Risk on Dynamic Behavior of Farmers in the Export Market:
A Case from the Pineapple Industry in Ghana

Aya Suzuki

University of Tokyo

ayaszk@k.u-tokyo.ac.jp

Abstract:

While the role of risks in technology adoption is a classical topic, its effects beyond adoption have not been examined well enough despite that dis-adoption of a technology is also common. This paper examines the role of risk preferences and an exogenous shock on the survival of farmers for a case of export pineapple industry in Ghana. Employing hazard analyses, we find that risk preferences indeed matter for survival and the hazard of exit increased significantly in the period after the occurrence of the exogenous shock. We also find that education has an effect of increasing the resilience of farmers against risks.

1. Introduction

The high-value horticultural export has received attention in recent years as a way to reduce poverty in developing countries (Jaffee and Morton 1995, World Bank 2008). Globalization connects producers in developing countries with the greater international demand and higher prices, but also with higher risks. These risks may originate from the perishability of horticultural crops, limited extent of domestic markets for these crops, as well as the readiness of importing countries to switch the origin of imports whenever some problems occur. They may increase the cost of entry and may be marginalizing small-scale producers (Glover 1987, Hazell 2005, Henson *et al.* 2008).

The role of risks in technology adoption is a classical topic (Feder 1980, Feder *et al.* 1985). Since the first attempt by Binswanger (1980), a strand of studies has tried to elicit risk preferences using simple games with or without real payment (e.g., Ghadim *et al.* 2005, Tanaka *et al.* 2010, deBrauw and Eozenou 2011, Liu 2013). While many of them are based on the theoretical framework of expected utility theory, which posits that a rational individual maximizes the probability-weighted average of the utility from each possible outcome, some recent studies follow the concept of prospect theory (Kahneman and Tversky 1979), which consists of probability weighting function that is related to risk preferences and sensitivity to differences in probability and value function that reflects utility that differentiates gains and losses (Camerer *et al.* 2004). Based on either theory, empirical evidences show that risk preferences do matter in producers' decision-making.

However, the literature on the effects of risk preferences has focused mostly on the entry point of adoption decision but not beyond the adoption. In other words, the role of risks on dynamic behavior of producers has not been examined well enough. Dis-adoption of a technology is a commonly-observed phenomenon, particularly when the technology is new and the farmer learns something unexpected during production. For example, Kijima (2011) has found that more than 50% of NERICA adopters abandoned it in two years in Uganda. De-Graft Johnson *et al.* (2013) shows that among the five technologies examined in the rice production in Ghana, the rate of dis-adopting new technology is between 5% and 43%. Suri (2011) reports that 30-39% of farmers switched between adopting and dis-adopting hybrid maize in Kenya. In these studies, risk preferences are not considered. Once they decide to enter, would risk preferences still play a role in surviving? Further, when some exogenous shocks occur, such as a steep price drop or demand shrinkage as often observed in the competitive global market, how would these events affect the producer behavior and effects of risk preferences on survival? These questions are important in considering

the long-term impacts of adopting export crops for farmers, particularly the small-scale producers who tend to be more vulnerable. Existing literature examines the welfare impact of adopting export crops and find positive results, but do not capture the farmers' behavior over time with regards to the risks that they face (Maertens and Swinnen 2009, Minten *et al*. 2009). As the risks are inherent in participating in the global market, it is important to consider the effects of risk on farmers' behavior over time.

This paper examines the role of risks in adopting horticultural crops and surviving over years, for a case of the growing pineapple sector in Ghana. This sector is very relevant to study the questions raised as risk is found to be an important factor in this sector (Suzuki *et al*. 2011) and it experienced a serious exogenous shock, i.e., a shift in the dominant variety of pineapples demanded in the EU market from the traditional Smooth Cayenne to the MD2, which was developed and promoted by the multinationals (Fold *et al*. 2008, Vagneron *et al*. 2009). This incidence was a great shock to the Ghanaian producers, and many exporting companies went bankrupt, unable to sell the traditional variety. Many small-scale producers, who have sold the fruit to exporters on credit were unable to collect the due, also exited the pineapple production. The total volume of export from Ghana declined sharply with the introduction of the new variety until it started to increase again in recent years (Figure 1).

To examine the role of risks on farmers production decision over time, we use the primary panel data collected from 250 farmers in the export pineapple production area in Ghana in 2007 and in 2012. We conducted a simple game in the field during the 2012 survey to directly elicit the farmers' risk preferences which involves real payment. We estimate the hazard rate of exiting the pineapple sector, employing several methods, including the Cox proportional model, Gompertz model, and Weibull model. We find that hazard rate is positively associated with the risk aversion indicators, suggesting that the likelihood of exiting the pineapple market is higher for risk-averse farmers than less risk-averse farmers. We also find that this effect of risk preferences on exiting is dampened with more years of schooling, i.e., education strengthens resilience of farmers against risks. Further, we find that the hazard rate of exiting increased after the exogenous demand shock, suggesting that after the MD2 incidence, the likelihood of farmers abandoning pineapple production increased relative to pre-incidence period. In other words, the pineapple production became much more risky business in the post-MD2 incident relative to the pre-MD2 period.

The next section explains the presence of risks in the Ghanaian pineapple sector in detail. The section 3 describes the data and the games played to elicit risk preferences. The section 4 contains the estimation method, and the results are presented in the

section 5.   The last section includes conclusions and policy implications.

2.   Presence of Risks in Ghanaian Pineapple Sector

Before we move on to analyze the role of risks in the dynamic behavior of farmers, it is important to understand the significance of risks in the context of the Ghanaian pineapple sector.   Note that though this is a particular case, many aspects also hold in other horticulture sector in other developing countries.

