment with long term expected return (Perret and Stevens 2006), therefore one would expect that in the lack of financial assistance farmers with higher income are more able to invest on new technology than those with lower income. Farmers are often reluctant to adopt new irrigation system because they need a stable and high income and more reliable water resources (Schaible et al. 2010).Crops with higher price fluctuation are expected to have higher expected revenue than those with less variation. It is also expected that producing high value crops would increase the income of farmers. Water resource availability and reliability would be an important issue on adoption of new

[1]Qanats are constructed as a series of well-like vertical shafts, connected by gently sloping tunnels.

irrigation technology (Marques et al.2005). Having access to permanent water supply source as well as less pumping cost is expected to accelerate the adoption procedure. Type of crops regarding whether they are perennial or annual could also effect on application of new irrigation system. It seems that the production of perennial crops in contrast with annual crops would reduce the average cost of investment on new technologies and may results in diffusion of new technologies. This study contributes to the literature on adoption of modern irrigation technologies (drip and sprinkler systems) by studying the impact of product price variability proposed by Carey and Zilberman 2002,water supply source, crop price and perennial crop as well as household and farm level characteristics on adoption of water saving technology in Alborz Province of Iran. We are expecting that the results of this study would help the policy makers to facilitate the transition from conventional irrigation systems to more water saving irrigation systems. The study area is located in the north of Iran, which is surrounded by mountains and has moderate climatic conditions.

Materials and Methods

Description of data

Source of Data:
Lack of published data and nature of the study requires the collection of primary data. Questionnaires were completed from a sample survey of 204 randomly selected farmers (98 adopters and 106 non-adopters) in year 2016. The size of sample was determined according to Cochran method. In addition, the required data to compute the price variability a time series data for 26 years (1990-2016) obtained from the statistical center of Iran.

Variables:
a:age measured in years, b: educational level measured using four categories ; illiterate, primary school, high school and higher educated farmers, *c*:farm size measured in hectare, d: farming experience measured in years, e: farm income measured in million Rials, f: number of plots, g: four dummy variables denoting land position, membership in cooperatives, off farm occupation, Soil quality, type of crop (perennial and annual) and water supply sources (surface and groundwater), h: crop price index defined as the sum of weighted crop price by the share of each crop from total farm, and finally the crop price variability index.

The computation procedure of crop price variability index follows three steps. First we computed the Coefficient Variation (CV) of price for different products in the study area. Second we used the share of each crop from total farm size and multiplied by the Computed value of CVs to get the crop price variation index for each crop. Third we added the crop price variation of all crops produced in each farm to get the Crop price variation index for each farm.

Water Sources:
Due to the low rainfall and draught seasons which farmers have been facing during last decade in the region, majority of farmers are using both surface and underground water sources. Surface irrigation system is the oldest and most common system applied. The water resources development and rights for various sectors falls under the responsibility of the Water Affairs Division of the Ministry of Energy. The surface water comes from rivers which are controlled and distributed by the government and Qanats which are controlled by the farmers. Qanats are constructed as a series

of well-like vertical shafts, connected by gently sloping tunnels. These two sources are considered as a public source and therefore almost all farmers in the region have the right of using water from these sources according to the farm size. Water from the rivers and Qanat are transferred by different canals to the farm level. The amount and time of water received from rivers and Qanat is rationalized according to farm size and availability of water.

But due to reduction in surface water, modern pumping technologies are becoming into widespread use. Farmers are using two types of wells to extract the underground water. Group wells are owned by a group of farmers and each farmer has a small share from the well according to his farm size. Group wells water is distributed by the canals based on time schedule determined by the representatives of farmers. More reliable source of water supply is considered to be private well which farmers have complete control on them.

Study Model

In this study we assumed that the farmers decides on the irrigation technology to adopt by taking in to account the price variation of crops, easy access to reliable water sources, crops with higher value as well as farm and farmers characteristics. A pre-test has been done at the beginning and farm size was used as the proposed index after obtaining required parameters from Cochran formula in the situation that there is no collected society statistical volume and statistical samples volume is 204 farmers.

In a static framework the common approach to identify the factors affecting on farmers' decision choice to adopt the new technology is using binary choice models (Zhou 2008, Green et al. 1996) to explain adoption or non-adoption. Our article belongs to the latter group of models as our data contains information about the choice of a single cross-section of farmers to adopt or not a new and recently available irrigation technology.

The farmers are assumed to decide to choose a technology to maximize their expected return under selected technology.

