Determinants of Using Cold Storage Technology: Insights from Onion Farmers in Bongabon and San Jose City, Nueva Ecija, Philippines

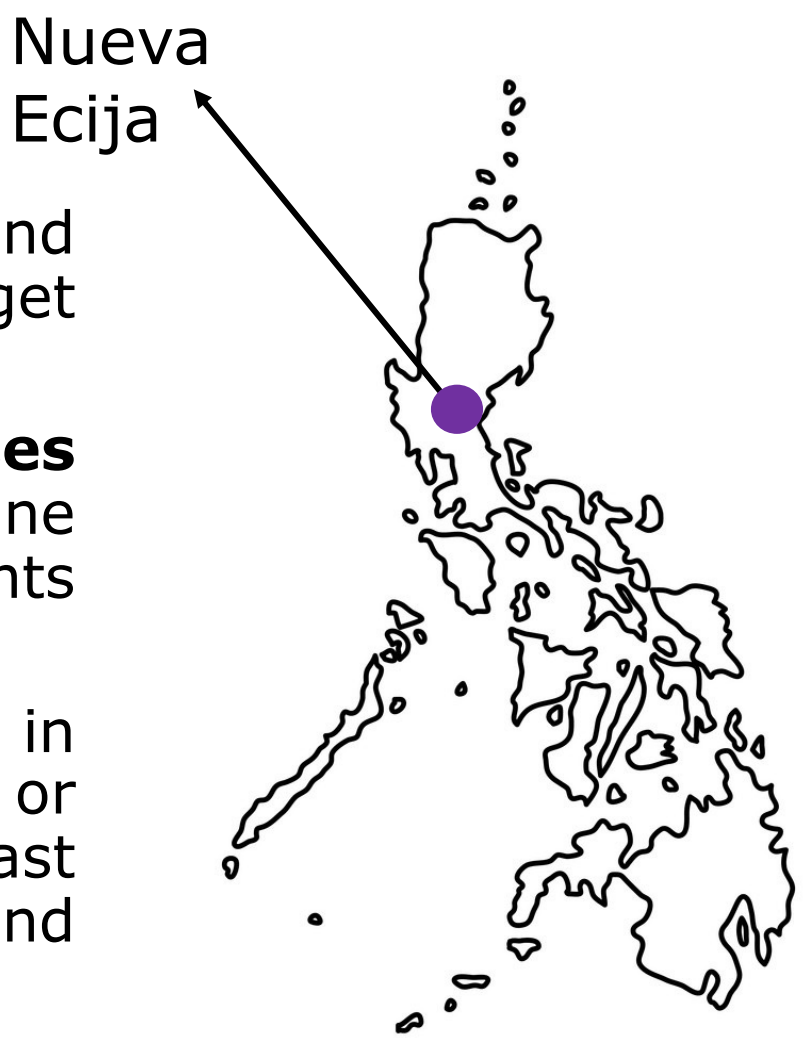
Reymond Denver Buenaseda[1,2], Apichart Daloonpate, Ph.D[1], and Kampanat Vijitsrikamol, Ph.D[1]

[1]*Department of Agricultural and Resource Economics, Kasetsart University*

[2]*Department of Agricultural and Applied Economics, University of the Philippines Los Baños*

Introduction

- The goal of reducing food losses (production and postharvest losses) is articulated in SDG Target 12.3
- In the interest of **abating postharvest losses** and **expanding farmer's income**, the Philippine government has been ramping up its investments on cold storage facilities.
- In 2019, there are 14 cold storage facilities in Nueva Ecija with a capacity of 2.42 million bags or 72,000 metric tons (MT) of onion (Southeast Asian Regional Center for Graduate Study and Research in Agriculture, 2022).



Source: vectorstock.com

Introduction

- Since 2022, however, at least four cooperatives have received cold storage facilities under state funding in the province of Nueva Ecija (Department of Agriculture Philippine Rural Development Project (DA PRDP), 2023; Philippine News Agency, 2023).
- An additional 5,100 MT can be stored and thus presents an opportunity for small-scale farmers to augment their profit on top of their net returns on farm production.
- Considering that onion is a highly seasonal crop (i.e., it is only planted once a year), farmers can take advantage of a high price during the lean season (LS).
- During LS, prices are higher than the average monthly price by 46.8% (December). During peak harvest season, prices are lower by 39.4% (March).

