Food Processors' Use of Contracts to Purchase Agricultural Inputs: Evidence from a Pennsylvania Survey

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Using data from a survey of Pennsylvania food processors, we investigate what firm-level characteristics make a processor more or less likely to buy agricultural inputs and ingredients though contracts. We find that over 20 percent of Pennsylvania processors use contracts, and over 44 percent of agricultural inputs (based on value) are purchased under contract. We also analyze the two related questions of what firm attributes, attitudes, or other factors make a firm more likely to use contracts at all, and what factors lead a processor who does contract to use them more intensively.

Key Words: contracting, food processors, logit, sample selection

The use of contracts for producing and marketing agricultural products has become increasingly prevalent and even nearly universal in some agricultural sectors in the United States. For decades now, nearly all broilers and canned or frozen vegetables have been produced and marketed according to contracts offered by processors. More recently, newly developed high-value grains, such as high-oil corn, have been produced exclusively under contract. In 2003, according to the U.S. Department of Agriculture, 39 percent of the total value of U.S. agricultural commodities was produced or marketed under contract. Approximately 85 percent of this amount covers the following eight commodity groups: corn, soybeans, fruit, vegetables, cattle, hogs, poultry and eggs, and dairy (MacDonald and Korb 2006).

Contract use by producers in Pennsylvania and other parts of the Northeast is not quite as prevalent as in the United States as a whole. In several USDA-labeled regions of the country, the growth of contract use between producers and processors is associated with specific commodities: hogs and tobacco in the Southern Seaboard, rice and cotton in the Mississippi Portal, and hogs again in the Heartland. Pennsylvania falls mostly in a region that USDA calls the Northern Crescent, which is the most populous of USDA's nine regions and is generally associated with dairy, general crop, and cash grain farms.[1] According to MacDonald et al. (2004), contract use covers 32.6 percent of the total production value in this region, a figure just under the 2001 national average of 36.4 percent.

Contract activity aside, Pennsylvania is a leading food processing state, ranking near the top in several measures (U.S. Census Bureau 2005). According to statistics for the food manufacturing category (NAICS code 311) in the 2002 Census, Pennsylvania ranks fourth among all states in a number of Census categories, including the value of shipments, annual payroll in the industry, number of establishments, and number of employees. Moreover, Pennsylvania food manufacturing shipments represent 30.7 percent of the value of all shipments in the Northeast (defined broadly to include Maryland, Delaware, and West Virginia, as well as traditional Northeast states). Within Pennsylvania, sugar and confectionary product manufacturing represents 18.4 percent of total food manufacturing shipment value, followed

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[1] USDA's Northern Crescent covers all of Pennsylvania except the extreme southeast portion and also includes all of New England, New York, New Jersey, Michigan, and Wisconsin, and parts of Minnesota, Ohio, and Maryland. Southeast Pennsylvania falls in USDA's Eastern Uplands region, which also covers all of West Virginia and parts of other states through which the southern Appalachian mountains run.

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closely by "other food manufacturing" (which includes snack food manufacturing) with 17.6 percent, meat processing with 17.0 percent, bakery activity with 14.4 percent, and dairy processing with 13.4 percent.

A number of studies, focused mostly on agricultural activity outside the Northeast, have surveyed processors or other agricultural intermediaries for their views on why contracting has grown. For example, after surveying the largest beef and pork packers, Lawrence, Schroeder, and Hayenga (2001) find that packers believe that contracts and other forms of vertical coordination are better vehicles than market transactions to achieve the higher and more consistent quality products demanded by consumers. They also find that more than half of the surveyed packers claim that producers are asking for contracts in order to mitigate risks associated with financing their operations and securing an output market. Another survey of lettuce and cut vegetable shippers finds that technology and increased consumer demand for convenience have led to more formal relationships, including more written contracts, between shippers and retailers (Glaser, Thompson, and Handy 2001). And finally, a survey of California fruit, nut, and vegetable intermediaries shows that contracts in ten of 15 commodities specifically employ some form of in-house quality measurement (Hueth et al. 1999). Collectively, these studies suggest that processors or other intermediaries are keenly interested in the ability of contracts to improve coordination of high-quality products through the supply chain, and to help manage the production and price risks faced by producers.[2]

Consistent with these empirical surveys, two broad theoretical rationales are often cited as reasons for the increased use of agricultural contracts by agricultural producers and food processors (see, for example, MacDonald et al. 2004, or Boehlje and Schrader 1998). The first explanation focuses on the beneficial role that contracts play in sharing risks between processors and producers. Because processors are generally less exposed to production and price risks, contracts can be designed to transfer risks away from producers, often in exchange for lower but certain prices or for output that meets particular specifications. The second explanation covers a wide range of issues related to producer-processor transaction costs where the spot market is believed to be inadequate, and ultimately costly, in providing the proper incentives to producers. This transaction cost explanation focuses on the efforts to coordinate production technology and product specifications between producers and processors, and to meet consumers' demand for high-quality products.

