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Volume 3 Number 1
June 2017

ISSN: 2564 - 1001 (Print)
ISSN: 2564 - 101X (Online)

Journal of Economics, Management & Agricultural Development

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Seasonal Integration and Co-Integration in the Prices of Key Aquaculture Species in the Philippines

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Abstract

This paper investigates the relationship between retail and wholesale prices of milk-fish (*Chanoschanos*), tilapia (*Tilapianilotica*), and tiger prawn (*Peneaus monodon*) using techniques that recognize the role of seasonal factors for testing orders of integration of and the existence of cointegration between these prices. This paper finds that seasonality plays an important role in explaining movements in the prices of these farmed species. This is so because, with the exception of the wholesale price of tiger prawn, unit roots occur at all frequencies for all of the prices that were examined. None of the pairs of prices were found to be cointegrated at all frequencies. However, the retail and wholesale prices of tilapia were found to be cointegrated at zero and annual frequencies. These findings suggest that regressions on the levels of retail and wholesale prices of milkfish and tiger prawn could lead to spurious results. Hence, price formation based on level of prices for these two aquaculture species can send wrong signals to the market stakeholders, i.e., producers, middlemen, and consumers.

Keywords: *seasonality, integration, cointegration, aquaculture, Philippines*

Introduction

Fish occupies a special place in the diet of Filipinos. It is an important source of food and animal protein, accounting for about half of annual per capita expenditures on meat products (PSA 2014). In 2014, the industry also contributed close to a fifth of the gross value added of the Agriculture, Fishery and Forestry sector and provided a source of income to about 1.4 million fishers and fish farmers in the country [Philippine Statistical Authority (PSA) 2015].

Papers by Garcia and Salayo (2009) and Garcia et al. (2015) addressed the issue of price dynamics in selected farmed fish species in the Philippines. By examining the relationship between wholesale and retail prices, the studies recognized the implications of pricing efficiency on distribution and food security. The studies also confronted the issue of spurious relationships or regressions that incorrectly suggest a meaningful relationship between market prices at various stages of the supply chain by testing for the presence of cointegration between these prices.

The objective of this study is to investigate the relationship between retail and wholesale prices of milkfish (*Chanoschanos*), tilapia (*Tilapianilotica*), and tiger prawn (*Peneaus monodon*). It builds on the work of Garcia and Salayo (2009) and Garcia et al. (2015) by recognizing the role of seasonal factors in testing for the existence of cointegrating relationships between such prices.

The use of seasonally adjusted data and dummy variables are two common approaches to address seasonality. However, Harris (1995) stated that there are short-comings to such methods. Citing the work of McKinnon and Davidson (1993), it was noted that using seasonal filters to eliminate seasonality tends to distort the underlying processes of the data series. The authors also added that the standard Dickey-Fuller tests tended to the conclusion that a variable is non-stationary more often than it should if seasonally adjusted variables are used.

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On the other hand, when using the dummy variable approach, it was asserted that this instrument should only be employed when the variable is a stationary seasonal process. If such is not the case, however, the implementation of appropriate differencing of the variables in place of dummy variables is recommended.

Accounting for seasonality in tests for cointegration is not new and has been applied extensively in the literature. Leong (1995), Beaulieu and Miron (1993), and Osborn (1990) provide applications to macroeconomic variables in Australia, United States, and United Kingdom, respectively. The IRIC and Muresk Institute of Agriculture (1998) applied the technique to examine the long term relationships of economic variables in the livestock sector of Australia. In the case of the Philippines, Redoblado (2007) tested for seasonal integration in selected macroeconomic variables. This paper is one of the initial attempts to apply seasonal cointegration in the prices of farmed fish species in the country.

Methodology

Investigating the possibility of spurious relationships typically commences with tests for the order of integration of the variables. If variables are found to be stationary or integrated of order zero [I(0)], then a meaningful relationship is possible between the levels forms of the variables. If variables are found to be integrated of different orders, then the conclusion is that a meaningful relationship between the levels forms of the variables does not exist. However, if the variables are integrated of at least order one [I(1)] and are of the same order, then a meaningful relationship can exist if the variables are cointegrated. In what follows, this paper describes the methods used to test for the order of integration and the existence of cointegration in high frequency data that are not adjusted for seasonality.

Testing for Integration

In order to explain the role of seasonality in testing for the degree of integration, it is instructive to begin with the basic concepts of stationarity and non-stationarity in time series variables. Following the discussion in Harris (1995), suppose that Equation 1 describes the data generating process of time series variable y_t. The variable is stationary or integrated of order zero or I(0) if $|p| < 1$. On the other hand, y_t is said to have a unit root or is non-stationary if $p = 1$. The variable y_t is integrated of order one or I(1) if its first difference $(y_t - y_{t-1})$ or $(1 - L)\, y_t$ is stationary. If further differencing is required to make the variable stationary, then it is deemed to be integrated of a higher order.

$$y_t = \rho \cdot y_{t-1} + u_t \;\; ; \;\; \text{where } u_t \sim N(0, \sigma^2) \qquad (1)$$

One of the common methods to check for stationarity is the Augmented Dickey-Fuller (ADF) test[4]. This involves estimating Equation 2 and conducting a hypothesis test on β. If the null hypothesis of $\beta = 0$ cannot be rejected, then the variable is deemed to be non-stationary. Otherwise, the variable is concluded to be stationary.

$$y_{t-1} + \sum_{i=1}^{p} \psi_i \cdot (1 - L) y_{t-i} + \varepsilon_t \qquad (2)$$

4 For a discussion on alternative tests, the interested reader might want to consult Harris (1995), Enders (1995) and other econometrics textbooks.

The ADF test in Equation 2 is designed for testing a zero frequency or non-seasonal unit root. In quarterly data for example, ADF is incapable of checking for the presence of unit roots at semi-annual and annual frequencies. Elaborating on the work of Hylleberg et al. (1990), Harris (1995) presents Equation 3 as a means to test for multiple unit roots in the case of high frequency data that are likely to show cyclical behavior. The z_i in this equation are seasonal filters designed to remove unit roots at various frequencies. Their use, therefore, isolates the specific unit root that is being tested in the process.

$$\left(1-L^4\right)y_t = \pi_1 \cdot \left(z_1 y_{t-1}\right) + \pi_2 \cdot \left(z_2 y_{t-1}\right) + \pi_3 \cdot \left(z_3 y_{t-2}\right) + \pi_4 \cdot \left(z_3 y_{t-1}\right) + \sum_{i=1}^{p} \psi_i \cdot \left(1-L^4\right) y_{t-i} + \sum_{i=1}^{4} \alpha_i \cdot D_{it} + \delta \cdot t + u_t$$

where; $z_1 = \left(1 + L + L^2 + L^3\right)$; $z_2 = -\left(1 - L + L^2 - L^3\right)$; $z_3 = -\left(1 - L^2\right)$;

D_{it} is a dummy variable for quarter i at year t; $i = 1,\ldots,4$; and

u_t is a random disturbance term.

Conclusions from hypothesis tests on the various parameters of Equation 3 are fairly straightforward. A test which concludes that $\boldsymbol{\pi_1 = 0}$ implies the existence of a zero frequency unit root. Finding $\boldsymbol{\pi_2 = 0}$ suggests the existence of a unit root at semi-annual frequency. A test which concludes that $\boldsymbol{\pi 3 = \pi 4 = 0}$ implies the presence of an annual unit root. Finding $\boldsymbol{\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0}$ means that unit roots are present at all frequencies.

In practice, t-type tests are implemented for the hypotheses that $\boldsymbol{\pi_1 = 0}$ and $\boldsymbol{\pi_2 = 0}$. On the other hand, an F-type test is conducted for $\boldsymbol{\pi_3 = \pi_4 = 0}$ due to the simultaneous restrictions imposed on the values of these two parameters. The critical values for the test statistics are provided in Hylleberg et al. (1990).

An important issue that arises in the implementation of the test is the optimal length for of the lagged dependent variable on the right hand side of Equation 3; i.e., the value of *"p"*. Harris (1995) suggested two approaches for addressing this concern. The first is to find the lag length that generates the highest $\bar{R}^2$ in the estimating equation. The other uses a fixed lag length defined in Equation 4 as suggested by Schwert (1989). These two approaches will in most cases suggest different lag lengths and potentially different findings. In choosing between the two approaches, this paper will draw its conclusions from the model that has the longer lag length. This follows the spirit of Banergee et al. (1993, as cited in Harris 1995) which asserted that while having too many lags leads to a potential loss in efficiency, it reduces the risk of having residual autocorrelation that comes with having too few lags.

$$Lag\ \ Length = \text{int}\left[12 \cdot \left(\frac{T}{100}\right)^{1/4}\right] \qquad (4)$$

Where T = number of observations

Seasonal Cointegration

Just like tests for stationarity, standard tests for cointegration are also modified when dealing with seasonally unadjusted variables. Harris (1995) describes an approach whereby a series of regressions are used to test for cointegration at zero, semi-annual, and annual frequencies. The approach is analytically similar to Engel and Granger (1987) in that the residuals from a preliminary regression between the variables are tested for stationarity. The key difference, however, is the use of seasonal filters to isolate the frequency for which cointegration is being tested.

Harris (1995) provides three groups of equations to test cointegration at various frequencies between two similarly integrated time series variables y_t and x_t. Equations 5 and 6 are used to test for cointegration at zero frequency. It begins by the estimation of Equation 5 using ordinary least squares (OLS). The estimated residuals ($\hat{\varepsilon}_t$) from Equation 5 are then used in estimating the parameters of Equation 6 and a *t-type* test is implemented for the parameter ϕ_1. The null hypothesis that $\phi_1 = 0$ is tested against the alternative that $\phi_1 < 0$. A rejection of the null hypothesis is interpreted as the existence of a cointegrating relationship between y_t and x_t at zero frequency. Harris (1995) adds that ϕ_1 follows a distribution suggested by McKinnon (1991). As in the previous and succeeding tests, lagged values of the dependent variable $[(1 - L)\varepsilon_{t-i}]$ are added to Equation 6 in order to eliminate serial correlation.

$$z_1 y_t = \beta_1 \left(z_1 x_t\right) + \varepsilon_t \tag{5}$$

$$\left(1-L\right)\hat{\varepsilon}_t = \mu + \delta \cdot t + \phi_1 \hat{\varepsilon}_{t-i} + \sum_{i=1}^{p-1} \psi_i \cdot \left(1-L\right)\hat{\varepsilon}_{t-i} + \omega_t \tag{6}$$

where μ is the intercept term and ω_t is the random error term.

Equations 7 and 8 are used to test for cointegration at semi-annual frequency. Rejecting the null hypothesis that $\boldsymbol{\phi_2 = 0}$ suggests the existence of a semi-annual cointegrating relationship. The coefficient also has a distribution that is identical to $\boldsymbol{\phi}_1$.

$$z_2 y_t = \beta_2 \left(z_2 x_t\right) + v_t \tag{7}$$

$$\left(\hat{v}_t + \hat{v}_{t-1}\right) = \mu + \delta \cdot t + \phi_2 v_{t-i} + \sum_{i=1}^{3} \alpha_i D_{it} + \sum_{i=1}^{p-1} \psi_i \cdot \left(\hat{v}_{t-i} + \hat{v}_{t-1-i}\right) + \omega_t \tag{8}$$

Finally, Equations 9 and 10 are used to test for cointegration at annual frequency. It is implemented by verifying the null hypothesis $\phi_3 = \phi_4 = 0$. This is an *F-type* test in which the test statistic has a distribution suggested by Engle et al. (1993). A rejection of the null hypothesis is interpreted as suggesting the existence of annual cointegrating relationship between y_t and x_t.

$$\begin{aligned} z_3 y_t &= \beta_3 \left(z_3 x_t\right) + \beta_4 \left(z_4 x_{t-1}\right) + \zeta_t \\ \left(\hat{\zeta}_t + \hat{\zeta}_{t-2}\right) &= \mu + \phi_3 \left(-\hat{\zeta}_{t-2}\right) + \phi_4 \left(-\hat{\zeta}_{t-1}\right) + \sum_{i=1}^{3} \alpha_i D_{it} + \delta \cdot t \end{aligned} \tag{9}$$

$$+\sum_{i=1}^{p-1}\psi_i \cdot\left(\hat{\xi}_{t-i}+\hat{\xi}_{t-2-i}\right)+\omega_t \qquad (10)$$

The Dataset

This study uses national quarterly data on the retail and wholesale prices of milkfish, tiger prawn, and tilapia. These prices were calculated using monthly data from 1990 to 2007 that were sourced from the Philippine Statistics Authority (PSA). Quarterly averages of monthly price indices for "food and beverages" from the National Statistics Office were used to deflate fish prices.

Results and Discussion

Table 1 shows the results from tests of seasonal integration on the retail and wholesale prices of the three fish species. It indicates that the retail and wholesale prices of milkfish and tilapia have unit roots at the zero, semi-annual and annual frequencies. With the exception of the wholesale price of tilapia, the conclusions are the same regardless of the method used to determine optimal lag length. If the formula of Schwert (1989) is used to determine the optimal lag length, the estimates indicate that the wholesale price of tilapia is stationary at semi-annual frequency. This is contrary to the findings when the adjusted R2 is used to determine the optimal lag length. Despite the contradictory findings, the authors tend to favor the conclusion that the wholesale price of tilapia is non-stationary at semi-annual frequency because the latter approach has a longer lag length.

Table 1. Tests for stationarity in retail and wholesale prices, by farmed fish species, Philippines, 1990-2007

Variable	Lags	Test Statistic for Coefficient		
		π_1 [a]	π_2 [b]	$\pi_3 \cap \pi_4$ [c]
Lag length determined by Schwert (1980)				
Milkfish				
Retail price	11	-3.02	-1.99	0.78
Wholesale price	11	-1.17	-2.25	1.60
Tiger prawn				
Retail price	11	-1.25	0.26	4.69
Wholesale price	11	-2.76	-2.00	8.05*
Tilapia				
Retail price	11	-1.17	-2.25	1.60
Wholesale price	11	-2.82	-3.37*	4.46
Lag length determined by Adjusted R-squared				
Milkfish				
Retail price	17	-0.14	-1.72	0.64
Wholesale price	18	-0.12	-2.56	2.57
Tiger prawn				
Retail price	6	-1.00	-0.60	6.44
Wholesale price	16	-2.00	-3.00*	3.29
Tilapia				
Retail price	18	-0.12	-2.56	2.57
Wholesale price	18	0.57	-1.59	1.85

[a] At the 5% level of significance, Hylleberg et al. (1990) stated that the critical values for 100 and 48 observations are -3.53 and -3.71, respectively. For the 1% level of significance, the critical values for 100 and 48 observations are -4.09 and -4.46, respectively.

[b] At the 5% level of significance, Hylleberg et al. (1990) stated that the critical values for 100 and 48 observations are -2.94 and -3.08, respectively. For the 1% level of significance, the critical values for 100 and 48 observations are -3.60 and -3.80, respectively.

[c] At the 5% level of significance, Hylleberg et al. (1990) stated that the critical values for 100 and 48 observations are 6.55 and 6.60, respectively. For the 1% level of significance, the critical values for 100 and 48 observations are 8.79 and 9.27, respectively.

* Statistically significant at the 5% level.

The estimates also suggest that the retail price for tiger prawn has unit roots at all frequencies. However, the same statement cannot be made for the wholesale price, where there is some evidence that it might be stationary at a semi-annual frequency. This is found for the case where the optimal lag length is determined using the adjusted R^2. While contradictory results are found in the case where the lag length is determined using the formula of Schwert (1989), such results can be ignored because the estimating equation contains a shorter lag length.

The existence of zero frequency and seasonal unit roots for the retail and wholesale prices of milkfish and tilapia suggests the need for further tests for cointegration. Given the possibility that the wholesale price of tiger prawn is stationary at semi-annual frequency, the retail and wholesale prices of this commodity were no longer tested for cointegration. This move is consistent with the general behavior of prices for tiger prawn in the country. Since this commodity is largely produced for processing and export, its wholesale price is generally observed to be stable, especially along the producer-middleman supply chain, hence the absence of zero and seasonal unit roots in this price series. Furthermore, due to the smallness of domestic demand relative to total production of tiger prawn, it is unlikely that its retail price can mimic the stable behavior of its wholesale price.

Table 2 shows the findings of a test for cointegration between the retail and wholesale prices of milkfish. The results are not too promising. In the test at zero frequency, the findings generally indicate that the variables are not cointegrated. There is only one instance which suggests cointegration – i.e., where the estimating equation excludes the time trend and intercept term. While these findings warrant further investigation on whether or not a time trend and intercept term should be included, the results from the succeeding tests makes such an effort moot and academic. The reason is that the test statistics do not support the existence of cointegrating relationships at semi-annual and annual frequencies.

The non-synchronized behavior of retail and wholesale prices for milkfish can be traced to the way the market for this fish species behaves. Generally, milkfish is grown in modular ponds where seeding and harvesting can be staged to even out the annual supply in the market, thus preventing large seasonal supply gaps. Similarly, since milkfish is acceptable to the consumers in fresh chilled form, supply can be managed and/or contained in refrigerated storage to prevent unanticipated price fluctuations due to oversupply and/or shortage in the market. As a result, the wholesale price can be expected to be more stable than the retail price, since the latter is usually affected by the prices of other fish substitutes that are in season, i.e., different types of wild-caught marine fish.

Table 3 shows the results from a test for cointegration between the retail and wholesale prices of tilapia. In all the tests, the inclination is towards relying on the results from which the adjusted R^2 is used to specify the lag structure of the model. This is due to the longer lags with this method relative to Schwert's formula.

Table 2. Tests of co-integration for milkfish wholesale and retail prices, Philippines, 1990-2007

Deterministic Components	Approach for Determining Lag Length		Critical Value	
	Schwert	Adjusted R^2	5%	1%
Zero frequency (t-type test on $\phi_1 = 0$)				
Intercept & trend	-2.36	-0.32	-3.48[a]	-4.10[a]
Intercept	-2.09	-1.88	-2.90[a]	-3.53[a]
No intercept & trend	-1.99*	-1.38	-1.95[a]	-2.60[a]
Memo: Lag length	11	20		
Semi-annual frequency (t-type test on $\phi_2 = 0$)				
Intercept & seasonal dummies	2.65	0.52	-3.48[b]	-4.10[b]
Intercept only	2.71	0.80	-2.90[a]	-3.53[a]
No intercept & no seasonal dummies	2.69*	0.79	-1.95[a]	-2.60[a]
Memo: Lag length	11	18		
Annual frequency (F type test on $\phi_3 \frown \phi_4 = 0$)				
Intercept & seasonal dummies	4.57	6.70	10.65 (10.12)[c]	14.11 (13.26)[c]
Intercept only	2.36	7.11	7.35 (7.10)[c]	10.51 (10.15)[c]
No intercept and seasonal dummies	2.37	6.97	7.46 (7.21)[c]	10.80 (10.24)[c]
Memo: Lag length	11	20		

[a] The critical values were taken from McKinnon (1991).
[b] The critical values were taken from McKinnon (1991). The formula for critical values in McKinnon does not allow for seasonal dummies. Hence, this is the critical value for an equation that has a constant and time trend.
[c] The critical values were taken from Engle et al. (1993). The first value is for 48 observations while the second value (in parenthesis) is for 100 observations.
* Statistically significant at the 5% level.

Table 3. Tests of co-integration for tilapia prices wholesale and retail prices, Philippines, 1990-2007

Deterministic Component	Approach for Determining Lag Length		Critical Value	
	Schwert	Adjusted R^2	5%	1%
Zero frequency (t-type test on $\phi_1 = 0$)				
Intercept & trend	-4.03*	-4.19*	-3.48[a]	-4.10[a]
Intercept	-2.76	-2.28	-2.90[a]	-3.53[a]
No intercept & trend	-2.46*	-1.99*	-1.95[a]	-2.60[a]
Memo: Lag length	11	13		
Semi-annual frequency (t-type test on $\phi_2 = 0$)				
Intercept & seasonal dummies	2.82	2.39	-3.48[b]	-4.10[b]
Intercept only	3.10*	2.55	-2.90[a]	-3.53[a]
No intercept & no seasonal dummies	3.01*	2.76*	-1.95[a]	-2.60[a]
Memo: Lag length	11	16		
Annual frequency (F type test on $\phi_3 \frown \phi_4 = 0$)				
Intercept & seasonal dummies	7.17	12.46*	10.65 (10.12)[c]	14.11 (13.26)[c]
Intercept only	4.14	14.14**	7.35 (7.10)[c]	10.51 (10.15)[c]
No intercept and seasonal dummies	4.35	14.16**	7.46 (7.21)[c]	10.80 (10.24)[c]
Memo: Lag length	11	18		

[a] The critical values were taken from McKinnon (1991).
[b] The critical values were taken from McKinnon (1991). The formula for critical values in McKinnon does not allow for seasonal dummies. Hence, this is the critical value for an equation that has a constant and time trend.
[c] The critical values were taken from Engle et al. (1993). The first value is for 48 observations while the second value (in parenthesis) is for 100 observations.
* Statistically significant at the 5% level.
** Statistically significant at the 1% level.

The results are mixed in the test for cointegration at zero frequency. The inclusion of an intercept term but exclusion of the time trend suggests the absence of a cointegrating relationship. This is contrary to findings where (a) an intercept and time trend are included, and (b) the intercept and time trend are both excluded. However, the residual sums of squares from the models are not too different from each other[5]. Hence, the model that excludes both the intercept and the time trend can fairly represent the other formulations. This leads to the conclusion that the retail and wholesale prices for tilapia are cointegrated at zero frequency.

The findings for seasonal cointegration are clearer. Based on equations which were specified using the highest adjusted R^2, Table 3 indicates that the variables are cointegrated at annual frequency. However, the estimation results also suggest the absence of a cointegrating relationship at semi-annual frequency, except when the intercept and seasonal dummies were excluded.

The seasonal cointegration that was found in the case of tilapia prices exemplifies the unique harvesting management of grow-out operators for this farmed species. In particular, producers often practice partial harvesting, which caters to the demand of the middlemen or consumers at hand. Specifically, both the small- and large-sized tilapia are desirable in the market, catering to the poor and more affluent consumers, respectively. Additionally, the latter consumers prefer live tilapia and are willing to pay price premium for freshness. These distinct market characteristics imply that the retail price plays an important role in the price formation for tilapia. In turn, this suggests that the wholesale price generally follows the movement of the retail price as was suggested by the Granger causality study of Garcia et al. (2015). Due to these factors, it is easy to comprehend why the retail and wholesale prices of tilapia move in cointegrated fashion, both at levels and seasonal frequencies.

Concluding Remarks

This paper examined the implications of accounting for seasonality in modeling the relationship between wholesale and retail prices of popular farmed fish species in the Philippines, i.e., milkfish, tilapia, and tiger prawn. In particular, it tested integration and cointegration in these prices at different frequencies - zero, semi-annual, and annual.

