PRODUCTION RISK AND CROP INSURANCE EFFECTIVENESS: ORGANIC VERSUS CONVENTIONAL APPLES[a]

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Abstract: This paper empirically examines the income risks for Pacific Northwest apple growers, both conventional and organic. Current yield based apple production insurance, the Growers Yield Certification (GYC), and hypothesized revenue based insurance are also examined for their risk management effect on growers. Results show that organic apple production is more risky but has higher expected return than its conventional counterpart. The current GYC is subsidized and subsidized more for organic growers. However, the current low price selection levels prevent these programs from offering effective risk reducing effect, and they also prevent the hypothesized revenue insurance from showing its advantage over yield insurance as in the case of other major field crops.

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I. INTRODUCTION

Apples are a major crop in the Pacific Northwest (PNW) states (Washington, Idaho, and Oregon). As the leading state of apple production since 1920s, Washington (WA) accounts for 58.8% of total US apple production in 2005. The value of apple production is $1.23 billion, representing 19 percent of total agricultural value produced in WA. Oregon is also a major producer of apples, and it generates $26 million value of production accounting for 11 percent total value of production in Oregon State (NASS, 2006). The value of apples production in Idaho was $12.5 million in 2005, ranking No.11 in the United States (US) apples production. The nutrient-rich soil, arid climate, plentiful water and advanced growing practices provide the right ingredients for producing top-quality apples in PNW region.

Due to health and environment concerns, a significant interest in organic apples production has developed over the last 10 to 15 years. WA orchards produce about 35 percent of the organic apples in the U.S. and about 20 percent of the organic apples in the world (Schotzko and Granatstein). The dry climate and ideal temperatures in central Washington reduce the number of disease and pest problems that can impact fruit and therefore reduces the need for applications to control insects and pests. Certified Washington State organic apple acreage increased from well below 500 total acres in the late 1980s to 9,861 acres in 2002[1]. Most of the PNW organic acreage is planted in Red Delicious followed by Granny Smith, Gala, Golden Delicious, Fuji and so on.

PNW apples are primarily grown for the fresh market with a higher quality and higher value. PNW especially Washington's quality standards for all apples are more stringent than grading standards used in any other growing region in the world. This higher quality also requires higher production costs, which in turn results in high profit risks for apple growers, when couple with adverse weather conditions, insects and plant diseases, and other factors. Apple crop insurance is a major risk management tool for apple growers. However, compared with major field grain crops, the current apple crop insurance program is quite limited with only yield based contracts. The basic choices include catastrophic coverage, higher coverage under Grower Yield Certification (GYC) which is a type of Multi Peril Crop Insurance (MPCI) policy, and optional coverage for fresh fruit quality.

A frequent complaint made by PNW apple growers is that national insurance programs do not provide adequate coverage for high valued PNW fresh apples, and are even less adequate for organic apples. The price selection level in GYC is set low compared to the fresh market price for PNW apples (4.65 $/box for Varietal B and 6.45 $/box for Varietal A). The yield coverage level is also low, ranges only to 75%. In 2000, USDA's Risk Management Agency (RMA) introduced a pilot coverage enhancement option (CEO) which was an option of increasing the coverage to 85%, but it was terminated recently.

An extensive amount of production-based research has been done on risk management of organic farms. Duram reported organic farmers were exposed in both production and price risks during the three-year transition period from conventional to organic production. Hanson et. al. (1990) compared conventional and organic grain rotation during the first nine years of production and found that the average annual profits of the conventional rotation were higher than the organic rotation without organic price premiums. Reganold et. al. compared conventional, integrated pest management, and organic apple production systems. Numerous studies have also been found on insurance programs for field crops such as wheat and barley (Ke and Wang; Wang, et. al.), corn and soybean (Sherrick, et. al.; Miranda and Glauber), and other field crops. However, little work has been done specifically assessing both production and price risks for organic fruit growers. Hansen et. al. (2004) indicated that most fruit and vegetable producers had little knowledge of crop insurance. No other work has been found assessing the crop insurance program for tree fruits.

Apples have many varieties for which production and price can differ markedly. Currently, GYC insurance groups all apples only into two groups, varietal A and B. Fuji, Gala and other newer varieties are in varietal A. Red delicious, golden delicious and other traditional varieties are in varietal B. This could limit the risk reducing effectiveness of the insurance.

The goal of this paper is to assess income risks of WA apple growers and the risk management effectiveness of apple crop insurance programs. Specifically, we will: (1) examine the income risks associated with conventional and organic production; (2) evaluate the roles of GYC for conventional and organic apples by variety; (3) evaluate presumed income based insurance (IP) and compare it with GYC.

II. METHODOLOGY

Income risks are represented by the distributions of growers' income from production.

(1) $$\pi_0 = PY - C$$

where π_0 is the profit function from producing apples; P is the farm gate price after harvest[2], Y is the corresponding realized production level, and C is the deterministic cost of producing Y.