Risk of having unsold fruit

First of all, probably the largest risk for farmers in adopting pineapple production in Ghana is the risk of having unsold fruit after harvesting.   Pineapples take about fourteen months to produce from planting to harvesting and including the months for plantlet re-production for the next planting season and fallowing, the opportunity cost of land is very high if the fruit remain unsold.   Behind the risk of having unsold fruit, we can think of two important factors, which are perishability of horticultural crops and the limited extent of domestic market.   The shelf-life of horticultural crops is generally short and thus the produce need to be sold immediately after harvesting.   The time allowed for farmers to find potential buyers is short, and this may negatively affect the bargaining power of farmers in negotiating with buyers.   While this factor also holds true in developed countries, an additional factor that enhances the risk in developing countries is the limited extent of domestic market to absorb the unsold horticultural produce due to limited domestic demand for these fresh produce and under-developed processing sector.   Processing sector is in general capital intensive and thus the initial cost of starting a processing factory is high.   This is particularly so in countries where the industrial sector is still largely under-developed as it cannot benefit from low input costs (i.e., input materials and labor) which are often made possible by industrial clusters (Sonobe and Otsuka 2011).   In Ghanaian pineapple sector, some exporters import carton boxes to carry pineapple fruit to EU from France due to inferior quality of domestically-produced carton boxes.   Similarly, some juice-processors were importing packaging materials all the way from Taiwan.   Further, it is also not rare that private companies have to invest in building the necessary infrastructure such as roads, water piping, and electricity, to start their factories because of inadequate government support. As such, because the processing sector as well as domestic market demand is limited, the perishability of horticultural crops translates into a large risk for farmers in developing countries.

Difficulty of contract enforcement

Secondly, farmers also face the risk of contract breaching. Contract farming is one way to ensure the sales outlet for farmers and has been developed for many commodities in developing countries. It is considered a good mechanism that benefits the advantage of small-scale production and large-scale production. However, difficulties in contract enforcement have been reported by many studies (e.g., Fafchamps 2004). The typical problem is the hold-up by traders/exporters who do not show up to purchase the harvest despite the original promise and farmers have no outlet to sell the crops. Another problem is "side-selling," in which farmers sell the provided inputs (such as fertilizer or seed) to other farmers to receive monetary income or sell the harvested crops to other buyers who present higher prices than the contracted buyers. These contract breaching can in theory be settled by judicial process, but in reality these processes are too costly, particularly for the poor farmers. In Ghana case, we have often encountered cases that the farmers cannot retrieve the payments from exporters. Although the farmers jointly sued the exporting company, the process was too costly both in terms of money and time and the farmers in the end gave up. This difficulty of contract enforcement also contributes to increase the risks that farmers face in adopting pineapple production.

Shocks from international market

Lastly, farmers who adopt export commodities also need to face the risks that may be transmitted from international market. This could be a large price fluctuation, sudden changes in the trade policy (such as preferential agreement) or requirement (such as standards and certification), or shift in the trend. In Ghanaian pineapple sector, a shift in the variety of pineapples demanded in the EU market changed in the mid-2000s and affected the stakeholders involved in this chain drastically. The new variety called MD2 was originally developed by the Hawaii Pineapple Research Institute and modified further by Del Monte in their plantation farms in Costa Rica (Fold and Gough 2008). MD2 is sweeter, smaller in size, more yellowish in appearance, and more consistent in flavor than the traditional variety of Smooth Cayenne, while it requires much more chemical inputs and more care during the production than Smooth Cayenne (more capital- and labor- intensive). Del Monte carried out a large promotion campaign on this variety branded with the name "Gold Extra Sweet," and the MD2 became a large hit in the US market in the mid-1990s. Following the US market, MD2 was introduced in the EU and became popular in the mid-2000s. While the EU market was traditionally supplied by the Cote d'Ivoire as much as 90% in the 1980s, the share

fell to two-thirds that in 1990, losing to the rise of Costa Rica. With this change, the Ghanaian exporters were suddenly losing their share in the EU market. They could not find outlets to sell their fresh Smooth Cayenne. Although many exporters wished to switch to the new variety, the transition was not smooth. The new MD2 requires very high initial investment costs, and much more care is necessary during the production processes than for Smooth Cayenne. Small-scale farmers were also hard-hit (Fold 2008; Fold and Gough 2008). Normally, the payment for small-scale farmers is given two to three months after the actual transfer of fruit from farmers to exporters. When the MD2 shift occurred, the exporters had already "purchased" fruit from smallholders, but because they could not sell to the EU market, they could not pay to the smallholders. Those who sold to exporters which went bankrupt could not receive payment, and even the surviving exporters owed a large amount to smallholders (Fold 2008; Fold and Gough 2008; Barrett *et al.* 2010). During our interviews, we encountered a case that the amount of debt that an exporter owed to one farmer was as high as USD13,000. This incidence was a great shock to the Ghanaian pineapple sector, and we suspect that this affected farmers' behavior.

3. Data, Risk Aversion Index, and Descriptive Statistics

We use the primary data collected from about 250 small-scale farmers in the Central, Eastern, and Greater Accra Regions of Ghana in 2007 and 2012. In lieu of a complete list of pineapple producers in the country, we used the stratified approach for sampling. We first identified the areas where export pineapples are produced and selected seventeen villages for study that had different geographical features, ensuring that villages of various types were included. We conducted household surveys of 153 pineapple-producing smallholders, 47 of whom had contracts with exporters and 106 who did not, and to 100 non-pineapple-producing farmers. Interviews were conducted by enumerators who are fluent in local languages. We also interviewed village chiefs to obtain community-level information. In 2012, the same farmers were identified and interviewed again in the same way. Out of the 264 original samples, the number of attrition was 31, which is due to passing away or moving out of the original place. We also added 15 more observations and excluded 4 outliers. Finally we have a total of 244 observations in 2012 data.