As a whole, the findings suggest that seasonality plays an important role in explaining movements of the prices of farmed fish. With the exception of the whole-sale price of tiger prawn, all of the price series have unit roots at all frequencies. However, none of the pairs of prices were found to be cointegrated at all frequencies. Nevertheless, the retail and wholesale prices of tilapia were found to be cointegrated at zero and annual frequencies. These findings suggest that simply building models in the levels form of fish prices using quarterly data could lead to spurious regressions. Furthermore, results of the study implied that basing production and harvest decisions on market price signals for farmed fish species that showed no cointegrating price relationship can be misleading. However, by accounting for these features of the data, stakeholders and researchers may be able to identify more meaningful relationships between prices, and consequently among prices and other relevant market variables. Such relationships and models may then provide more accurate inputs for market planning, policy analysis, and stakeholder's action.

[5] The residual sum of squares from the model that excludes both the time trend and intercept term is 374. Finally, the model that includes both deterministic components has a residual sum of squares of 364. There are a total of 68 observations in the estimating equation.

The objectives of this study only represent initial steps in the analysis of the role of seasonality in farmed fish prices. Clearly, more work needs to be done in order to obtain a better understanding of price movements in the sector. One area that needs to be explored further is the role of policy; in particular, those which are believed to have an influence on fish prices and/or the relationship between retail and wholesale prices. Another would be an application of these techniques to prices of wild-caught marine fish where supply is generally affected by the moon cycle, weather disturbances and fishing effort of fishermen. An application of the analysis to monthly data might also be interesting at least from the perspective of validating the findings of Garcia and Salayo (2009) and Garcia et al. (2015).

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The Impacts of Male and Female Education on the Economic Growth of Philippine Provinces, 1991–2012

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Abstract

This study evaluated the level and distribution of educational attainments among male and female household heads in the Philippines. Estimates of average years of schooling (AYS) and education Gini coefficients show that the level and distribution of educational attainments for both subgroups were improving from 1991 to 2012. The study particularly found that females are becoming more educated than their counterparts at the turn of the millennium. Education Gini decomposition analysis then identified the within-males educational disparity as the main contributor (about 59–73% contribution) to the country's overall education inequality.

Sex-disaggregated effects of education on the economic growth of Philippine provinces were also explored using panel and instrumental-variable (IV) regression analyses. Results suggest that improving both male and female schooling is growth-enhancing, while it is growth-retarding for provinces with widening male-female AYSgap. And since the AYSgap has reversed in 2000, it is seen that the country would further reap economic benefits from a more-educated female workforce.

Keywords: *economic growth, education Gini coefficient, inequality, sex subgroups*

Introduction

Economists always regard education as one of the primary components, if not the most important subset, of human capital. Through that linkage, Thomas, Wang, and Fan (2001) argued that the level and distribution of education is growth-enhancing due to its spill-over effects on individual ability and labor productivity. This positive relation between education and growth is therefore confirmed in a number of literature such as Barro (1991), Temple (2000), and Krueger and Lindahl (2001). The literature also attributes the impact of education to other pressing socio-economic issues such as poverty, income inequality, and health (Ibourk and Amaghouss 2012 and Tomul 2009).

Given this wide-ranging influence of education to society, a particular branch of the education-growth literature considers the sex-disaggregated effects of education; that is, the impact of male and female educations on economic growth at cross-country and intra-country levels. For instance, Knowles, Lorgelly, and Owen (2002) found that female education has a significant positive effect on economic growth using cross-country data, while the coefficient for male education suggests a negative impact albeit being statistically insignificant. Knowles, Lorgelly, and Owen (2002) even argued that female education is far more important than that of males due to its direct and indirect effects on economic growth. The improvement in the quality of human capital is the direct effect of having a more educated female labor force on the economy's performance. Conversely, its indirect effects would be reduced fertility rate—assuming that educated women would find household production as less alluring—lower population growth, child mortality reduction, and an array of positive externalities on the next generation's human capital.

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Knowles, Lorgelly, and Owen (2002) also found a negative relationship between economic growth and the sex educational gap (the ratio between male and female average years of schooling). A similar finding was noted by Klasen and Lamanna (2009). However, extending the analysis to sex inequality in employment and its effects on economic growth, they also claimed that education equality may not translate to an equitable distribution of occupation, especially if a particular sex subgroup is experiencing discrimination or is facing considerable barriers to employment.

One can therefore note a lack of consensus at the cross-country level on the effects of male and female education on economic growth, as shown by the conflicting results of Barro and Lee (1993), Casseli, Esquivel, and Lefort (1996), and Knowles, Lorgelly, and Owen (2002). Barro and Lee (1993) found that both male and female education positively affect the growth of real GDP per capita. In fact, male education was reported to have a larger direct impact. Although they also hinted on the indirect effects of female education, their finding largely differs from Knowles, Lorgelly, and Owen (2002) who argued that only female schooling is growth-enhancing. Casseli, Esquivel, and Lefort (1996) also confirmed that female education positively affects economic growth, but in contrast to Knowles, Lorgelly, and Owen (2002), they observed that male schooling poses a significant negative impact. Unfortunately these sex-disaggregated effects of education on economic growth have not been explored under the Philippine setting.

This study therefore aims to determine the relationship between provincial economic growth and the average years of schooling by male and female subgroups in the Philippines. Specifically, it attempts to (1) examine the trend of the level and dispersion of male-female educational attainments by estimating the average years of schooling (AYS) and education Gini coefficients over the period 1991 to 2012; (2) determine which among the within-group and between-group inequalities contributed most to the overall education disparity of the Philippines in the past two decades; and, (3) evaluate the existence and significance of the impacts of education variables as well as the male-female AYS gap on the economic growth of Philippine provinces.

The paper is organized as follows: Section 2 elaborates on the framework which modifies the model of Barro and Lee (2010); Section 3 specifies the research methodology; Section 4 discusses the results of descriptive and empirical analyses; and lastly, Section 5 concludes.

Framework

In order to determine the relationship between the average educational attainment of each sex subgroup and economic growth, the simple model used by Barro and Lee (2010)[3] was adopted and modified. The model starts by assuming a Cobb-Douglas production function

$$Y_{it} = AK^{\alpha} H_{it}^{1-\alpha} \qquad (1)$$

where Y is the output/income of a particular province i at time t, A represents total factor productivity, K is the provincial stock of human capital, and H is the human capital stock. Barro and Lee (2010) further assumed that $H_{it} = h_{it}L_{it}$, in which h denotes the level of human capital per worker while L is the size of the worker population. Incorporating such specification to Eq. (1) yields

$$Y_{it} = AK_{it}^{\alpha}(hL)^{1-\alpha} \qquad (2a)$$

[3] Most of the previous studies actually adopted the augmented Solow growth model developed by Mankiw, Romer, and Weil (MRW 1992), as it enables them to conduct a more rigorous empirical analysis on the subject, particularly in estimating the marginal returns to schooling. However, this study is only interested in determining the direction of the relationship between economic growth and the sex subgroups' education variables. It deems that such complications will better serve their purpose under future researches.

Dividing Eq. (2a) by L and then expressing in natural log, we have

$$\ln y_{it} = \ln A + \alpha \ln k_{it} + (1-\alpha) \ln h_{it} \qquad (2b)$$

where y is the output/income per worker in province i at time t and k is the capital stock per worker.

Human capital per worker h is then thought to have the following relationship with the average years of schooling $\bar{E}_{it::}$

$$h = e^{\phi(\bar{E}_{it})} \qquad (4)$$

wherein Barro and Lee (2010) argued that $\phi(\bar{E}_{it:}) = \theta\bar{E}_{it;}$ it represents the efficiency of a unit of labor—they considered the measure as linear. Hence, Eq. (2b) can be amended as

$$\ln y_{it} = \ln A + \alpha \ln k_{it} + (1-\alpha)\theta\bar{E}_{it}. \qquad (5a)$$

Note further that we can include the average years of schooling of each subgroup in Eq. (5) by indicating that $\theta\bar{E}_{it}$ is an inner product, i.e.,

$$\ln y_{it} = \ln A + \alpha \ln k_{it} + (1-\alpha)\left(\theta_f \bar{E}_{f,it} + \theta_m \bar{E}_{m,it}\right). \qquad (5b)$$

Eq. (5b) therefore implies that the direction of the impact of male and female educational expansions on economic growth rests on the sign of their θs which are essentially the marginal returns to education and are thus expected to be positive. Such implication, however, is only true for production with constant returns to scale.

Methodology

The paper sourced its basic data from the 1991–2012 Family Income and Expenditure Survey (FIES) of the Philippine Statistical Authority (PSA), which were furnished in three-year intervals. This yields a time span of roughly 20 years—which is sufficient enough for the education variables to vary significantly—with about eight data points per province.

Prior to the estimation of pertinent education and economic variables, the paper first addressed the inclusion of new provinces in latter FIES datasets. Such provinces were identified as Biliran and Guimaras (both created in 1992), and *Compostela Valley* and *Zamboanga Sibugay* (created in 1998 and 2001, respectively). The former Kalinga-Apayao province was also partitioned into two new provinces—being *Kalinga* and *Apayao*—in 1995. Moreover, *Isabela City*, *Basilan* and *Cotabato City* also became distinct administrative structures due to issues pertaining to regional administrative divisions. The paper therefore based its estimations on the 1991 provincial structure. *Biliran* and *Guimaras*, for instance, were treated as if they are still components of Leyte and Iloilo provinces, respectively.

Deflating Income and Savings per Capita

The per capita income (savings) was calculated as the sum of household incomes (savings) for a certain province divided by its sample size. For accuracy, the study accounted for the FIES' adjustment factor *rfadj* or *rfact* in its calculations.

The estimates of household incomes and other monetary figures in FIES are still in nominal terms; and so to obtain their real values, one must remove the effect of inflation by dividing those figures with a deflator. The usual deflator is the ratio of a particular year's Consume Price Index (CPI) and the CPI of the base year being 1991; in essence,

$$\pi_t = \frac{CPI_t}{CPI_{1991}}$$

Table 1 below therefore presents the values of deflator π which were computed from the 1991–2012 Philippine CPI data of The World Bank (2016).

Table 1. Estimates of deflator π_t

t	1991	1994	1997	2000	2003	2006	2009	2012
π_t	1.000	1.280	1.552	1.867	2.067	2.434	2.826	3.167

Note: Basic CPI data were sourced from The World Bank (2016).
Source: Authors' calculation

Estimation of Average Years of Schooling and Education Gini Coefficient

The formula used in the computation of the Average Years of Schooling (AYS) is as follows:

$$\bar{E} = \sum_{i=1}^{n} p_i e_i \qquad (6)$$

where p is the proportion of household heads that attained a certain schooling level i, and e is the number of years of schooling ascribed to such schooling level. The categorization and valuation of schooling attainments are largely based on Mesa (2007:40-41) and Zamora and Dorado (2015). Since Mesa's (2007) categories are designed for the census data, the study thus modified them to fit with the categorization used in the FIES datasets. Table 2 presents the said modification.

Table 2. Categories and years of schooling

Educational Attainment Level	Description[a]	Years of Schooling (e_i)[b]
No Schooling	Those that were reported under the category of "No Grade Completed", and those who attained only preschool education	0
Partial Primary	Elementary undergraduate, Grades 1–4	3
Complete Primary	Elementary graduate, Grades 5–6	6
Partial Secondary	High school undergraduate, 1st–3rd Year High school	8
Complete Secondary	High school graduate	10
Partial Tertiary	Those classified under college undergraduate, 1st–2nd Year Post Secondary, 1st–3rd Year College, and "Other Programs"	12
Complete Tertiary	College graduate, 4th Year College; those under "Programs", "BS/BA", "Post Grad..." categories; Post Baccalaureate	14

[a] The descriptions reflect the levels of highest educational attainment in the 1991, 2000, and 2012 Family Income and Expenditure Survey.

[b] Values of years of schooling were calculated using the formulas specified by Thomas, Wang, and Fan (2001: 10).
Source: Mesa (2007: 40–41) for e_i values.

It must be noted that the valuation of years of schooling may exhibit biases, since almost all of the FIES datasets reported only the schooling categories and not the actual educational attainment of the respondents. For instance, those who finished 3rd year high school (or have 9 years of schooling) were placed under the category of "High School Undergraduate" with a value of only 8 years. The downward bias is even more evident for those who attained graduate education (over 14 years of schooling) as they were only given a schooling value of 14 years flat. In fact, it is only in FIES 2012 where the actual educational attainment level of a respondent was reported. Unfortunately, those respondents are just the household heads themselves whose education may not even be the average educational attainment of the family. Thus, as much as the study wanted to make the estimates more precise and representative, it is constrained by the less-detailed categorization and the household-head centrism of the pre-2012 datasets.

On the other hand, the calculation of the education Gini coefficient *G* used the following formula from Thomas, Wang, and Fan (2001):

$$G = \left(\frac{1}{\bar{E}}\right)\sum_{i=2}^{n}\sum_{j=1}^{i-1} p_i \left| e_i - e_j \right| p_j \tag{7}$$

where the variables are already defined above. The study then employed a decomposition analysis of education inequality by sex subgroups (i.e., male and female household heads). This decomposition determined the contribution of within-subgroup inequality—that is, the educational distribution experienced by males or females—and the between-group inequality which represented the Sex Gap in terms of the distribution of educational attainments. To do so, the study used Mesa's (2007) decomposition method which is a modified version of Zhang and Li's (2002):

$$100 = \left(\frac{p_1^2(\bar{E}_1/\bar{E})G_1}{G}\cdot 100\right) + \left(\frac{p_2^2(\bar{E}_2/\bar{E})G_2}{G}\cdot 100\right) + \left(\frac{G_B}{G}\cdot 100\right) \tag{8}$$

where G_i and $\bar{E}_i$ represent the education Gini coefficient and AYS of a particular subgroupi (i = 1,2), respectively, and G_B is the between-group inequality or the Sex Gap.

Regression Analysis

The growth-AYS dynamic panel regression model follows from Eq. (5b) and is expressed as:

$$\ln y_{it} = \beta_0 + \beta_1 \ln y_{t-5} + \beta_2 \ln s_{it} + \beta_3 \ln s_{it}^2 + \beta_4 \bar{E}_{m,it} + \beta_5 \bar{E}_{f,it} + \omega_i + u_i \tag{9}$$

in which ω_i and u_i are the unobserved entity fixed-effect and the error term respectively. The variable $\ln y_{t-5}$ is the 5-period (15-year) lag of income, which is motivated by the treatment of Teulings and van Rens (2008) in their dynamic panel regressions.

They argued that the introduction of the lag accounts for the fact that the "first cohorts" of skilled workers, whose demand was induced by the previous economic growth, will take at least ten (10) years to become the new labor market entrants. On a different note, it must be emphasized that $\ln k$ was represented by savings per capita ($\ln s$), for the data on gross capital formation is available up to the regional level only. The quadratic expression for lns, moreover, is the only specification that passed the Ramsey RESET test. When it comes to the AYS (E_m, E_f), some regressions used interaction dummies that allow the effect of these education variables to vary with respect to major island group. For instance, the variable E_m was multiplied to the dummy for the major island group that a certain province belongs to (say, D_{Luzon}).

Since the literature also investigated the relationship between SexAYSGap and economic growth (proxied here as the natural log of income per capita), the paper therefore tried to estimate:

$$\ln y_{it} = \gamma_0 + \gamma_1 \ln y_{t-5} + \gamma_2 \ln s_{it} + \gamma_3 \ln s_{it}^2 + \gamma_4 \left(\bar{E}_m - \bar{E}_f\right)_{it} + \phi_i + v_i \qquad (10)$$

where $\bar{E}_m$ - $\bar{E}_f$ pertains to the Sex AYS Gap in a particular province and is the difference of male AYS and female AYS, while ϕ_i and v_i are the unobserved entity fixed-effect and the error term for this regression, respectively. Time dummies were also included to control for time-specific effects and/or aggregate trends of the covariates.

The paper also estimated Eqs. (9) and (10) using random-effects (RE) model. The Hausman test and Sargan-Hansen test, however, consistently rejected RE model in favor of FE. Instrumental (IV) regressions using Generalized Method of Moments (GMM) estimator were also employed to address the endogeneity bias between economic growth and education as well as potential heteroscedascity problem. As motivated by Barro and Lee (2010), the study used the three-period (9-year)lags of male and female AYS as the over identifying instruments for each education variables. For growth-AYSgap regressions, AYS gap was instrumented by its three-period lag.

Results and Discussions

Trends on Male-Female Educational Levels and Distributions

Figure 1 presents the trend of the Male-Female AYS at the national level over the period 1991 to 2012. Before the start of the millennium, it was shown that male household heads have slightly higher average educational attainment than the females; the former's AYS ranges from 7.0 to 7.4 years during the period 1991 to 1997, while comparable figures for the females are about 6.7 to 7.2 years. Subsequent years then exhibited remarkable educational expansions[4], which enabled the female subgroup to surpass their counterparts at the turn of the millennium. The Female AYS now stands at about 8.6 years in 2012 compared to the Male AYS which is just about 8.2 years. This obviously means that on average, the female labor force has become and is continually becoming more educated over time vis-à-vis the male labor force. Such improvement is then viewed to be beneficial for the economy. For instance, if there are no substantial barriers to female employment, a more educated female labor force would mean an increase in the country's overall labor productivity and thereby economic growth.

[4] "Educational expansion" is defined here as the increase in the average educational attainment of the subgroup under study

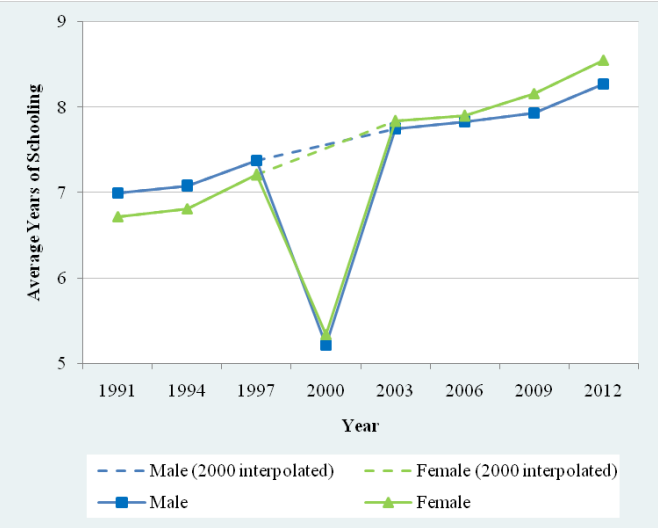

Figure 1. Evolution of male-female AYS at national level, 1991–2012

However, Figure 1 also shows a peculiar contraction of average educational attainments for both subgroups in 2000. Both subgroups, in fact, registered an AYS of only about 5 years for that period. This study unfortunately found that the 2000 FIES sampled a sizeable proportion of less-educated household heads, as about half of them are elementary undergraduates. This finding not only adversely affected the 2000 AYS estimates, but also those of the education Gini coefficient of each subgroup. Figure 2 below supports such assertion and infers that the educational distribution experienced by both sexes largely worsened at the beginning of the century. The study then replaced actual 2000 AYS estimates by their interpolated values—i.e., the average of each sub-group's actual 1997 and 2003 AYS. It subsequently observed that the AYS gap between males and females further narrowed down in 2000, such that male AYS (7.6 years) is now larger than the female AYS (7.5 years) by a meager 0.1 year. This finding nevertheless adheres to the argument of Morrison and Murtin (2010) that the education Gini coefficient is very sensitive to the proportion of population with low schooling attainments. Such an assertion is rather encouraging, according to Ibourk and Amaghouss (2012, 2013), for a policy addressing the literacy of the populace would surely improve the distribution of education of that society.

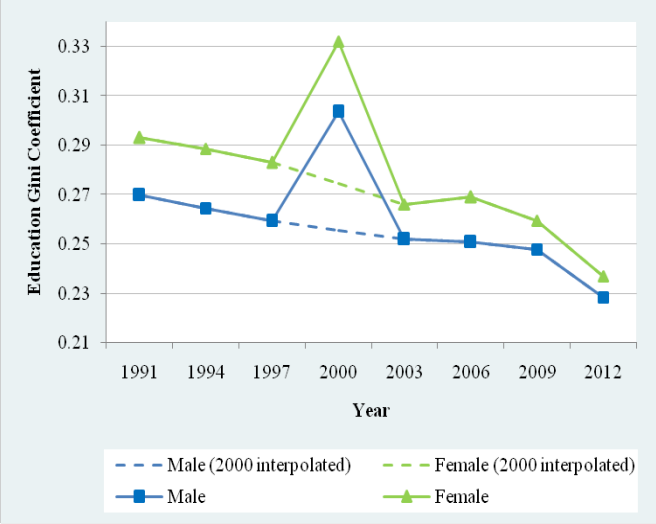

Figure 2. Evolution of the male-female education Gini coefficients at national level, 1991–2012

One can further infer from Figure 2 that, in contrast to the notable educational expansion of female household heads, education inequality among females remains worse than males for all periods under study. This finding is contrary to Mesa (2007) who noted that females experienced lesser educational disparity (0.234) among themselves in 2000 than from two decades earlier; adding that such distribution was more equitable than that of males (0.237). It must be emphasized, however, that Mesa (2007) used the 1980 and 2000 Census of Housing and Population instead of the FIES datasets. One reason for this difference in results could then be attributed to the fact that the female population proportion in FIES ranges only from about 15% to 20%, which clearly does not reflect the growing female population seen in census data. The population proportions, in turn, act as weights in the calculation of the Gini coefficient. Hence, the measure might likewise be sensitive to the size of the subgroup[5].

Decomposition Analysis

Another result which contrasted Mesa (2007) is the finding from our decomposition analysis (shown in Figure 3 below) that the within-males inequality contributed as much as 67% to the country's overall education disparity in2000. Her estimates using the census data are only about 25% and are at par with the within-females inequality contribution rate. Thus, she named the between-group inequality—i.e., the Sex Gap—as the main contributor. Meanwhile, this paper consistently points to the within-males inequality as the main contributor (at about 59% to 73% contribution rate), though it is declining over the decades. This divergence of this study's results from that of Mesa's can be attributed again to the sizeable proportion of males surveyed in FIES.

Figure 3 also highlights the rising trend of between-group inequality. This indicates that the education disparity between males and females is now becoming a significant concern. The Sex Gap stood at 24.77% in 1991 and it rose steadily to 35.91% in 2012, with the notable exception again of the year 2000 data. Such is an 11.14 percentage-point increase in a span of two decades. To grasp the importance of trimming down this Sex Gap, one could think of its contribution rate as the reduction in the country's educational inequality upon closing in the disparity in schooling attainments between males and females. Thus, that could have been about a 36 percentage-point reduction in 2012.

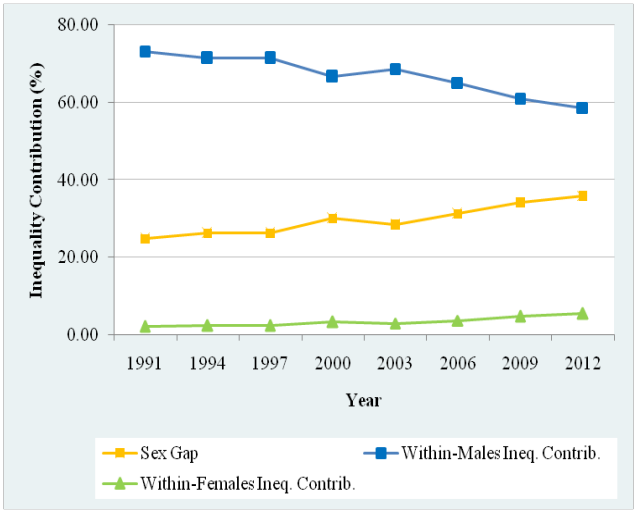

Figure3. Trend of within-group and between-group inequality contributions by sex subgroups at national level, 1991–2012

[5] This sensitivity of the education Gini coefficient to the subgroup size was exhibited by the Tawi-Tawi province in Zamora and Dorado (2015). It was found that the improvement in the educational distribution of Tawi-Tawi's urban areas was due to the decrease in that subgroup's population count—that its urban workforce may been experiencing a labor mobility.

