Effect of contract farming on the U.S. crop farmers' average return

Wu-Yueh HU

Department of Applied Economics, National Chung Hsing University, Taichung, Taiwan

Abstract: In the literature of contract farming, most of the studies focus on the functions of risk managements and reducing transaction costs. Only a few study the effect of contract farming on the productivity efficiency or profitability. Literature in the crop sector is especially lacking. In this paper, we use a unique farm-level dataset (Agricultural Resource Management Survey from the U.S. Department of Agriculture) to examine the effect of contract farming on the farmers' average return for the corn, soybean and wheat producers. The matching estimation is used in the nature to compare the farmers' average return with or without participating contract farming. We first run a logit model to calculate the propensity score from the farmers' contracting decision problem. Then, use the propensity score to match farmers using the contracts and not using the contracts and compare their average returns. The empirical results show that contract farming has a positive effect on the corn and soybean producers' average return and insignificant effect on wheat producers'.

Key words: average return, contract farming, grain industry marketing contract

Farmers have long used formal contracts for procuring inputs and selling their output. The increased reliance on contract farming happens not only in the U.S., but also in the EU and elsewhere. The percentages of the total value of the U.S. agricultural products covered by marketing contracts and production contracts are 28%, 36% and 38% in 1991, 2004 and 2008 respectively (MacDonald et al. 2004; MacDonald and Korb 2011). At present, the use of agricultural contracts is ubiquitous, and they are used in livestock, fruits and vegetables, wine grapes, tobacco, and even for the exchange traded commodities such as corn.

From the farmers' point of view, there are three main motivations to use contracts in the literature. First of all, risk management is one of the most important motivations for farmers to use contracts. The use of marketing contracts and production contracts helps farmers to reduce price and/or production risks (Knoeber and Thurman 1995; MacDonald et al. 2004; Zheng et al. 2008). Second, other studies show that reducing transaction costs, such as search, measurement and monitoring costs, is also an important incentive for farmers to use contracts (Allen and Luke 1993; Hobb 1997; Fukunaga and Huffman 2009). Third, the other studies focus on the effect of contract farming on the production efficiencies or the technology progress. Some positive relationships are found between contract farming and production efficiencies/technology improvement (Knoeber 1989; Ahearn et al. 2005).

In the literature, there are only a few studies discussing the effect of contract farming on the production efficiencies or profitability. Key and McBride (2003) showed that the use of production contracts in the hog industry helps the diffusion of the new technologies and leads to the improvement of productivity. Morrison et al. (2004) found some small impact of contract farming on the productivity improvement in the broiler industry. These studies mostly focused only on the livestock sector. There are much less studies examining the effects of contract farming on the farmers' returns and profitability. It is mainly because of the data limitation. To deal with the return or profitability problem, a performance measure is necessary and the performance measure of profitability and returns is very difficult to find empirically. The first difficulty is that the farm-level revenue and cost data are very hard to get. The second difficulty comes from the fact that most of the farmers in the U.S. are multi-enterprise producers, and it is hard to distinguish the effect of contract farming among enterprises. In this study, we are going to use a very abundant farm-level Agriculture and Resource Management Survey (ARMS) dataset, in which we can have the farmers' socioeconomic characteristics, the total production, the total value of production and contractual prices.

By using these micro-level data, it makes it possible to analyze the effect of contract farming on the farmers' average return by enterprise, more specifically of corn, soybean and wheat in the grain industry. The goal of this study is to estimate the impact of contract farming on the farmers' average returns. The estimation difficulty is that empirically, we can only observe either the farmers' average returns for the farmers using the marketing contract, or the farmers' average return for the farmers using the cash market only, but we cannot observe both of them together. Those two groups of the farmers might not have the same characteristics and that causes some sample selection problems such that the estimation results would be biased. As a result, it is natural to use the propensity score matching (PSM) estimation to reduce the selection biases. The PSM is widely applied to estimate the treatment effects in many issues. In this study, the contract participation could be treated as a treatment. We first estimate a logit model. The dependent variable is whether or not the farmer uses contracts to market the enterprise, and the explanatory variables are the observable farm/farmers' characteristics. Then, we use the estimation results from the logit model to calculate the propensity scores. Finally, the impact of contract farming on the farmers' average returns would be estimated.