When growers have insurance, their profit function is specified as revenue generated from sales, yield or revenue insurance indemnities less production costs and subsidized insurance premiums:

(2) $$\pi = \pi_0 + INS - PRE + SUB$$

the insurance income, *INS*, represents indemnity from GYC and the hypothetical IP as in the following:

(3) $$INS_{GYC} = x_1 p_b \max(0, x_2 \bar{y} - Y)$$

(4) $$INS_{IP} = \max(0, x_1 p_b x_2 \bar{y} - PY)$$

where p_b is the base price; x_1 is the price selection level of the grower; and x_2 is the GYC coverage level selected. The setting for INS_{GYC} is based on the actual GYC policy that growers can select a price level and a yield coverage level as a percentage of the established base price and Actual Production History (APH). The APH is established as the projected yield at planting time, and here we use mean yield for APH. The setting for INS_{IP} is based on the current IP program for field crops, except that the base price level is set at the same level as GYC instead of futures market price. *PRE* is the premium, calculated as both the actual premium currently set by RMA and the actuarially fair level for GYC, but only for the actuarially fair level for the IP; *SUB* is the RMA premium subsidy based on the current policy.

The risk management decision is presumed to be made based on growers' expected utilities.

We assume a representative apple grower chooses an insurance coverage level to maximize his or her expected utility of wealth, composed of a deterministic initial wealth, random production income and insurance transactions.

(5) $$\underset{x_1,x_2}{Max}\, E[U(w)], \text{ and } \quad w = w_0 + \pi$$

where *E*( ) is an expectation operator; *U*( ) is a von Neumann-Morgenstern utility function representing the risk attitude of the decision maker; *w* is the stochastic terminal wealth; and w_0 is an initial wealth level.

Welfare effects of the insurance programs are evaluated by the Certainty Equivalent (CE) of the insurance, i.e., the certain amount of income paid to the grower for him to achieve the same expected utility without using the insurance as using the insurance.

(6) $$MaxEU(w) = EU(w_0 + \pi_0 + CE)$$

The grower is assumed to have constant relative risk aversion, which has been commonly used in a similar focus (Wang, et al; Coble, et. al.; Mahul).

III. DATA AND SIMULTIONS

The empirical analysis is based on simulated risks faced by PNW apple production in crop year of 2006. Historical data are used to estimate random price and yield distributions used in the simulations. Data sources are: (1) WA Growers Clearing House (WAGCH) price data by variety, for both conventional and organic apples; (2) National Agricultural Statistics Service (NASS) aggregated state conventional yield data, long term but not by variety; (3) RMA farm level conventional APH records, not variety specific; (4) WAGCH conventional production data by variety; (5) Washington Fruit Survey (1993, 2001, 2002) acreage data by variety; and (6) farm-level data from our own survey for organic apple growers in the Pacific Northwest including yield from 2000 to 2005 and production cost by variety. The information from each source is combined together with reasonable assumptions to obtain farm level yields and prices by variety for both conventional and organic apple data.

To be able to capture the weather-related yield risks, a long time series of historical yields is needed while accounting for time trends. Several functional forms of time trends (linear, piecewise linear, quadratic, and loglinear) for the mean yield of conventional varietal apples are considered. The analysis showed no trend for Red Delicious and Golden Delicious and a piecewise trend for Gala and Fuji. For the organic varietal yields, no trend was considered based on limited recent six years data.

The proper crop-yield distributions have been debated in the agricultural economics literature since the early 1970's. Several studies have agreed that crop yields are skewed (Babcock and Hennessy; Coble et al.; Borges and Thurman; Nelson and Preckel). Some studies support positive skewness (Day) while others support negative skewness (Swinton and King; Ramirez). A few non-normal distributions are proposed such as Beta (Borges and Thurman; Nelson and Preckel), Gamma (Gallagher), and log-normal (Jung and Ramezani). Just and Weninger identify three common methodological problems in yield distribution analyses: use of aggregate yield data, inflexible trend modeling, and inappropriate interpretation of the Normality test results. They shed doubt on the validity of previous findings of yield nonnormality and renew support for the normal distribution of crop yields. Unfortunately, a consensus specification for crop yield distributions has not been reached in the agricultural economics literature. Thus this paper will use normal distribution to simulate the yields because: (1) the normality test of the residuals after time detrending can not be rejected; (2) there is no former work questioning the normality of apple yields; and (3) the multivariate joint normal distribution is well defined, which is convenient to simulate joint yield and price distribution with a correlation imposed.

Both conventional and organic varietal prices are obtained from WAGCH. Trends are identified and lognormal distributions are chosen to simulate the prices for 2006 against a few other candidate distributions. An empirical distribution with 10,000 samples is simulated for each variety's price and yield (See Appendix for details of the data process).

The independently simulated yield and price distributions are converted into joint distributions using a linear transformation to impose the correlation structure estimated from the data. The conventional yield-price correlation is about -0.6 for all varieties, and the organic correlations are about -0.7 with the exceptions for Fuji at -0.2.

Per acre production cost for conventional apples for established trees are obtained from Schotzko and Granatstein. The organic varietal costs are calculated as the average of the surveyed growers' costs for each variety.[3] Production cost ranges from 4,000 to 5,000 $/acre for conventional and 4,500 to 7000 $/acre for organic apples. The costs are assumed deterministic.