A critical review of previous reports reveals three gaps where new research will increase our understanding of contracting activity. First, there is an incomplete understanding of the specific firm-level factors or attributes that lead some processing firms but not others to use contracts, and of why some firms contract more intensively than others. Second, when specific firm-level factors that influence contracting are identified, they are not often linked to the theoretical rationale for contracting. Third, because previous empirical studies focus primarily on Midwest or California agriculture, we have little or no information about contracting by processors in the Northeast, even though such processors account for a significant proportion of U.S. production. Our study aims to address these gaps by investigating the use of input procurement contracts by Pennsylvania food processors, identifying firm-level factors that influence contract use or intensity, and linking these factors to theoretical rationales for contracting.

Using data from a survey of food processors, we first characterize the contracting activity in Pennsylvania and then analyze the two related questions of what factors make a firm more likely to use contracts, and what leads a processor who does contract to use them more intensively. Our survey and analysis lead to four main results and conclusions. First, we find that a substantial percentage of Pennsylvania processors do buy inputs under contract. Second, we find that Pennsylvania processors that use contracts have higher total sales on average than those Pennsylvania firms that do not use contracts. Third, several firm-level attributes and factors have a significant impact on both the likelihood of a firm's use of contracts and on the intensity of their use. Fourth, in general, our results provide mixed empirical support

[2] A number of studies investigating the design of contracts cite either quality considerations (see, for example, Boger 2001, Hueth and Ligon 1999, and Hueth and Melkonyan 2004) or risk-sharing properties (see, for example, Knoeber and Thurman 1995, and Martin 1997) as compelling factors in the design and implementation of contracts between producers and processors.

for linking these firm-level factors to the two broad theoretical explanations for contract use, namely the ability of contracts to provide risk sharing and transaction cost benefits. These findings are more thoroughly described below.

First, however, more background in two areas will help put the findings in context. We start by discussing in more detail how the theoretical rationales for contracting apply in the case of Pennsylvania food processors. In the following section, we describe the survey data—and their limitations—used to investigate contracting in Pennsylvania.

Reasons for Contracting by Food Processors

Over the past 40 years, one of the reasons most often cited for vertical contractual relationships in general and the increased use of contracting in agriculture in particular is risk sharing (for example, see Katz 1989 for a general discussion, and Mighell and Jones 1963 and Martinez 1999 for more detailed discussion of the agricultural case). From a risk-averse producer's perspective, contracts offer insulation from production and/or price risk. In return for risk protection, producers may be willing to accept a certain price that is less than the market may be expected to bear. Thus, processing firms that are able to provide risk-sharing services benefit through the risk-return tradeoff. Theory suggests, therefore, that these more able firms should be those more likely to contract for their inputs, all else equal. Fitting this criterion are firms that (i) are highly diversified, both in terms of their input purchases and their outputs, and (ii) have access to financial markets associated with their inputs or outputs.

In the empirical analysis that follows, we hypothesize that a number of firm-level attributes are associated with a firm's ability to provide risk-sharing services and therefore indicate an increased or decreased propensity for a firm to offer contracts. For example, a processor's size may be an indication of how well equipped it is to share risks.[3] Total sales, total expenditures on inputs, or even total number of employees all offer an indication of size, and potentially how likely a processor is to contract. Data on product diversification is not available, but some information on a firm's target market is. For example, whether or not a firm sells to a national or international market may be an indication of how easily a processor can share risks; a firm that is less dependent on its geographic region may be more likely to contract. These hypotheses, based on risk-sharing arguments, will be tested in the next sections.

A second commonly cited reason for contracting focuses on reduced transaction costs (see, for example, Holmstrom and Tirole 1989, and Williamson 1989). This explanation, which centers on improved coordination through the supply chain and overcoming incentive and informational problems within a firm, seems to be closely aligned with a processor's objectives. Transaction cost theory suggests that firms that benefit the most from using contracts are those that have a greater need of coordination through the supply chain, that rely on a higher proportion of specific assets, that incur increased levels of monitoring, that require consumer-driven quality specifications, and that pay substantial search costs in finding suppliers or buyers.