In 2012 survey, we have conducted a simple game to reveal the risk preferences of each respondent. As mentioned in the introduction, there are two major theories to explain the decision-making under uncertainty. Under expected utility theory, risk aversion is one main component of risk preferences while under prospect theory, risk

aversion, loss aversion (how utility of the same amount of money is different depending on whether it is a loss or a gain), and probability weighting (the level of weights assigned for the probability of occurrence of risky outcomes) are three important parameters that compose risk preferences.   For the simplicity of the method to elicit risk preferences, we based our study on the expected utility theory, which can be considered a special case of the prospect theory, and measured risk aversion only.[1]

       At the end of the household survey, we presented a table to farmers, which shows Project A and B with different prizes and probability of realizing those prizes for six games (Figure 2).   Project A is a certain choice of receiving 4 Ghana cedis for all the games while Project B is a risky choice, which has 50% of winning a higher prize and 50% of a lower prize (2 Ghana cedis).   The value of prize increases in the order of the games.   We asked the respondent which project s/he would choose to estimate the risk preferences.   For Game 1, Project A is a rational choice because the expected value of Project B is 3 cedis.   We recorded where the farmer decides to switch to Project B.   The earlier the switching point, the more risk-loving a person is.   For example, if the respondent remained to choose Project A for all games, it indicates that the person is very risk-averse and dislikes the uncertainty even if s/he is presented with a project with the expected value of 4.5 cedis.   On the other hand, if the person switches from Project A to B at Game 2, s/he is considered less risk-averse.   To avoid the hypothetical bias, after recording the choices, we have actually played one of the games and provided a prize that corresponds to the choice of the respondent.   We provided a bag with six balls and asked the respondent to pick one ball, which decides which game is played.   If the choice of the respondent for the corresponding game is Project B, in order to decide which state is realized, we again asked the respondent to pick one ball from the bag.   If the ball has an even number, it means that the good state is realized, while if it is the odd number, the bad state is realized.   The prizes are paid according to the payoff of the game.

       Using the information at which game the participant switched his/her choice from Project A to Project B, we have made a risk-aversion index from 1 to 6.   If the respondent chose the Project A (safe) for all six games, his/her RA index is 6, suggesting s/he is very risk averse.   On the other hand, if the respondent switched from Project A to B at Game 2, his/her index is 1, indicating that s/he is least risk averse. Out of the 244 answers, we had to drop 44 because their choices are considered

---

[1] While Tanaka et al (2010) and Liu (2013) concluded that prospect theory holds with empirical evidence, Harrison and Rutstrom (2009) concludes that neither theory is superior over the other (Ward and Singh 2013).

irrational.[2]   We note that the risk preferences are only measured at the 2012 survey and we assume that it does not change over time in our analyses as in the expected utility theory.   The prospect theory, on the other hand, holds that risk-preference is reference-based, particularly with regards to the wealth, which is higher for the pineapple producers than those who do not produce pineapples as shown in Table 1. This may possibly affect our result, but we think that effect may not be too large as we only use observations who have ever adopted pineapples.   Besides, we find that on average, risk aversion index is actually higher for our pineapple producers than non-pineapple producers and that the difference is not statistically significant.   Thus, the wealth effect on the risk preferences may not be large in our sample.

Table 1 reports the socio-economic characteristics of producers by the status of pineapple production as of 2007.   We observe many statistically significant differences between the two groups.   Pineapple production tends to be dominated by men. Ability of producers, as represented by years of schooling and receipt of Best Farmer Award, is also higher for pineapple producers.   Wealth indicators, such as household asset, farming equipment, and total land owned, are also by far higher for pineapple producers.   Size of household and years of pineapple production in village also are higher for pineapple producers.   Surprisingly, risk aversion index is higher for pineapple producers than non-pineapple producers, but it does not exhibit statistical difference between the two groups.

To examine the impact of MD2 incident on farmers, we use group dummies that indicate production period.   We use data of those who have ever adopted pineapples and transform the data in such a way that each production span of pineapples is the unit of observation.   Then we divide the farmers' production spans into three groups; (Group 1) the entire production span is pre-MD2 shock, (Group 2) the production span is both in pre- and post-MD2 shock, and (Group 3) the entire production span is post-MD2 shock.   In Table 2, socio-economic characteristics of producers by these groups are presented.   We do not find much difference across these groups, except for the size of household between Group 2 and 3.   Risk-averse index is the highest in Group 1 and descends in magnitude as we move to Group 2 and 3. Although the differences are not statistically significant, it provides weak evidence that the farmers who adopted the pineapple production before the MD2 incident were on average more risk-averse than those who adopted it after the incident.

---

[2] These respondents started with Project B, whose expected value is lower than the Project A, and either switched to Project A in some games or stayed choosing B for all the games.   As we suspect that the respondent did not have a good understanding of the game, we decided to drop these observations.

4. Estimation Methods

To analyze the factors determining the survival, we examine the hazard rate of exiting the pineapple production. Although we have a panel data of two periods indicating the production status in that corresponding year, estimating who remained adopting over these two periods is not adequate because survey periods do not necessarily capture the end or start of the production span for each observation (i.e., censoring). Besides, using linear models would be susceptible to bias because of the high likelihood that the distribution of time to an event is not normal as assumed in linear regression models (Cleves *et al*. 2002). In order to cope with these problems, we employ a hazard model.

We define a density function $f(t) = \Pr(T = t)$ which indicates the probability that a spell (a production span) lasts exactly t-period long and a corresponding cumulative distribution function $F(t) = \Pr(T < t)$ which indicates the probability that a spell is less than t-period long. A survivor function $S(t) = \Pr(T \geq t) = 1 - F(t)$ is defined as the probability that a spell is at least t-period long. The hazard function that shows the instantaneous rate of failure or the probability that a spell lasts for exactly t-periods long (i.e., exits at period t) given that it has lasted for at least t-periods long is then $h(t) = \Pr(T = t \mid T \geq t) = f(t) \big/ S(t)$. To model the hazard function, we employ a semi-parametric model, the popular Cox proportional hazard model in particular. In the Cox proportional hazards regression model, the hazard rate, or the probability that the respondent leaves the state of pineapple production at period t given that s/he is in that state for t-periods in the context of this study, is assumed to have the following form:

$$h(t \mid \mathbf{x}_j) = h_0(t) \exp(\mathbf{x}_j \beta_x)$$

where t is analysis time, $\mathbf{x}$ contains covariates for j-th respondent, and $h_0(t)$ is the baseline hazard (hazard that everyone faces). Using this hazard function, the partial likelihood function defined by Cox is:

$$L(\beta) = \prod_{j=1}^{k} \frac{\prod_{m \in D(t_j)} \exp(\mathbf{x}_j \beta_x)}{\left[\sum_{l \in R(t_j)} \exp(\mathbf{x}_j \beta_x) \right]^{d_j}},$$

where $D(t_j)$ is the set of spells that fail at time t_j, $R(t_j)$ is the set of spells at risk at time t_j, and d_j denotes the number of spells that fail at t_j (Cameron and Trivedi 2005). Here, the denominator indicates the probability of having spells that are at risk at time t_j, and the numerator indicates the probability of having spells that fail at time t_j. This ratio

for each spell in $D(t_j)$ that fails at time t_j is multiplied together and is multiplied over all the analysis time from t_1 to t_k. The coefficients β are obtained by maximum likelihood estimation.