In accordance with current GYC options, the maximum price selections are 4.65 $/box for Red Delicious and Golden Delicious and 6.45 $/box for Gala and Fuji. The price selection level can be chosen from 67% to 100%. The yield selection level ranges from 50% up to 75% with 5% increment. The current policy provides an aggressive base premium rate and a regressive subsidy rate based on the growers' choice of yield coverage levels. The rates for base premium are 3.2%, 3.7%, 4.5%, 5.4%, 6.5% and 7.7% of liabilities and subsidy rates are 67%, 64%, 64%, 59%, 59%, 55% corresponding to coverage levels of 50%, 55%, 60%, 65%, 70% and 75%, respectively. The organic apple premium is inflated by an optional organic factor of 1.05.

The value of the relative risk aversion coefficient is set at $\theta = 2$, which is based on previous research (Wang, Hanson and Black; Coble, Heifner and Zuniga; Pope and Just). Thus the initial wealth (farm equity) for organic and conventional Red Delicious and Golden Delicious growers is 6,685 $/acre based on the debt/asset ratio for Washington farmers (17%, WASS) and the average WA apple orchard asset, 8,066 $/acre, including land value, the cost of irrigation system and tree value (Glover, et. al.). The initial wealth for Gala and Fuji is 8,803 $/acre since the trees value for those two is much higher than traditional varieties.

IV. RESULTS

The descriptive statistics of simulated varietal yields, prices and profits for both conventional and organic apples are shown in Table 1. Organic apple growers have higher expected revenue and higher risks than conventional apple growers. Among conventional apples, the newer Gala and Fuji varieties have higher expected revenue and lower risk than Red Delicious and Golden Delicious. This may explain why Gala and Fuji have increased their market shares dramatically in recent years. Organic Fuji has the highest expected revenue and risk among all the organic varieties. Different from conventional Gala apples, organic Gala has lower risk (standard deviation) and also lower expected revenue than both organic Fuji and organic Golden Delicious.

Besides the benchmark case of no insurance, six other scenarios are investigated for each of conventional and organic varieties. GYC under current policy premium rates, GYC under actuarially fair premium rates, and hypothesized IP under actuarially fair premium rates, all of which have two cases of with and without USDA subsidies. These scenarios allow us to compare: (1) GYC and IP at a similar basis (actuarially fairness); (2) the effect of insurance on conventional and organic apples; (3) insurance influence by varieties. The optimization results are shown through Tables 2 to 5.

Sensitivity analysis of risk aversion level is also conducted. We examine the risk aversion levels from 1.5 to 3 with 0.5 increments. The rankings of insurance programs in all the comparisons do not change except the values of CE increase as the risk aversion level goes up.

GYC vs IP

The optimization results show that both GYC and hypothesized IP provide risk protection to the farmer as shown by reduction in the standard deviation of profit for most insurance options. Both conventional and organic growers will choose full coverage in most cases. The exceptions will be discussed later in varieties comparison. As expected, the grower has a higher welfare as measured by certainty equivalent (CE) and pays lower premium with subsidy than without subsidy for both GYC and hypothesized IP programs.

The hypothesized IP gives the conventional Red Delicious grower higher protection (less risk as measured by standard deviation of profit) and higher welfare (CE) than GYC program, although the grower pays more premium. This is because both their production and marketing risks are protected by IP which results in receiving a higher indemnity and a higher government subsidy.

Different to conventional Red Delicious apples, the income protection gives less risk protection for all the other apple growers than GYC. This is because that price selection (4.65 $/box for Red Delicious and Golden Delicious and 6.45 $/box for Gala and Fuji) in the current GYC programs is too low compared to the market cash price, especially for organic apples. For example, the expected market price for organic Red Delicious is 9.27 $/box and 13.55 $/box for Gala. It's more difficult to get indemnity from IP than GYC program even when yields are low because the price is often considered "high" based on the price selection levels and no revenue loss is observed. The expected market price for conventional Red Delicious is only 4.37 $/box, which is lower than the price selection. In that case, IP provides better protection than GYC.

However, from the point of view of the premium paid by the grower and government investment in premium subsidy, hypothesized revenue insurance, IP, is more cost effective for both conventional and organic practices. For example, the per dollar subsidy investment will bring a $4.21 welfare gain by GYC and $9.34 welfare gain by IP under actuarially fair premium structures for organic Red Delicious. The per dollar grower investment in insurance (premium paid) will gain $5.14 welfare by GYC and $11.41 by IP under the same scenario. Notice, the $0.61 welfare gain brought by each dollar of government subsidy in conventional GYC suggests that it would be more economic for the government to give the $1 directly to growers instead of subsidizing the GYC program.

Conventional vs Organic

The organic apple grower's income risk is reduced more dramatically by insurance than conventional grower. For example, the standard deviation reduction of profit ranges from 0 (GYC without subsidy) to 239.07 (IP) for the conventional Red Delicious grower and from 288.27 (IP) to 662.87 (GYC) for the organic grower when insurance is used. Consequently, the organic apple grower's welfare gain from insurance is higher than that of the conventional grower although he has to pay much higher premium for GYC than the conventional grower so as to reduce more risks.