The above descriptive results thus show that the level and distribution of the educational attainments of male and female labor force are improving over the decades: an observation that is consistent with the literature. Linking this to human capital acquisition, these improvements in the level and dispersion of education are expected to enhance the productivity of labor and more so yield higher growth levels. The question then pertaining to the impacts of male and female educational expansion and of the AYS gap on provincial economic growth shall be dealt by the succeeding subsection on regression analysis.

Regression Results

Since the previous discussion unraveled the potential downward bias of 2000 AYS estimates, the study evaluated the growth-AYS panel regressions using the full sample and the sample that excludes the data points for year 2000. All regressions—except the IV regression for the sample without the year 2000 data (henceforth dubbed as the "restricted sample")—employ time-fixed effects to control for the aggregate trends of the covariates. Table 3 below nonetheless provides the descriptive statistics of the variables used in the regressions.

Table 3. Descriptive statistics of covariates

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
y	Provincial income per capita	616	60635.110	25653.960	20160.290	222486.300
s	Provincial savings per capita	616	16386.350	18328.000	-867.026	164739.600
ln$y$	Natural log of provincial per capita	616	10.944	0.354	9.911	12.313
ln$s$	Natural log of provincial savings per capita	614	9.355	0.779	5.819	12.012
lns^2	Squared of ln s	614	88.130	14.948	33.856	144.291
E_m	Male AYS	616	6.957	1.436	2.628	10.675
E_f	Female AYS	615	6.616	1.662	1.364	14.000
E_m-E_f	Sex AYS Gap	615	0.335	0.912	-3.467	4.772

Source: Authors' calculation using 1991–2012 FIES data

Column (1) of Table 4 summarizes the results of the growth-AYS dynamic panel regressions using the full sample. It was shown that the level and squared of log savings per capita (the proxy for physical capital per capita) are significant, which suggests that capital accumulation has a U-shaped trend with the provincial economic growth[6]. This implies that as the capital stock of a province initially increases, the province's economic performance initially worsens until a certain turning point in which further capital accumulation leads now to higher growth levels. Ibourk and Amaghouss (2013) took the negative effect of physical capital stock as evidence that it is still below the long run equilibrium. The study, however, relegates the explanation of such growth-capital trend to future research. One explanation from economic theory that such studies could look into is the possibility of labor-capital substitutability. Moving on to the education variables, it was found that both male and female AYS have a significant positive effect on provincial economic growth similar to the findings of Knowles, Lorgelly, and Owen (2002) and Klasen and Lamanna (2009). Their estimated coefficients infer that, ceteris *paribus*, a one-year increase in male and female AYS would lead to about 5% and 4% increase in provincial economic growth, respectively.

[6] This U-shaped trend between provincial economic growth and capital stock is always statistically significant in all regressions considered.

Table 4. Panel and IV regression results of ln *y* and male-female AYS

ln *y*	(1) Panel	(2) Panel	(3) Panel	(4) IV	(5) IV (T=2000 data excluded)
ln y_{t-5}	-0.00578	-0.00819	0.00114	0.02640	0.03389
	(0.10)	(0.14)	(0.02)	(0.38)	(0.41)
ln *s*	-0.89732	-0.88735	-0.77385	-1.15296	-1.26000
	(5.79)***	(5.99)***	(5.14)***	(6.48)***	(5.82)***
ln s^2	0.06037	0.06032	0.05397	0.07252	0.07810
	(6.61)***	(6.87)***	(6.13)***	(7.03)***	(6.59)***
E_m	0.05254			0.14267	0.16231
	(2.66)***			(1.38)	(1.97)**
E_f	0.03980			0.14049	0.17341
	(2.71)***			(3.02)***	(2.70)***
E_m•D_{Luzon}		0.01500	0.00873		
		(0.61)	(0.34)		
E_f•D_{Luzon}		0.04926	0.04794		
		(1.86)*	(1.76)*		
E_m•$D_{Mindanao}$		0.05739			
		(1.58)			
E_f•$D_{Mindanao}$		0.02776			
		(1.68)*			
E_m•$D_{Visavas}$			0.04857		
			(1.98)*		
E_f•$D_{Visayas}$			0.02185		
			(1.59)		
Constant	13.50620	13.69552	13.20050	12.71787	12.72762
	(16.13)***	(16.33)***	(15.70)***	(11.21)***	(10.80)***
F statistics	37.27	27.60	32.26	.	.
Prob > F	0.0000	0.0000	0.0000	.	.
Wald X^2	.	.	.	22048.10	21346.90
Prob > X^2				0.0000	0.0000
R^2	0.6772	0.6602	0.6464	0.9381	0.9126
Adjusted R^2	0.6670	0.6463	0.6318	0.9027	0.8623
N	229	229	229	229	228
RESET test	passed	passed	passed	na	na
Hausman	FE	FE	FE	.	.
Sargan-Hansen*FE*		FE	FE	.	.
Year Dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Province Dummies				yes	yes

Note: * p<0.1; ** p<0.05; *** p<0.01. Numbers in parentheses are t-statistics for columns (1)-(3) and z-statistics for columns (4)-(5).

Source: Authors' calculation

Columns (2) and (3) then reintroduce the education variables as interaction terms that would differentiate their impacts according to major island groups (i.e., Luzon, Visayas, and Mindanao). Only the female AYS of Luzon and Mindanao provinces are found to be significant at 10% under the dynamic panel regression in column (2). Both covariates are growth-enhancing such that a one-year increase in the AYS of their female household heads could raise the economic performance of Luzon provinces by 6% and Mindanao provinces by 3%. For dynamic panel regression in column (3), only the male AYS of Visayan provinces is significant at 10% and likewise has a positive effect on their economic growth—about 5% for every one-year increase. It must be noted that the marginal effects of these education variables are just short-run effects since the lagged dependent variable is statistically insignificant. Thus, no rate of convergence can be considered in the calculation of the long-run effects.

Although the signs of the education variables above adhere to those specified in the framework, the study surmises that the panel regressions might still have a simultaneity bias because of the feedback between economic growth and education. Thus, the study also employed an IV regression using GMM estimator to address the said bias and to control for heteroscedasticity. The results using full and restricted samples are then presented in columns (4) and (5) of Table 4, respectively. Both education variables were again found to be growth-enhancing, but only female education is consistently significant (at α=1%) in both regressions. Male education lost its statistical significance when the full sample was used. The study would also like to emphasize that the IV estimates were larger than those derived using the dynamic panel model. Marginal effects showed that a one-year increase in the average educational attainment of male (female) household heads could improve provincial economic growth by 14%-17%. Specifically, it was observed that the growth-enhancing effect of male education is larger than that of females for the dynamic panel regression; but after accounting for the endogeneity of economic growth and education, it is now female education that has a slightly larger impact on provincial economic growth. This finding is rather supportive of those advanced by Knowles, Lorgelly, and Owen (2002) and Klasen and Lamanna (2009), who argued that the female education has wider indirect effects on growth as well as positive externalities than male education. In Klasen and Lamanna (2009), female education is said to influence the demography through reduced population growth and also the investment levels through higher savings. These altogether translate as positive indirect effects of female education on economic growth.

Finally, Table 5 presents the results of growth-AYS gap regressions under the full sample [columns (1)–(2)] and restricted sample [columns (3)-(4)]. All regressions yet again yielded highly significant coefficients for the level and squared of log savings per capita, thereby stressing the U-shaped relationship between economic growth and capital stock for the period 1991 to 2012. The Sex AYS Gap is found to be growth-retarding under the full sample and is significant at 10% and 1% in dynamic panel regression and IV regression, respectively. For the restricted sample, the Sex AYS gap still has a negative relationship with provincial economic growth; however, such relationship is significant only at 10% when the lagged dependent variable was dropped. Nonetheless, this unambiguous negative effect is in line with the findings of Knowles, Lorgelly, and Owen (2002) that used a parameterized version of the MRW model. Holding male education constant, this implies that an increase in female educational attainments would result in lower male-female AYS gaps and therefore foster the economic growth of a particular province.

Table 5. Panel and IV regression results of ln y and male-female AYS gap

ln *y*	Full Sample		T=2000 data excluded	
	(1) Panel	(2) IV	(3) IV	(3) IV, excluding ln y_{t-5}
ln y_{t-5}	-0.01207	0.01242	0.00853	
	(0.20)	(0.22)	(0.14)	
ln *s*	-0.84228	-1.01774	-1.00365	-1.00999
	(6.06)***	(6.77)***	(4.67)***	(5.90)***
ln s^2	0.05818	0.06808	0.06700	0.06836
	(6.96)***	(7.75)***	(5.50)***	(6.83)***
E_m-E_f	-0.02943	-0.12330	-0.11079	-0.11311
	(1.90)*	(3.50)***	(1.32)	(1.89)*
Constant	13.94356	14.39018	14.38351	14.45273
	(15.23)***	(16.64)***	(14.75)***	(18.89)***
F statistics	46.46	.	.	
Prob > F	0.0000		.	
Wald X^2	.	30106.40	53391.88	17428.62
Prob > X^2		0.0000	0.0000	0.0000
R^2	0.6285	0.9442	0.9502	0.9411
Adjusted R^2	0.6184	0.9128	0.9221	0.9193
N	229	229	228	305
RESET test	*passed*	na	na	na
Hausman test	*FE*	.	.	.
Sargan-Hansen test	*FE*	.	.	.
Year Dummies	*yes*	*yes*	*yes*	*yes*
Province Dummies		*yes*	*yes*	*yes*

Note: * p<0.1; ** p<0.05; *** p<0.01. Numbers in parentheses are t-statistics for column (1) and z-statistics for columns (2)-(3).

Source: Authors' calculation

Klasen and Lamanna (2008) also obtained the same direction of the impact of the educational gap on economic growth. To enrich their study's discussion, they also examined the impact of sex inequality in employment (proxied by the ratio of female-male labor force participation rate) on economic growth in the MENA region. They found that a more egalitarian distribution of employment in terms of sex is growth-enhancing as well. Klasen and Lamanna (2008) further noted that the constrained economic growth of the MENA region arises from this sex inequality in employment and not from the sex educational disparity, as the said region was already experiencing improvements when it comes to the distribution of male-female schooling. Hence, a low male-female education inequality does not necessarily lead to enhanced labor productivity especially in cases where the female labor force is being discriminated.

Conclusion

This paper focused on the assessment of the level and dispersion of male and female educational attainments and their impacts on provincial economic growth in the Philippines during 1991 to 2012. It then found that over the course of just two decades, the Philippines exhibited significant improvements in the average educational attainments of the sex subgroups. One interesting result is that the female labor force has become more educated now than their counterparts since the turn of the century, thus concurring with the findings of Mesa (2007). The literature argues that female education is very advantageous to a country's economic performance due to its direct positive effect on human capital quality and its positive externalities on the demography (reduced fertility) and investments (Klasen and Lamanna 2009 and Knowles, Lorgelly, and Owen 2002).

However, estimates of education Gini coefficients and decomposition analysis diverged from the findings of Mesa (2007). Mesa (2007) reported that females have been experiencing a more egalitarian distribution since year 2000, and that the between-group inequality is the main contributor to the country's overall educational disparity. To the contrary, this study found that the female household heads are consistently experiencing a relatively less egalitarian educational distribution vis-à-vis their male counterparts. The within-male inequality, moreover, was named as the main contribution for all periods under study. The study explained that this difference in results may have been due to the difference in the source of basic data and the large proportion of male household heads surveyed in the FIES datasets. Nevertheless, it advanced the significance of universal literacy policies in improving the level and dispersion of education among provinces and sex subgroups, as education variables worsen with an increase in the proportion of non-schooled, among others. Such was particularly exhibited by the fall of male-female AYS and the worsened educational distributions in year 2000, in which half of the household heads surveyed in FIES were but elementary undergraduates.

The existence and significance of the relationship between male and female education with provincial economic growth was then evaluated using dynamic panel and IV regressions. Results showed that both male and female educations are growth-enhancing, although the former lost its statistical significance under the full-sample IV regression. The magnitudes of the impacts of male and female educations were particularly higher in IV than in dynamic panel estimations. The study also stressed that the coefficient of female education is slightly larger than that of male education under the restricted-sample IV regression, suggesting that female education may indeed have indirect effects on economic growth as observed in the literature. On a similar note, the male-female AYS gap has a significant negative effect on the economic performance of Philippine provinces. But since the sex AYS gap has recently reversed, it is then expected that the country would reap economic benefits from such a more-educated female workforce, holding other factors constant.

Klasen and Lamanna (2009), nevertheless, pointed out that sex inequality in employment must also be addressed for the country to benefit from these improved female educational attainments and distributions. This, therefore, indicates that future researches may as well be interested in assessing the sex employment inequality in the Philippines. Future researches may also revisit this relationship between male-female education and economic growth, since the paper was not able to address some caveats pertaining to statistical analysis, e.g., possible omitted variable bias and lack of suitable instruments. Such studies may therefore be interested in using the MRW model which has a stronger and more direct link to theories on growth and human capital.

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Analyzing the Relationship Between Exposure to Extreme Weather and Economic Inequality in the Philippines

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Abstract

This paper looks into the relationship between typhoon exposure and inequality in per capita income and per capita expenditure of households in the Philippines by comparing the change in the Theil L and Theil T inequality indexes between 2009 and 2012 across different exposure groups. A decomposition analysis of the Theil index was also undertaken to establish the relative contributions of within-exposure group inequality and between-exposure groups inequality to total inequality. Conforming to the paper's hypothesis, the group that has the highest exposure to typhoons was found to experience a worsening of both income and expenditure inequality while the group with the least exposure showed no change in expenditure inequality and an improvement in income equality. The result supports the importance of implementing policies that increase the resilience of local communities in the Philippines. Apart from short-term financial damages, exposure to adverse weather may also bring an added burden of worsening economic inequality.

Keywords: *inequality decomposition, extreme event exposure, Theil decomposition analysis*

Introduction

Developing countries, including the Philippines, are expected to sustain severe impacts from anthropogenic climate change, one consequence of which is the increased frequency of extreme weather events (IPCC 2014). In order to identify efficient solutions to minimize the impacts of extreme weather, economists conduct cost-benefit or valuation studies. However, concern for social justice necessitates going one step further and requires the analysis of the redistributive or inequality impacts of extreme weather events.

Studying inequality is important because this social problem is associated with various negative social impacts. Empirical studies have shown that rising inequality has an effect on environmental quality (Hao et al. 2016), on drug use and HIV prevalence among drug users (Friedman et al. 2016), on adolescents' physical health (Rözer and Volker 2016), on adolescents' emotional health (Vilhjalmsdottir et al. 2016), and on the incidence of violent crimes (Enamorado et al. 2016).

From a philosophical perspective, Cowell (1995) offered two explanations why individuals would prefer an "equal" society. The first explanation is based on preferences and risk aversion. In this explanation, individuals see being poor as a result of drawing a losing ticket in a lottery of life chances. This lottery is represented by the income distribution of the society. Being risk-averse, people will want to minimize their hypothetical risk of drawing a losing ticket and hence, they will prefer an income distribution that is more equal rather than unequal. The second explanation is based on altruism and envy. People care for the least advantaged but they are also envious of those that are inordinately rich, hence they will prefer a more equal distribution of income in the society.

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The Philippines has one of the highest income inequality indexes among Southeast Asian countries (Bock 2014).Various studies (see for example, Estudillo 1997, Balisacan and Fuwa 2003, Zamora and Dorado 2015) have tried to identify contributory factors by employing inequality decomposition analysis, including decomposition by locality (e.g., rural versus urban, provincial, regional), by income source, and by household characteristics (e.g., educational attainment, gender, employment, source of remittances). However, the decomposition of inequality in the Philippines according to exposure to extreme weather has not been examined. A handful of studies on this topic exist but most were done in African countries. Moreover, the results of these studies were conflicting. For instance, some studies found that weather shocks exacerbate existing income and power disparities in some areas, while they reduce inequality in other areas (Silva et al. 2015 and Reardon and Taylor 1994). On the other hand, a study done in Ethiopia (Thiede 2014) showed that livestock asset inequality actually decreased in response to weather shocks. This study hopes to contribute to the existing empirical literature by examining the relationship between exposure to typhoons and inequality, in the case of the Philippines.

Conceptual Framework

This section explains the underlying process of how adverse weather may cause a rise in economic inequality. In formulating the hypothesis for the study, several assumptions were made. First, the study posits that different types of households, when exposed to the same weather shock, will experience varying degrees of impacts, depending on their degree of mobility and adaptive capacity. When households are immobile, they cannot easily shift from one source of livelihood to another, and hence they will sustain greater damage from extreme weather than mobile households. Borrowing from climate change literature, adaptive capacity is the ability of a system to minimize adverse impacts or even maximize potential benefits from climate change. Households with greater adaptive capacity will incur lower impacts than households with lower adaptive capacity (Mendoza et al. 2014).

Second, households that belong in the lower income category are expected to sustain more severe negative impacts from adverse weather. This is based from the observation that low-income households generally rely on livelihoods that are natural-resource dependent (e.g., fishing and farming) which means that they are more vulnerable to adverse weather. Studies have shown that agriculture and fisheries-dependent households have higher incidence of vulnerability than non-agriculture households (Arias et al. 2016), while rural households are more vulnerable than urban households (Günther and Harttgen 2009). Moreover, low income households have lower adaptive capacity and less mobility (in both spatial and economic terms), further adding up to their vulnerability.

Third, *ceteris paribus*, an increase in income or consumption of households in the lower strata improves equality, while a decline in their income or consumption worsens inequality. This is an implication of using the Theil index as a measure of inequality. One property of the Theil index is the ‘weak principle of transfer’, which means that a hypothetical transfer from the rich to the poor improves the inequality index.

Lastly, the heterogeneity or diversity of an area will determine whether inequality will change or remain the same given weather shocks. Heterogeneity can be measured in terms of economic and social characteristics such as income levels, types of livelihood, and even gender of the household head which are determinants of adaptive capacity and mobility.

Given these assumptions, the hypothesized economic inequality outcomes of combinations of weather scenarios and area diversity/heterogeneity are presented in Figure 1. Considering the extreme case of complete homogeneity, regardless of whether exposure is low or high, inequality is expected to remain constant. If weather is good, everyone will experience proportionate level of benefits, and when the weather is bad, everyone will sustain proportionate level of damages.

On the other end of the spectrum is complete diversity or heterogeneity. If exposure is low, inequality is expected to decrease. This is based from the assumption that those in the lowest income strata (the most vulnerable to adverse weather shocks) are also the ones who are expected to benefit the most from good weather. On the other hand, if exposure is high, inequality in a completely heterogeneous area will increase.

Lastly, an area with some degree of heterogeneity will sustain ambiguous inequality impacts. Low exposure may result in either a decrease in inequality index (if close to perfectly heterogeneous) or no change in inequality index, (if close to perfectly homogeneous). Correspondingly, high exposure may result in either an increase in, or a constant, inequality index.

		Exposure to Adverse Weather	
		Low	*High*
Diversity of the Area	*Completely Homogenous*	no change in inequality	no change in inequality
	In-between	no change or â inequality	no change or á inequality
	Completely Diverse	â inequality	á inequality

Figure 1. Inequality in response to exposure to adverse weather

Methodology

Data and Sources

The study used household-level micro data from the 2009 and 2012 Family Income and Expenditure Survey (FIES) undertaken by the Philippine Statistics Authority (PSA). Since the FIES does not include questions pertaining to household exposure to typhoons and meteorological hazards, household data were cross-referenced with the severe weather bulletin issued by the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), based from the provincial location of the households.

Categorization of Households

The study chose typhoon as the weather hazard to be examined since this is the most prevalent weather hazard in the country. Households were classified into four exposure groups based from their typhoon exposure in 2009, 2010, and 2011. The three-year period was deemed adequate since it has been observed that the impact of weather disasters on the economy has an expected turnaround of about three years (Chaiechi 2014). From the PAGASA bulletin, the total frequency of typhoons by province was tabulated.

The total frequency was divided by three (3) to get the average number of typhoons per year, and this was compared to the historical expected typhoon occurrence estimated by Concepcion (2004) as cited in Bareja (2011) (Table 1). Since the main interest is extreme weather, the deviation from the historical typhoon occurrence was used as the basis for the exposure categorization. The final categorization is as follows: less than 2; 2 to 3; 4 to 5; and 6 to 7.

Table 1. Historical mean annual rainfall and typhoon frequency by region, Philippines

Region	Average Annual Rainfall (mm)	Typhoon Frequency
CAR	2,500-3,600	2-2.5 times per year
Region I	2,000-2,750	1.7-2.5 times per year
Region II	1,700-3,000	1.7-2.5 times per year
Region III	1,800-3,800	1.7 times per year
Region IV	1,550-3,500	1.5 times per year
Region V	1,450-3,750	1.5 times per year
Region VI	2,250-3,350	once per year
Region VII	1,350-1,800	once per year
Region VIII	2,850-3,250	1.7 times per year
Region IX/ARMM	1,750-2,450	once in 12 years
Region X/CARAGA	2,150-3,650	once in 12 years to once per year
Region XI/CARAGA	800-4,500	once in 12 years to once per year
Region XII/ARMM	1,700-2,250	once in 12 years
Philippines	800-4,500	-

Source: Concepcion (2004) as cited in Bareja (2011)

Inequality Index

To assess the relationship between extreme weather and inequality, the change in the inequality index from 2009 to 2012 was examined and compared across the different exposure groups. In empirical research, welfare is usually proxied by variables such as utility, income, wealth, consumption, and expenditures. This study considered both total income and total expenditures. Adjustments were made on these variables to account for differences in the size of the households included in the FIES survey. Ideally, one wants to compute what is called the adult equivalence scale. The adult equivalence scale has an advantage over simply computing for per capita values since the former takes into consideration possible economies of scale in household consumption as well as the difference in the relative needs of adults versus children.

However, since the 2009 dataset and the 2012 dataset have different levels of disaggregation of household members according to age, the study resorted to the use of per capita income and per capita consumption.

There are several measures of inequality such as the Lorenz Curve, the Gini Coefficient, the Atkinson Index, and several General Enthropy Indexes which include the Theil L and Theil T indexes. The Theil index has several properties which make it a desirable measure of inequality (Cowell 1995): 1) Weak principle of transfer (a hypothetical transfer of income from a rich person to a poor person will result in a lower inequality index); 2) Income scale independence (a proportional increase in the income of everyone in the population will not alter the computed inequality index); 3) Principle of population (inequality index is not dependent on the size of the population); and 4) Decomposability (there is a coherent relationship between inequality in the whole of society and inequality in its subgroups).