The advantage of using the Cox models is that we do not have to impose any assumptions on the shape of the hazard over time ($h_0(t)$ is left unspecified) while we could still control for other covariates. Non-parametric hazard models also do not impose any assumptions, but covariates cannot be taken into account. In our case, heterogeneity among the respondents is found to play some roles in adopting pineapples from our earlier studies (Suzuki 2008). As robustness check, we also conduct non-parametric and parametric analyses (Weibull and Gompertz models, in particular). Note that because coefficients are in exponential forms in hazard analyses, we compute the hazard ratio for our results for the ease of interpretation. Thus, if the hazard ratio is greater than one, it would indicate that as the corresponding covariate increases by one, the hazard of abandoning pineapple production increases and vice versa. We use standard errors clustered at village levels in our estimation to take care of the unobserved factors that are common within villages.

5. Estimation Results

Figure 3 is the result of nonparametric hazard analyses and shows how the risk of exit changes over analysis time, separating the hazard for those who with risk aversion index between 1 and 3 (less risk averse; RAindex=0) and those who between 4 and 6 (more risk averse; RAindex=1). We find that those with higher risk aversion index face higher hazard ratios, i.e., the probability of exiting is higher for more risk-averse individuals than less risk-averse individuals. The risk of exit tends to be high initially with analysis time about 5, declines as the time passes by, and increases rapidly after analysis time about 15. It implies that the risk of exit increases in the initial months of entry, but once a farmer is able to sustain production over this period, the risk of exit declines. These initial months of entry may be acting as a screening period of good farmers. However, after some time again, the risk of exit tends to increase.

Figure 4 shows the hazard estimates for three groups defined according to the period in which the production span lies. Group 1 includes production spans that reside exclusively in the pre-MD2 period, Group 2 includes production spans that start in pre-MD2 period and end in post-MD2 period, while Group 3 rests exclusively in post-MD2 period. We find that the hazard ratio for Group 2 is by far higher than other two groups, indicating that during this period, the probability of exiting was very high for farmers. The hazard of exit for Group 1 and 3 do not seem to differ much although

one may expect that it should be higher for Group 3. However, this is actually not surprising because those farmers who enter in post-MD2 period (Group 3) has made entry decisions after observing the exogenous shock of MD2 (self-selection). Probably those farmers are less risk-averse (as indicated in Table 2) and thus more "resilient" to the risks that they face.

To control for heterogeneity across observations, the hazard ratios of exit estimated using semi-parametric models (columns (1) to (3)) and parametric models (columns (4) and (5)) are presented in Table 3. The results are consistent across these models. Note that because the numbers reported are hazard ratios, if it is higher than one and statistically significant, it means that risk of exit is higher for the respective independent variable. As expected, we find that risk aversion index is statistically significant and more than one for all models, suggesting that more risk-averse farmers tend to face higher risk of abandoning pineapple production. This result confirms that the risk preference matters not only at the entry point of adopting new technology but also in surviving to adopt that technology over years. In magnitude, a unit increase in the risk-aversion index increases the risk of exit by approximately 10% and it is consistent across models. The hazard ratio for risk-aversion index is 1.1 in column (1) (thus, 10%), and in column (2) where we control for the interaction term, the effect of risk preference on the hazard is given by: $\frac{\partial h(t)}{\partial RA} = 0.27 - 0.02 \times years\ of\ schooling$ (as $exp(0.27)=1.31$). Evaluating this at the average years of schooling (about 8 years), $\frac{\partial h(t)}{\partial RA} = 0.1084$, and $exp(0.1084)=1.11$, which is about 11%. Group 2 dummy (the span starts before and goes beyond the MD2 incident) and Group 3 dummy (the span is after MD2 incident) are also statistically significant and higher than one. In particular, the hazard ratio is four times larger for Group 2 than that for Group 1, as seen in the nonparametric analysis of Figure 4. These mean that risk of exiting the pineapple production is significantly higher in post-MD2 period than in pre-MD2 period, confirming the serious effect that MD2 incident had on farmers' behavior in Ghana. The higher magnitude of hazard for Group 2 than for Group 3 is also reasonable considering that Group 3 includes only those ones who started pineapple production after MD2 shock, i.e., those who are "brave enough" or "risk-loving enough" to enter the market while Group 2 includes farmers who started without knowing the possibility of demand shock as serious as the MD2 incident.

In order to examine whether the producer heterogeneity influences the effect of risk preferences on the hazard of exit, we included an interaction term between risk

aversion index and years of schooling in column (2).   The hazard ratio on the interaction term is statistically significant and below one, indicating that education has an effect of reducing the effect of risk aversion on the risk of exit.   For example, if there are farmer A and farmer B with the same level of risk aversion index, but farmer A has one more year of education relative to farmer B, then the effect of the risk-aversion on the hazard of exit is 2% lower for farmer A than farmer B.   This finding has an important policy implication that education has a power to make farmers more resilient against risks in export market.   The reason may be that education allows people to make more-informed decisions.

We also included interaction terms between the risk-aversion index and span period dummies in column (3) but found neither of them are significant and the hazard ratios are very close to one.   It suggests that the effect of how people's risk preferences affect exit decision itself does not change even with a serious exogenous shock.

Columns (4) and (5) report the results using particular functional forms, Weibull and Gompertz.   The results, both significance levels and magnitudes, are very similar to the Cox Proportional model, supporting the robustness of the analyses.