The conventional grower is better off (higher CE and less premium) when the insurance is actuarially fair than when the premium is set as in the current policy. This implies a loading exists in the current premium rates.

However, the organic grower pays higher premium and is less willing to pay for GYC when the premium is actuarially fair than set by current policy except for Gala apples. The reason is that the organic apple production risks are so high based on our survey, that the current GYC premium is set below the expected indemnity even after the organic premium is inflated by 5 percent in the policy. This is also why in our scenario of current GYC without subsidy the grower still chooses the highest coverage level. Although the insurance price is quite low compared to the market organic apple prices, organic growers still benefit more than their conventional counterpart from the GYC. The organic inflation factor needs to be increased so as to make the insurance actuarially fair.

Red Delicious vs Golden Delicious vs Gala vs Fuji

The optimization results in Table 2 for Red Delicious show that both conventional and organic growers choose full coverage in all cases except GYC without the subsidy for conventional apples. In this case, the grower does not choose insurance because the current premium is too high relative to his/her risks and no subsidy is provided.

When the premium is higher than the actuarially fair level and no subsidy, the conventional Golden Delicious grower chooses not to buy insurance (See Table 3). When subsidy is added, the grower chooses full yield coverage and a reduced price selection level at 92%. The Golden Delicious grower chooses full coverage in all other cases.

As for Gala, the conventional grower is not interested in current GYC or hypothesized IP either with or without subsidies based on Table 4. The conventional grower chooses insurance only for actuarially fair GYC, but this plan does not provide much value to him either. Thus both GYC and IP are not effective in reducing the risk for conventional Gala growers. The price selection and yield coverage are too low to provide significant protection. Or, this grower's risk is not high enough for him/her to benefit from the insurance as shown by the coefficients of variation (CV) in Table 1.

GYC and hypothesized IP can protect organic Gala growers from risk. The grower chooses full coverage in all cases except when current premium is high without subsidy for GYC. If the subsidy is removed from the current GYC, the organic grower will reduce their insurance level from maximum to minimum (67% price selection level and 55% coverage level).

Different from other organic varieties, the organic Gala grower pays less premium and is more willing to pay for GYC when the premium is actuarially fair than set by current policy. This means the GYC premium for organic Gala is set above the expected indemnity, which is a normal practice. The reason that organic Gala is an exception is that Gala production risk is much lower than the other organic apples and thus reduces the expected indemnity.

According to Table 5, the current GYC is not beneficial to the conventional Fuji grower with or without subsidy because the premium is set too high relative to the grower's risk. The conventional grower chooses full coverage in all other cases. However, the conventional grower does not receive much protection from insurance in any of these cases. The organic Fuji grower is much more willing to pay for insurance since it exhibits the highest profit risk of all varieties (Table 1). Although the yield risk is lower than for both Red Delicious and Golden Delicious, the low price and yield correlation for organic Fuji apples makes its income highly risky. This makes the insurance value for organic growers the second highest following Red Delicious among all varieties.

V. SUMMARY AND CONCLUSIONS

PNW, especially the state of Washington, is the leading region in both conventional and organic apple production. PNW apples are primarily grown for the high value fresh market due to their high quality. Multiple perils (production cost) and market fluctuation (price risk) results in revenue risk. Crop insurance is a major risk management tool for apple growers. The current apple insurance program offers only a yield based program. Both price selection and coverage level are set very low to provide adequate protection. In this paper, we examined the income risks associated with conventional and organic production and evaluated the roles of GYC and hypothesized IP insurance schemes for conventional and organic apples by variety.

Results show organic apple growers earn higher expected revenue, incur higher production cost (excluding establishment cost), make higher expected profit, but face higher income risks than conventional apple growers.

We assume the apple grower makes decisions on insurance coverage and price election levels to maximize expected utility of after harvest wealth, composed of initial wealth, random production income and insurance transactions. Results show, in terms of certainty equivalent, that income insurance is not necessarily preferable than yield insurance by growers if the prices selection is set at the same level as in the current GYC programs, because it is too low compared to the market cash price. Only conventional Red Delicious growers will benefit from IP more than GYC under comparable premium subsidy structures since the base selection is very close to Red Delicious market price. From the point of view of the government investment in premium subsidies, revenue insurance is always more cost effective for all varieties and for both conventional and organic practices.

The conventional apple growers' welfare gain from the current insurance is less than the organic growers because their income risk is lower. Organic apple production risks are higher than their conventional counterparts', causing the current GYC premium to be below the expected indemnity even before the subsidy and after the organic premium inflation factor (except Gala) based on our survey data. Although the insured price is quite low compared to the organic market prices, organic growers still benefit more than their conventional counterparts from the GYC. This doesn't mean that we should not consider increasing organic apple price selection level to give growers more protection. Currently, the low price selection and low premium setting do not provide enough indemnity when losses occur, although the higher subsidy provides a higher risk free income at all times, and thus reduce its risk reduction value.