MATERIAL AND METHODS

This study focuses on the grain industry in the U.S. Corn, soybean and wheat are our target commodities because of their popularity and the significance in contract farming. Since production contracts are usually used in the livestock sector and marketing contracts are wildly used in the crop sector (MacDonald et al. 2004), in this study, we define that a farm is involved in contract farming if the operator(s) use marketing contracts to sell their product. Marketing contracts are verbal or written agreements between a contractor and a grower to transfer the ownership of the commodity in question at some time in the future. A marketing contract sets a price (or a pricing mechanism) and an outlet before the commodity is ready to be transferred. Contracts often specify product quantities and the range of the acceptable quality measures, and delivery schedules. Most management decisions remain with the growers because they retain the ownership of the animal or crops during the growing stage. Growers typically assume all production risk, whereas the pricing mechanism limits their exposure to price risk. The fundamental difference between marketing contracts and production contracts is that marketing contracts involve the transfer of ownership (buying and selling) between the two parties and the ownership of the commodity never changes. With respect to both ownership and control, in a continuum of various marketing arrangements, marketing contracts can be visualized as spanning the interval between spot/cash markets and production contracts.

Data used in this research are from the Agricultural Resource Management Survey (ARMS) Phase III, for 2004. This survey has been done by the USDA's Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS) since 1975. The AMRS is a series of interviews containing three phases in the data collection process from the summer (June) of the reference year to the spring (April) of the year following the reference year. In the phase I, farmers are selected and filtered by a variety of the planting commodities during the summer. Then farmers in the phase I are randomly chosen and interviewed during the fall and winter (phase II). In this stage, a series of field-level or production-unit level enterprise surveys are done. Next, in the spring of the following year, the phase III is conducted. Information on a farm's costs and returns are collected at the whole farm level by interviewing the representative farmers, who are selected from the nationwide samples in the phase II. In the nature of the survey, farmers selected every year are different. As a result, the ARMS data cannot be used as a panel dataset. In this study, we use the 2004 data, which is a cross-sectional dataset. The ARMS Phase III data are collected at the farm level to obtain information about the farm financial statements, production practices and the farm operator's household characteristics. The farm and farmer characteristic variables include age, gender, education level, the number of family members, the total acres operated, farm income, off-farm income and farm assets. Besides, the survey provides a rich and detailed source of data on agricultural contracts. Farmers are asked whether they use production or marketing contracts. They are also asked about the volume of production, receipts, and unit prices or fees for each commodity under contract.

The original dataset includes 20 579 observations. After the missing values and unreasonable negative values are excluded, the total number of observations is 16 771. Table 1 shows the summary statistics of the farm/farmer characteristics. Maximum and minimum are not reported because of the confidential problem. Among our observations, most of the main operators are male (over 95%) and most of the farms concentrate in Midwest and South (about 80%). The farm income is almost twice as much as the off-farm income in average, but the variance for the off-farm income is much less than it is for the farm income. We further screen the data for the

Table 1. Summary statistics for the dataset

Variable	Description	Mean	Standard deviation
Age	Operator's age	54.77	12.42
Sex	Operator's gender	0.95	0.22
Education	Education level: 1–5*	2.79	1.05
nfamily	number of family member	2.83	1.42
Total Acres	In thousand acres operated	1.13	4.03
Income	Farm income in 100 thousand U.S. dollar	0.78	7.00
Offfarm	Income in 100 thousand U.S. dollar	0.41	1.00
Asset	In 100 thousand U.S. dollar	11.31	31.58
R1	dummy for North East	0.03	0.18
R2	dummy for Midwest	0.40	0.49
R3	dummy for South	0.37	0.48
R4	dummy for West	0.06	0.24
R5	dummy for Western Mountain	0.14	0.34

*1 = lower than high school; 2 = high school; 3 = college; 4 = BA or BS; 5 = graduate school

Regions: R1 = ME, NH, VT, MA, RI, CT, NY, PA, NJ; R2 = WI, MI, IL, IN, OH, ND, SD, NE, KS, MN, IA, MO; R3 = DE, MD, DC, VA, WV, NC, SC, GA, FL, KY TN, MS, AL, OK, TX, AK, LA; R4 = ID, MO, WY, NV, UT, CO, AZ, NM; R5 = AK, WA, OR, CA, HI

Source: ARMS data summarized by this study

analysis. Farmers might produce more than one of our target commodities at the same time. The average return of the commodity is calculated as the total value of the commodity reported divided by the total quantity produced. Table 2 shows the frequencies of farmers producing corn, soybean and wheat, and the percentage of the farm involved in contract farming by commodity. The percentage of corn, soybean and wheat producers using marketing contracts are 28%, 22% and 13%, respectively. It shows the significant use of marketing contracts on corn, soybean and wheat.