Seasonal indices are based on authors' calculation and basic data is obtained from the Philippine Statistics Authority

Review of related literature

- Empirical evidence shows that transaction costs and risk aversion serve as roadblock in exploiting intertemporal price arbitrage.
- Cardell and Michelson (2022) considered a model to reflect household's decision to store or sell grains after harvest and found that **risk averse farmers** tend to opt out of storage because of the possibility of negative returns.
- Using bivariate logit and probit regression, **longer distance** from the farm to a passable road (Gitonga et al., 2013) reduces the likelihood of adopting metal silos (i.e., grain storage) or the distance from a market stall to the cold storage reduces the likelihood of use (Takeshima et al., 2022).

Review of related literature

- Wealth (total land area owned), liquidity measures, and factors that increase farmers' capacity make it more likely for farmers to use the storage technology.
- Using a multivariate sample selection model, **access to credit and off-farm income** reduces the likelihood of market entry as sellers in the harvest period (Stephens and Barrett, 2010).
- The greater the **land area owned** and the **more quantity sold** by the farmer will also lead to greater likelihood of cold storage use (Minten et al., 2014).

Review of related literature

- Cooperative membership and training related to improved storage technology increases their likelihood of adoption (Alemu et al., 2021; Bokusheva et al., 2012).

Objective

- In the Philippines, cooperatives engaged in onion production recently received cold storage facilities that are **expected to increase the involvement** of farmers in the practice of onion storage.
- Thus, this paper examines the **factors that are associated with the use of cold storage technology** in Nueva Ecija, Philippines.

Methodology

- **Study area:** Nueva Ecija is the major producer of onion in the country providing 58.5% to the national production and it also has the most number of cold storage facilities.
- The municipality of **Bongabon** and the city of **San Jose** are chosen since they have the greatest volume of production in both Red Creole and Yellow Granex varieties. Each area also has one cold storage facility provided by the Department of Agriculture. The top three producing villages are then selected.

Cold storage facility in San Jose City, Nueva Ecija, Philippines
Source: Department of Agriculture

Methodology
Sampling procedure

- DA High Value Crops Development Program provided a list of onion farmers and was considered the sampling frame.
- Since the proportion of farmers who are using the cold storage technology is unknown, a proportion of 50% is assumed. Margin of error was set at 5% and confidence level at 95%.
- The computed sample size exceeds 5% of the population (N=946). Using Cochran’s sample size correction formula, the appropriate sample size is 214.
- As of January 2024, there are 169 farmer respondents and initial insights and model estimations are based on this sample.

Methodology
Sampling procedure

- Since there is a considerable variation in the population of farmers across villages, stratified random sampling with proportional allocation was used.

Municipality	Population (N)	Sample size (n)
Bongabon		
Vega	128	29
Pesa	119	27
Kaingin	61	14
San Jose City		
Tayabo	253	57
San Agustin	217	49
Villa Marina	168	38
Total	946	214

Methodology

- **Data collection**: pre-testing of questionnaires, training of enumerators, and the actual interview with farmers were conducted from December 2023 to February 2024

Methodology

Types of data collected

- **Socio-economic, farm, and risk characteristics**; **production, marketing and storage behavior**; and costs and benefits associated with the use of cold storage facility.
- The harvest and off-season in 2023 was considered in collecting data on production, marketing, and storage.
- The marketable surplus was calculated by deducting the quantity consumed and given away from the harvest.
- The marketable surplus is categorized into: onion sold immediately after harvest, onion sold after cold storage, and postharvest loss.

Methodology
Data analysis

- **Descriptive statistics** was used to characterize the onion farmers across their socioeconomic, farm, and risk characteristics.
- For quantitative data, **comparison of means** using t-test **and medians** using Mann-Whitney U test were employed as a preliminary step to determine the factors that are associated with cold storage use.
- For qualitative data, **comparison of proportion** using Chi-square test of independence was used.

Methodology

Estimation strategy

- **Binary logit model** was employed to identify the factors affecting the use of cold storage technology.
- $Y_i^* = \beta' x_i + \varepsilon_i$, $D_i = \begin{cases} 1, if\ Y_i^* > 0 \\ 0, otherwise \end{cases}$
- Y_i^* is the unobserved preference of farmer *i* representing the latent utility on the use of cold storage technology
- β' is the vector of coefficients representing the effect of unit changes in the vector of observable factors, x_i. The selection of covariates is based on the literature review and initial farm survey and are summarized in Table 1.