Theil decomposition analysis was employed using the Stata[3] "ineqdeco" module (Jenkins 1999). Both the Theil T and Theil L measures were used. The Theil T is sensitive to changes in the upper income levels, while Theil L is sensitive to changes in lower income levels. The formula for the general Theil T and L inequality indexes are (Estudillo 1997):

$$T = \frac{1}{n}\sum_{i}^{n} \frac{y_i}{\bar{y}} log\left(\frac{y_i}{\bar{y}}\right) \quad (1)$$

$$L = \frac{1}{n}\sum_{i}^{n} log\left(\frac{y_i}{\bar{y}}\right) \quad (2)$$

The decomposition equations are:

$$T = \sum_j^J \left(\frac{n_j}{n}\frac{y_j}{\bar{y}}\right) T_j + \sum_j^J \left(\frac{n_j}{n}\frac{y_j}{\bar{y}}\right) log\left(\frac{y_j}{\bar{y}}\right) \quad (3)$$

$$L = \sum_j^J \left(\frac{n_j}{n}\right) L_j + \sum_j^J \left(\frac{n_j}{n}\right) log\left(\frac{y_j}{\bar{y}}\right) \quad (4)$$

Where n is the number of people in the population, y_i is the income of person i, $\bar{y}$ is the mean income of the population, n_j is the number of people in the population subgroup j, y_j is the mean income of population subgroup j, and Tj, Lj, is the Theil index (T and L) of population subgroup j.

The first term on the right-hand side of the decomposition equations is the within-group inequality component, while the second term is the between-group contribution to inequality. In the paper by Estudillo (1997), between-group inequality is considered a significant contributor to total inequality if its contribution is at least 20% of total inequality.

To formalize the measure of group diversity/heterogeneity, a variation of the Herfindahl Index was estimated based on the major income source of the household. The Herfindahl Index is considered superior among other indices but it is criticized for assigning greater weights to large sectors of the economy (Palan 2010). As such, the version of the Herfindahl Index introduced by Keeble and Hauser (1971) as cited in Palan (2010) was used:

$$HD_i = 1 - \sqrt{\sum \left(\frac{e_{is}}{e_i}\right)^2} \quad (5)$$

Where e_{is} is the total number of households under exposure category i relying on source s as their main source of income, and e_i is the total number of households in exposure category i.

[3] StataCorp. 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP. Single-user Stata Perpetual License Serial number: 40120584463.

Results and Discussion

Descriptive Analysis

From 2009 to 2011, there were 35 typhoons/storms with public storm warning signal that entered the Philippine Area of Responsibility. Eighty-two provinces were categorized into four groups according to typhoon exposure defined in terms of deviations from the historical mean: Group A – less than 2 typhoons, Group B –2 to 3 typhoons, Group C – 4 to 5 typhoons, and Group D – 6 to 7 typhoons. Five provinces posted the highest exposure to typhoons (Abra, Ifugao, Kalinga, Mountain Province, and Apayao), all of which are located in the Cordillera Administrative Region. The provinces with the next highest exposure (between 4 to 5, Group C) are also in Luzon; and these are Pangasinan, Isabela, Benguet, Quezon, Nueva Ecija, Cagayan, Zambales, Aurora, and Batanes. A total of 23 provinces have an exposure of between 2 to 3 (Group B), and they are mostly in Central and Southern Luzon. Those with exposure of less than 2(Group A) number 45, and are mostly located in the Visayas and Mindanao (Table 2).

Table 2. Categorization of provinces by level of exposure to typhoon (in terms of deviation from historical mean)

Group/ Frequency	No. of Provinces	Provinces
A: less than 2	45	Cebu, Davao del Sur, Negros Occidental, Leyte, Iloilo, Zamboanga del Sur, South Cotabato, Misamis Oriental, Maguindanao, Sulu, Cotabato, Zamboanga del Norte, Agusan del Norte, Palawan, Negros Oriental, Bukidnon, Bohol, Lanao del Sur, Oriental Mindoro, Davao, Surigao del Sur, Sultan Kudarat, Lanao del Norte, Agusan del Sur, Capiz, Masbata, Western Samar, Compostela Valley, Misamis Occidental, Eastern Samar, Davao Oriental, Saranggani, Zamboanga Sibugay, Occidental Mindoro, Romblon, Southern Leyte, Aklan, Antique, Basilan, Biliran, Isabela City, Guimaras, Cotabato City, Siquijor, Camiguin
B: 2 to 3	23	Metro Manila, Cavite, Bulacan, Laguna, Batangas, Camarines Sur, Pampanga, Rizal, Albay, Sorsogon, Tarlac, La Union, Ilocos Sur, Surigao del Norte, Ilocos Norte, Camarines Norte, Northern Samar, Nueva Vizcaya, Bataan, Marinduque, Quirino, Tawi-Tawi, Catanduanes
C: 4 to 5	9	Pangasinan, Isabela, Benguet, Quezon, Nueva Ecija, Cagayan, Zambales, Aurora, Batanes
D: 6 to 7	5	Abra, Ifugao, Kalinga, Mountain Province, Apayao

Source of raw data: PAGASA Severe Weather Bulletin 2009, 2010, 2011, Philippine Atmospheric, Geophysical, and Astronomical Services Administration

Table 3 presents several socio-economic indicators for the four exposure groups. Groups A, C and D are predominantly rural, while Group B is predominantly urban. In terms of agricultural/non-agricultural share, the distribution has not significantly changed from 2009 to 2012. Group D has the highest proportion of agricultural households (about half of the sample), while Group B has the lowest proportion of agricultural households of about a tenth. Majority of households in all groups are male-headed. The proportions of male-headed households in 2012 are just 1-2% points higher than their corresponding proportions for 2009 for all groups.

Table 3. Selected socio-economic characteristics of households, by exposure group, 2009 and 2012

Item	Group A		Group B		Group C		Group D	
	2009	2012	2009	2012	2009	2012	2009	2012
No of households	18,883	19,917	13,476	13,926	5,152	5,390	889	938
Proportion (%) of total households								
Rural	67	68	33	44	61	79	86	90
Agricultural	35	33	11	10	29	28	43	43
Female-headed	18	19	24	25	19	21	17	18
Highest educational attainment	100	100	100	100	100	100	100	100
No grade completed	5	4	1	1	2	2	8	5
Elementary undergraduate	29	28	14	13	17	17	29	28
Elementary graduate	18	19	18	18	24	24	20	18
High School undergraduate	13	13	11	11	11	11	10	10
High School graduate	16	17	28	28	26	27	15	19
At least College	19	19	28	29	20	19	19	20

Source of raw data: Family Income and Expenditure Survey, 2009 and 2012, Philippine Statistics Authority

Generally, Table 3 reveals that the profiles of households for each of the four exposure groups between 2009 and 2012 are similar, and hence comparable. Moreover, it was observed that the distribution of households based on income source also has not changed much between the two periods (Table 4).

All of the exposure groups show a relatively high degree of heterogeneity with Herfindahl indexes ranging from 0.46 to 0.6.[4] Group B was the least heterogeneous, while Group A was the most heterogeneous (Table 5).

The population shares of the different groups remained constant from 2009 to 2012 as shown in Table 6. The highest population share was for Group A, followed by Group B, then Group C, and last by Group D. From 2009 to 2012, the mean expenditures and mean income for all groups have increased in nominal terms. For both years, the group with the highest mean per capita income and mean per capita expenditure is Group B, followed by Group C. In 2009, Group D had the lowest per capita expenditures and lowest per capita income while in 2012, Group D still had the lowest per capita expenditure, but Group A had the lowest per capita income.

[4] The index is between 0 and 1-√(1/S), where *S* is the number of sectors.Perfect homogeneity yields a value of zero while perfect heterogeneity yields a value of 0.796.

Table 4. Distribution of households according to main source of income, percentage share, by exposure group, 2009 and 2012

Main Source of Income	Group A		Group B		Group C		Group D	
	2009	2012	2009	2012	2009	2012	2009	2012
Wage/salary from agri. activity	10.7	12.0	3.3	3.6	10.3	11.9	7.1	7.2
Wage/salary from non-agri. activity	31.3	32.1	48.8	51.2	33.0	33.4	25.0	30.4
Crop farming and gardening	18.5	14.7	5.5	4.0	16.9	14.6	29.9	26.3
Livestock and poultry raising	0.5	0.5	0.4	0.2	0.4	0.5	2.4	0.7
Fishing	4.4	4.0	2.1	1.8	0.9	0.9	0.1	0.3
Forestry and hunting	0.5	0.5	0.2	0.1	0.6	0.4	-	0.2
Wholesale and retail	6.4	6.6	6.8	6.6	6.0	6.3	3.4	3.0
Manufacturing	1.1	1.0	1.0	0.9	0.7	0.8	0.3	0.9
Community, etc. services	1.2	1.0	1.8	1.7	1.1	1.0	0.2	0.6
Transport and communication	2.9	2.9	2.7	2.1	2.9	3.1	1.2	1.6
Mining	0.3	0.3	0.2	0.2	0.4	0.2	0.2	0.1
Construction	0.1	0.1	0.2	0.1	0.2	0.0	0.2	0.1
Entrep. activity N.E.C.	0.2	0.2	0.4	0.5	0.3	0.2	-	0.1
Net share of crops and others	0.9	0.9	0.5	0.3	1.0	0.6	2.0	1.6
Assistance from abroad	6.7	7.2	13.0	12.6	12.1	12.0	8.7	9.1
Assistance from domestic source	6.4	9.1	4.8	6.5	5.2	6.7	6.6	7.6
Rental of lands and other properties	0.3	0.3	0.5	0.6	0.3	0.3	0.3	0.1
Interests from banks / loans	0.0	0.0	0.0	0.0	-	0.0	0.1	-
Pensions and retirements benefits	2.7	3.0	2.4	3.0	2.4	3.1	2.2	3.8
Dividend from investments	0.0	0.0	0.1	0.1	0.0	-	-	-
Rental value of owner-occupied dwelling	1.8	1.3	3.5	2.9	2.9	2.5	4.4	1.9
Income from family sustenance activities	0.5	0.6	0.2	0.2	0.4	0.2	1.3	1.4
Received as gifts	2.4	1.6	1.5	1.0	2.0	1.3	4.2	2.9
Other income	0.0	0.0	0.0	0.0	0.0	0.0	-	-

Table 5. Herfindahl index of diversity in terms of income source, by exposure group, 2009 and 2012

Year	Group A	Group B	Group C	Group D
2009	0.60	0.48	0.59	0.58
2012	0.60	0.46	0.58	0.57

Source of raw data: Family Income and Expenditure Survey, 2009 and 2012, Philippine Statistics Authority

Table 6. Mean per capita expenditures and income, by exposure group, 2009 and 2012

Group	Population Share		Mean per Capita Expenditures (PhP)		Mean per Capita Income (PhP)	
	2009	2012	2009	2012	2009	2012
Group A	0.49	0.50	32,000	35,300	38,000	43,200
Group B	0.35	0.35	57,000	61,000	65,900	71,000
Group C	0.13	0.13	38,900	42,600	51,000	53,800
Group D	0.02	0.02	30,400	32,300	36,500	45,300

Source of raw data: Family Income and Expenditure Survey, 2009 and 2012, Philippine Statistics Authority

Theil Inequality Decomposition Analysis

Tables 7 and 8 show the Theil L and Theil T inequality indexes for per capita expenditures and per capita income, respectively. The trends were similar for both Theil L and Theil T categories although the Theil T estimates were consistently higher than the Theil L index. Also, the estimated inequality indexes were higher for per capita income than for per capita expenditure, suggesting the possibility that households undertake some form of consumption smoothing.

Table 7. Theil inequality index for per capita expenditures, by exposure group, 2009 and 2012

Group	Per Capita Expenditures					
	Theil L			Theil T		
	2009	2012	Change	2009	2012	Change
Group A	0.30	0.31	0.00	0.36	0.36	0.00
Group B	0.32	0.31	(0.01)	0.37	0.35	(0.02)
Group C	0.26	0.25	(0.01)	0.32	0.29	(0.03)
Group D	0.24	0.26	0.02	0.28	0.33	0.05

Source of raw data: Family Income and Expenditure Survey, 2009 and 2012, Philippine Statistics Authority

Table 8. Theil inequality index for per capita income, by exposure group, 2009 and 2012

Group	Per Capita Income					
	Theil L			Theil T		
	2009	2012	Change	2009	2012	Change
Group A	0.39	0.39	(0.01)	0.48	0.46	(0.02)
Group B	0.38	0.36	(0.02)	0.44	0.40	(0.04)
Group C	0.41	0.33	(0.08)	0.62	0.40	(0.22)
Group D	0.35	0.42	0.07	0.40	0.63	0.23

Source of raw data: Family Income and Expenditure Survey, 2009 and 2012, Philippine Statistics Authority

During the reference period (2009), Group B had the highest inequality index for expenditures, followed by Group A and Group C, while Group D exhibited the least inequality. During the same period, the highest per capita income inequality was estimated for Group C, followed by Group A, by Group B, and last by Group D.

Considering that Group D had the highest exposure to typhoons from 2009 to 2011, it is expected that income and consumption inequality for this group will increase in 2012 vis-à-vis 2009. Results of the analysis seem to suggest that the above hypothesis is true. It can be seen that Group D experienced a +0.02 rise in the Theil L per capita expenditure inequality, while the Theil T index rose by +0.05. In terms of per capita income, the Theil L index rose by +0.07, while the Theil T index rose by +0.23.

For the group with the lowest exposure (Group A), per capita expenditure inequality did not change from 2009 to 2012, but per capita income inequality declined. Specifically, the per capita income inequality changed by -0.01 using the Theil L index, and by -0.02 using the Theil T index. The group with the second lowest exposure (Group B), on the other hand, experienced a decline in both income and expenditure inequality.

An unexpected result was observed for Group C, the group with the second highest exposure. Among all the exposure subgroups, Group C exhibited the greatest decline in inequality, contradicting a priori expectations. Theoretically, the above result is possible if the households belonging in the upper income levels are the ones who are more vulnerable to adverse weather. Another possible explanation is that there may have been other shocks that could have adversely affected those in the higher income levels than those in the lower income strata, or there may have been positive shocks that benefited those in the lower income more than those in the higher income strata.

Lastly, the contribution of within-group and between-group inequality to total inequality is presented in Table 9. The within-group inequality is the weighted average of subgroup inequality values, while the between-group inequality represents the level of inequality obtained by using the mean income/expenditure of the respective groups instead of the income/expenditure of the household (Shorrocks and Wan 2004).

Table 9. Theil decomposition of per capita expenditures and per capita income

Theil Decomposition	Per Capita Expenditures				Per Capita Income			
	2009		2012		2009		2012	
	Theil L	Theil T	Theil L	Theil T	Theil L	Theil T	Theil L	Thei l T
Within-group inequality	0.30	0.36	0.30	0.35	0.39	0.48	0.37	0.43
Between-group inequality	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Total inequality	0.34	0.40	0.33	0.38	0.42	0.51	0.40	0.45
Contribution of between group inequality (%)	10.66	9.35	9.75	8.75	7.69	6.35	6.56	5.80

Source of raw data: Family Income and Expenditure Survey, 2009 and 2012, Philippine Statistics Authority

It was estimated that the between-group inequality represents about 10% of total per capita expenditure inequality, while it represents about 6% of total per capita income inequality. However, one must not automatically dismiss adverse weather conditions as unimportant, since it can be seen in the previous analysis that significantly higher levels of inequality are present in the area with the highest exposure. Shorrocks and Wan (2004) also observed that low between-group component is typical in subgroup decompositions.

Conclusion

The study found that weather exposure played a role in determining the total inequality level of the Philippines in 2012. This is consistent with the findings of Datt and Hoogeveen (2000) which found that the El Niño phenomenon has an impact, albeit small, on household inequality in the country.

It was found that the group with the greatest exposure to typhoons (in terms of deviation from historical mean) was the only group that experienced a rise in inequality from 2009 to 2012. On the other hand, the group with the least exposure experienced no change in per capita expenditure inequality, and a decline in per capita income inequality. This finding supports the hypothesis of the paper that adverse weather conditions may be associated with the worsening of inequality in a particular area. It was also found that there is a higher per capita income inequality compared to per capita expenditure inequality in all subgroups. This suggests the presence of consumption smoothing among households especially those in the high exposure group. However, our finding that the group with the second highest exposure had a decline in inequality contradicts a priori expectations. Nonetheless, this scenario is possible if the households in the upper income levels are the ones more vulnerable to adverse weather.

It is important to highlight the limitations of the study. First, the study used the deviation of the actual frequency of typhoons from the historical mean over a three-year period instead of a longer period climatology as used in Silva (2004). Lastly, there may have been other shocks that affected the economy apart from adverse weather such as the global financial crisis of 2008, the effects of which are difficult to disentangle from the effects of weather during the period under study.

The results of the analysis magnify the importance of building the resilience of households and communities against weather shocks because of their possible repercussions that extend beyond financial losses. The social consequence seems to be equally serious, since it has been demonstrated that a rise in inequality is concurrent in areas with high exposure to typhoons. Building resilience entails government provision of safety nets such as insurance or disaster assistance, as well as strengthening the adaptive capacity of households through information and education, among many others. Moreover, this highlights the urgency of pursuing aggressive climate change mitigation at the global level, which the international community seems to be backtracking on in recent years.

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Impact of Trade Liberalization on Research and Development (R&D) Expenditures in the Philippines

Mary Joyce N. Vidanes[1]

Abstract

This paper examines the effects of tariff reductions endorsed under GATT-WTO and AFTA-CEPT on R&D expenditures of Philippine manufacturing firms. It also considers firm characteristics like exports, capital intensity, and size as explanatory factors. Using pooled firm-level data that are harmonized with the international nomenclatures for traded products, the results uphold that intensified competition from foreign players drive domestic firms to develop their production processes and products. Accordingly, the main findings of the paper reveal that reductions in MFN and ASEAN tariffs increase the growth rate of R&D within manufacturing firms. Likewise, a rising export share is associated with higher R&D growth rate and this is suggestive of how export profits further incentivizes firm innovation. The findings also link capital intensity and firm size to higher R&D growth rate. Overall, the results provide support for the role of tariff changes as conduits through which trade liberalization influences expenditure decisions of manufacturing firms.

Keywords: *trade liberalization, R&D, Philippine manufacturing, firm-level data*

Introduction

After more than three decades of adopting a protective policy stance, the Philippine government has undertaken considerable measures in integrating its marketplace into the world economy. Primarily branded by import controls and high tariff rates, the tariff structure underwent successive unilateral reform programs that were moored on an extensive liberalization across products. Beginning in the early 1980s, the trade regime started to loosen with the elimination of tariff and non-tariff barriers as legislated by the Tariff Reform Programs (TRPs). By 2004, no unilateral trade adjustment has been made. Thereafter, the ASEAN Free Trade Area-Common Effective Preferential Tariff (AFTA-CEPT) scheme became the basis for tariff reductions (Aldaba 2013).

As the country acceded to General Agreement on Tariffs and Trade-World Trade Organization (GATT-WTO) in 1995, the global predominance of bilateral and regional trading agreements has induced the Philippine government to engage further in Free Trade Agreements (FTAs) with several states and trade blocs.

Such trade liberalization efforts and intensified economic interdependence among countries broaden horizons for employment and productive efficiency. As implied by the Heckscher-Ohlin (H-O) model, the specialization strategy fostered by freer trade allows for gains to be realized as resources are effectively reallocated within firms and across industries. Yet, this globalization process has constructed an economic atmosphere for developing countries that breeds competition from which opportunities and challenges abound. Relatedly, the Product Life Cycle model provides another alternative account to the observable pattern of international trade and how it affects innovation decisions among firms in the market.

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Relatedly, Wood (1995) expounded the response of firms to freer trade through his "defensive innovation" hypothesis. It acknowledges the urgency for domestic producers to increase capital stock and R&D activities with heightened competition. While it can be presumed that profit-maximizing firms are already employing labor- and cost-saving inputs, the fact that these firms will never be completely knowledgeable of the technical prospects should not be overlooked. On the other hand, Fernandes and Paunov (2009) recognized the positive effect of import competition on product quality upgrading. As foreign competition intensifies, domestic firms are induced to develop novel products to bridge the gap between them and their foreign counterparts.

In the Philippines, trade policies have become the primary mechanism for commencing and strengthening industrialization. However, several studies still accentuate the industry sector's weak performance and negligible contribution to growth and employment. While this paper endeavors to get an overview of the country's investment status, it places utmost focus on how Philippine manufacturing firms, specifically their R&D expenditures, have been influenced by the tariff changes enforced under GATT-WTO and AFTA-CEPT.

International Trade, Competition, and Innovation

Generally, there is a broad consensus among economists that a freer trade strategy incites output growth and efficiency gains. However, as trade liberalization influenced countries at varying levels, the complexities from the growing international interdependence also became palpable. Fittingly, trade-induced phenomena became part of the discussions.

There are two conflicting ideas regarding competition and innovation. First, competition is perceived as an impediment to innovation and technological progress. As suggested by the Industrial Organization models, heightened competition cuts innovative activities as the monopoly rents disbursed to successful innovators are reduced. Conversely, the opposing view reasons that competition is likely to promote innovation as economic agents struggle to escape from their competitors (Aldaba 2012). In this vein, Aghion et al. (2002) developed a model wherein innovation incentives are determined by the disparity between the pre-innovation rent and post-innovation rent. According to them, intensified competition may raise profits from innovation and induce further investments on R&D to escape antagonism. However, this was only possible for industries within neck-and-neck competition where it is difficult to point out who the market leader is. For industries with less neck -and-neck competition, innovation among less productive firms falls as their rewards to catch up with the technological leader decline.

Upon reducing barriers to trade, competition has subjected economic producers to greater vulnerability. Congruently, scholars recognize the profound effects of trade policy changes on a firm's decision and incentive to invest. According to Wood (1995), the response of firms to international trade can be explained by his "defensive innovation" hypothesis. Under this principle, he pointed out that heightened competition from foreign firms is expected to motivate domestic companies to improve capital stock and to engage more on R&D. As profit-maximizing firms are already presumed to be employing labor- and cost-saving inputs that are already in the market, the concept may seem inconsistent with economic theory. However, he underpinned that firms can never have complete knowledge of the technical prospects.

To know more about these possibilities, it will have to incur search costs that may be in the form of R&D expenditures. Pissarides (1995) discussed that as competition among trading partners intensifies, firms have the incentives to innovate. In less advanced countries where superior technology is unknown or costly to employ, R&D activities undertaken are usually aimed at imitating or assimilating production techniques from superior countries. In light of this, Acemoglu (2003) held technology as an endogenous response to the profit incentives from trade.

On the other hand, Licandro and Ruiz (2010) established a two-country endogenous growth model in assessing the impact of trade openness on innovation and productivity growth. They articulated that trade liberalization has encouraged market competition and R&D efforts, which has led to aggregate productivity growth. Through intensified competition, markups are reduced and firms are prompted to innovate more in response to the profits from a larger market size. Likewise, Atkeson and Burstein (2010) supported the principle that falling trade costs have a considerable impact on the firm's decision to leave the market, export, and capitalize on R&D.