The objective of this study is to examine the effect of contract farming on the farmers' average return. More precisely, we would like to examine whether the use of marketing contracts has any impact on the average return for those farmers using the cash/spot market only to sell their product. We do observe the average return of those farmers who use the cash/spot market only, but we do not observe the average return of the same group of farmers who turn out adopting contract farming. If we treat contract farming as a program and farmers can choose to participate, it is natural to use the matching estimation to solve this problem. Matching estimation is a wildly used method to compare the treatment effect of participating in some programs (Todd 2008). Basically, it compares the outcome of the program participants with the outcome of nonparticipants with similar observed characteristics. We first assume that there are two potential outcomes, Y_0 and Y_1. Y_1 is the outcome of the person participating the program and Y_0 is the outcome of the person not participating the program. A person can only either participate or not participate the program, and therefore there will be only one outcome observed. As a result, the treatment effect, $\Delta = Y_1 - Y_0$, is not directly observable. We then define

Table 2. Marketing arrangements frequencies by commodity

Commodity	Cash/spot market		Marketing contracts		Total	
	frequency	%	frequency	%	frequency	%
Corn	3060	71.76	1204	28.24	4264	100
Soybean	3659	77.74	1048	22.26	4707	100
Wheat	2671	86.60	413	13.40	3084	100

Source: ARMS data summarized by this study the observed outcome, $Y = DY_1 + (1 - D)Y_0$, where D is a state variable. $D = 1$ if the person involves in the program, and else $D = 0$. The key interested parameter to be estimated, the mean impact of treatment on the treated (ATT), then could be written as

$$\Delta_{ATT} = E(Y_1 - Y_0 | D = 1)$$

According to Rosenbaum and Rubin (1983), the procedure of the matching estimation can be separated into two steps. In the first step, we estimate the following discrete choice logit model:

$$D_i = \beta Z_i + \varepsilon_i$$

The dependent variable D_i defined as 1 if farmer i uses marketing contracts and 0 otherwise. The explanatory Z_i or the matching variables are the farm characteristics (total acres farmed, farm income, off-farm income, farm assets, location dummies) and the farmer characteristics (age, gender, education level and number of family members). ε_i is the error term for farmer i following a type I extreme value distribution. The probability for farmer i to adopt the marketing contract then can be written as

$$Pr(D_i = 1 | Z_i) = \frac{\exp(\beta Z_i)}{1 + \exp(\beta Z_i)}$$

In the second step, by using the estimation result from the logit model, the propensity scores, or the predicted probabilities for the farmers using marketing contracts, are calculated and used to estimate the mean impact of the treatment on the treated (Δ_{ATT}) on farmers average return (Y). The Δ_{ATT} can be estimated as follows:

$$\widehat{ATT} = \frac{1}{N^t} \sum_{i:D_i=1} \left[Y_i(1) - \hat{Y}_1(0) \right]$$

N^t is the number of farmers using contracts in the sample. $Y(1)$ is the observed average return for the farmer actually using marketing contracts and $\hat{Y}(0)$ is the estimated counterfactual average return for the same farmer not using marketing contracts. By using the matching estimation, we will be able to construct a suitable comparison group to estimate the impact of contract farming on the farmers' average return

RESULTS AND DISCUSSION

Empirical results by commodity for the logit models are presented in Table 3. Midwest is set to be the baseline region, and the regional dummy for Midwest is not included. In some regions, not all

Table 3. Logit estimation results for corn, soybean and wheat

	Corn		Soybean		Wheat	
	estimate	*t*-stat	estimate	*t*-stat	estimate	*t*-stat
Age	–0.0243**	–7.05	–0.0199**	–5.7	–0.0126*	–2.56
Sex	0.0001	0.00	0.6190	1.59	0.6196	1.18
Education	0.1883**	4.96	0.1787**	4.59	0.2089*	3.65
nfamily	–0.0155	–0.61	–0.0397	–1.55	0.0316	0.84
Total Acres	0.2305**	8.46	0.2589**	9.02	0.0603*	3.74
Income	0.0270**	2.26	–0.0003	–0.10	–0.0002	–0.29
Offfarm	0.0612	1.12	–0.0027	–0.05	0.0535	0.70
Asset	–0.0834	–0.52	–0.4250*	–1.75	0.0067	0.05
R1	–	–	–1.3483**	–2.23	–1.7986*	–1.77
R3	–0.7270**	–6.65	–0.3840**	–4.09	–0.0691	–0.45
R4	–0.9656**	–2.44	–	–	0.2168	1.49
R5	–0.4531	–1.05	–	–	0.3489**	2.18
Constant	–0.3733	–0.90	–1.4087**	–3.03	–2.7154**	–4.19
log likelihood	–2407		–2400		–1182	
# of observation	4264		4707		3084	