Gala apple production is less risky for both conventional and organic apple growers. Consequently, Galas benefit little from insurance and organic Gala becomes an exception from the other organic varieties, namely, the current GYC premium is above the expected indemnity. In the future insurance parameter setting, it would be good to separate at least Gala from the other varieties. This implies that the current Varietal A and B categorization is not accurate enough to assess a fair premium structure for apple growers which may cause adverse selection problems.

The results depend heavily on the simulated distribution. Our organic grower survey sample is small, and the organic results can be more reliable only when more grower production records are available in the future.

ENDNOTES

[1]2002 estimated figures from Washington State University Center for Sustaining Agriculture and Natural Resources.

[2]Apples are sent to packing house after harvested, and then sorted, stored, packed and marketed to retailers year round. The growers usually receive the payment from the packing house based on the average price over the crop year less a packing house cost. Therefore, the price is stochastic until way after the harvesting time.

[3]Both costs do not include establishment cost. There is a large amount of establishment cost in the first few years of new trees. These costs are usually amortized into later years when the trees get matured, so that the profit levels would be greatly reduced. However, we don't find this information by variety and by conventional/organic practice.

REFERENCES

Babcock, B.A. and D.A. Hennessy. "Input Demand Under Yield and Revenue Insurance." *American Journal of Agricultural Economics* 78 (1996): 416-427.

Ke, B. and H.H. Wang. "An Assessment of Risk Management Strategies for Grain Growers in the Pacific Northwest." *Agricultural Finance Review* 62 (2002): 117-133.

Borges, R. and W. Thurman. "Marketing Quotas and Subsidies in Peanuts." *American Journal of Agricultural Economics* 76 (1994): 809-817.

Coble, K.H., T.O. Knight, R.D. Pope and J.R. Williams. "Modeling Farm-level Crop Insurance Demand with Panel Data." *American Journal of Agricultural Economics* 78 (1996): 439-447.

Coble, K. H., R. G. Heifner and M. Zuniga. "Implications of Crop Yield and Revenue Insurance for Producer Hedging." *Journal Agricultural and Resource Economics* 25 (2000):432-52.

Day, R.H. "Probability Distributions of Field Crop Yields." *Journal of Farm Economics* 47 (1965): 713-741.

Duram, L.A. "Factors in Organic Farmers' Decision Making: Diversity, Challenge, and Obstacles." *American Journal of Alternative Agriculture* 14 (1999): 2–10.

Gallagher, P. "U.S. soybean Yields: Estimation and Forecasting with Nonsymmetric Disturbances." *American Journal of Agricultural Economics* 71 (1987): 796-803.

Greene, C. and A. Kremen. *US Organic Farming in 2000-2001: Adoption of Certified Systems*. Washington, DC, US Department of Agriculture, Economic Research Service, AIB No. 780, February 2003.

Hanson, J.C., D.M. Johnson, S.E. Peters, and R.R. Janke. "The Profitability of Sustainable Agriculture on a Representative Grain Farm in the Mid-Atlantic Region, 1981–89." *Northeastern Journal of Agricultural and Resource Economics* 19 (1990): 90–98.

Hanson, J., R. Dismukes, W. Chambers, C. Greene, and A. Kremen. "Risk and Risk Management in Organic Agriculture: Views of Organic Farmers." *Renewable Agriculture and Food Systems* 19 (2004): 218-227.

Jung, A.R., and C.A. Ramezani. "Valueing Risk Management Tools as Complex Derivatives: An Application to Revenue Insurance." *Journal of Financial Engineering* 8 (1999): 99-120.

Just, R.E. and Q. Weninger. "Are Crop Yields Normally Distributed?" *American Journal of Agricultural Economics* 81 (1999): 287-304.

Mahul, O. "Hedging Price Risk in the Presence of Crop Yield and Revenue Insurance." *European Review of Agricultural Economics* 30 (2003):1-23.

Miranda, M.J. and J.W. Glauber. "Systematic Risk, Reinsurance, and the Failure of Crop Insurance Markets." *American Journal of Agricultural Economics* 79 (1997): 206-215.

NASS. *National Agricultural Statistical Services*, 2006. www.nass.usda.gov.

Nelson, C.H. and P.V. Preckel. "The Conditional Beta Distribution as a Stochastic Production Function." *American Journal of Agricultural economics* 71 (1989): 370-378.

Pope, R. D. and R. E. Just. "On Testing the Structure of Risk Preferences in Agricultural Supply Analysis." *American Journal of Agricultural Economics* 73 (1991):743-48.

Ramirez, O.A. "Estimation and Use of a Multivariate Parametric Model for Simulating Heteroskedastic, Correlated, Nonnormal Random Variables: The Case of Corn Bell Corn, Soybean and Wheat Yields." *American Journal of Agricultural Economics* 79 (1997): 191-205.

Reganold, J. P., Glover, J. D., Andrews, P. K., and Hinman, H. R. "Sustainability of Three Apple Production Systems." *Nature* 410 (2001): 926-930.

Schotzko, T. R. and D. Granatstein. "A Brief Look at the Washington Apple Industry: Past and Present." WSU extension publications, 2004.