Table 1. Description of variables

Variable	Description
Use	Onion farmer used the cold storage technology after the harvest season in 2023
Total land area	Total land area for agricultural production in hectares
Total land area for onion	Total land area allocated for onion production in hectares
Total quantity sold	Marketable surplus that was sold in kilograms
Distance	The distance from the farm to the closest cold storage facility in kilometers
Profit last season	The profit of farmer from onion production in 2022 in Philippine pesos
Age	The age of the farmer in years
Farming experience	Number of years in farming
Formal education	Number of years spent in formal education
Price expectation	The farmer expected the price of onion to increase after the harvest season
Cooperative membership	The farmer is a member of a cooperative
Training	The farmer attended a training on postharvest management
Access to formal credit	Farmer loaned from either a bank, cooperative, or a microfinance institution
Off-farm income	Farmer has access to off-farm income
Farmer under financier	Trader provided inputs to the farmer as loan
Risk averse	Risk aversion based on the hypothetical investment choice method
Stored previously dummy	The farmer stored onion prior to 2023

Table 2. Summary statistics and test of normality on quantitative explanatory variables, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Mean	Standard deviation	Coeff. of variation	Median	Skewness	Shapiro-Wilk p-value
Total quantity sold	18,413.20	49,625.60	269.51	4,725.00	5.34	0.000
Total land area	1.77	2.97	167.80	1.00	5.47	0.000
Total land area for onion	1.20	2.12	176.67	0.10	5.19	0.000
Distance	22.65	17.60	77.70	19.00	0.36	0.000
Profit in 2022	97,573.96	342,147.88	350.65	41,000.00	1.90	0.000
Age	53.87	11.52	21.38	55.00	-0.15	0.233
Farming experience	28.53	13.06	45.78	29.00	0.26	0.009
Formal education	9.36	2.92	31.20	10.00	-0.08	0.000

Only age is normally distributed. Total quantity sold, total land area, total land area for onion, and profit in the last cropping season is positively skewed.

On the average, farmers allocated 0.10 hectares for onion production with a median quantity sold of 4,725.00 kg or 157.50 bags.

Table 3. Median and mean comparison between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Non-user (n=148)	User (n=21)	p-value
Total quantity sold	4,410.00	27,900.00	0.000
Total land area	0.80	2.00	0.000
Total land area for onion	0.50	1.75	0.000
Distance	25.00	8.00	0.029
Profit last season	30,000	100,000.00	0.033
Age	55.00	57.00	0.297
Farming experience	29.00	30.00	0.429
Formal education	10.00	10.50	0.035

At a glance, it seems that socio-economic characteristics are unrelated with participation in cold storage activity.

Total quantity sold, total land area, total land area for onion production, distance, and profit from onion production last season are statistically different between users and non-users.

Farmers who are reliant on financiers are forced to liquidate their harvest immediately

Table 4. Comparison of proportion between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Non-user (n=148)	User (n=21)	p-value
Farmer under financier			
No financier	107 (72.30%)	21 (100.00%)	0.006
With financier	41 (27.70%)	0 (0.00%)	

There are two common modes of financing, *samak* and *pabuto* system.

Samak is an Ilocano term for profit sharing wherein farmers rely on either a trader or another farmer (collectively called as financiers) for their inputs. All the costs are incurred by the farmer and after deducting the total cost from the gross revenue, the profit is shared between the farmer and financier.

Farmers who are reliant on financiers are forced to liquidate their harvest immediately

Table 4. Comparison of proportion between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Non-user (n=148)	User (n=21)	p-value
Farmer under financier			
No financier	107 (72.30%)	21 (100.00%)	0.006
With financier	41 (27.70%)	0 (0.00%)	

There are two common modes of financing, *samak* and *pabuto* system.

In *pabuto* system, the financier typically provides the seed (*buto* is the Tagalog term for seed) and in return, the farmer needs to pay the seed plus the interest and must sell all the harvest to the financier.

Urea fertilizer (left) and insecticides (right) from the residence of a financier in Bongabon

Farmers can avail fertilizer and insecticide from a small warehouse of the financier’s residential lot. Financier accounts for the quantity of input availed.

Participation in onion trading increases the capacity of farmers to engage in cold storage activity

Table 4. Comparison of proportion between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023 *(continuation)*

Variables	Non-user (n=148)	User (n=21)	p-value
Access to off-farm income			
No access	98 (66.22%)	6 (28.57%)	0.001
With access	50 (33.78%)	15 (71.43%)	
Farmer-trader			
Not a trader	146 (98.65%)	12 (57.14%)	0.000
Also a trader	2 (1.35%)	9 (42.86%)	

Additional sources of income include agricultural wages (seasonal farm labor), non-agricultural wage (construction), and self-employed income (convenience store, agricultural supply store, and agricultural products trading)

Members of cooperative seems to drive cold storage activity (particularly on Bongabon farmers)

Table 4. Comparison of proportion between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023 *(continuation)*

Variables	Non-user (n=148)	User (n=21)	p-value
Cooperative membership			
Not a member	135 (91.22%)	12 (57.14%)	0.000
Member	13 (8.78%)	9 (42.86%)	
Training			
Not attended	136 (91.89%)	12 (57.14%)	0.000
Attended	12 (8.11%)	9 (42.86%)	

7 of 9 respondents who are members of a cooperative are from **Vega Primary Multipurpose Cooperative** (PMPC) in Bongabon, Nueva Ecija. The members of Vega PMPC can store onion without a specific volume requirement.