*10% significance level, **5% significance level; for explanation R1–R5 see Table 1

Source: Statistical results from this study three commodities (corn, soybean and wheat) are produced. Therefore, region 1 is excluded in the corn model, and region 4 and 5 are excluded in the soybean model. Among the three commodities, age, education level and the total acres farmed have consistent and significant effects on contract farming. Age has a negatively significant effect, which means the younger operator is more likely to use marketing contracts. Education level has a positively significant effect on contract farming, which means that the operator with a higher education level is more likely to use marketing contracts. The total acres farmed have a positively significant effect on contract farming, which means that if the size of the farm is larger, it is more likely to use marketing contracts. These results are consistent with the relevant studies in the literature (Lambert and Wilson 2003; Katchova and Miranda 2004; MacDonald et al. 2004; Hu et al. 2012). For the regional dummy, corn and soybean farmers in Midwest are more likely to use marketing contracts. For wheat producers, farmers in region 5 is more likely to use marketing contracts compared to the wheat farmers in Midwest, and location does not have a significant effect in other 4 regions.

The main results in this study are presented in Table 4. The results are showed by commodity (corn, soybean and wheat). In the table, unmatched samples show the different observable average returns for the group of farmers using marketing contracts (*contract farming*) and for the group of farmers using the cash/spot market only (*cash only*). *Different* in the table shows the difference between *contract farming* and *cash only*. From the results for unmatched samples, the average returns of the treated (contract farming) and control (cash only) are statistically different. The difference of the average returns between the farmers using marketing contracts and the farmers using the cash/spot market only for corn, soybean and wheat are $0.1573, $0.0757 and $0.045 per bushel, respectively. If we take the average return for the farmers using cash market only as the base, the percentage differences of the average returns between farmers using contracts and farmers not using contracts are 7.47%, 1.17% and 1.32% for corn, soybean and wheat, respectively. The unmatched results show that the average returns for farmers using marketing contacts are consistently and significantly higher than the average returns for the farmers using the spot/cash market only which means the contract farming has a positive and significant effect on the farmers' average return.

The other part in Table 4 shows the matching estimation results or the mean impact of treatment on the treated (ATT). For corn and soybean, the results are consistent with the unmatched sample: the average returns for farmers using contracts are significantly greater than the average returns for farmers not using contracts. The corn farmers using marketing contract can earn $0.1735/bushel (or 8.31%) more than the corn farmers using the cash market only to sell their product. The soybean farmers using marketing contract can earn $0.0788/bushel (or 1.22%) more than the soybean farmers using the cash market only to sell their product. Compared the unmatched and matched (ATT) results, the effect of contract farming on the corn and soybean farmers' average returns is a bit greater for the matching estimation. For corn, the difference of the farmers' average returns between the farmers using contract farming and cash market only increases from the unmatched 7.47% to matched 8.31%; for soybean the difference increases from the unmatched 1.17% to matched 1.22%. It shows that after controlling farm and farmer characteristics, the impact of contract farming on corn and soybean farmers' average returns could be even larger. If we simply compare the average returns between farmers using contracts and farmers using the ash/spot market only, we might underestimate the impact of contract farming on the average return for corn and soybean. For wheat, with matching estimation the

Table 4. The effect of contract farming on the farmers' average returns (U.S. dollar/bushel)

Commodity	Sample	Contract farming	Cash only	Difference	*t*-stat
Corn	unmatched	2.2620	2.1047	0.1573**	9.24
	ATT	2.2620	2.0886	0.1735**	9.93
Soybean	unmatched	6.5533	6.4776	0.0757**	2.84
	ATT	6.5533	6.4745	0.0788**	2.77
Wheat	unmatched	3.4547	3.4098	0.0450**	2.71
	ATT	3.4547	3.4315	0.0232	1.41

*10% significance level, **5% significance level

Source: Statistical results from this study difference of the average returns between the treated and controlled groups turns out to be statistically insignificant. It means that the impact of contract farming on the average return of the wheat farmers might be negligible. Our results provide some empirical evidence that the contract farming can increase the corn and soybean farmers' average returns, which means by using the marketing contracts farmers are able to sell their product at a higher price. Since both the seller and the buyer can benefit from using the agricultural contract, it is possible that the processors/buyers would be willing to pay a higher price to ensure that their inputs are kept at a level high enough to produce efficiently or to reduce the risk of the input price variation.