For other covariates, we find that the hazard of exit is higher for younger farmers.   In magnitude, one year of age reduces the hazard by 2%.   Another significant variable is gender dummy, which indicates that male farmers face lower risk of exit than females, as much as 50% less.   The difference in the behavior against risks between male and female is commonly reported in other literature and also found in our case.   The effect of education seems to have a direct effect of increasing the hazard and an indirect effect of decreasing the hazard through the risk-averseness of the individual. When we do not include the interaction term between risk aversion and schooling as in column (1), these contrasting effects seem to be cancelled out and thus the education becomes insignificant.   For village characteristics, being located by main road has a large effect of reducing the hazard of exit by 40%, implying that those who are far from main roads are the first ones to be pushed out of the supply chain.   The years of pineapple production in village also has an effect of reducing the hazard while the years of exporters' visit to the village increase the hazard though the magnitudes are not large.

In Table 4, we changed the dependent variable to lengths of production span rather than hazard of exiting and conducted OLS regressions using the same set of covariates. Although due to the aforementioned reason, hazard analyses are more appropriate, OLS results are provided for illustrative purpose.   We find that risk aversion index reduces the production span, i.e., more risk-averse farmers tend to abandon the pineapple production faster than less risk-averse farmers.   The production

span dummies indicating the post-MD2 period are negative and statistically significant in all models. Consistent with the hazard analyses, in the post-MD2 period, farmers' production spans became shorter than pre-MD2 period. The interaction term between risk-aversion index and education are positive and significant in columns (2) and (3), suggesting that education dampens the negative effect of risk-aversion on the length of production. This is also in line with the finding from the hazard analyses. Other covariates also show similar effects as in Table 3.

6. Conclusion

In this paper, we examined whether risk preferences play a role in surviving to adopt a new technology and whether an exogenous shock alter farmers' decision to exit the market over years, for a case of the export pineapple sector in Ghana. Using the primary data of farmers, we employed hazard analyses and found that indeed that risk preferences matter not only at the entry point of adopting a technology, as often found in other studies, but also in the decision to dis-adopt the technology. Specifically, the risk of exit is higher for more risk averse farmers than less risk averse farmers. We also find that the risk of exit increased after the MD2 incidence relative to the periods before. Further, we find that education has an effect of reducing the effect of risk preferences on the decision to exit. In other words, education makes farmers more resilient to the risk that they face. These results are robust to different specifications and models used.

These findings lead to several policy implications. First, the effect of participating in the export market needs to be evaluated considering the risks that farmers may face. Second, education contributes to making farmers more resilient against risks and thus should be promoted. Third, because risk preferences matter significantly in the farmers' decision-making, it is important to reduce the presence of risks themselves in the market, such as by developing processing sector.

References:

Barrett, Christopher B.; Maren E. Bachke; Marc F. Bellemare; Hope C. Michelson; Sudha Narayanan; and Thomas F. Walker. 2010. "Smallholder Participation in Agricultural Value Chains: Comparative Evidence from Three Continents." Working Paper.

Binswanger, H. (1980). "Attitudes toward Risk: Experimental Measurement in Rural India." *American Journal of Economics* 62(3): 395-407.

Camerer, C.F., G. Loewenstein, and Matthew Ragin. (2004) *Advances in Behavioral Economics*. Princeton University Press.

Cameron, A.C., and P.K. Trivedi. *Microeconometrics: Methods and Applications.* (2005) Cambridge University Press.

Cleves, M., W.W. Gould, R.G. Gutierrez, and Y. Marchenko. *An Introduction to Survival Analysis Using Stata*. (2002) Stata Press.

DeBraw, A and P. Eozenou (2011). "Measuring Risk Attitudes among Mozambican Farmers." Harvest Plus Working Paper No. 6, International Food Policy Research Institute Working Paper.

DeGraft-Johnson, M., A. Suzuki, T. Sakurai, and K. Otsuka. (2014) "On the Transferability of the Asian Rice Green Revolution to Rainfed Areas in Sub-Saharan Africa: An Assessment of Technology Intervention in Northern Ghana." *Agricultural Economics* 45: 1-16.

Fafchamps, M. (2004). *Market Institution in Sub-Saharan Africa: Theory and Evidence*. Cambridge, MA: MIT Press.

Feder G. (1980). "Farm Size, Risk Aversion, and the Adoption of New Technology under Uncertainty." *Oxford Economic Papers* 32(2): 263-283.

Feder, G., R.E. Just, and D. Zilberman (1985) "Adoption of Agricultural Innovations in Developing Countries: A survey." *Economic Development and Cultural Change* 33(2): 255-298.

Fold, Niels. 2008. "Transnational Sourcing Practices in Ghana's Perennial Crop Sectors." *Journal of Agrarian Change* 8, no. 1: 94-122.

Fold, Niels, and Katherine V. Gough. 2008. "From Smallholders to Transnationals: the Impact of Changing Consumer Preferences in the EU on Ghana's Pineapple Sector." *Geoforum* 39: 1687-1697.

Ghadim, A.K.A., D.J. Pannell, and M.P. Burton. (2005) "Risk, Uncertainty, and Learning in Adoption of a Crop Innovation." *Agricultural Economics* 33: 1-9.

Glover, Dennis. 1987. "Increasing the Benefits to Smallholders from Contract Farming: Problems for Farmers' Organizations and Policy Makers." *World Development*

15(April): 441-448.

Harrison, G. and E. Rustrom (2009). "Expected Utility Theory and Prospect Theory: One Wedding and a Decent Funeral." *Experimental Economics* 12(2): 133-158.

Hazell, Peter. 2005. "Is There a Future for Small Farms?" *Agricultural Economics* 32(January): 93-101.

Henson, Spencer; Steven Jaffee; John Cranfield; Jose Blandon; and Paul Siegel. 2008. "Linking African Smallholders to High-Value Markets: Practitioner Perspectives on Benefits, Constraints, and Interventions." Policy Research Working Paper 4573, World Bank.

Jaffee, Steven, and John Morton. 1995. *Marketing Africa's High-Value Foods*. Dubuque, IA: Kendall/Hunt Publishing Company.

Kahneman, D. and A. Tversky (1979). "Prospect Theory: An Analysis of Decision Under Risk." *Econometrica* 47(2): 263-291.

Kijima, Y. (2011) "An Inquiry into Constraints on a Green Revolution in Sub-Saharan Africa: the Case of NERICA Rice in Uganda." *World Development* 39(1): 77-86.

Liu, E. "Time to Change What to Sow: Risk Preferences and Technology Adoption Decisions of Cotton Farmers in China." *Review of Economics and Statistics* October 2013, 95(4): 1386–1403.