A Logit model can be used to estimate the probability of farmers' adoption of new irrigation technology.The logit model is expressed as:

$$Y_i = \beta X_i + u_i \qquad (1)$$

Where X_i is the vector of factors affecting on adoption of new technology and $\beta$is a vector of parameters of model to be estimated and also u_t is an error in model assumed to be normally distributed. The dependent variable Y_i is binary indicator variable and takes value 1 if adoption occurred and value 0 if adoption did not occur.

$$\begin{cases} \text{if} \quad Yi^* > 0 \quad \Rightarrow Yi = 1 \\ \text{if} \quad Yi^* \leq 0 \quad \Rightarrow Yi = 0 \end{cases}$$

The probability of adoption of the new technology can berepresented as:

$$P_i = \Pr\ (Yi = 1) \ = \ \Pr\ (Y_t^* > 0) \ = \ \Pr\ (\beta' Xi + ui > 0)$$
$$= \Pr\ (ui > -\beta' Xi) \ = \ 1 - \Pr\ (ui \leq -\beta' Xi) \ = \ 1 - F\ (-\beta' Xi) \qquad (2)$$

Where F is the cumulative distribution function for error term.

The Probability that ith farmer who uses the water-saving technology is as follows:

$$P_i = \Pr(Yi = 1) = \frac{\exp(\beta' Xi)}{1 + \exp(\beta' Xi)} = \Lambda(\beta' Xi) \qquad (3)$$

where Λ indicates a link function, the cumulative standard logistic distribution function which is defined as follow.

$$F(t) = \frac{1}{1 - \exp(-t)} \qquad (4)$$

As indicated earlier, crop price variation, source of water supply and crops with higher value normally influences the type of irrigation technology adopted. So rather than assuming above variables to be in the vector X, we can express equation (1) to specifically include these variables as follows;

$Y_i = \beta_0 + \beta_1 X_i + \beta_2 PV_i + \beta_3 WS_i + \beta_4 PC_i + \beta_5 HV_i + \varepsilon_i$(5)

Where X represents a vector of socio-economics characteristics of farmers that affect technology choice, PV represents an index of price variation of crops, WS represents water supply source, PC represents type of crops (perennial or annual), HV represents the index of crop value and ε is the error term. PC and HV are two binary variables in the equation.

In Logit model the estimated coefficients is not given much weight in judging the model's performance, instead value of marginal effects are the most indicators of the model. The marginal effect of a continuous independent variable is the partial derivative with respect to that variable. The discrete change of a binary independent variable (dummy variable) is the difference in predicted probabilities of x_i=1 and x_i=0 , holding all other independent variables constant at their reference points. Finally a descriptive analysis of data was done to indicate the main factors affecting on farmers' decision on adoption of new technologies.

Results and discussion

Descriptive statistics of socio- economic characteristics of the study sample is given in table1. Figures in table 1 indicates that adopters of water saving technology are younger and more experience. On average farmers using new irrigation technology are 45 and those using traditional technology are 48 years. Whereas the adopters are more educated and operating in larger farm. It is also clear that adopters are with larger average farm size, less plots number and with high income. According to data provided in table 1, the adopters are producing more perennial and higher value crops with a large price variation. It is evident that being a member of cooperatives and soil type also is statistically significant different between the two groups. Both groups are less dependent on off farm work (28%). The type of land cultivated by the adopters are more sandy whereas the land of farmers using traditional irrigation system is clay land. In overall statistical testing confirms that there are indeed statistically significant differences between adopters and non-adopters in almost all factors except age, off farm work and agricultural experience.

Table 1: Summary Statistics of Socio-Economics Characteristics

Variables	Adopters (n=98)	Non-Adopters (n=106)
Age (year)	45.27	47.61
Education (*)	2.9	1.92
Agricultural work experience(year)	28	23.8

Off-farm job (0 and 1)	0.28	0.27
Farm size(Hectares)	10.54	6.02
Number of plots	2.27	3.09
Slope of the land (0 and 1)	0.551	0.453
Type of soil (**)	1.40	0.95
Membership in Cooperatives	0.88	0.46
Crop value index	7522	5597
Perennial Crop	0.32	0.21
Crop Price Variability Index	1.04	0.94
Total revenue (million rial)	179	128

Source: Research Results

*Education: 1 illiterate, 2 elementary school, 3 high schools, 4 higher education

** Type of soil: 1 clay, 2 sandy

In order to compare the adoption rates among traditional and new irrigation technology, the Statapackage is used to estimate the parameters of the Logit model. There are thirteen independent variables in the model; six continues variables (i.e. age, farming experience, number of plots, farm income, crop price variation and price of products) and seven discrete variables (i.e. source of water, land position, quality of soil, membership in cooperatives, main occupation, perennial crops and water supply sources) and one categorical variable (education). The statistical results of logit model are given in Table 4.