Sherrick, B. J., F. C. Zanini, G. D. Schnitkey, and S. H. Irwin. "Crop Insurance Valuation under Alternative Yield Distributions." *American Journal of Agricultural Economics* 86 (2004): 406-419.

Swinton, S., and R. P. King. "Evaluation Robust Regression Techniques for Detrending Crop Yield Data with Nonnormal Errors." *American Journal of Agricultural Economics* 73 (1991): 446-451.

Wang, H. H., S. D. Hanson, R. J. Myers and J. R. Black. "The Effects of Alternative Crop Insurance Designs on Farmer Participation and Welfare." *American Journal of Agricultural Economics* 80 (1998):806-20.

Wang, H. H., S. D. Hanson and J.R. Black. "Efficiency Costs of Subsidy Rules for Crop Insurance." *Journal of Agricultural and Resource Economics* 28 (2003):116-137.

Wang, H.H., L. Makus and X. Chen. "The Impact of US Commodity Programmes on Hedging in the Presence of Crop Insurance." *European Review of Agricultural Economics* 31(2004): 331-352.

Table 1. Descriptive Statistics of the Simulated Varietal Conventional and Organic Yields, Prices and Revenues

Variable	Conventional						Organic					
	Mean	StDev	CV	Min	Max	Skewness	Mean	StDev	CV	Min	Max	Skewness
Yield												
Red Delicious	902.23	278.32	0.31	0	1958.21	0.04	1139.8	518.6	0.45	0	3224.4	0.12
Golden Delicious	1032.9	269.7	0.26	48.5	2050.7	0.06	1067.3	449.2	0.42	0	2845.3	0.07
Gala	929.52	103.7	0.11	523.76	1364.67	0.03	744.24	209.67	0.28	0	1615.47	-0.01
Fuji	832.16	200.74	0.24	83.87	1640.3	0	1000.7	404.8	0.4	0	2431.6	0.03
Price												
Red Delicious	4.37	1.57	0.36	1.1	16.74	1.09	9.27	2.32	0.25	3.75	22.83	0.76
Golden Delicious	6.22	2.04	0.33	1.82	20.04	0.99	11.77	3.94	0.33	3.5	37.77	0.96
Gala	9.25	1.71	0.18	4.5	18.04	0.52	13.55	2.94	0.22	5.84	27.9	0.66
Fuji	10	2.56	0.26	3.69	25.08	0.8	13.58	3.25	0.24	4.61	38.53	0.76
Revenue												
Red Delicious	3712	1232.9	0.33	0	10378.5	0.74	9645.8	3404.2	0.35	0	21261.9	-0.45
Golden Delicious	6112.5	1756.6	0.29	727	18181.3	0.74	11237	3624	0.32	0	26093	-0.16
Gala	8501.3	1292.7	0.15	5042.5	14087.5	0.43	9704.6	2311.8	0.24	0	21247.5	0.09
Fuji	7890.2	1124.1	0.14	1753.7	12910.7	0.12	13319	5889	0.44	0	43335	0.5

Note: Yield unit is boxes per acre. Price unit is dollars per box. Profit unit is dollars per acre.

Table 2. Optimization Results for Red Delicious Apple

	Profit								
	Mean	Std Dev	CE	Price Election	Optimal Coverage	Premium	CE / Premium	Subsidy	CE / Subsidy
Conventional									
No insurance	6487.00	1232.85							
GYC	6529.21	1135.70	81.77	1.00	0.75	109.03	0.75	133.26	0.61
GYC (W/O subsidy)	6487.00	1232.85	0.00	0.00	0.00	0.00	N/A	0.00	N/A
GYC (Actuarially fair,W subsidy)	6570.18	1135.70	122.43	1.00	0.75	68.06	1.80	83.18	1.47
GYC (Actuarially fair,W/O subsidy)	6487.00	1135.70	39.87	1.00	0.75	151.24	0.26	0.00	N/A
IP (Actuarially fair,W subsidy)	6610.23	993.78	213.99	1.00	0.75	100.83	2.12	123.23	1.74
IP (Actuarially fair,W/O subsidy)	6487.00	993.78	92.80	1.00	0.75	224.06	0.41	0.00	N/A
Organic									
No insurance	11373.68	3404.19							
GYC	11669.21	2741.32	1064.03	1.00	0.75	144.62	7.36	176.75	6.02
GYC (W/O subsidy)	11492.45	2741.32	915.33	1.00	0.75	321.37	2.85	0.00	N/A
GYC (Actuarially fair,W subsidy)	11615.76	2741.32	1018.86	1.00	0.75	198.06	5.14	242.08	4.21
GYC (Actuarially fair,W/O subsidy)	11373.68	2741.32	816.56	1.00	0.75	440.14	1.86	0.00	N/A
IP (Actuarially fair,W subsidy)	11444.87	3115.92	664.76	1.00	0.75	58.25	11.41	71.19	9.34
IP (Actuarially fair,W/O subsidy)	11373.68	3115.92	605.28	1.00	0.75	129.44	4.68	0.00	N/A