Maertens, Miet, and Johan F.M. Swinnen. 2009. "Trades, Standards, and Poverty: Evidence from Senegal." *World Development* 37, no. 1:161-178.

Minten, Bart, Lalaina Randrianarison, and Johan F.M. Swinnen. 2009. "Global Retail Chains and Poor Farmers: Evidence from Madagascar." *World Development* 37: 1728-1741.

Sonobe, T. & Otsuka, K. (2011). *Cluster-Based Industrial Development: A Comparative Study of Asia and Africa.* Basingstoke: Palgrave Macmillan.

Suzuki, A. (2008) *Three Essays on Agricultural Marketing in Developing Countries: An Industrial Organization Approach.* Unpublished Doctoral Dissertation, University of California, Davis.

Suzuki, Aya, Lovell S. Jarvis, and Richard J. Sexton. 2011. "Partial Vertical Integration, Risk Reduction, and Product Rejection in the High-value Export Supply Chain: The Ghana Pineapple Sector." *World Development* 39 (9): 1611-1623.

Suri, T. "Selection and Comparative Advantage in Technology Adoption." *Econometrica* Vol. 79, No. 1 (January, 2011), 159–209

Tanaka, T., C. Camerer, and Q. Nguyen (2010). "Risk and time preferences: Linking Experimental and Household Survey Data from Vietnam." *American Economic Review* 100(1): 557-571.

Vagneron, Isabelle, Guy Faure, and Denis Loeillet. 2009. "Is There a Pilot in the Chain? Identifying the Key Drivers of Change in the Fresh Pineapple Sector." *Food Policy* 34: 437-446.

Ward, P.S. and V. Singh. (2013) "Risk and Ambiguity Preferences and the Adoption of New Agricultural Technologies: Evidence from Field Experiments in Rural India." Selected paper prepared for presentation at the Agricultural & Applied Economics Association 2013 AAEA & CAES Joint Annual Meeting.

World Bank. 2008. *World Development Report 2008 – Agriculture for Development*. Washington D.C.: World Bank.

Table 1: Socio-economic characteristics of producers by the status of pineapple production (as of 2007)

	Producing pineapple (145)	Not producing pineapple (88)	*Diff*
	(1)	(2)	(3)
Age (years)	41.7	44.3	
	(11.32)	(12.89)	
Male (%)	93.8	76.1	***
	(24.21)	(42.87)	
Years of schooling	9.3	7.1	***
	(3.66)	(4.10)	
Size of household (person)	5.5	4.9	*
	(2.76)	(2.49)	
Best Farmer Award (%)	13.8	4.6	**
	(34.60)	(21.06)	
HH asset (100USD)	21.4	7.1	***
	(41.79)	(10.22)	
Farming equipment	6.5	1.0	***
(100USD)	(18.63)	(3.31)	
Total land owned (acre)	35.5	5.8	**
	(130.84)	(6.90)	
Village by road (%)	41.4	46.6	
	(49.42)	(50.17)	
Years of exporters visit	19.4	18.2	
	(8.24)	(7.82)	
Years of pineapple	26.4	21.8	***
production in village	(14.17)	(10.89)	
RA index (1=risk loving,	2.84	2.38	
6=very risk averse)	(2.11)	(1.63)	

NOTE:
Column (3) shows the significant differences in means between Group 1 and 2 while column (5) shows that between Group 1 and 3.   * indicates significance at 10% level, ** at 5% level, and *** at 1% level.   Standard deviations are reported in the parentheses.

Table 2: Socio-economic characteristics of producers by the timing of production spans

	Group 1	Group 2	*Diff*	Group 3	*Diff*
	(96)	(32)		(137)	
	(1)	(2)	(3)	(4)	(5)
Male (%)	90.6	90.6		89.8	
	(29.30)	(29.61)		(30.40)	
Years of schooling	9.1	8.5		8.8	
	(3.84)	(3.65)		(3.83)	
Size of household (person)	5.7	4.9		5.1	*
	(2.42)	(2.78)		(2.63)	
Best Farmer Award (%)	16.8	9.4		10.2	
	(37.60)	(29.61)		(30.37)	
HH asset (100USD)	20.3	13.3		15.3	
	(39.37)	(10.94)		(30.04)	
Farming equipment	5.9	2.3		4.4	
(100USD)	(15.67)	(2.38)		(14.97)	
Total land owned (acre)	23.4	15.2		38.0	
	(58.35)	(20.04)		(170.24)	
Village by road (%)	37.5	46.9		43.8	
	(48.67)	(50.70)		(49.80)	
Years of exporters visit	19.3	20.8		19.2	
	(7.52)	(7.73)		(8.06)	
Years of pineapple	26.4	30.0		26.1	
production in village	(13.77)	(14.25)		(12.49)	
RA_index (1=risk loving,	2.96	2.75		2.69	
6=very risk averse)	(2.05)	(2.01)		(1.99)	

NOTE:
Group 1: The entire production span is before the MD2 shock.
Group 2: The production span is both in before and after the MD2 shock.
Group 3: The entire production span is after the MD2 shock.
Column (3) shows the significant differences in means between Group 1 and 2 while column (5) shows that between
Group 1 and 3.   * indicates significance at 10% level.   Standard deviations are reported in the parentheses.