Meanwhile, **Kalasag Farmers Producers Cooperative** (another recipient of cold storage facility) practice storage as an organization.

Training on postharvest management seems to drive cold storage activity

- DA Philippine Rural Development Project and the DA Philippine Center for Postharvest Development and Mechanization has been providing trainings to the farmers that are related on proper storage techniques.
- As an anecdote, a farmer mentioned that the cooperative was advised to put the onion in an anteroom with a temperature of about 17 degree Celsius before subjecting the onion to the cold storage. For Yellow Granex onion, the appropriate temperature ranges between 2 to 5 degrees Celsius while Red Creole onion needs to be stored at 0 degrees Celsius.

Estimation strategy

Table 5. Logit regression showing the average marginal effects of total quantity sold on use of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Parsimonious model			
	Coeff.	p-value	dy/dx	p-value
Intercept	-13.410	0.000	-	-
Total quantity sold (log)	1.219	0.000	0.087	0.000
Wald χ^2	30.40			
Prob χ^2	0.0000			
Pseudo R^2	0.3187			

A parsimonious model is shown above. The bivariate regression model already has a decent explanatory power with a pseudo R-squared of 0.3187.
An increase in the **quantity of onion sold** (in logarithm) increases the likelihood of cold storage use by 8.7%.

Volume requirement serves as a barrier in using the cold storage facility

- This conforms the typical reason of farmers regarding their non-participation of storage. Privately owned cold storage facilities require at least 30,000 kg or 1,000 bags of onion (Median quantity sold is only 4,725 kg).
- That is why it is evident that those **farmers who engaged in trading** have the capability to store since they are able to consolidate the onion bought from several smallhold farmers.
- **Farmers who are members of a cooperative** also have the opportunity to store since there is no strict volume requirement being imposed.

Table 6. Logit regression showing the average marginal effects of various factors on use of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Long logit model			
	Coeff.	p-value	dy/dx	p-value
Intercept	-31.69	0.003	-	-
Total quantity sold (log)	1.227	0.054	0.033	0.083
Total land area	0.008	0.954	0.000	0.953
Distance	0.102	0.086	0.003	0.024
Profit from last season	0.000	0.584	0.000	0.570
Age	0.098	0.340	0.002	0.268
Farming experience	0.072	0.430	0.001	0.466
Formal education	0.011	0.950	0.000	0.950
Expect	2.057	0.081	0.055	0.054
Risk averse	0.133	0.618	0.004	0.594
Cooperative membership	2.364	0.017	0.063	0.023
Training	3.130	0.023	0.084	0.023
Access to formal credit	-3.360	0.033	-0.090	0.043
Access to off-farm income	2.931	0.076	0.079	0.077
Farmer-trader	9.123	0.001	0.246	0.000
Stored previously	5.402	0.131	0.145	0.029
Wald χ^2	31.68			
Prob χ^2	0.0071			
Pseudo R^2	0.7598			

Previous storage behavior

- Previous storage behavior increases the likelihood by 14.5%. The percentage of those who stored in 2022 and the preceding years is 25.4% (43) while the adoption rate in 2023 is only 12.4% (21).
- 2023 is a unique year in the sense that the farmgate price considerably increased.
- Price attracted both farmers and traders to sell immediately thus reducing the rate of cold storage use.

Table 7. Farmgate price of onion during peak harvest month, 2022 and 2023

Price (USD/kg)	March 2022 (PSA data)	March 2023 (survey data)
Red Creole onion	0.68	1.08
Yellow Granex onion	0.26	0.90

Summary

- Recent developments in the Philippine onion industry include investments on cold storage technology to abate postharvest losses and to provide farmers an option to increase their profit.
- However, there are still barriers to adoption such as liquidity constraints, transaction costs, and risk aversion. Thus, the paper examined the factors that are associated with use of cold storage technology in Bongabon and San Jose City, Nueva Ecija, Philippines.
- Results show that members of a cooperative are more likely to use cold storage. The collective action and clustering approach which are the key tenets of a cooperative can be a solution to the strict volume requirement being implemented by privately owned cold storage facilities.