On a more recent study, Bas and Ledezma (2015) enunciated that freer trade prompts incentives for productivity-enhancing technologies by raising expected profits. However, heterogeneous firms have distinctive responses to profit opportunities. According to the authors, lower trade costs affect firms' profits differently. The net effect thereof sways the incentives to improve productivity, which they regarded as contingent to firm characteristics such as the export status. Hence, they only conferred the benefits of freer trade to exporters.

Philippine Trade and Innovation

Following significant trade reforms, several studies have also dwelled on the themes of trade, competition, and innovation in the Philippines. Dismally, the failure of the implemented liberalization policies to engender competitive gains and productivity growth has also been underpinned by scholars. In light of this drawback, several studies have dwelled on the innovation structure of the country. Focusing on the estimation of R&D gap in the Philippines, Cororaton (199a) underscored several indicators affirming the country's underinvestment on R&D. During the 1980s, R&D gap was at 0.6%. Accordingly, the ratio of R&D expenditure to GNP was reported to be 0.2% in 1992. This was substantially behind the maximum value of 3%. Additionally, he articulated that the number of scientists and engineers in the country is insufficient. As implied by the UNESCO data, the Philippines has only 152 scientists and engineers per million population. Again, this makes it far behind the average maximum number of 6,736 scientists and engineers per million population. Patalinghug (1999) reported that focus and clear direction for technological innovation has been out of the government's science and technology policies. Therefore, among his recommendations were to enhance the incentive system and R&D undertakings.

Still focusing on innovation, Cororaton (199b) examined the rates of return to R&D investments in his subsequent research. According to him, the rates of return in the primary and service sectors are substantially large at around 60%. For both sectors, the rates of return to other capital investments are relatively lower than R&D investments, with a difference of approximately 20%. Nonetheless, production was still deemed inefficient due to the minor spillover effects and negative total factor productivity growths. On the other hand, the rates of return to R&D activities were much lower in the industry sector at around 10 to 12%. For this sector, a higher rate of return is projected from capital machineries and equipment compared to R&D investments. On a brighter note, the industry sector still scored a positive total factor

The influence of R&D endeavors and the rates of return differ from sector to sector. Hence, this reveals how proper allocation of resources is essential to making R&D activities more effective in spurring economy-wide efficiency and growth. In this vein, it was highlighted by Patalinghug (2003) that the national innovation system of the country is moored on the viewpoint that technological capability is necessary for industrial expansion. Correspondingly, he accentuated that the development of technology is more acute at the firm level.

Using an unbalanced firm-level panel dataset, Aldaba (2008) provided evidence for the stylized fact that trade liberalization instigates productivity gains, and conversely protection leads to losses. According to her, trade liberalization leads to a process of resource restructuring and reshuffling such that lucrative activities expand while unprofitable ones contract. It allows for the entry of more productive firms, and drives the exit of less efficient ones. However, she stressed that the optimum gains from the trade reforms were not maximized. Amidst the transition to a more market-oriented trade policy, the government adopted a selective protection policy that reduced the credibility of the reforms. Consequently, there was a time-consistency problem because firms were not adjusting quickly with the expectation of further government protection in the future.

Still, there are subsequent studies that show the efforts of firms to overshadow the challenges brought about by foreign competition. While wage skill premium in developed countries started to fall, empirical evidence supports backward results for developing countries. Accordingly, it was deemed that production activities shifted to more skill-intensive technologies with the introduction of foreign competition in the latter countries. Adopting a panel micro data set and three trade policy proxies (MFN, ASEAN, EPR), Aldaba (2013) took into consideration the impact of trade reforms on wage skill premium in the country. According to the results of her study, trade liberalization generally reduced wage skill premium in the country. However, the interaction of skill intensity with tariffs and exports confirms that tariff reductions in 1996, 1997, 1998, and 2000 worsened the wage skill premium. Hence, firms have been shifting their production processes to more skill-intensive ones with the hopes of yielding better-quality products.

Framework

The Heckscher-Ohlin (H-O) model[2] remains to be one of the traditional avenues for examining the liberalization of trade regimes, and how benefits from it are furnished. Under its simple model with two countries, two factors, and two goods, it is assumed that a country will choose to export the good that intensively uses its relatively abundant factor. Goods that primarily employ the country's scarce factors as their inputs will then be imported. As countries decide to dismantle their trade barriers, say a reduction in tariffs, each of the countries will be able to sell its exports at a higher price in the world market while being able to purchase its imported inputs at lower prices.

While there is greater unanimity among economists that international trade fosters nationwide benefits for each country, empirical studies have stretched the focus to several efficiency and equity concerns. Correspondingly, a related strand of this literature deals with how smaller units in the economy have been responding to trade reforms, specifically the domestic producers.

[2] The reader is referred to Markusen et al. (1995) for a full discussion of the H-O model.

Amidst the upsurge in trade volumes with the annihilation of trade barriers, it is noticeable that more players are incentivized by the rising profit opportunities to enter the world market. While a freer trade regime delivers economy-wide benefits, it has engendered competitive pressures to business units. In this vein, the Product Life Cycle theory developed by Raymond Vernon offers another justification on the observable pattern of international trade, which may also elucidate the influence of tariff reductions on firm investment decisions. Its principle concedes that despite the growing sales volume from international trade, domestic firms have been under intensified pressure from foreign competition. Import-competing firms are driven to devise enhanced organizational schemes, production techniques, and products that will mitigate the threats from the inflow of cheaper and better-quality commodities from abroad. Likewise, the reduction of trade costs in the world market has enabled exporting-firms to assess and bridge the gap between them and their foreign counterparts to retain or expand their market share in the international arena. Consequently, firms have been engaging their finances on strategic ventures like R&D.

Methodology

Empirical Model

To assess the impact of trade policy changes on R&D expenditures of manufacturing firms, the study adopted a modified version of Aldaba's (2013) model. The pooled OLS regressions done made use of the following equation:

$$lnR\&D_{ij} = \beta_0 + \beta_1 Exports_{ij} + \beta_2 KL_{ij} + \beta_3 Firm\,Size_{ij} + \beta_4 Trade_j + \beta_5 Industry + \beta_6 Time + \mu_i$$

where the dependent variable, *lnR&D*, is the log of the total R&D expenditures for firm *i* belonging to industry *j*. Trade is the trade policy variable, which is proxied by MFN and ASEAN tariff rates. *Exports* (export share), KL (capital intensity) and *Size* (firm size) are the supplementary independent variables. For *Size,* (see Table 1), Industry (see Table 2) and *Time*, dummy variables were applied. Lastly, μ_i is the error term.

To carry out the analysis, the 1994 Philippine Standard Industrial Classification (PSIC) codes at the two-digit level were used as the basis in harmonizing firm-level data from the annual surveys. Subsequently, MFN and ASEAN tariffs averaged at the two-digit level classification codes were calculated and linked to their corresponding 1994 PSIC codes at the two-digit as well.

Table 1. Description of firm size dummy variables

Variable	Description (Total Employment)
Size 0	1 - 4
Size 1	5 - 9
Size 2	10 - 19
Size 3	20 - 49
Size 4	50 - 99
Size 5	100 - 199
Size 6	200 - 499
Size 7	500 - 999
Size 8	1000 - 1999
Size 9	2000 and over

Source: 2012 CPBI Explanatory Text

Table 2. Description of industry dummy variables

Variable	Industry Description
Industry 15	Manufacture of Food products and Beverages
Industry 16	Manufacture of Tobacco Products
Industry 17	Manufacture of Textiles
Industry 18	Manufacture of Wearing Apparel
Industry 19	Tanning and Dressing of Leather; Manufacture of Luggage, Handbags, and Footwear
Industry 20	Manufacture of Wood, Wood Products and Cork, except Furniture Manufacture of Articles of Bamboo, Cane, Rattan, and the Like; Manufacture of Plaiting Materials
Industry 21	Manufacture of Paper and Paper Products
Industry 22	Publishing, Printing and Reproduction of Recorded Media
Industry 23	Manufacture of Coke, Refined Petroleum and other Fuel Products
Industry 24	Manufacture of Chemicals and Chemical Products
Industry 25	Manufacture of Rubber and Plastic Products
Industry 26	Manufacture of Other Non-Metallic Mineral Products

Explanatory Variables Used

One of the reasons that can be put forward to expect a negative relationship between tariff cuts and R&D outlay is the pro-competitive effect of a freer trade. Aghion et al. (2002) and Bustos (forthcoming) point out that such removal of trade barriers boosts competition as more foreign players enter the market. Domestic firms are, then, enthused to accelerate their innovative efforts to escape competition. The two trade variables used are as follows:

- *Most Favored Nation (MFN) tariff rates*. Endorsed under GATT-WTO, these rates are custom duties levied on goods originating from all sources except those from Foreign Trade Agreement (FTA) partners.

Variable	Industry Description
Industry 27	Manufacture of Basic Metals
Industry 28	Manufacture of Fabricated Metal Products, except Machinery and Equipment
Industry 29	Manufacture of Machinery and Equipment, n.e.c.
Industry 30	Manufacture of Office, Accounting and Computing Machinery
Industry 31	Manufacture of Electrical Machinery and Apparatus, n.e.c.
Industry 32	Manufacture of Radio, Television and Communication Equipment and Apparatus
Industry 33	Manufacture of Medical, Precision, and Optical Instruments, Watches
Industry 34	Manufacture of Motor Vehicles, Trailers and Semi-Trailers
Industry 35	Manufacture of Other Transport Equipment
Industry 36	Manufacture and Repair of Furniture
Industry 37	Recycling
Industry 39	Manufacturing, n.e.c.

Source: 1994 Philippine Standard Industrial Classification

• *Association of South East Asian Nations (ASEAN) tariff rates*. The ASEAN Trade in Goods Agreement (ATIGA) rates, which is formerly known as the ASEAN Free Trade Area-Common Effective Preferential Tariff (AFTA-CEPT) Scheme, are import tariffs on goods coming from the ASEAN countries.

Recent work on international trade has also made firm heterogeneity a primary concentration since it came to emerge as an outlet for clarifying the nonconformity of most developing countries to the repercussions of the traditional trade theories. Relatedly, the succeeding variables were considered to ascertain how some firm characteristics are correlated with a manufacturing firm's R&D growth rate:

• *Export Share*. Taken as the share of exports to total revenue, this uncovers the firm's status in the export market. In 1986, Hughes (as cited in Parameswaran 2010) articulated that an upsurge in production due to higher export volumes is positively related to a firm's ability to exploit economies of scale. Moreover, better export prospects are projected to sway firms into making the necessary investments for innovation and growth to fleetingly materialize.

• *Capital Intensity*. Considered as the ratio of the book value of assets and the total number of workers, capital intensity is anticipated to be positively associated with R&D growth rate. As Cameron (2000) enunciated, capital intensity is reflective of the efficacy of firm investments. A higher capital to labor ratio renders R&D to be more effective.

• *Firm Size*. To account for this, the categories for the dummies were based on the codes that are commissioned to each employment stratum and used in the ASPBI and CPBI. A positive coefficient for firm size is expected, as larger firms are likely to have better footing when it comes to financing innovative investments like R&D (Cohen and Klepper 1996 and Parameswaran 2010).

Sources of Data

The firm-level data for the manufacturing sector used in this study are from the Census of Philippine Business Industry (CPBI), which is formerly the Census of Establishments, and the Annual Survey of Philippine Business and Industry (ASPBI). Both are designated statistical activities of the National Statistics Office (NSO). Records for 2006, 2009, and 2012 were utilized. Due to confidentiality concerns of the establishments in the said surveys, access of the microdata was only possible within the premises of the Philippine Statistics Authority (PSA). As for the tariff data, the ATIGA rates were acquired from the ASEAN Secretariat database and MITI website. On the other hand, MFN tariffs were obtained from the World Bank UNCTAD-TRAINS database.

Results and Discussion

Trajectory of Investment in the Philippines

Over the years, the progress of the Philippine economy has been stellar. By 2012, its growth rate of 6.8% was already higher relative to the average growth of its ASEAN peers (PSA 2013). To sustain the momentum, the government has strengthened its efforts to shore up investments that are essential to economic expansion and job creation. Expressed as the ratio of aggregate investment and gross domestic product (GDP), Figure 1 exhibits the overall trend of gross capital formation or investment in the Philippines from 2006 to 2012.

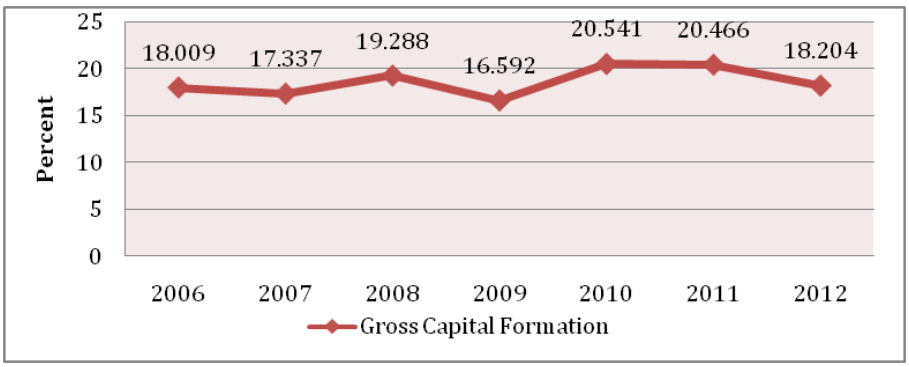

Figure 1. Philippine gross capital formation (% of GDP), 2005-2012
Source: World Bank 2017

Throughout the period, the share of investment in total production has been volatile and constantly within the range of 18% to 20%. With the onslaught of the global economic crisis in 2008 and 2009, the country's gross capital formation took a plunge to 16.59% in 2009. This was followed by a temperate progression to 18% by 2012. Yet, the investment climate remains critical to sustaining the country's rapid economic growth. As Bernardo (2015) emphasized, the country's gross capital formation (as a % of GDP) is still the lowest within the ASEAN community.

As global challenges abound from the integration of the national market into the world economy, there has been the urgency to enrich the country's productivity and competitiveness. Accordingly, the government has raised awareness on the state of science and technology that may be strategic to the aforesaid matter. With the collective participation of public and private institutions, investments on innovative activities have been considerably reinforced.

In light of this, research and development (R&D) has been one of its manifestations. Expenditures on R&D include the aggregate spending on scientific and creative work that are systematically done to increase the stock of knowledge, which is essential to creating or enhancing products, processes, and applications. It comprises of basic research, applied research, and experimental development. Accordingly, Table 3 presents the country's R&D spending (in absolute terms) in 2005, 2007, 2009, 2011 and 2013.

Table 3. Philippine gross expenditures on R&D, 2005-2013

Year	R&D Expenditures (In Million Pesos)
2005	6,326.74
2007	7,556.36
2009	8,779.16
2011	11,383.97
2013	15,914.71

Source: DOST 2015

From PhP 6.337 billion spent on R&D in 2005, gradual increases were noted through the years until it reached PhP 15.915 billion in 2013. Remarkably, expenditures on R&D sped up from its level in 2009. Among the sectors, the Department of Science and Technology (DOST) (2015) articulated that the private industry sector has contributed the highest share which is about 36% of the aggregate R&D expenditures. This was followed by 34% share from the higher education sector, 30% share from the government sector, and 0.82% share from the private non-profit sector.

Relatedly, Figure 2 shows the trend of R&D expenditures (% of GDP) in the Philippines from 2005 to 2013. Akin to the previous statistics, R&D spending in proportion to the country's GDP exhibits a growing trend. It marginally dropped in 2007, but has gradually increased to almost 14% in 2013. While the absolute value of R&D expenditures has substantially grown, its ratio to GDP remains minimal.

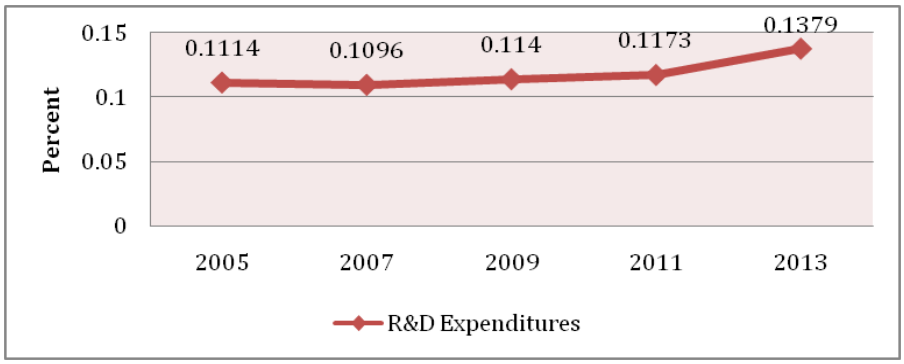

Figure 2. Philippine R&D expenditures (% of GDP), 2005-2013

Source: World Bank 2017

Apart from directing innovation and economic growth, R&D has been evoked as a measure for mitigating threats from global competition. Accordingly, the next subsection discusses the response of firm-level R&D to the tariff changes under the country's current trade liberalization commitments. The manufacturing sector was specifically considered since empirical reports affirm that it has not generated an exceptional growth despite the buttressing it has been given. As Aldaba (2013) recounted, the aggregate productivity of the sector has declined over the past years. It has failed to generate ample employment opportunities for both the new entrants and the migrating laborers from the agricultural sector.

Trade Liberalization and R&D Expenditures

In analyzing the impact of trade liberalization on firm behavior towards R&D, the empirical model was estimated separately using MFN tariff rates and ASEAN tariff rates. The second and third columns in Table 4 present the results using MFN tariffs as the trade variable. On the other hand, the fourth and fifth columns summarize the results with ASEAN tariffs as the trade proxy variable.

Table 4. Pooled OLS regression results using MFN and ASEAN tariff rates

Variable	MFN	Robust Standard Error (MFN)	ASEAN	Robust Standard Error (ASEAN)
Exports	380.7601***	135.0233	379.3959***	134.5314
KL	1.29E-08**	6.57E-09	1.29E-08**	6.59E-09
Size				
1	0.0500	0.0445	0.0498	0.0445
2	0.0801**	0.0362	0.0775**	0.0362
3	0.3642113***	0.0415	0.3640***	0.0416
4	0.6659***	0.0556	0.6641***	0.0556
5	0.9329***	0.0673	0.9307***	0.0673
6	1.1473***	0.0808	1.1455***	0.0808
7	1.5479***	0.1358	1.5441***	0.1357
8	1.4662***	0.1984	1.4638***	0.1980
9	2.0628***	0.2575	2.0594***	0.2579
MFN	-0.0297***	0.0083		
ASEAN			-0.0564**	0.0247
Industry				
16	0.1652	0.4021	0.3383	0.4008
17	-0.5391***	0.0735	-0.4746***	0.7370
18	-0.4505***	0.0609	-0.4743***	0.0585
19	-0.1521	0.0931	-0.0984	0.0956

Variable	MFN	Robust Standard Error (MFN)	ASEAN	Robust Standard Error (ASEAN)
20	-0.2271**	0.0107	-0.1235	0.0938
21	-0.4813***	0.1072	-0.3131***	0.0996
22	-0.3814***	0.0708	-0.2743***	0.0695
23	-0.4873	0.5524	-0.2320	0.5501
24	(omitted)		0.1751	0.1117
25	-0.2985***	0.0790	-0.1523**	0.0734
26	-0.2464***	0.0869	-0.1146	0.0818
27	-0.5398***	0.1054	-0.3614***	0.0951
28	-0.4375***	0.0704	-0.2782***	0.0611
29	-0.2633**	0.1117	-0.0670***	0.0974
30	-0.8460***	0.2014	-0.6509**	0.1948
31	-0.4383***	0.1340	-0.2780***	0.1285
32	-0.5616***	0.1374	-0.3993***	0.1322
33	-0.4583**	0.1876	-0.3002	0.1859
34	0.1360	0.1426	0.1544	0.1429
35	-0.3334**	0.1554	-0.1865	0.1517
36	0.1557*	0.0888	0.2338**	0.0909
37	-0.5386***	0.2056	-0.3978*	0.2034
39	0.0411	0.1226	0.1924*	0.1166
Year				
2009	0.0197	0.0337	-0.0375	0.0429
2012	4.0236***	0.1758	3.8788***	0.1893
Constant	0.5415***	0.1048	0.3512***	0.0911
Number of Observations	13810		13810	
Prob> chi^2	0.0000		0.0000	
R^2	0.1449		0.1452	

* significant at 10%, **significant at 5%, ***significant at 1%.

On both regressions done, the results reveal that the coefficients of the trade variables MFN and ASEAN are highly significant and negatively correlated with the growth rate of R&D expenditures. At par with the conclusions of Fernandes and Paunov (2009) and Bustos (forthcoming), this suggests that a fall in tariffs is associated with an increase in the growth rate of the manufacturing firms' R&D expenditures.

By the same token, firm characteristics such as export share, capital intensity, and firm size also matter in assessing the growth rate of R&D expenditures within firms. In the second and fourth columns of Table 4, the export share coefficient is highly significant at 1% level and positively correlated with R&D expenditure growth rate. Analogous with the report of Aw, Robert, and Xu (2009), this implies that exporting within manufacturing firms has, indeed, increased their innovative activities. Similarly, the significant and positive link between capital intensity and R&D expenditure growth rate coincides with Cameron's (2000) view that a high capital to labor ratio is indicative of greater R&D effectiveness. It is also notable in each of the regression results that the size dummy variables (Size 2 to Size 9) are significantly positive, thus making it consistent with the sentiments of Schumpeter (1950) and Cohen and Klepper (1996). The assumption is that larger firms (cet. par.) are more capable of manipulating the economies of scale and scope from R&D activities. Still, the positive and insignificant coefficient on Size 1 indicates that R&D may not substantially matter for firms with fewer personnel.

Furthermore, most of the industry dummy variables from both regressions have coefficients that are negative and significant. This reveals that the food products and beverage subsector (coded as Industry 15) outpaces the other manufacturing subsectors in terms of R&D ventures. Promisingly, Macabasco (2011) reported that this subsector has dominated the Top 1,000 Corporations as it contributed to almost 58% of the total manufacturing output and 12% of the country's GDP in 2009. This has been attributed to the growing demand for convenience, share of working women, and health and lifestyle consciousness. Furthermore, Singian (2014) regarded that the food and beverage processors are among the largest corporations in the country. Knowing that this is the case, it would be sensible to expect that firms engaged in this activity will register higher growth of R&D expenditures. Nonetheless, results also show that Industry 36 has a positive and significant coefficient at 10% probability level. This implies that the growth of R&D spending is higher for firms engaged in the manufacture and repair of furniture than those in the food and beverage subsector. In a website jointly created by the Department of Trade and Industry (DTI) and Board of Investments (BOI), it has been reported that since 2010, the export value of furniture has soared to US$ 179,709,000 in 2012. Dubbed as the "Milan of Asia," the country's furniture industry is still targeting to be more competitive for it to become a prime design innovator in the local and global market by 2030. Hence, the justification for the subsector's immense R&D expenditures aimed towards product development and capacity building. Finally, the positive and highly significant year dummy for 2012 implies that the growth rate of R&D expenditure within firms is higher in 2012 than in 2006 and 2009.