Table 3: Hazard Estimates

|	Cox Proportional			Weibull	Gompertz
	(1)	(2)	(3)	(4)	(5)
Individual characteristics					
Risk aversion (RA)	1.10	1.31	1.33	1.39	1.37
	(0.06)*	(0.14)**	(0.17)**	(0.20)**	(0.18)**
Group 2 dummy	4.02	4.04	3.93	5.30	4.76
	(1.00)***	(1.04)***	(1.74)***	(2.85)***	(2.31)***
Group 3 dummy	1.77	1.73	2.18	2.18	2.00
	(0.42)**	(0.44)**	(0.83)**	(1.01)*	(0.90)
RA x Years of schooling		0.98	0.98	0.98	0.98
		(0.01)**	(0.01)**	(0.01)**	(0.01)**
RA x Group 2 dummy			1.01	0.97	0.98
			(0.13)	(0.13)	(0.12)
RA x Group 3 dummy			0.93	0.91	0.92
			(0.09)	(0.09)	(0.10)
Age	0.98	0.98	0.98	0.98	0.98
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***
=1 if male	0.54	0.43	0.42	0.38	0.40
	(0.10)***	(0.09)***	(0.09)***	(0.09)***	(0.10)***
Years of schooling	1.00	1.08	1.08	1.09	1.08
	(0.02)	(0.04)*	(0.04)**	(0.05)**	(0.04)**
Size of household	1.05	1.04	1.04	1.04	1.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
=1 if received Best Farmer Award	0.63	0.69	0.69	0.75	0.72
	(0.32)	(0.37)	(0.37)	(0.41)	(0.39)
Village characteristics					
=1 if by road	0.61	0.59	0.58	0.58	0.60
	(0.06)***	(0.06)***	(0.07)***	(0.07)***	(0.06)***
Years of exporters' visit	1.02	1.02	1.02	1.02	1.02
	(0.01)**	(0.01)*	(0.01)*	(0.01)	(0.01)
Years of pineapple production	0.97	0.97	0.97	0.96	0.96
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***
District FE	Yes	Yes	Yes	Yes	Yes
R2_P	0.05	0.05	0.05	-	-
N	222	222	222	222	222
Chi2	263.3***	435.1***	516.6***	1,268.3***	1,158.2***
F-test of interaction terms (p-value)		0.04	0.05	0.03	0.02

* $p<0.1$; ** $p<0.05$; *** $p<0.01$ Standard errors clustered at village levels are reported in the parentheses. Time at risk is 1,497.   Covariates are evaluated at 2007.

Table 4: Determinants of Lengths of Production (OLS)

	(1)	(2)	(3)
Individual characteristics			
Risk aversion (RA)	-0.14	-0.60	-0.89
	(0.09)	(0.17)***	(0.29)***
Group 2 dummy	-5.14	-5.11	-4.67
	(0.98)***	(1.03)***	(2.36)*
Group 3 dummy	-8.71	-8.68	-10.11
	(0.91)***	(0.94)***	(1.37)***
RA x Years of schooling		0.05	0.05
		(0.02)***	(0.02)***
RA x Group 2 dummy			-0.18
			(0.82)
RA x Group 3 dummy			0.51
			(0.26)*
Age	0.08	0.09	0.09
	(0.03)***	(0.03)***	(0.03)***
=1 if male	2.64	3.06	3.23
	(0.58)***	(0.69)***	(0.72)***
Years of schooling	-0.05	-0.21	-0.22
	(0.06)	(0.09)**	(0.09)**
Size of household	-0.04	-0.02	-0.02
	(0.12)	(0.11)	(0.12)
=1 if received Best Farmer Award	1.58	1.36	1.38
	(1.39)	(1.42)	(1.45)
Village characteristics			
=1 if by road	0.47	0.48	0.52
	(0.44)	(0.45)	(0.52)
Years of exporters' visit	-0.02	-0.02	-0.02
	(0.03)	(0.03)	(0.03)
Years of pineapple production	0.11	0.11	0.11
	(0.02)***	(0.02)***	(0.02)***
Constant	4.01	4.87	5.49
	(1.55)**	(1.56)***	(1.99)**
District FE	Yes	Yes	Yes
R2_P	0.56	0.57	0.57
N	222	222	222
F-test of interaction terms (p-value)		0.01	0.02

* $p<0.1$; ** $p<0.05$; *** $p<0.01$ Standard errors clustered at village levels are reported in the parentheses.

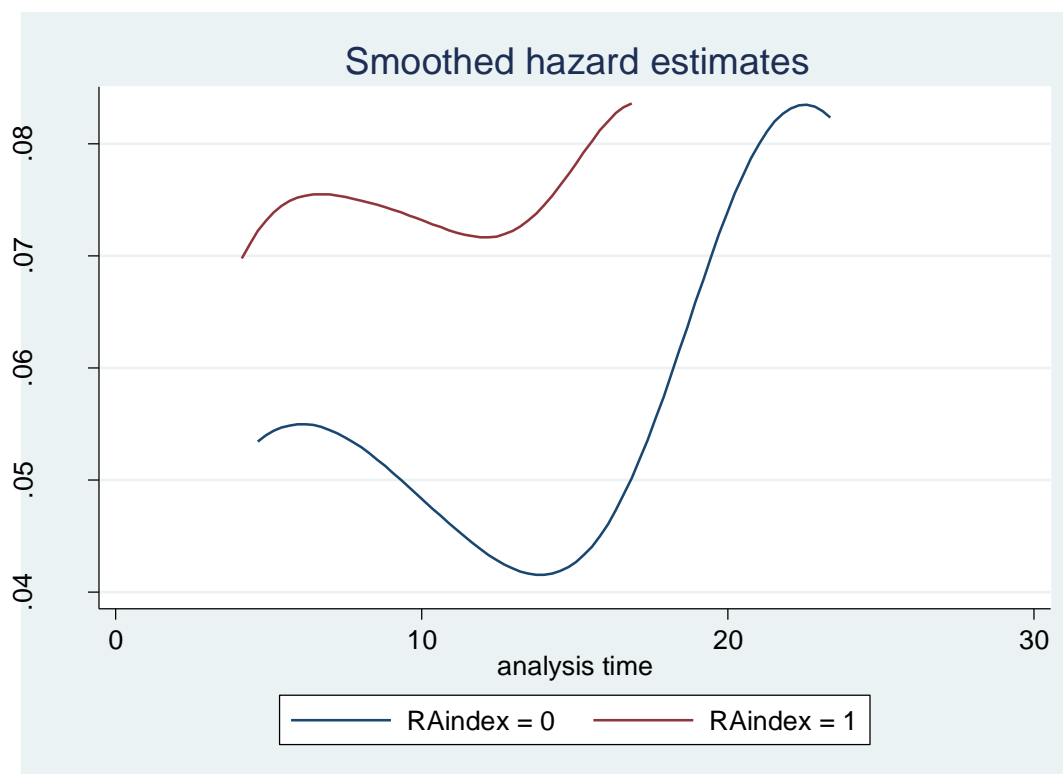**Figure 1: Export Volume of Pineapples from Ghana**
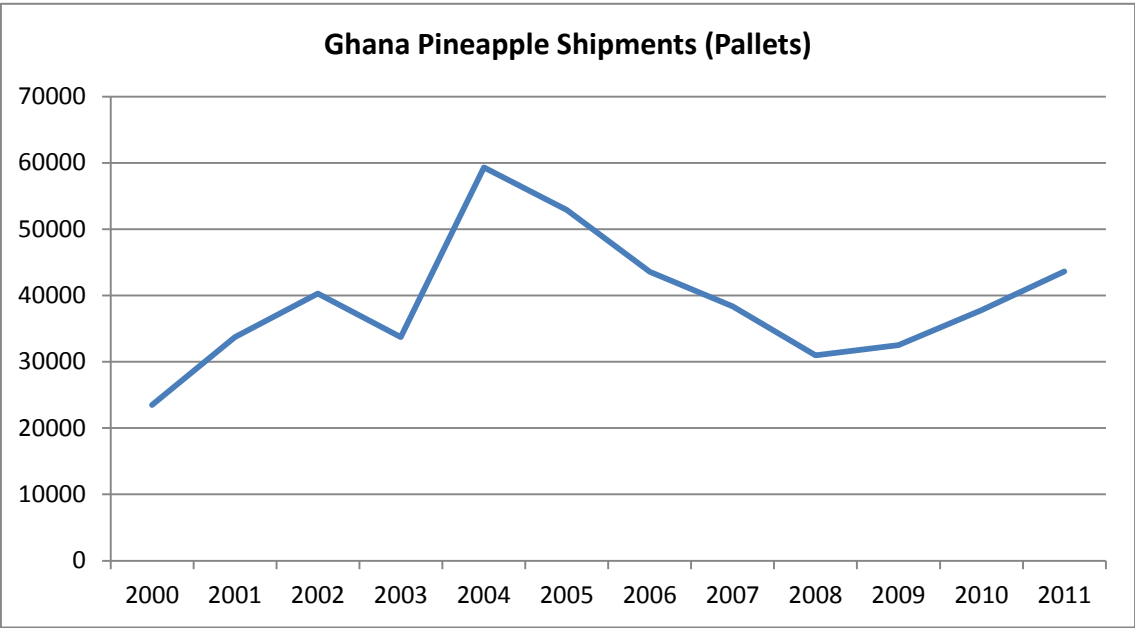
Note) 2003 volume is low because of missing data between Jan-Mar 2003.