Recommendation for future research

- Previous storage behavior is also positively associated with use of cold storage. Given that farmgate prices in 2023 are relatively high as compared to the previous year, some of the farmers who stored previously decided to sell onion immediately.
- Panel data series which considers the farmgate price of onion may be explored to enhance external validity further leading to a better understanding of storage behavior.

Acknowledgment

- I would like to thank the DAAD (German Academic Exchange Service) & SEARCA for funding this research.
- The authors also acknowledge the enumerators, Ms. Angelica Montalla, Ms. Jackie Cabading, and Mr. Stephen Victor Marcos, for their vital role in data collection.

References

Alemu, G. T., Nigussie, Z., Haregeweyn, N., Berhanie, Z., Wondimagegnehu, B. A., Ayalew, Z., Molla, D., Okoyo, E. N., & Baributsa, D. (2021). Cost-benefit analysis of on-farm grain storage hermetic bags among small-scale maize growers in northwestern Ethiopia. *Crop Prot*, *143*, 105478. https://doi.org/10.1016/j.cropro.2020.105478

Bartlett, J., Kotrlik, J., & Higgins, C. (2001). Organization research: Determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal*, *19*(1), 43-50.

Bokusheva, R., Finger, R., Fischler, M., Berlin, R., Marín, Y., Pérez, F., & Paiz, F. (2012). Factors determining the adoption and impact of a postharvest storage technology. *Food Security*, 4(2), 279-293. https://doi.org/10.1007/s12571-012-0184-1

Cardell, L., & Michelson, H. (2022). Price risk and small farmer maize storage in Sub Saharan Africa: New insights into a long-standing puzzle. *American Journal of Agricultural Economics, 105(3), 737-759. https://doi.org/10.1111/ajae.12343*

Department of Agriculture Philippine Rural Development Project. (2023). http://prdp.da.gov.ph/100-complete-kasamne-onion-cold-storage-subproject-finishes-construction/

Fausti, S., & Gillespie, J. (2000). A Comparative Analysis of Risk Preference Elicitation Procedures Using Mail Survey results. Western Agricultural Economics Association. http://ageconsearch.umn.edu/bitstream/36469/1/sp00fa03.pdf

Gitonga, Z. M., De Groote, H., Kassie, M., & Tefera, T. (2013). Impact of metal silos on households' maize storage, storage losses and food security: An application of a propensity score matching. Food Policy, 43, 44-55. https://doi.org/10.1016/j.foodpol.2013.08.005

Minten, B., Reardon, T., Singh, K., & Sutradhar, R. (2014). The new and changing roles of cold storages in the potato supply chain in Bihar. Economic and Political Weekly, 49(52), 98-108.

Nwet, Y. Y., Lantican, F. A., Aragon, C. T., & Sumalde, Z. M. (2018). Analysis of profitability on rice storage by farmers in the selected areas of Ayeyarwaddy Region, Myanmar. Food and Fertilizer Technology Center Agricultural Policy Platform. Food and Fertilizer Technology Center Agricultural Policy Platform. https://ap.fftc.org.tw/article/1326

Philippine News Agency. (2023). https://www.pna.gov.ph/articles/1197024

Philippine Statistics Authority. (2022). Farmgate prices of Red Creole and Yellow Granex. https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2M__NFG/0032M4AFN04.px/table/tableViewLayout1/?rxid=8715bb5b-56ae-41fe-9cd8-991ba34b96cd

SEARCA. (2022). Analysis of Fruit and Vegetable Value Chains in the Philippines. https://www.adb.org/projects/documents/reg-52239-001-tacr-0

Stephens, E. C., & Barrett, C. B. (2010). Incomplete Credit Markets and Commodity Marketing Behaviour. Journal of Agricultural Economics, 62(1), 1-24. https://doi.org/10.1111/j.1477-9552.2010.00274.x

Takeshima, H., Yamauchi, F., Edeh, H. O., & Hernandez, M. A. (2023). Solar-powered cold-storage and agrifood market modernization in Nigeria. Agricultural Economics, 54(2), 234-255. https://doi.org/10.1111/agec.12771

Thank you for listening!

Reymond Denver Buenaseda
Department of Agricultural and Resource Economics, Kasetsart University
Department of Agricultural and Applied Economics, University of the Philippines Los Baños

Email: reymonddenverquilaton.b@ku.th
rqbuenaseda@up.edu.ph