Summary and Conclusion

The import substitution policy pursued throughout the 1950s failed to provide an efficient mechanism of apportioning the country's economic resources. Hence, beginning in the early 1980s, the Philippine government was propelled to open up and integrate its domestic market into the world economy. Since then, the country has been exposed to the intricacies of the evolving global economic landscape. To continue acquiring the gains from international trade, sustaining the competitive spirit and growth of domestic firms became critical.

One of the conventional rulings from the trade and growth literature recognizes that international trade influences the attitude of economic agents towards innovative activities. Bustos (forthcoming), Licandro and Ruiz (2010), and Bas and Ledezma (2015) point out that tariff cuts from trade reforms incite productivity growth by encouraging market competition that eventually stimulates innovation among firms.

Correspondingly, the results presented in this study show that the Philippine manufacturing has been subjected to substantial competition as trade liberalization became central in sectoral and economic reforms. The association of MFN and ASEAN tariff reductions sanctioned by GATT-WTO and AFTA/ATIGA-CEPT to an increasing R&D growth rate implies that trade liberalization has a pro-competitive effect that provokes domestic firms to hasten their innovative efforts in order to enhance their productive capacities, and retain or expand their existing market shares. This estimated relationship acquiesces with the principle of the Product Life Cycle model. Additionally, in accord with the existing literature focusing on firm heterogeneity, firm characteristics like export share, capital intensity, and size were also reported to be statistically and economically significant.

The said results affirm the importance of trade policy changes as a conduit through which trade liberalization affects a firm's outlook on R&D endeavors. Relatedly, the termination of import substitution policies in the Philippines has contributed to the promotion of technological development. However, it has also made the manufacturing sector vulnerable to more external threats. Given this, it is essential for manufacturing firms to pursue innovative activities in order to survive international competition. With R&D as one of the primary channels for firm innovation, the results of the preceding analysis suggest the need to step up the education system and technical capability of the country. Specifically, the dissemination of exceptional management skills within manufacturing firms will be valuable to directing interests on emerging technologies. Congruently, a workforce that can direct and ride the tide of technological revolution is also extremely vital amidst the rising globalization and economic integration. By fortifying the efficiency and productivity of manufacturing firms, the manufacturing sector as whole can bolster its involvement and position in the world market.

While this study has attempted to investigate the impact of trade liberalization on R&D expenditures, it is important to note that an array of other elements like market regulations and institutional factors may have affected the growth of innovative activities at the firm level. However, a more complex and detailed examination is beyond the scope of this study due to limitation concerns of the available micro data.

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Household Food Vulnerability Under an Extreme Weather Event in Sta. Cruz Subwatershed, Laguna, Philippines

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Abstract

This study is an assessment of the vulnerability of households to food insecurity under an extreme weather event. A subjective-qualitative technique primarily based on the perceived food security status of the households and their food insecurity coping strategies was used to examine household food vulnerability. Key findings reveal that households living in the vulnerable areas of Sta. Cruz subwatershed were generally resilient to extreme weather events and only suffered from slight to moderate form of food security problems. Impacts of extreme weather events on them were generally moderate but the highest impact was observed in their income sources, logistics, and assets or properties, all of which are important elements of an adequate access to food. While no severe form of food insecurity was found among the households, results of the food vulnerability analysis show that the likelihood of a household to fall under a state of food insecurity may rise under an extreme weather event if it fails to have an early warning system, adopt effective coping strategies against extreme events, and maintain adequate physical and economic access to food. With these, suggestions to improve mechanisms such as early warning system, public food distribution systems, food assistance programs, and capacity building on adaptation strategies and coping mechanisms for climate resilience and food production are recommended to help households ensure their food security in times of an extreme weather event.

Keywords: *food security, vulnerability, extreme weather event, climate impacts*

Introduction

Increase in frequency and intensity of extreme weather events is one of the most adverse impacts of climate change that human population has to deal with at present and in the immediate future (IPCC 2007). In the Philippines, this is even a more daunting challenge, being one of the countries most affected by extreme weather events. The increasing frequency and intensity of tropical cyclones in the country, together with other climate-related extremes such as heavy precipitation events and increase in intensity of floods and droughts are already posing serious threats to food and nutrition security. This is due to their direct impacts on ecosystems and agro-ecosystems, which in turn affect food production, marketing and distribution, as well as the livelihood and income of communities and households. These risks to food security are multiplied in areas most exposed and vulnerable to natural hazards and disasters, hence, households should adopt strategies to manage the risks (Misra 2014). In the face of climate change, fighting hunger and malnutrition and ensuring food security are expected to become more difficult for vulnerable groups, especially if they are unable to build resilience and cope with the adverse impacts of climate change.

For the purpose of this paper, we define vulnerability as the "degree to which geophysical, biological, and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change, including climate variability and extremes" (IPCC 2007).

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On the other hand, food security is referred to as the state wherein "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs, and food preferences for an active and healthy life" (World Food Programme 1996). It can be analyzed at different levels – global, regional, national, community, or household - but in this context, the analysis was done at household and to some extent, community level. Therefore, the focus is mainly on the food access dimension of food security. The operational definition of household food security is that "a household is food secure when it has access to the food needed for a healthy life for all its members (i.e., adequate in terms of quality, quantity and culturally acceptable), and when it is not at undue risk of losing such access" (SCN 1991).

As one attempts to understand the interplay between climate change and food security, it is important to analyze food security through the lens of vulnerability. The Intergovernmental Panel on Climate Change (IPCC 2012) asserts that the net impact of a climatic shock on food security does not only depend on the intensity of the shock itself but also on the vulnerability of the food system and its components to that particular shock. In various literature, the influence of vulnerabilities and the ability to respond to or cope with a cascade of risks of climate change are emphasized as important factors in analyzing food security of households (Ahammad et al. 2015, Elbeheri et al. 2015, FAO 2016, FAO 2015, IISD 2013, and Maharjan and Khatri-Chhetri 2006).

It is in this light that this study was framed within the context of food security vulnerability to climate change, or simply put, "food vulnerability," which is defined as the people's propensity to fall or remain below a certain threshold of food security in the near future. Here, food vulnerability refers to the propensity of households not to be able to deliver food security outcomes due to extreme weather events. It is determined by exposure to risk factors associated with food insecurity and by the capacity to cope with the effects of those risks in order to survive the crisis (FAO 1996).

This paper examines the vulnerability of households to food insecurity under an extreme weather event. Specifically, it describes the extent to which food security of households in the vulnerable areas of Sta. Cruz subwatershed in Laguna, Philippines are affected by an extreme weather event and how they cope with it. It also determines their coping strategies against extreme weather events and the food security problems they experience. This study hopes to provide an understanding of the resilience of households and their food security to a changing climate, which is critical when developing appropriate mechanisms.

Framework of Analysis

The analytical framework is centered on the household – the level where food security is manifested in food access. IPCC (2014) identified at least two climate risks that have direct and indirect consequences on household food security. One is the loss of rural livelihoods and income; and the other one is the breakdown of food systems. These risks brought about by climate change have cascading effects on food security. From a range of physical, biological, and biophysical impacts of climate change, which translate into impacts on agricultural production, including postproduction; consequences are cascaded to the quantity, quality, and price of food available. These in turn affect the livelihoods of farm and non-farm households, and ultimately, food security (IPCC 2014).

These cascading impacts of climate change may be amplified or reduced depending on the intensity of climate hazards and on the underlying vulnerabilities of the food system to such climate hazards. FAO (2016) states that reducing vulnerabilities is key to reducing impacts of climate hazards on food security. The key to reducing vulnerability is to enhance the adaptive capacity of people (Thornton et al. 2014). Depending on the adaptation strategies used to cope with the impacts, food security under an extreme weather event may vary across households.

Methodology

Study Area and Data Collected

It is the intention of this study to select an area that is vulnerable to climate change. One of the most vulnerable areas is the Laguna Lake watershed. Home to over 12 million Filipinos, which represent 13% of the country's population, Laguna Lake supports a range of environmental goods and services to its communities as well as to other stakeholders within and outside the basin. Its proximity to Metro Manila and growing industrial development areas surrounding the province is already putting pressure on its ecosystem due to exacerbating environmental stress and climate hazards that impair the environmental condition in the watershed.

The study was conducted in the Sta. Cruz subwatershed, which is part of the Laguna watershed. Based on the flood and landslide hazard maps generated by the Mines and Geoscience Bureau, Department of Environment and Natural Resources, this area is considered vulnerable. Within the subwatershed, three municipalities were selected to represent high, medium, and low elevation areas and within each municipality, two barangays were included as survey areas (Table 1). The choice of the sites was based on the availability of secondary data on biophysical and climate-related characteristics and the accessibility of the location.

A total of 169 randomly selected households equally distributed in six barangays participated in the survey. This sample size was calculated based on the 4,855 household population in the study areas with 95% confidence level and 7% confidence interval. Budget and time constraints were also factors in the determination of the sample. Primary information on the households' socio-economic profile, food sources, knowledge, and perceptions on extreme weather events and food security; perceived impacts of the extreme weather events they experienced; perceived household food security status and vulnerability; and their coping strategies against extreme weather events and food security problems were obtained from the household-respondents using a pre-tested questionnaire. Prior to the survey, focus group discussions and key informant interviews were also conducted to determine the type of extreme weather events most commonly experienced in the areas and to validate the information to be generated from the survey. Secondary data were also gathered from the provincial and municipal agricultural offices, national government agencies, and related studies available.

Table 1. Study sites and number of survey respondents, Sta. Cruz subwatershed, Laguna, 2014

Study Sites (Muncipality/ City/ Barangay)	Elevation	Household Respondents	
		No.	%
Nagcarlan	High (more than 470 meters		
San Francisco	above sea level)	28	17
Bucal		28	17
Liliw	Medium (20-470 meters		
Calumpang	above sea level)	27	17
Bungkol		28	17
Sta. Cruz	Low (10-20 meters above sea		
Patimbao	level)	29	17
San Pablo		29	17
Total		169	100

Analytical Methods

Descriptive statistics using frequency counts, percentages, and cross-tabulations were used to describe the socioeconomic profile of the households, other characteristics related to their food access and exposure to extreme events, and their coping strategies for extreme events and food security problems.

The food security status and food vulnerability of households in the face of an extreme event was analyzed using a subjective-qualitative technique. While objective -quantitative methods often provide a more direct, accurate, and valid measures of food security, the strength of self-assessment or perception-based food security analysis that deals with the subjective dimension of food security cannot be discounted. With the multi-faceted nature of food security, which has no single indicator that can capture all its aspects, acceptable alternative indicators have already been developed to enable the gathering of relevant and timely information especially when the cost and time required in collecting objective-quantitative data are limited (Migotto et al. 2005). Since the 1990s, there has been an increased emphasis on the subjective dimension of food security – that is, as household members perceive their own food security (Maxwell 1990, Gillespie and Mason 1991).

Guided by this notion, this study used two sets of indicators based on retrospective information about their past extreme event experiences to analyze household food vulnerability. These are (1) households' perception of food security under an extreme weather event and (2) their perceived extent of impact of the extreme weather event on factors related to food security – that is, their "vulnerability as experienced." For both indicators, a five-point Likert scale method with factor analysis (i.e., principal component analysis) was used to generate nominal ratings of households' perceptions, which were then used to create a food vulnerability index.

The index was calculated using a summated score of the households' impact ratings of the extreme weather event experienced and the corresponding score of their level of agreement to statements related to food security under an extreme event. The scores for these two indicator sets, which were composed of 11 items, served as the basis for categorizing households as either "more likely to be food insecure" or "less likely to be food insecure" during extreme weather event. A respondent could have a maximum summative score of 55 points and a minimum score of 11 points. The summative scores were then divided by 11 to generate the mean score rating that would categorize the respondents into either of the following:

Less likely to be food insecure (1.00-2.99): Respondents registered a food vulnerability index score of at most 32 points out of the 55 possible points. They were perceived to be less likely to be vulnerable to food insecurity when an extreme weather event occurs.

More likely to be food insecure (3.00-5.00): Respondents registered a food vulnerability index score of at least 33 points out of the 55 possible scores. They were perceived to be more likely to be vulnerable to food insecurity when an extreme event occurs.

The food vulnerability categories were further subjected to analysis by determining the factors that could affect food insecurity during extreme weather event using a binary logit model estimation. With food vulnerability category as the dependent variable, the model was defined as function of the explanatory variables listed in Table 2 and expressed as:

$$Fsvul = \alpha + \beta_1 Inc + \beta_2 Tenure + \beta_3 Assist + \beta_4 Fsknow + \beta_5 Eeinfo + \beta_6 Elev + \beta_7 Vul + \beta_8 Farming + \beta_9 Farminc + \beta_{10} Cropdiv + \beta_{11} Mktdep + \beta_{12} Mktkm + \beta_{13} Incdiv + \beta_{14} CS\_EE + \beta_{15} CS\_FS + \varepsilon$$

The analysis also included examination of the household coping strategies for addressing food security problems. Coping strategies are a widely accepted indicator of food security that is relatively simple and quick to use, straightforward, and correlates well with more complex measures of food security (Maxwell and Cadwell 2008). According to the World Food Programme (2009), it is the nature of people to respond using coping strategies when they do not have "enough" food to eat, as they feel. They do not wait until they completely have nothing to eat but rather find strategies to minimize risks to their livelihoods and food security. The type of coping strategies adopted by households thus reflects the severity of the disruptive conditions that put their food security at risk. Here, the coping strategies were pre-identified based on the literature and information obtained from the focus group discussions. It should be noted, however, that information about how frequent the coping strategies were employed, which is a common component of other coping strategy indices for food security, was not deduced in this study but focused only on the type of coping strategies that households applied during the last time they experienced food security problems in the face of an extreme weather event.

Results and Discussion

Household Characteristics

The majority of the households are male (82%), married (76%), have a household size between four to six members (55%), and are elementary graduates and high school undergraduates (40%) (Table 3). In terms of primary occupation of household head, the majority work as farmer or in farm-related jobs (60%).

Table 2. Definition of variables in the binary logit model of food vulnerability

Variable-Name	Variable	Definition
Dependent Variable		
Fsvul	Food vulnerability during extreme event	1 if household is more likely to become food vulnerable in times of extreme event, 0 otherwise
Independent Variables		
Human Risks		
FSknow	Knowledge about food security	1 if household has an understanding of the concept of food security, 0 otherwise
Eeinfo	Information about the arrival of a calamity	Number of hours the household received an information before a calamity comes
Physical Risks		
Elev	Barangay with high elevation	1 if household lives in barangay with high elevation, 0 otherwise
Vul	Vulnerability of barangay	1 if household lives in vulnerable barangay, 0 if living in less vulnerable barangay
Economic Risks		
Inc	Household income	Total annual income of household during the year with extreme event (PhP/year)
Tenure	Ownership of farmland	1 if household owns the farm land he is using, 0 otherwise
Incdiv	Income diversification	Total number of income sources of household during the year with extreme event
Farming	Engagement in farming	1 if household engages in farming for a living (farm household), 0 otherwise
Farminc	Farm income contribution	Proportion (%) of farm income to total household income per year
Assist	Assistance received	1 if household received assistance to cope with the effects of extreme event, 0 otherwise
Food availability and access risks		
Mktdep	Market dependency for food	1 if the primary source of rice of household during the year with extreme event is the market, 0 otherwise
Mktkm	Distance to source of food	Average distance to primary source of food of household (kilometer)
Cropdiv	Number of agricultural commodities produced	Total number of types of agricultural commodities (crops and animals) produced by households during extreme event
Coping Strategies		
CS_FS	Coping strategies against food shortage	Total number of coping strategies of household against food shortage/ deprivation
CS_EE	Coping strategies against the impacts extreme event	Total number of coping strategies of household before, during, and after the occurrence of extreme event
α and β's	Parameters to be estimated	
ε	Error term	

Table 3. Distribution by socio-demographic characteristics, 169 households, Sta. Cruz subwatershed, Laguna, 2014

Household Characteristic	No.	%
Sex		
Male	139	82
Female	30	18
Marital status		
Single	8	5
Married	128	76
Widow/widower	19	11
Others	15	9
No. of years in school (average)	9.15	
Elementary level	12	7
Elementary graduate/ high school level	68	40
High school graduate	56	33
College level/graduate	35	21
Primary occupation		
Farming/farm-related activities	51	30
Laborer	37	22
Trade-related jobs	19	11
Service worker	37	22
Others	25	15
Household size (average)	4.44	
1-3 members	57	34
4-6 members	93	55
more than 6 members	19	11

Food Security Definitions of Households

Prior to the analysis of household food security, it is essential to know how households define food security. Almost half of the respondents (49%) interpreted food security as having sufficient food for their families (Table 4). Others (12%) viewed food security as a short-term concern of having enough meals per day. Other definitions include "having available and accessible food" (6%) and "having safe and nutritious food" (3%). About 21% of the households were not able to explain what food security is. Examining their answers, it is apparent that food security is generally interpreted by households in the context of the food access dimension of food security.

Table 4. Definition of food security, 169 households, Sta. Cruz Subwatershed, Laguna, 2014

What is your understanding of food security?	No.	%
Having enough food supply	83	49
Having enough daily meals	20	12
Having available and accessible food	10	6
Having safe and nutritious food	5	3
Others	14	8
Don't know/no answer	37	22

Food Access of Households

At household level, food access is the most important component of food security. It can be influenced by different economic, physical, and socio-political factors. Here, households were described in terms of the indicators of economic and physical access to food, which include household income, diversity of income sources, engagement in agricultural activities as a source of income, market dependency, and distance to source of food. The selection of food access indicators was based on the determinants used by WFP (2009) in its Emergency Food Security Assessment (EFSA), but focused mainly on household measures only. Market indicators related to food access (e.g., market characteristics, prices, trade volumes, consumer price index, etc.) are not covered in this paper.

Almost all households (92%) in the vulnerable areas of Sta. Cruz subwatershed are net food buyers (Table 5). The average distance from home to market was recorded at 1.98 kilometers (km) per way. For those engaged in agri-food production, results indicate that only 9% of their produce is used for home consumption while the rest is sold to earn income. Most of these farm households produce only one type of food commodity, indicating non-diversity in their food production. About 29% of them own the land that they till while the remaining farmers are tenants or renting their lands.

Table 5. Food access characteristics, 169 households, Sta. Cruz subwatershed, Laguna, 2014

Food Access Indicator	No.	%
Source of basic food		
Rice		
Own-produced	10	6
Bought	155	92
Given	3	2
Fruits and vegetables		
Own-produced	25	15
Bought	128	76
Given	14	8
Meat, fish, and poultry		
Own-produced	5	3
Bought	164	97
Given	0	0
Distance from home to market (km)	1.98	
Food stocks (% of farm harvests used for home consumption)	8	9
Number of types of commodities produced		
None	61	36
One (1)	71	42
Two (2)	27	16
Three (3) to five (5)	10	6
Number of sources of income		
One (1)	57	34
Two (2)	74	44
Three (3)	27	16
Four (4) to five (5)	7	4
Households with income from farming/farm activities	57	34
Proportion of farm income to total income (%)	22.32	
Farm land tenure (owns the land used in farming)	49	29
Average household income (PhP/year)		
Latest year without extreme event (2014)	174,818	
Year with worst extreme event (various years)	130,509	

In terms of income, 78% of households indicated only one or two sources of income, the majority of which include farming activities, unskilled labor, and service -related work (Table 5). Among them, 34% had income coming from farm and farm-related activities. On the average, income of households was found to be lower in the year when they were hit by the "worst" extreme weather event (PhP130,509) than their latest income in the year without any extreme event (PhP174,818), although the difference may be smaller if adjusted for inflation.[4]

Extreme Weather Events Experienced by Households and their Coping Strategies

All households interviewed live in vulnerable areas within Sta. Cruz subwatershed and are expected to have experienced at least one type of extreme weather event. But for the purpose of this study, the analysis focused only on one type of extreme weather event. Through the focus group discussions and survey, the most common and most notable extreme weather event experienced by households in the last 10 years was determined to serve as the key reference point in analyzing their food security and vulnerability. Data reveal that the most common and unforgettable extreme weather event experienced is strong typhoon. More than half of the households (52%) particularly identified typhoon *Ondoy* as the worst that they experienced, with some identifying other typhoons such as *Santi* (22%) and *Milenyo* (15%) (Table 6). Given this information, the reference extreme weather event used in the interviews and analysis is strong typhoon. Hence, for the rest of this paper, the extreme weather event refers to the worst strong typhoon experienced by households.

Table 6. Extreme weather events experienced,169 households, Sta. Cruz subwatershed, Laguna, 2004-2013

Extreme Weather Event	Experienced the Extreme Weather Event		Considered as the Worst Extreme Weather Event Experienced	
	No.	%	No.	%
Yolanda	19	11	12	7
Ondoy	101	60	88	52
Milenyo	46	27	25	15
Santi	51	30	37	22
Others[a]	20	12	7	4

[a] Others include other typhoons (Frank, Pablo, Sendong, Osang, and Reming), El Niño phenomenon, and monsoon rain (habagat)

Source: Quilloy et al. (2014)

With reference to the "worst" extreme weather event identified, respondents were asked what coping strategies they adopted before, during, and after the occurrence of the event. Figure 1 shows that 56% of the households bought and stored food to have reserves and 40% of them reinforced their house to prevent serious damage prior to the calamity. During the calamity, securing assets (13%) and evacuation or relocation (12%) were done by few respondents while many did not employ any coping strategy as it might not be safe to get out of their homes while there is a calamity. After the extreme weather event, 80% said that they reinforced again their houses, which suggests that most of their houses were damaged.

[4] Bangko Sentral ng Pilipinas official exchange rate of Philippine pesos (PhP) per U.S. dollar (US$) was PhP47.64 in 2009 and PhP44.05 in 2014.

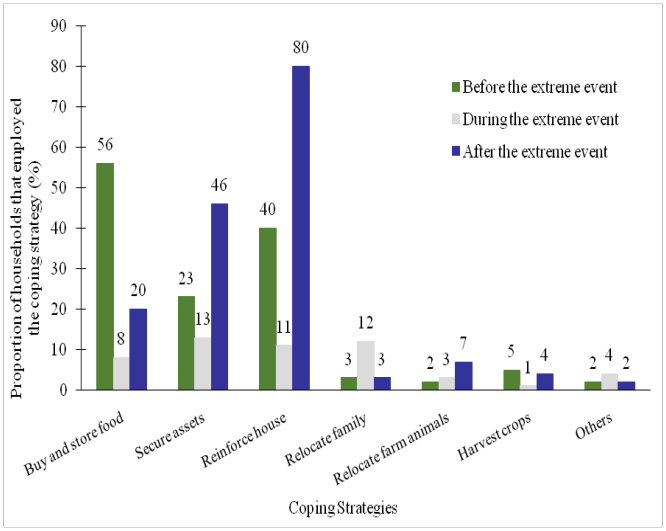

Figure 1. Coping strategies employed for the "worst" extreme weather event, 169 households, Sta. Cruz subwatershed, 2004-2013 (multiple responses allowed)

Source: Quilloy et al. (2014)

Food Vulnerability of Households During Extreme Weather Event

Perceived Impacts of Extreme Weather Events

Households were asked to self-assess using a 5-point rating scale (with 1 being the lowest indicating no or minimal impact and 5 being the highest indicating severe impact) the extent of impact or damage of the "worst" extreme weather event that they experienced on different aspects or categories related to food security which are listed in Table 7. Of all the categories, the logistics aspect – access to road, infrastructure, water, and electricity – appeared be the most affected, as denoted by its mean score rating of 3.43. This is followed by the job or source of income and assets or properties, which received an average rating of 3.18 and 2.56, respectively. The mean score ratings for the rest of the impact categories were found to be below the median score of 2.50, indicating less severe impact of the extreme event. These findings indicate that the households are most affected by extreme weather events in terms of those factors related to physical and economic access to food. Overall, the extent of impact on households was found to be moderate, given the average extreme event index score of 19.85, which is almost half of the maximum possible index score (40) that a household could give.