Figure 2: Risk Preference Game

|	Project A	Project B		Would you choose A or B?
	①②③④⑤⑥⑦⑧⑨⑩	①②③④⑤	⑥⑦⑧⑨⑩	
Game1	4	4	2	
Game2	4	5	2	
Game3	4	6	2	
Game4	4	6.3	2	
Game5	4	6.5	2	
Game6	4	7	2	

Figure 3: Hazard Estimates by Risk-Averse Index (Non-parametric Analysis)

Note) RAindex=1 indicates that farmers are more risk-averse (RA index between 4-6) while RAindex=0 indicates that farmers are less risk-averse (RA index between 1-3).

Figure 4: Hazard Estimates by Production-Span Groups (Nonparametric Analysis)
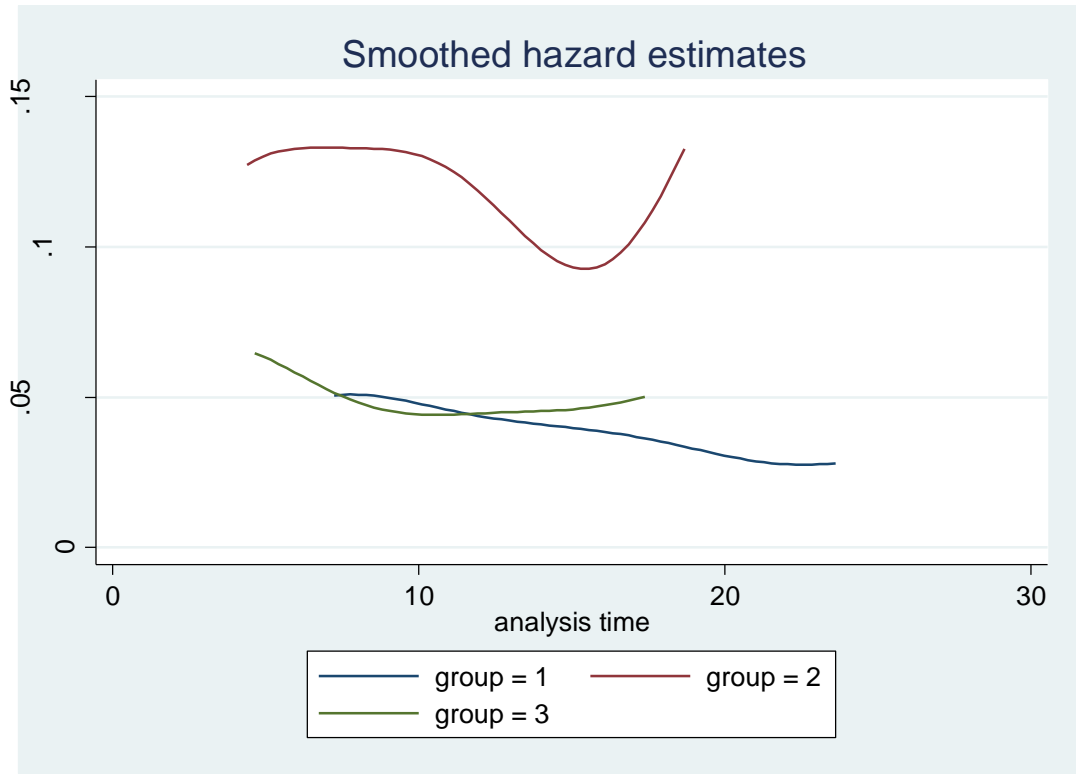
Note) Group1 indicates production span that starts and ends in pre-MD2 period, Group 2 indicates that it starts in pre-MD2 and ends in post-MD2 period, and Group 3 indicates that it starts and ends in post-MD2 period.