Table 3. Optimization Results for Golden Delicious Apple

	Profit		CE	Price Election	Optimal Coverage	Premium	CE / Premium	Subsidy	CE / Subsidy
	Mean	Std Dev							
Conventional									
No insurance	8697.47	1756.58							
GYC	8683.43	1687.57	18.20	0.92	0.75	114.83	0.16	140.35	0.13
GYC (W/O subsidy)	8697.47	1756.58	0.00	0.00	0.00	0.00	N/A	0.00	N/A
GYC (Actuarially fair,W subsidy)	8757.72	1684.09	93.24	1.00	0.75	49.30	1.89	60.25	1.55
GYC (Actuarially fair,W/O subsidy)	8697.47	1684.09	33.28	1.00	0.75	109.55	0.30	0.00	N/A
IP (Actuarially fair,W subsidy)	8710.16	1717.20	37.89	1.00	0.75	10.38	3.65	12.69	2.99
IP (Actuarially fair,W/O subsidy)	8697.47	1717.20	25.26	1.00	0.75	23.08	1.09	0.00	N/A
Organic									
No insurance	13334.29	3623.67							
GYC	13556.31	3137.56	800.41	1.00	0.75	135.42	5.91	165.52	4.84
GYC (W/O subsidy)	13390.79	3137.56	655.25	1.00	0.75	300.94	2.18	0.00	N/A
GYC (Actuarially fair,W subsidy)	13530.88	3137.56	778.02	1.00	0.75	160.85	4.84	196.59	3.96
GYC (Actuarially fair,W/O subsidy)	13334.29	3137.56	606.04	1.00	0.75	357.44	1.70	0.00	N/A
IP (Actuarially fair,W subsidy)	13366.75	3473.45	423.96	1.00	0.75	26.56	15.96	32.46	13.06
IP (Actuarially fair,W/O subsidy)	13334.29	3473.45	395.42	1.00	0.75	59.02	6.70	0.00	N/A

Table 4. Optimization Results for Gala Apple

	Profit								
	Mean	Std Dev	CE	Price Election	Optimal Coverage	Premium	CE / Premium	Subsidy	CE / Subsidy
Conventional									
No insurance	10156.33	1292.74							
GYC	10156.33	1292.74	0.00	0.00	0.00	0.00	N/A	0.00	N/A
GYC (W/O subsidy)	10156.33	1292.74	0.00	0.00	0.00	0.00	N/A	0.00	N/A
GYC (Actuarially fair,W subsidy)	10157.82	1291.52	1.81	1.00	0.75	1.22	1.48	1.49	1.21
GYC (Actuarially fair,W/O subsidy)	10156.33	1291.52	0.32	1.00	0.75	2.72	0.12	0.00	N/A
IP (Actuarially fair,W subsidy)	10156.33	1292.74	0.00	0.00	0.00	0.00	N/A	0.00	N/A
IP (Actuarially fair,W/O subsidy)	10156.33	1292.74	0.00	0.00	0.00	0.00	N/A	0.00	N/A
Organic									
No insurance	11738.63	2311.77							
GYC	11747.36	2112.44	142.52	1.00	0.75	130.99	1.09	160.09	0.89
GYC (W/O subsidy)	11692.17	2263.74	7.28	0.67	0.55	68.72	0.11	0.00	N/A
GYC (Actuarially fair,W subsidy)	11815.48	2112.44	208.90	1.00	0.75	62.87	3.32	76.85	2.72
GYC (Actuarially fair,W/O subsidy)	11738.63	2112.44	134.01	1.00	0.75	139.72	0.96	0.00	N/A
IP (Actuarially fair,W subsidy)	11742.10	2292.07	40.04	1.00	0.75	2.84	14.09	3.47	11.52
IP (Actuarially fair,W/O subsidy)	11738.63	2292.07	36.61	1.00	0.75	6.32	5.80	0.00	N/A

Table 5. Optimization Results for Fuji Apple

	Profit		CE	Price Election	Optimal Coverage	Premium	CE / Premium	Subsidy	CE / Subsidy
	Mean	Std Dev							
Conventional									
No insurance	9790.18	1124.14							
GYC	9790.18	1124.14	0.00	0.00	0.00	0.00	N/A	0.00	N/A
GYC (W/O subsidy)	9790.18	1124.14	0.00	0.00	0.00	0.00	N/A	0.00	N/A
GYC (Actuarially fair,W subsidy)	9845.31	1037.71	78.93	1.00	0.75	45.10	1.75	55.12	1.43
GYC (Actuarially fair,W/O subsidy)	9790.18	1037.71	23.99	1.00	0.75	100.23	0.24	0.00	N/A
IP (Actuarially fair,W subsidy)	9790.63	1120.80	2.51	1.00	0.75	0.37	6.77	0.45	5.54
IP (Actuarially fair,W/O subsidy)	9790.18	1120.80	2.05	1.00	0.75	0.82	2.49	0.00	N/A
Organic									
No insurance	15110.17	5889.15							
GYC	15294.42	5479.92	909.20	1.00	0.75	126.97	7.16	155.18	5.86
GYC (W/O subsidy)	15139.24	5479.92	775.65	1.00	0.75	282.15	2.75	0.00	N/A
GYC (Actuarially fair,W subsidy)	15281.34	5479.92	897.89	1.00	0.75	140.05	6.41	171.17	5.25
GYC (Actuarially fair,W/O subsidy)	15110.17	5479.92	750.79	1.00	0.75	311.22	2.41	0.00	N/A
IP (Actuarially fair,W subsidy)	15177.85	5673.25	676.69	1.00	0.75	55.38	12.22	67.68	10.00
IP (Actuarially fair,W/O subsidy)	15110.17	5673.25	618.95	1.00	0.75	123.06	5.03	0.00	N/A