Household Perception of Food Security During Extreme Weather Event

The perceptions of household respondents about food security as affected by extreme event were also examined using the following statements to which they were asked to agree or disagree:

- Food security can be affected by extreme events;
- Food are less available and accessible during times of extreme event; and
- We are less food secure during times of extreme event.

The majority of households (83%) agreed that food security can be affected by extreme weather events and 68% agreed that food are less available and accessible in times of extreme weather event (Table 8). Lastly, 64% perceived themselves as less food secure when there is an extreme weather event.

Table 7. Perceived extent of impact of extreme weather event, 169 households, Sta. Cruz subwatershed, Laguna

Impact Category	Mean Score Rating
Assets/ properties	2.56
Logistics	3.43
Job/source of income	3.18
Food sources	2.46
Food consumption	2.20
Health and nutrition	1.75
Education of children	2.02
Emotional well-being	2.25
Impact index score (40/40)	19.85

Source: Authors' calculations

Table 8. Perception of food security under an extreme weather event, 169 households, Sta. Cruz subwatershed, Laguna, 2014

Statement	Level of Agreement					% of Households that Agree
	Strongly Agree (%)	Agree (%)	Do not know/ Undecided (%)	Disagree (%)	Strongly Disagree (%)	
Food security can be affected by extreme weather events.	23	60	9	5	2	83
Food are less available and accessible dur-ing times of extreme weather	17	50	10	21	2	68
We are less food secure during times of extreme weather event.	14	50	12	20	4	64

Source: Quilloy et al. (2014)

Likelihood of Food Vulnerability During Extreme Weather Event

Based on the summated scores from data in Tables 7 and 8, results reveal that 62% of households are more likely to be food insecure when an extreme event occurs (Table 9). Only about 38% fell under the category "less likely to be food insecure in times extreme weather event."

Table 9. Food vulnerability during extreme weather events, 169 households Sta. Cruz subwatershed, Laguna, 2014

Food Vulnerability Category	No.	%
Less likely to be food insecure (food vulnerability index score: 1.00 – 2.99)	64	38
More likely to be food insecure (food vulnerability index score: 3:00 – 5.00)	105	62

Among the explanatory variables in the binary logit model for food vulnerability, nine factors appeared to significantly affect the likelihood of a household to become food insecure when an extreme weather event occurs. These include the number of hours households received early warning before the arrival of extreme weather event, elevation of barangay, household income and diversity of its sources (number of income sources), ownership of farmland or tenurial status, access to assistance for coping with extreme weather event impacts, distance from the source of food bought, variety of crop produced (number of types of food commodities produced), and number of coping strategies against extreme weather event employed by households (Table 10).

Table 10. Marginal effects of the explanatory variables in the binary logit model of foodvulnerability, Sta. Cruz subwatershed, Laguna, 2014

Variable Name	Marginal Effect	p-value
Fsknow	0.7696*	0.100
Eeinfo	-0.0055*	0.085
Elev	0.2780**	0.030
Vul	0.1521	0.356
Inc	-0.000001*	0.052
Tenure	0.3592***	0.010
Incdiv	0.1712*	0.078
Farming	-0.2702	0.612
Farminc	-0.0006	0.208
Assist	0.3998**	0.049
Mktdep	0.2666	0.342
Mktkm	-0.0508**	0.050
Cropdiv	-0.1151*	0.076
CS_EE	-0.0789*	0.068
CS_FS	-0.0416	0.178
Likelihood Ratio test (c^2)	36.31	
Pseudo R^2	51.07	
p-value	0.0026	

Notes: Dependent variable is food vulnerability, where 1= more likely to be food vulnerable, 0 otherwise
***,**,* Significant at 1%, 5%, and 10% probability levels, respectively

Source: Authors' calculations

The number of hours of getting information about a calamity is critical in preparing coping strategies against extreme weather events. The lesser the time a household learns or is warned about the arrival of the calamity, the greater the probability of falling below the food security threshold when the extreme weather event occurs. Households living in high elevation are also found to have greater chances of becoming food vulnerable compared to those in medium or low elevation areas.

Income is negatively related to food vulnerability, which means that the higher the income of the household, the less likely it could be food vulnerable due to extreme weather event. One reason could be that households with higher income are likely to have more capacity to handle extreme weather events and food insecurity because they are financially-capable to employ coping strategies. What is surprising is the positive influence of land ownership and income source diversity on the likelihood of a household to become food vulnerable. This result can be explained by the fact that the majority of the sources of household income (e.g., farming, construction, and office work), though diverse, are found to be climate-sensitive.

Land ownership, on the other hand, might have failed to represent asset ownership in this study because of the very small area (less than a hectare) of landholdings of most of the households. Households that receive assistance from the outside during extreme weather event are also found to have greater probability of becoming food insecure in the occurrence of an extreme weather as this may manifest high dependence on the government, non-government, and other institutions for help (e.g., relief goods and donations), which has the risk of being inadequate or delayed.

For food access factors, the number of commodities produced by households and the distance from home to market are found to both negatively affect the probability of a household to become vulnerable to food insecurity when there is an extreme weather event. These results are reasonable since having more commodities produced would mean more choices for consumption and more ease in shifting to other commodities that may be more resilient to climate hazards. As such, effects of the extreme weather event on food security can be minimized. Moreover, households acquiring their food from distant sources are more likely to experience physical access problem when a calamity arrives, for instance, when the roads going to the market are flooded or when it is raining too hard and it is dangerous to travel far.

Finally, the number of coping strategies of households against extreme weather events is found to be a significant factor. The negative coefficient indicates that the fewer coping strategies employed by the household, the greater the probability of becoming food insecure in times of an extreme weather event. Understandably, if a household is able to cope with the effects of an extreme weather event, particularly on its economic and livelihood activities, then it is more likely to limit its indirect effects on food security.

*Coping Strategies for Food Security Problems During Extreme Weather Eve*nt

The number and type of coping strategies that a household employs are also a reflection of the severity of the food security problems such as food deprivation and food shortage experienced during an extreme weather event. There were 11 coping strategies identified, which generally involve food consumption- and income-related mechanisms that the households employ to prevent food insecurity.

A typology of household food security problems was made based on the number and type of coping strategies (Figure 2). It indicates that income-related coping strategies imply less severe form of food security problem compared to food consumption-related coping strategies, except if the consumption-related strategy is to produce their own food. Conversely, food consumption-related strategies such as food rationing and relying on others for food denote a relatively severe food security problem. In terms of number, employing more coping strategies is associated with dealing with more serious problem of food insecurity.

About 20% of households indicated that they did not employ any coping strategy mainly because they never suffered from any food security problem (Table 11). On the other hand, for households that employed coping strategies, the majority (33%) adopted two to three types of coping strategies, 28% employed only one coping strategy, and 19% employed at least four strategies. Based on the number of coping strategies, it can be deduced that most of the households are likely to be experiencing moderate food security problems, with a few suffering from severe ones.

	Mild Food Security Problems	Moderate Food Security Problems	Severe Food Security Problems
Income-related Strategies	• Use savings • Avail agricultural insurance	• Delay payment of utility bills • Reduce health and education expenses • Sell assets • Borrow money/ buy food on credit	
Food Consumption-related Strategies	• Produce own food	• Substitute preferred food with cheaper or less preferred food	• Consume smaller volume of food (rationing) • Dine at other's house • Ask for food assistance from the outside
Number of Coping Strategies Employed	One (1)	Two (2) to three (3)	More than three (3)

Figure 2. Typology of household food security problems based on coping strategies

Table 11. Number of food insecurity coping strategies, 169 households, Sta. Cruz subwatershed, Laguna

Number of Coping Strategies Employed	No.	%
None	34	20
Only 1	47	28
2 to 3	56	33
4 to 5	27	16
More than 5	5	3
Average number of coping strategies per household	2.04	

Among the coping strategies, the most commonly employed were the income-related strategies. About 42% of the households used their savings to buy sufficient food for their family (Figure 3). The "use of savings" is a mechanism that makes use of monetary savings or saved commodities from harvest (e.g., seed stock and fruits and vegetables for sale) to augment the cash available for household to spend on food or to have readily available food for their consumption, respectively. With this type of strategy, it is understood that households have savings that can be used in times of food stress. This indicates a mild form of food security problem since food availability and access are immediately maintained with the available emergency funds or food reserves at home.

The next prevailing coping strategy is the "borrowing of money to spend on food or purchasing food on credit" (36%), which is a short-term strategy used to immediately augment a household food supply. Compared to the "use of savings," borrowing money to buy food or purchasing food on credit implies a moderately more serious form of food security problem because the action suggests that the household does not have own financial means to buy food, hence the need to rely on credit. From the interview, most of the respondents (75%) said that they usually borrow money from their friends and relatives and about a quarter of them buy food on credit from neighborhood stores. Only one respondent indicated that he borrowed money from a microfinance institution.

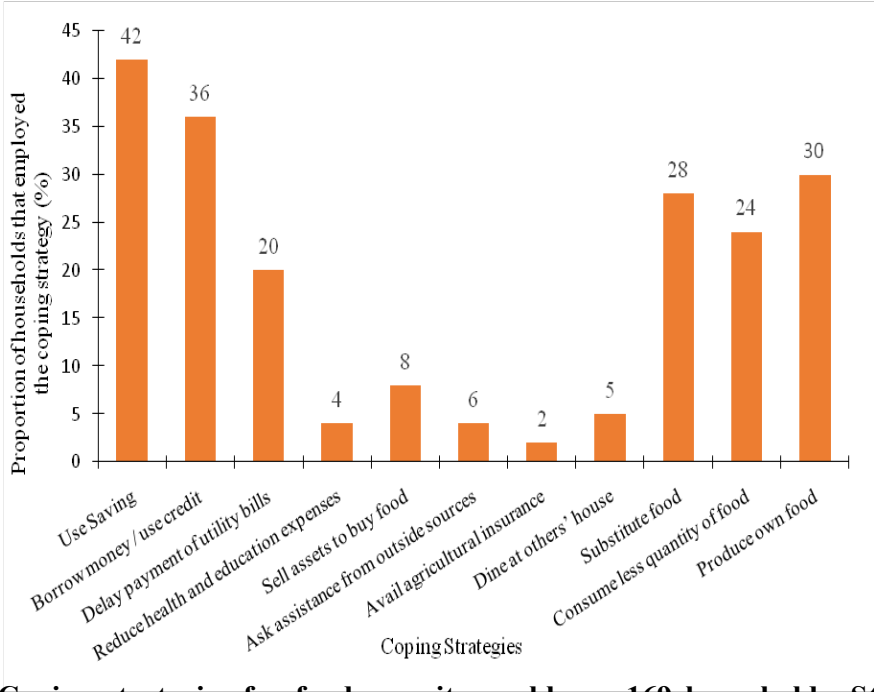

Figure 3. Coping strategies for food security problems, 169 households, Sta. Cruz subwatershed, Laguna

Source: Quilloy et al. (2014)

Other income-related coping strategies employed by households included "delaying their payment of utility bills" (20%) and "reduction of health and education expenses" (4%) to prioritize food spending; and "selling of assets" to generate income for purchasing food (8%). All these coping strategies reflect a moderate household food security problem.

For farm households, "availing of agricultural insurance" is a distinct way to cope with the risk of food insecurity that could result from unexpected losses in farm income and food production. While income-related coping strategies initially affect household assets and do not reflect a severe food security problem, food security status of households may worsen in the long run if these strategies are continuously adopted over a long period of time until its impacts, especially on economic access to food, become irreversible.

For consumption-related coping strategies, two mechanisms appeared to be predominant. One is the "production of own food" (30%), particularly of vegetables, instead of relying on the local sellers in the market (Figure 3). Like "availing of agricultural insurance", this strategy is a positive mechanism, which most likely, is intended to prevent problems related to availability of affordable food in the markets. The capacity of a household for own food production suggests that it has the capacity and means to engage in food production despite experiencing food security problems.

The other food consumption-related coping strategy commonly employed is the "substitution of preferred food with less preferred and cheaper ones" (28%), which is a form of dietary change used to cope with food deprivation and food shortage. This coping strategy implies that a household's capacity or purchasing power to buy their preferred food is being affected by the food security problems to the point that it already needs to adjust its regular food consumed. As some of the respondents specified, they shifted from rice to sweet potato during the time they experienced food shortage. Others did not buy protein-rich food like meat and fish anymore and instead settled with vegetables, which are relatively cheaper. While such dietary change can be reversible, employing it in the long run could worsen the state of household food insecurity due to its serious repercussion on the dimension of food utilization.

A related coping strategy is rationing or managing of shortfall by reducing food intake. About 24% of the household respondents indicated that they employed this strategy (Figure 3). Among all the coping strategies, "consuming less quantity of food" can be considered as the most destructive mechanism for households. Households resorting to such coping strategy are presumed to be suffering from severe food security problem. This rationing strategy may involve cutting portion size of each household member during mealtimes, restricting consumption of adults to prioritize adequate consumption of children, reducing number of meals eaten in a day, or the worst, skipping entire days without eating. Like shifting to less preferred or cheaper food, reducing food intake can be reversed if no longer needed. However, if done regularly in the long run, state of food insecurity may worsen due to its serious consequences on households, especially on their health and nutrition.

Conclusion

This study reveals that households in the vulnerable areas of Sta. Cruz subwatershed are generally resilient to extreme weather events with impacts on their food security being moderate. Households are most affected by extreme weather events in terms of their job or source of income, logistics, and assets or properties, all of which are important elements of having adequate economic and physical access to food. For most households, resilience to food insecurity during an extreme weather event is found to rely on maintaining enough economic access to food.

The type and number of coping strategies for food security problems indicate that the majority of households suffered only from slight to moderate form of food security problems but felt less food secure when an extreme weather event occurred. In addition, households are able to successfully apply coping strategies before, during, and after an extreme weather event, which could have contributed to minimizing the negative impacts of the event on the state of their food security.

While no severe form of food insecurity was found among the households, the food vulnerability analysis results show that the likelihood of a household to fall under a state of food insecurity may rise when there is an extreme weather event if it fails to have an early warning on climate hazards, adopt effective coping strategies against extreme weather events, and maintain adequate physical and economic access to food – one way is through own production of a variety of food. Overdependence on food assistance programs may not also be a sustainable strategy to cope with food security problems. Therefore, mechanisms such as early warning systems, public food distribution systems, controlled and targeted food assistance programs, and capacity building on adaptation strategies and coping mechanisms for climate resilience as well as in food production (e.g., home gardening and farming practices) must be put in place or strengthened to help households living in vulnerable areas ensure food security in times of extreme weather events.

Acknowledgments

This paper was drawn from the research outputs of the research project entitled, "Environment and Food Security Interactions under Climate Change in Selected Communities in the Marikina and Sta.Cruz/Pagsanjan Watersheds, and Manila Bay Coastal Areas." The authors would like to thank the Center for Integrative and Development Studies (CIDS), University of the Philippines for funding the research. The contributions of the project staff, Ms. Cristeta A. Foronda and research assistant, Mr. Armand Christopher C. Rola are also appreciated.

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Social Vulnerability to Climate Variability and Extremes of Farming Households in Puerto Princesa City, Palawan, Philippines

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Abstract

Climate-sensitive livelihoods are in the frontline of sectors which will be affected most by climate change. Without proper intervention, smallholder farmers would suffer from declining crop production, yield, and on-farm income, among others. Hence, this study aims to assess the social vulnerability of farming households residing in northern part of Puerto Princesa City, Philippines. Sustainable Livelihoods Framework (SLF) was used in developing separate social vulnerability indices for drought, typhoon, and early onset of rains. Unbalanced weighted approach through principal component analysis (PCA) was employed in assigning weights to the variables. Findings showed that financial capital has the highest contribution to the three indices generated through PCA. Results of independent t-test statistics show that farmers are more vulnerable to typhoon and early onset of rain compared to drought. The results of the study can generate new knowledge on how to determine the social vulnerability of a community in terms of livelihood.

Keywords: *social vulnerability, sustainable livelihoods framework, principal component analysis, smallholder farmers*

Introduction

Climate change is one of the greatest environmental challenges faced by mankind at present. Across literature, it is recognized that climate-sensitive livelihoods are in the frontline of the sectors which will be affected most and by alteration in climate (e.g., Vincent and Cull 2010,Wongbusarakum and Loper 2011, Olsson et al. 2014). Resource-dependent communities would more likely feel its impacts due to its combined effects on natural and social systems (Adger 2003 and Wongbusarakum and Loper 2011). The recent report of IPCC classifies rainfed smallholder agriculture and fishing as some of the directly sensitive livelihoods to climate-related events (Olsson et al. 2014).

The Philippines is considered as highly vulnerable to the projected impacts of climate change, wherein manifestations include rise in temperature and changes in precipitation such as increase in mean rainfall (IPCC 2007). It was observed that the country became warmer in the last few decades, recording an increase in annual mean temperature by 0.57°C in 1951-2009 period (PAGASA 2011). The country ranked fourth in terms of the countries most affected by climate-related events in 1995 to 2014 (Kreft et al. 2015). In 2013 alone, Typhoon Haiyan, one of the strongest typhoons on record to hit land, struck the country resulting to an economic loss of more than US$ 13 billion and 6,000 deaths (Kreft et al. 2014).

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Aside from being exposed to extreme events, the country's geographic location, low income, and its greater reliance on climate-sensitive sectors such as water resources and agriculture enhances its vulnerability (Hilario et al. 2009). PAGASA (2011) cited that changes in temperature, together with alteration in rain regimes and patterns, could severely distress the agriculture sector. For instance, scheduling of cropping season including the duration of the growing period of the crop could be altered due to changes in climate patterns. Hence, in the absence of timely interventions or management technologies, change in rain patterns or frequent occurrence of extreme events such as floods or droughts will lead to decline in the production of grain and other agricultural products (PAGASA 2011). In order to avoid mal-adaptation, there is an increasing need to conduct vulnerability assessment studies for appropriate program and policy formation.

Social vulnerability aims to assess the vulnerability of households in terms of their socio-economic characteristics. It pertains to the state of individual, of groups, of communities defined in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being (Adger and Kelly 1999). For the purpose of this study, social vulnerability was defined as the propensity of the household to suffer decline in production and income as a result of climate variability and extremes. Moreover, their present-day vulnerability was determined by examining their livelihood profile, specifically livelihood assets.

This paper is one of the first few attempts to assess the vulnerability of farming households in Puerto Princesa City using Sustainable Livelihood Framework (SLF) and principal component analysis (PCA). Unlike previous studies in the context of climate change vulnerability, this paper aims to discuss the varied determinants of vulnerability of farming households to three climate-related events — drought, typhoon, and early onset of rains. Specifically, it seeks to answer the following questions: What are the determinants of vulnerability of farming households to climate variability (i.e., early onset of rains) and extremes (i.e., drought, typhoon)? Among these determinants, what are the variables that account most for the differences in their vulnerability scores? The findings of this study can generate new learnings on how to effectively determine the social vulnerability of a community in terms of livelihood.

Methodology

Site Description

The study covered four *barangays* (districts) in Puerto Princesa City—Barangays San Rafael, Concepcion, Binduyan, and Langogan. It has a total land area of 39,521 hectares which are distributed to 32 *purok* (zones). The site is adjacent to Honda Bay, an important fishing ground and tourism destination in the city. Puerto Princesa City was chosen as the study site due to limited number of researches that were conducted in the area in the context of social vulnerability to climate-related events. Moreover, the four identified villages are heavily dependent on climate-sensitive livelihoods such as farming and fishing activities. Generally, almost 60% of the population relies on farming as main source of income. The livelihood profile of these barangays represents the condition of the whole province wherein agriculture remains as the prevalent source of income of residents.

Based on the Modified Corona's Classification of Climate, the area has Type III climate which is characterized by short dry season with varying heavy rainfall months. Dry period usually runs from January to April, while rainy season covers the rest of the year with September as the wettest month (City Government of Puerto Princesa, 2007). Figure 1 shows the administrative map of the study site.

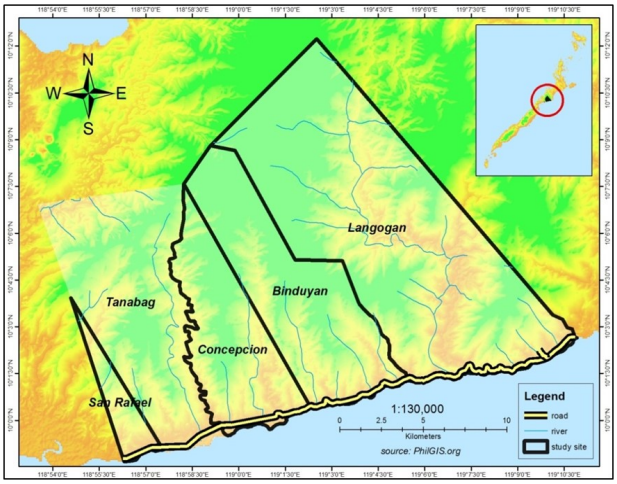

Figure. 1. Administrative map of the study site

Data Collection

Through extensive literature review and input from key informant interview (KII) and focus group discussion (FGD), 33 parameters belonging to seven indicators were selected as possible determinants of social vulnerability of farming households (Table _). Apart from the five capital assets which reflect the characteristics of the households, two more indicators were added to capture their climate-related experiences and adaptation. The proposed parameters were used in developing the survey instrument which was administered to household heads of the farming households in December 2012.