CONCLUSION

Contract farming is one of the most important phenomena in the modern agriculture. It is proposed to help farmers to reduce risks, to save transaction costs, and to improve production efficiency/profitability. There are many studies examining those advantages in the livestock sector. However, the research in the crop sector is lacking. Because of the data limitation, instead of examining the effect of contract farming on the farmers' profitability, the objective of this study is to examine the effect of contract farming on the average returns of the corn, soybean and wheat farmers. Since in our dataset we only observe the average returns under one of the two possible states, farmers using contracts or farmers using the cash/spot market only, it is natural to use the matching estimation examining the treatment effect (contract farming) on the farmers' average returns.

By using an unique and abundant farm level dataset, our matching estimation results show that the use of marketing contracts can increase the average returns for the corn and soybean producers, and the impact of contract farming has a negligible (statistically insignificant) effect on the wheat producers' average returns. The wheat results also show some sample selection problems if the matching estimation is not used. This study provides a different viewpoint of the contract farming from the return side but not the productivity side, and it focuses on the crop sector. Productivity efficiencies do not imply profitability, and vice versa. The price or the average return plays an important role in determining the profitability of a farm and this study finds some empirical support that contract farming has a certain positive impact on the farmers' average return. Because of the data limitation, it is difficult to directly estimate the profitability effect of contract farming. This study gives some inspiration for the issues regarding the effect of contract farming on the farmers' profitability.

Acknowledgement

This project was funded by the National Science Council of Taiwan (NSC 100-2410-H-126-041).

REFERENCE

Ahearn M., Yee J., Korb P. (2005): Effects on differing farm policies on farm structure and dynamics. American Journal of Agricultural Economics, *87*: 1182–1189.

Allen D., Luke D. (1993): Transaction costs and the design of cropshare contracts. RAND Journal of Economics, *24*: 78–100.

Fukunaga K., Huffman W.E. (2009): The role of risk and transaction costs in contract design: Evidence from farmland lease contracts in U.S. agriculture. American Journal of Agricultural Economics, *91*: 237–249.

Hobbs J. (1997): Measuring the importance of transaction costs in cattle marketing. American Journal of Agricultural Economics, *79*: 1083–1095.

Hu W.-Y., Phaneuf D., Zheng X. (2012): Quantify the benefits associated with the use of alternative marketing arrangements by the U.S. farmers. China Agricultural Economic Review, forthcoming.

Katchova A.L., Miranda M. (2004): Two-step econometric estimation of farm characteristics affecting marketing contract decisions. American Journal of Agricultural Economics, *86*: 88–102.

Knoeber C. (1989): A real game of chicken: Contracts, tournaments, and the production of broilers. Journal of Law, Economics and Organization, *5*: 271–292.

Knoeber C., Thurman W. (1995): Don't count your chickens: Risk and risk shifting in the broiler industry. American Journal of Agricultural Economics, *77*: 486–496.

Key N., McBride W. (2003): Production contracts and productivity in the U.S. hog sector. American Journal of Agricultural Economics, *85*: 121–133.

Lambert D., Wilson W. (2003): Valuing varieties with imperfect output quantity measurement. American Journal of Agricultural Economics, *85*: 95–107.

MacDonald J.M., Perry J., Ahearn M.C., Banker D., Chambers W., Dimitri C., Key N., Nelson K.E., Southard L.W. (2004): Contracts, Markets, and Prices: Organizing the Production and Use of Agricultural Commodities. USDA-ERS Agricultural Economic Report No. 837. Available at http://ssrn.com/abstract=753567

MacDonald J., Korb P. (2011): Agricultural contracting update: Contracts in 2008. Economic Information Bulletin, EIB-72: 1–35.

Morrison C.P., Nehring R., Banker D. (2004): Productivity, economies and efficiency in U.S. agriculture: A look at contracts. American Journal of Agricultural Economics, *86*: 1308–1314.

Todd P. (2008): Matching Estimators: The New Palgrave Dictionary of Economics. 2nd ed. Palgrave Macmillan, New York; ISBN 0333786769.

Rosenbaum P., Rubin D.B. (1983): The central role of the propensity score in observational studies for causal effects. Biometrika, *70*, 41–55.

Zheng X., Vukina T., Shin C. (2008): The role of farmers' risk aversion for contract choice in the U.S. hog industry. Journal of Agricultural and Food Industrial Organization, *6*, Article 4. Available at http://www.bepress.com/jafio/vol6/iss1/art4

Received: 15th October 2012
Accepted: 28th March 2013

Contact address:

Wu-Yueh Hu, Department of Applied Economics, National Chung Hsing University, 250 Kuo Kuang Rd., Taichung 402, Taiwan
e-mail: wyhu@nchu.edu.tw