Table 4: Estimated Coefficients of the Logit Model

Variables	Coefficients	Standard Error	z-values	P>[Z]	Marginal Effects
Constant coefficient	-19.037	3.838	-4.96	0.000	-
Age (year)	-.0053	0.0259	-0.21	0.837	-0.0033
Farm size (ha)	0.1936**	0.0704	2.75	0.006	0.0121**
Plot Numbers	-0.2196	0.1891	-1.16	0.245	-0.0137
Income(Million Rials)	0.0239**	0.0077	3.11	0.002	0.0015**
Education 2 (Category) 3 4	0.8155 1.0801 3.6735**	0.8563 0.9418 1.2475	0.95 1.15 2.94	0.341 0.251 0.003	0.0558 0.0743 0.2605**
Main occupation (Dummy)	0.8305	0.7390	1.12	0.261	0.0519
Land Slope (Dummy)	0.7249	0.6298	1.15	0.250	0.0453
Soil type(Dummy)	1.3716*	0.6439	2.13	0.033	0.0857*
Member of Cooperative (Dummy)	2.2334**	0.6908	3.23	0.001	0.1396**
Crop Price Index	0.0049**	0.0013	3.60	0.000	0.0031**
Crop price Variability Index	5.4798**	2.1048	2.60	0.009	0.3427**
Type of Crop (Dummy)	2.097**	0.7987	2.63	0.009	0.1311**
Source of Water D1 D2 D3	 1.1515 3.0312 -0.8829	 1.2644 1.0004 0.9619	 0.91 3.03 -0.92	 0.362 0.002 0.359	 0.0720 0.1895** -0.0552
Log likelihood = -41.8 LR statistics = 198.89 Number of observation = 204 McFadden R^2= 0.70 Probability =0.0000					

**,* Significant at 1and 5 percentlevel respectively.
Source: Research Results

1- The estimated value of the McFadden R^2 and likelihood ratio test and the percentage of correct prediction presented in the table show the strong explanatory power of the Logit model.
2- According to the table the signs of almost all variable entered in the model are consistent with the theory and findings of other empirical researches. According to Table as it was expected variables such as farm size, income, education, water source, crop value, type of crops and crop price variation variables have positive impact on adoption of new technology. But variables such as age and number of plots have negative impact on probability of adopting new irrigation technology. Though field slope and off farm job variables have expected sign but their marginal effect is not statistically significant.
3- The figures in table 4 indicate that the adoption of new irrigation technology is highly dependent on farm and farmer's characteristics. Education, Farm income, farm size, type of soil, membership in cooperatives, type of crops, crop price and crop price variation are the most significant factors affecting on probability of adopting new technology. The other variables in the model were not significant.
4- Variation in soil permeability has also a significant impact at 5 percent level on the probability of adopting new irrigation technology. Sandy soil usually increase the water requirement of crops thus induces farmers to adopt new irrigation technology with higher water saving potential. This implies that farmers with sandy land are more likely to adopt the new technology than those with clay land.
5- The highly significant value of coefficient on high-value crops implies that farmers who are producing high value crops are most likely to utilize the new irrigation system comparing to those who are producing relatively low value crops. One would expect that the production of high value crops would increase the economics strength of farmers and increase the probability of adoption new technology.
6- The significant values of coefficients related to education suggest that having higher education can increase the perceived returns of new irrigation technology and encourage their adoption. The marginal effects in table 4 show that the probability of adoption increases as education level increases. This can be explained by the fact that more educated farmer are more likely to be aware of advantage on new irrigation system, so the probability of adoption among the farmers with higher education is higher than those with less educated.
7- The larger size of farms could be another reason for relatively higher tendency to choose water saving technologies. This finding may be explained by the fact that application of new technology in large farms is more applicable than small ones.
8- The results also indicate that growers of perennial crops such as tree fruits have higher rates of adoption of water saving technologies than those growing annual crops such as cereal crops. Since application of new irrigation system is more capital intensive therefore use of new technology in perennial crops farms is more economically feasible.
9- Private well as a water supply source is found to play a prominent role in the decision to adopt a new irrigation technology.Transferring water from river, Qanat and group wells to

the farms is most costly to the farmers to use it in their new irrigation system. They have to indirectly pump in to their high pressure irrigation system which is more costly for them. On the other hand water from above sources is lee reliable. It depends on the availability of water. They cannot get the water anytime they need and it depends on their share and scheduled time. But water from their own private well is more reliable and therefore they can use it on required time. So as the results indicate farmer who are using water from their own wells are more likely to adopt the new irrigation technology than are farmers using surface and group wells water supply sources. Water received from surface and group wells are less reliable and involved with higher pumping costs. Thus those farms which are irrigated by surface water are less likely to be irrigated by new irrigation technologies.