Table 1. Proposed indicators and parameters for the Social Vulnerability Indices (SVI) of farming households in the study site

Indicator	Description	Parameter	Hypothesized Relation to SVI	Source
Natural	Natural resource stocks from which resources flows and services useful for livelihoods are derived	1. Area of managed farms, 2. Number of types of crops planted 3. Average gross monthly farm productivity per hectare without extreme drought (1990, 1998, 2012) 4. Average gross monthly farm productivity per hectare without extreme typhoon (1990, 1994, 2012)	Negative	Wang et al., 2014;Pandey& Jha, 2012,Acosta-Mich-lik&Espaldon, 2008; Cutter and Finch, 2003; Moss et al., 2001 as cited in Vin-cent, 2004

Indicators	Description*	Parameters	Hypothesized Relation to SVI	Sources
Physical	Basic infrastructure and producer goods needed to support livelihoods	5. Number of farm equipment 6. Number of farm animals 7. Ave. frequency usage of pesticide per cropping 8. Ave. frequency usage of inorganic fertilizers per cropping 9. Ave. frequency usage of organic fertilizers per cropping	Negative	Pandey & Jha, 2012; Moss et al., 2001 as cited in Vincent, 2004
Financial	Financial resources that people use to achieve their livelihood objectives	10. Total household monthly income 11. Number of income sources 12. Area of farms owned 13. Percentage of on-farm income	Negative Positive	Ahsan, N. & Warner, J., 2014; Grasso et al., 2013; Pandey& Jha, 2012; Hahn et al., 2009;Acosta-Michlik&Espaldon, 2008; O'Brien et al., 2004; Cutter and Finch, 2003; Adger, 1999
Human	Characteristics that enable people to pursue different livelihood strategies and achieve their livelihood objectives	14. Number of working members 15. Number of farming skills of farmer 16. Years of education 17. Number of trainings attended 18. Years of farming 19. Age 20. Dependency ratio 21. Number of disabled members 22. Household size	Negative Positive	Wang et al., 2014; Grasso et al., 2013; Pandey & Jha, 2012; Hahn et al., 2009; Acosta-Michlik&Espaldon, 2008; Vincent, 2004; Cutter and Finch 2003; Moss et al., 2001 as cited in Vincent, 2004
Social	Social resources upon which people draw in pursuit of their livelihood objectives	23. Number of organizations 24. Distance to the nearest relative 25. Number of positions in the organizations 26. Length of residency in	Negative	Cutter and Finch, 2003

Indicators	Description*	Parameters	Hypothesized relation to SVI	Sources
Climate-related experiences		27. Number of experienced climate-related hazards	Negative	Wang et al., 2014; Hahn et al., 2009; Vincent, 2004;
		28. Sources of information on climate-related events		
		29. Number of changes in climate pattern that affected them	Positive	
		30. Monthly production loss per hectare on remarkable drought		
		31. Monthly production loss per hectare on remarkable typhoon		
		32. Monthly production loss per hectare on early onset of rain (2012-CV)		
Adaptation Strategies		33. Number of adaptation strategies	Negative	Wanget al., 2014

Source: DFID (1999), Morse and McNamara (2013)

Climate extremes were represented using the most remarkable drought and typhoon which were experienced in the study site. Based from the results of FGD, drought in 1994 as caused by El Niño and Typhoon Norming in December 1998 were, the most notable climate extremes which occurred in the villages. The households' observation was also supported by other villagers during the pre-testing of questionnaire. These events had caused crop failure which resulted in great financial loss for the farmers. On the other hand, climate variability was represented by early onset of rain. It is the most notable event among the climate anomalies which are being experienced in the study site.

Slovin's formula with a confidence level of 95% was used in determining the sample size, while simple random sampling was employed in selecting respondents. A total of 247 farming households were interviewed, but 11 questionnaires were dropped due to incomplete and inconsistent answers. The remaining 236 samples represent 75.40% of the total population of farming households.

Data Analysis

Three sets of indices indicating the farming households' vulnerabilities to drought, typhoon, and climate variability were constructed separately using principal component analysis (PCA)— a variable reduction procedure. PCA transforms large number of variables in a data set into smaller and more coherent set of uncorrelated factors or principal components (Krishnan 2010). It should be noted though that the results of the said indices pertain to present-day vulnerability. Apart from the volume of yield, number of crops, and number of adaptation strategies, other parameters in the three indices have the same values since they were based on the household assets during the time of interview. On the other hand, the first three parameters were based on their perceived impacts of drought and typhoon. For easy recollection, the most remarkable drought and typhoon in the area were used as the point of reference. For instance, majority of the respondents recalled that the drought in 1994 and typhoon in 1998 had the worst impact on their crops and farms.

Normalization of variables is recognized as an important step prior to an aggregation process (e.g., PCA) due to differences in measurement units of indicators in a data set (Vincent 2004, OECD2008, Krishnan 2010). Hence, to equate the variables at a scale of 0 to 1, two formulas were used depending on their hypothesized relationship to social vulnerability (Arias et al. 2014). Variables with positive influence were normalized using the following equation (Hahn et al. 2009, Arias et al. 2014):

$$y = \frac{(x_n - x_{min})}{(x_{max} - x_{min})} \quad (1)$$

while those with negative relationship were normalized using the following (Arias et al. 2014):

$$y = \frac{(x_{max} - x_n)}{(x_{max} - x_{min})} \quad (2)$$

Where, Y is the normalized value, X_n is the original value of the X variable of a certain respondent, while X_{min} and X_{max} are the minimum and maximum values of the entire X variable of the sampled respondents.

Following the procedure used by Krishnan (2010), variables from retained components with coefficients or loadings of more than 0.4 were chosen. Factor loading of significant variables were multiplied to the normalized value of the corresponding variables, then their products were summed to compute for the total component score. Since the variances of different components are not the same, their importance in explaining social vulnerability varies. The following formula was used for computing the non-standardized social vulnerability index (Krishnan 2010):

$$NSI = \left(\frac{var_1}{var_{total}}\right)(comp.1\ score) + \left(\frac{var_2}{var_{total}}\right)(comp.2\ score) + \left(\frac{var_3}{var_{total}}\right)(comp.3\ score) + \cdots \left(\frac{var_n}{var_{total}}\right)(comp.n\ score) \quad (3)$$

Where, Var_n is the percent of variance of component n and Var_{Total} is the total variation. The result was then multiplied to the corresponding component scores.

Since the resulted index is non-standardized, values can be positive or negative. Hence, standardization was applied to equate the values within a range of 0 to 1, wherein 0 represents the least vulnerable while 1 the most vulnerable (Abson et al. 2012).

$$SVI = \frac{(NSI_n - NSI_{min})}{(NSI_{max} - NSI_{min})} \quad (4)$$

where, NSI_n is the computed vulnerability score of a certain respondent while NSI_{min} and NSI_{max} are the minimum and maximum values of the vulnerability scores of the sampled respondents. Table 2 shows the level of vulnerability and corresponding value as adopted from Arias and colleagues (2014).

Table 2. Level of social vulnerability and corresponding value

Level of social vulnerability	Value
Low	0.0-0.49
Moderate	0.5-0.79
High	0.8-1.0

Results and Discussion

Socioeconomic Characteristics of the Sampled Households

A total of 247 farming households were included in the survey with 11 households discarded due to inconsistent information. As reflected in Table 3, majority of the respondents from farming households were male and have attained elementary education. Their age ranged from 19 to 85 years with a mean age of 46.32 years. On the average, the household size was 4.19 and each household has usually one working member. Monthly income varied from PhP 1,000 to PhP 70,000 per household, with an average of PhP 8,589. Using the annual poverty threshold for Palawan for 2012 (NSCB 2013), each household member should have a budget allocation of at least PhP 1,361.33 per month. This implies that a five member-household should have at least PhP 6,806.67 monthly income. This information suggests that, in general, households in the area were living above poverty thresholds.

Table 3. Descriptive statistics of respondents in Puerto Princesa City, 2012

Characteristic	Response	Percent
Gender		
Male	207	87.6
Female	29	12.4
Age (years)		
Mean	46.32	
Range	19-85	
Highest education attainment		
Pre-school	1	0.2
Elementary level/graduate	123	52.4
High school level/graduate	91	38.4
College level/graduate	19	8.1
Vocational	2	0.9
Household size		
Mean	4.19	
Range	1-10	
Number of working members		
Mean	1.41	
Range	1-5	
Household monthly income (PhP)		
Mean	8,589	
Range	1,000-70,000	

Note: Official exchange rate is 1US$= PhP 50.18 as of 28 March 2017, available at http://www.bsp.gov.ph/statistics/sdds/exchrate.htm

Determinants of Social Vulnerability to Drought

The profile of 121 respondents representing 51.27% of the sample households were used to develop the social vulnerability index to drought. Only the respondents who experienced the extreme drought in 1994 were included in the analysis.

This was done to ensure that the respondents will give a precise estimate of the impacts considering that it was based on their first-hand experience. Table 4 shows that four components with ten variables were significant in the model (factor loadings are greater than 0.4), which has an overall Kaiser-Meyer-Olkin(KMO) measure of sampling adequacy of 0.7010 indicating that the data set was middling and acceptable for the analysis. Also, all the significant variables have positive loadings, hence supporting their hypothesized relationship to social vulnerability to drought.

Table 4. PCA results for social vulnerability to drought of farming households

Variable	Relation to SVI	Comp 1	Comp 2	Comp 3	Comp 4	Un-Explained
1. Number of income sources	-	0.5209				0.1782
2. Percentage of on-farm income	+	0.5151				0.2701
3. Total household monthly income	-	0.4397				0.2159
4. Area of managed farms	-		0.6065			0.1246
5. Area of farms owned	-		0.5936			0.1543
6. Number of positions in the organizations	-			0.6093		0.3236
7. Number of trainings attended	-			0.5127		0.3413
8. Number of farming skills of farmer	-			0.4124		0.453
9. Number of changes in climate pattern that affected them	+				0.7335	0.2184
10. Number of types of crops planted	-				0.4028	0.5627
11. Number of working members	-					0.4017
12. Household size	+					0.6981
13. Number of organizations	-					0.4611
		21.63	18.49	14.86	11.14	
Number of observations= 121		Trace= 13		Rho=0.661		

Component 1 was named as Financial Capital considering that its three variables were income-related. Since this component has the highest percent of variance, it has the greatest contribution to the overall computation of social vulnerability to drought. This component suggests that farmers who have diversified income sources and high household monthly income will more likely exhibit lower vulnerability, while those who derive a large percentage of their monthly income from farming were more vulnerable to drought. Farmers who have other income sources are less vulnerable since they could use their off-farm or non-farm income to provide for their families and recover from impacts of drought. On the contrary, those who solely rely on their on-farm income are exposed to higher risk of financial loss considering that drought results to crop failure.

This concurs with the study of Vincent and Cull (2010) indicating that households which heavily depend on activities utilizing natural resources such as farming will more likely exhibit greater vulnerability to climate change. Meanwhile, farmers with higher household monthly income are less vulnerable since they could use their financial resources to cope with the impacts of drought. As cited by some of the respondents who have low income and savings, they have to apply for loans in order to replenish their capital and be able to plant again.

Although the second component was comprised of two variables from different capital assets, it was named as Natural Capital since its parameter (i.e., area of managed farms) obtained a higher score compared to that of financial capital (i.e., area of farms owned). As reflected in Table 4, both of these variables have negative relationship to vulnerability. This implies that the larger their managed and owned farms, the lesser will be their vulnerability to drought. Considering that decline in crop production is the most immediate impact of drought, farmers who have small farms are also faced with harvests that are too small to even feed their families. In the case of farm ownership, farmers who own larger piece of land will more likely be less vulnerable to drought since they could allocate some portions to planting while others to fallow; hence, reducing the cost of production and financial loss. As argued by Wood and colleagues (2014), wealthier farmers are more likely to make farm-associated changes to lessen the impacts of climate shocks in general.

The third component was comprised of two variables of human capital (i.e., number of trainings attended and number of farming skills) and one variable of social capital (i.e., number of positions in the organization). This component suggests that having more training, skills, and positions in organizations will lower the vulnerability of farming households. Intuitively, farmers who have attended trainings and possess different skills in farming are more likely knowledgeable of strategies to cope with the impacts of drought. Meanwhile, those who hold positions in the organization will more likely be the first to benefit from information-sharing within the group. Moreover, their large circle of influence could mean more hands to help in time of need such as crop failure from drought.

Meanwhile, the fourth component is categorized as climate-related experience since variable 'number of changes in climate pattern that affected them' has higher component loading as compared to 'Number of types of crops planted', an indicator of Natural Capital. This component indicates that their exposure to different climate anomalies increases their vulnerability to drought. This is expected since farmers who have been affected by different stressors might lack the resources or capital assets to cope with drought. Lastly, diversity of crops implies lower vulnerability since they cited that monoculture plantations are more prone to pests and diseases.

Using the generated scores from PCA, majority of the households exhibited low vulnerability (59.60%) to drought, while only 4.13% recorded high level of vulnerability. On the average, their score was 0.56 indicating moderate level of vulnerability to drought.

Determinants of Social Vulnerability to Typhoon

The respondents with first-hand experience on the impact of Typhoon *Norming* in 1998, the most remarkable typhoon in the area, were included in the analysis for social vulnerability to drought. They comprised 57.21% of the total number of sample households. Referring to Table 5, a total of 10 variables which are grouped into four components were found to be significant in the PCA model which has an overall KMO of 0.7034 implying that the data set was middling and acceptable.

Table 5. PCA results for social vulnerability to typhoon of farming households

Variable	Relation to SVI	Comp 1	Comp 2	Comp 3	Comp 4	Un-Explained
1. Number of income sources	-	0.525				0.1852
2. Percentage of on-farm income	+	0.5226				0.2739
3. Years of farming	-		0.579			0.2981
4. Length of residency in the community	-		0.5558			0.3927
5. Age	+		-0.5204			0.2794
6. Number of positions in the organizations	-			0.6094		0.3255
7. Number of trainings attended	-			0.5734		0.3305
8. Number of organizations	-			0.4493		0.45
9. Years of education	-				0.6433	0.354
10. Number of farming skills of farmer	-				0.4781	0.5004
11. Number of farm equipment	-					0.6333
12. Total household monthly income	-					0.5095
13. Number of working members	-					0.3632
		21.23	15.31	14.82	10.98	
Number of observations= 121		Trace= 13		Rho=0.6234		

As presented in Table 5, component 1 pertains to Financial Capital since both of its two variables are related to income. The same with vulnerability to drought, financial capital has the highest impact on vulnerability to typhoon of farming households. This component suggests that diversity of household income sources and lesser dependence on on-farm income will result in lower vulnerability to typhoon. Farmers who have other income sources and less dependent on on-farm income could still provide the needs of their families despite financial loss from farming. Moreover, they have higher capacity to cope with the impacts of typhoon on their livelihood since they could use their other income to replenish their capital for farming. Some farmers who lack sufficient income tend to avail loans and assistance from the government to be able to plant again.

Component 2 was named as Human Capital considering that two out of its three variables represent this type of capital (i.e., years of farming and age). It also included one social capital variable— length of residency in the community. This component indicates that the longer the involvement on farming activities and length of residency in the community, the lesser will be their vulnerability to typhoon. Farmers who have been engaged in faming activities for a longer time will more likely possess more knowledge on coping with the impacts of different climate-related shocks including typhoon.

Meanwhile, those who have been members of the community for a longer period might be more familiar with different climate-related shocks and have developed adaptation strategies to reduce their impacts. Moreover, they already established relationship with other community members who could help them to recover from the impacts of typhoon. Variable 'age', on the other hand, has obtained a negative score indicating the opposite of the hypothesized relationship. This suggests that older farmers more likely exhibit lower vulnerability to typhoon. As argued by some of the key informants, older farmers have already tested different strategies to adapt to the impacts of typhoon such as planting appropriate crops. For instance, those who used to plant cashew trees have shifted to planting of other crops since they observed the drastic decline in their production.

Among the three variables of the third component, two variables are related to social capital (i.e., number of positions in the organizations and number of organizations) while the other one is an indicator of human capital (i.e., number of trainings attended). Hence, the third component was named as Social Capital. This component implies that a farmer who is affiliated with many organizations, especially those who are holding a position, will exhibit lower vulnerability to typhoon. This is associated with higher likelihood of farmers to get assistance, either financially or in kind (e.g., farming inputs and labor), from their circle of influence. Moreover, they could benefit from information-sharing within the group. Meanwhile, those who have attended trainings on farming will more likely possess knowledge on recovering or coping with the impacts of typhoon (e.g., adoption of contour-farming to reduce flooding).

The fourth component refers to Human Capital with a specific focus on skill sets. It suggests that the higher the educational attainment and number of farming skills of the farmer, the lesser his/her vulnerability to typhoon. This is expected since these farmers will more likely possess knowledge and capacity to cope with the impacts of typhoon. Moreover, those who have higher educational attainment could seek other jobs to replenish their capital for farming. Also, they will more likely have the capacities to easily comprehend climate-related information (e.g., disaster preparedness). Saldajeno and colleagues (2012) cited that high educational attainment would mean more skills and opportunities for livelihood strategies.

Based on the results of PCA, majority of the farming households exhibited moderate vulnerability (65.19%) to typhoon, while 14.07% of the respondents were highly vulnerable. The mean social vulnerability to typhoon of the farming households was 0.61 implying moderate level of vulnerability.

Determinants of Social Vulnerability to Early Onset of Rains

Among the climate anomalies experienced by the farming households, the most notable was early onset of rain; hence, it was used as an indicator of climate variability. Residents in the villages observed higher frequency of early onset of rain as compared before 1990s. This has been mentioned by the participants of the FGD and KII, as well as respondents of the household survey, although some of them were not affected by this climate anomaly.

For the formulation of the vulnerability index to climate variability, profiles of the 236 farming households were included in the analysis. A total of 10 variables from four components were found to be significant in the PCA model with an overall KMO of 0.7091 implying that the data set is middling and acceptable. Table 6 shows the significant variables in the model.

Table 6. PCA results for social vulnerability to climate variability of farming households

Variable	Relation to SVI	Comp 1	Comp 2	Comp 3	Un-Explained
1. Number of income sources	-	0.5574			0.1896
2. Percentage of on-farm income	+	0.5248			0.2762
3. Number of working members	-	0.4524			0.4366
4. Total household monthly income	-	0.4313			0.4705
5. Number of positions in the organizations	-		0.645		0.3377
6. Number of trainings attended	-		0.5398		0.3859
7. Number of organizations	-		0.5176		0.4295
8. Area of farms owned	-			0.6887	0.2865
9. Number of types of crops planted	-			0.5056	0.5709
10. Length of residency in the community	-				0.788
Percent of variance		24.37	18.13	15.79	

Number of observations= 236 Trace= 10 Rho=0.5829

Component 1 refers to Financial Capital since three (i.e., number of income sources, percentage of on-farm income and total household income) out of its four variables are income-related. This component has the highest contribution to social vulnerability index to early onset of rains. It suggests that diversity of income sources, more working members, and higher household income lessen the vulnerability of the farming households. As explained in other vulnerability indices, diversity of income and higher household income would enable farmers to meet their family needs and replenish their capital in farming in case they suffer a decline on their on-farm income. Meanwhile, more working members in the family would mean more hands to carry the burden of providing for the family and purchasing farm inputs. On the other hand, higher dependence on on-farm sources of income enhances their vulnerability to climate variability since there is a higher risk of financial loss.

Component 2 was named as social capital, although one of its three variables is an indicator of human capital. This component implies that affiliation with more organizations lessens the vulnerability to climate variability of farming households, especially if they are holding some positions. This is associated with higher likelihood that farmers could learn and adopt some techniques from their fellow members. Moreover, they could seek assistance from them. For instance, seedlings were shared by some respondents to other famers and some even help in land preparation and planting activities. Meanwhile, this component also suggests that farmers who attended more training are less vulnerable to climate variability. Through these events, they could obtain new information and techniques for climate-smart agriculture. These trainings are beneficial to the farmers considering that they are experiencing some changes in their planting calendar.

The last component pertains to Natural Capital and it suggests that the larger the farm area owned by the household and the more diversified their crops, the lesser will be their vulnerability to climate variability. Farmers who own large areas of land have full control on farm-decision making and could plant different crops in some portions of their lands. In that way, they could lessen the risk of financial loss since they could earn from some crops which are less prone to abrupt rains.

Through the generated scores of the PCA, the average score of the farming households was 0.62 implying moderate level of vulnerability to early onset of rains. Specifically, majority of the households (55.51%) exhibited moderate vulnerability to climate variability. Although those who were highly vulnerable accounted for only 19.92%, this value is higher compared to the corresponding vulnerabilities to drought and typhoon.

Comparative Analysis of Social Vulnerability to Different Climate-related Events

T-test statistics was employed to determine if there is a significant difference between the mean social vulnerability of farming households to three climate-related events (i.e., drought, typhoon, and early onset of rains). As reflected in Table 7, there is a significant difference at 1% level of significance between the vulnerability scores of farming households during early onset of rain and drought. It shows that more farming households are vulnerable to early onset of rain as compared to drought. As argued by some of the FGD participants, they can easily cope with the impacts of drought by increasing the frequency of watering the plants. On the other hand, early onset of rain would affect their crop production, especially that of fruit trees like cashew. Once damaged, they need to wait for another year for the flowers to bloom again. Meanwhile, there is no significant difference between the social vulnerability scores of farming households to climate variability and typhoon. Hence, this implies that the difference in mean scores of the sampled respondents for the two events does not represent a meaningful difference in general.

Table 7. Independent T-test of mean vulnerability to different climate events of farming households

Group	Obs	Mean	Std Err	P-Value (Two-Tailed) Pr (|T| > |t|)	P-Value (One-Tailed) Pr (T <t)	P-Value (One-Tailed) Pr (T >t)	Tstat
Early onset of	236	0.6208	0.0125	--	--	--	--
Drought	121	0.4521	0.0175	0.0000	1.0000	0.0000	7.8504
Typhoon	135	0.6142	0.0164	0.7482	0.6259	0.3741	0.3213

Conclusion and Recommendations

Climate-sensitive livelihoods are in the frontline of sectors which will be affected most by the changing climate. This holds true in the study site since climate variability and extremes have been affecting the production of farming households.

Several factors could explain the social vulnerability of farming households to different climate-related events (i.e., drought, typhoon, and early onset of rains). Financial capital has the highest contribution to their social vulnerability. Number of livelihood sources and percentage of on-farm income relative to the total household income were significant in the three indices generated through PCA. This suggests that diversity of income sources lessens their social vulnerability, while higher dependence on on-farm income enhances their social vulnerability to the three hazards of interest. Meanwhile, number of position in the organization and number of trainings attended are found to be significant in the three indices. It is also interesting to note that parameters of physical capital were not significant in the analysis of their vulnerability. Since the subject of the survey is mostly smallholder farmers, there is little variation in their physical capital since they are using the same basic farm equipment and inputs in farming activities. Also, contrary to the hypothesized positive relationship of farmers' age to social vulnerability, the PCA model indicated that the older the farmer, the lesser will be his/her vulnerability to typhoon. Intuitively, this could be associated to their vast experience on farming and climate events in the village.

The result of the study shows that farming households are more vulnerable to typhoon and early onset of rains. Typhoon has direct impact on farmers' production since it could totally damage the crops making recovery costly, and it could be labor and time extensive. Early onset of rains, on the other hand, could damage crop species, especially flowers of fruit trees resulting to decline or no production at all. Meanwhile, farmers are less vulnerable to drought since its impacts are gradual and there are measures that they can do to reduce its impacts.

This study is one of the first few attempts in the country to estimate the vulnerability of farmers using the Sustainable Livelihoods Framework and principal component analysis. However, validity of the index is site-specific and could only reflect present-day vulnerability in the area. Because of change in people's behavior, attitude, perception, and livelihood profiles over time, formulated indices are not applicable in assessing future vulnerabilities.

Future studies could look into the impact of climate change on forest and other non-forest products considering that residents rely on these resources as other sources of income during climate extremes. Also, future studies could enhance the scope of this study by including other types of livelihood. Moreover, increasing the sample size would be more effective, especially on the use of PCA.

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