Appendix: Yield, Price and Income Risk Simulation for PNW Apple Growers

We have explored four sources of data available for the apple risk research. First is the NASS published data. Second is APH RMA records. Third is the WA Clearing House data. The last one will be from our own survey. They each have advantages and disadvantages in terms of representing the risks as listed in the following table.

	NASS	RMA	Clearing House	Survey
Period	>30 years	24 years	4 years	5 year
By variety	No	No	Yes	Yes
Aggregation	State level	Farm level	State level	Farm level
Organic/Conventional	mixed	mixed	Separated	Organic only

Ideally, to analyze the income risks of an apple grower, we will need farm level data, by variety, by grade/size category because they are sold at different prices, by conventional or organic practice, and longer period so as to represent the production risk caused by weather. Some bad weather might have not appeared in recent four or five years. However, from the above table we see that there is no one source that can satisfy all the research needs. The information from each source is combined together with reasonable assumptions to obtain farm level yields and prices by variety for both conventional and organic apple data.

1. Yield, Price and Income Simulation for Conventional Apples

We first need to estimate the model parameters, and simulation can be easily carried in computer software based on the parameters. We first identify the long term trend using NASS data, and examine the detrended residual yield distribution. The test statistic of Shapiro-Wilk normality test for the residuals is 0.96, which means we cannot reject that the residual of the yield following a normal distribution. Because we will need the farm yield which may have a higher risk than the state level, we turn to RMA data. Assuming they follow the same trend because of the same technical development, we can measure the farm level yield distribution and calculate the farm level variance.

Clearing House data is the only source with output quantity by variety. We use these data as a proxy to the total WA state output of each variety excluding cull. Based on an average state cull rate, we converted the packed output into total output including culls. Then based on the two Washington Fruit Surveys in January 1993 and 2001, and the by variety acreages changes for the years after, we estimated the acreage for each year for each variety, and use them to divide the total output to get yield by variety. These yields by variety are estimated based on many assumptions, with about ten years of data, and are at state level. With these yields, we can estimate the trends of each variety, detrend them, and estimate the distributions. We then convert the state level by variety distributions into farm level by simply enlarging their variances while maintain all other distributional parameters at the state level. We follow the same variance ratios between state and farm from the above all variety samples in this conversion of by variety samples. These farm level yield distribution by variety estimations can be used in simulation.

It is relatively easier to estimate the price distribution because prices are at the state level and individual farms face the same prices. First, the Clearing House website provides the average by variety FOB data for over ten years. Specifically, Reds and Goldens: 1980-2004, Granny Smith: 1984-2004, and Gala and Fuji: 1991-2004. The FOB prices are then converted into farm gate prices by subtracting the warehouse cost. Again, trends are identified and lognormal distributions are adopted after refutable tests.

The correlations between the yield of all varietal apples and their prices are estimated from the historical data. A negative correlation is identified for the established varieties because of the market supply demand relationships. The correlation is then imposed in the joint price-yield simulation. The growers per acre revenue distribution can be calculated by the price times the yields, under the assumption of all apples are sold at an average market price.

2. Yield, Price and Income Simulation for Organic Apples

A survey on organic apple growers in the PNW was conducted by Washington State University and University of Idaho. We have Red Delicious, Golden Delicious, Fuji, Gala, Braeburn, and Granny Smith apples in our survey with a total of 118 observations for 33 farms for 6 years (2000-2005). Although the number of farms is not large, it has a good representability given the whole population of PNW growers with no less than five acres of organic apples is very small. We only keep the first four varieties because the others have only one or two farms with multiple years of yield records which are not enough for risk analysis purposes.

No trend is modeled because we believe that the conventional long term trend does not represent the organic technology, and the six years of farm data is not long enough to model the trend. As a result, we average the annual yields to represent the expected yield for each variety by farm, and the sample standard deviations is also used to represent the yield risks for each variety by farm. Then, the averages and standard deviations of all the farm yield are used as the representative farm's expected yield and standard deviation. Following the same normal distributions of conventional yields, 10,000 random yields are simulated for each variety representing the upcoming crop year 2006.

The organic FOB price data (1998-2004) is found from the WA Growers Clearing

House (WAGCH) website, the same place as conventional apple. Following the same procedure as in the conventional price estimations, a lognormal model is used and 10,000 random prices are simulated for each variety.

The price-yield correlations are calculated based on the WAGCH and survey data over years 2000 through 2004, during which both price and yield have observations. A joint price-yield distribution is then obtained from a linear transformation of the independently simulated price and yield distributions. The revenue distribution from growing each variety of apples is obtained by multiplying the prices and yields in the joint distribution.