10- The sign and significant magnitude of the coefficient denoting cooperative membership suggest a higher tendency to choose the modern irrigation system. This finding suggest that farmers who are the member cooperative are able to get more financial, marketing and technical assistant from cooperatives and as a result it seems to have more motivation on technology choice.

11- Finally, the coefficient on the crop price variation variable is significant at 1 percent level. The marginal effect shows that a one unite increase in price variation index results in almost 0.366 unites increase in the probability that new technology will be chosen.This result demonstrates the effectiveness of product price variation on probability of adopting new technology. One would expect that farmers usually are risk averse and production of crops with a high price risk may increase the farmer's risk and leads less adoption of new technology. This may be explained by the fact that usually crops with high price fluctuation are expected to have higher expected income to make the farmers more financially feasible.

Descriptive Analysis

To facilitate the adoption of new irrigation technology it is important to ensure that policy priorities are in line with farmers` believes, expectation and constraints. Farmers cannot adopt new irrigation technology if they do not have access to all the required information and support. Without considering farmers constraint, in last two decades various extension programs aimed in the adoption of modern irrigation technologies have been implemented in Iran in order to convince the farmers to adopt the new methods. But according to the evidence the result is not promising. Thus in the next part of the paper we tried to identify and analysis the advantages of new irrigation technology and the main reasons for the low adoption of conservation technologies in the study region based on farmers opinion.

The Likert Scale method was applied to indicate the importance of each factors. Producers were asked to choose from a list of factors those that had impeded them from adopting new technologies, and then to indicate the level of effectiveness. The results are summarized in table 2.

Table 2: Main Factors Affecting on Non-Adoption Behavior of Farmers

Variable	Very Much	Much	Average	Little	Very Little
High Capital requirement	67.95	20.51	10.26	1.28	-
Unavailability of Funds	65.38	11.54	14.10	5.13	3.85
Loan Repayments	53.85	28.21	5.13	7.7	5.13
High maintenance costs	47.44	28.21	8.97	13.82	2.56
Land dispersion	35.9	20.51	14.10	12.82	16.67
Lack of information	29.49	30.77	19.23	12.82	6.41
Small size of farms	29.48	19.23	15.38	12.82	23.1
Lack of Expertise	28.21	10.26	33.33	19.23	8.97
Not effecting in net income	6.41	17.95	29.48	38.46	7.7
Distance from the city	2.56	2.56	46.2	29.5	19.23
Insufficient connection between firms and farmers	25.54	10.26	19.23	20.51	24.36
Lack of access to new technology	11.54	16.67	29.5	32.1	10.26
Lack of after-sales services	8.9	12.82	37.2	25.64	15.38
Water quality	6.41	16.67	38.46	28.21	10.26
Failure of modern systems	3.85	6.41	8.97	20.51	60.26

Source: Research Results

According to the results reported in table 2, more than 65 percent of the farmers indicated that high capital requirement and lack of access to credit market are the main reasons of not adopting new irrigation system. This indicate that new irrigation technologies require relatively high capital investment and farmers with a low income received from agricultural activities need to be supported by the financial institutions. Loan repayment (54%) and high maintenance cost involved with new technology (47%) were rated the next most important factors. Almost thirty percent of farmers believed that land dispersion, Luck of information, small size of farms, luck of information and insufficient connection between farmers and the firms providing irrigation equipment are also important factors affecting their adoption behaviors.
Small proportions of farmers identified the failure of modern irrigation system and water quality, and after sale services have less impact of adoption of new technology. Factors such as lack of after sales services, water quality and failure of modern irrigation system in the region were rated less important factors.

Conclusion and Suggestions

The main objective of this study is to determine the factors affecting the application of water saving technologies by farmers in Alborz province. This paper has demonstrated that high value crops, variation in crop price, type of crops and water supply source have significant impact on the tendency to adopt water saving technology. The use of new irrigation technology in high value crops such as fruits and vegetables was very significant. Therefore, the probability of adoption is highly related crop price and its variation. This means that the price of products generally stimulate the adoption of water saving technology. This suggests that product price would be a strong policy tool of adoption. The results indicate that the user of groundwater from private wells for irrigation seems to be more likely to adopt the new irrigation technology than users of surface water and group wells sources. Findings also show that variables such as; farm size, income, education, agricultural main occupation and the type of products have a significant positive effect in the possibility using of modern irrigation technologies. While variable such as; age, plot pieces, land ownership, dry resistant varieties have a significant negative effect in the possibility of using modern irrigation technologies by the farmer. Moreover, the study has indicated that the factors such as; lack of capital and loan facilities, high maintenance cost of modern system, loan repayment capacity of farmers, provision of loan security, risk of technology failure and lack of information can reduce the use of new irrigation technology. The results of this study suggest that diffusion of water saving technology would be more effective in regions that produce high value products which normally have more price fluctuation.

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