Practically, it may be difficult to observe firm attributes that link to these criteria unless firms are surveyed directly about their operations. Our empirical analysis, therefore, will investigate hypotheses about contracting by relying on survey responses to questions that only indirectly reflect a firm's ability to lower transaction costs. These questions, for example, help gauge firms' concerns about the cost of finding suppliers or buyers, meeting specific input quality concerns, adhering to product labeling requirements, and maintaining a product's identity and traceability through the supply chain. Processors with greater concerns over these issues and higher potential transaction cost savings may be more inclined to use contracts. Alternatively, when potential transaction cost savings are low, such as when a processor is located in close proximity to input supplies or output markets, firms may be less inclined to contract.

In addition to factors that fit the risk-sharing and transaction cost explanations for contracting, MacDonald et al. (2004) and MacDonald and Korb (2006) note several other commodity-specific, regional, and farm-size factors that are as-

[3] An anonymous reviewer points out that larger firms may also have increased motivation to contract in order to fill their larger capacity. If true, the effect of firm size on the likelihood of contracting would be similar, but the rationale would be different. The rationale for contracting would be more akin to minimizing transaction costs.

sociated with increased rates of contract use. For example, these studies find that contracting does in fact vary by commodity. In 2003, the percentage of production value sold under marketing or production contracts was 88.1 percent for poultry and eggs, 68.1 percent for fruit, 57.3 percent for hogs, 50.6 percent for dairy, and 42.7 percent for vegetables (MacDonald and Korb 2006).[4] MacDonald and Korb (2006) also find that contract use increases as farm revenue increases.[5]

Models for Processors' Contract Adoption and Intensity

In this section, we describe a model to test hypotheses that relate processors' use of contracts to firm-level attributes linked to firms' abilities to provide risk-sharing opportunities and to reduce transaction costs. More specifically, we develop models to investigate two closely related questions on contracting. We first model the likelihood that a food processor will choose to use contracts to purchase agricultural inputs or ingredients based on firm attributes that indicate these risk-sharing and transaction cost reducing opportunities. This particular firm decision is similar to a technology adoption decision where the observed outcome is binary—whether or not a processor has chosen to adopt the use of contracts. In this way, a processor's decision to adopt the use of contracts can be modeled as a discrete choice where the dependent variable, y_1, takes the value of 1 if a firm adopts the use of contracts and 0 if it rejects it. The factors thought to explain this decision compose a vector, $\boldsymbol{x}_1$, so that

$$y_1^* = \boldsymbol{x}_1'\beta_1 + \varepsilon, \tag{1}$$

where $\boldsymbol{x}_1'\beta_1$ here takes a linear form by assumption, and $y_1 = 1$ if $y_1^* > 0$ and $y_1 = 0$ if $y_1^* \leq 0$. Given a cumulative distribution, $F(.)$, the associated probabilities for y_1 are the following:

$$\text{Prob}\,(y_1 = 1) = F(\boldsymbol{x}_1'\beta_1), \text{ and} \tag{2}$$

$$\text{Prob}\,(y_1 = 0) = 1 - F(\boldsymbol{x}_1'\beta_1). \tag{3}$$

Routinely, one may choose a normal distribution for the form of $F(.)$ resulting in a Probit model, or a logistic distribution resulting in a Logit model. Based on the logistic, (2) becomes

$$\text{Prob}\,(y_1 = 1) = \frac{e^{\beta_1' x_1}}{1 + e^{\beta_1' x_1}}. \tag{4}$$

Second, for those firms that have chosen to contract, we model the intensity of the use of contracts. Measured as a proportion of inputs purchased under contract, the observed outcome of this decision is bounded below by zero and above by one. Data censored in this way is commonly estimated by the following model:

$$y_2^* = \boldsymbol{x}_2'\beta_2 + \varepsilon, \tag{5}$$

where $y_2 = y_2^*$ if $0 > y_2^* > 1$, $y_2 = 0$ if $y_2^* \leq 0$, and $y_2 = 1$ if $y_2^* > 1$. Moreover, because the proportion of inputs purchased under contract is observed only if a firm has first decided to contract, there is the potential for sample selection bias (Greene 2003). In other words, $y_2 = 1$ may be observed, but $y_2 = 0$ is not observed. To correct for sample selection bias, therefore, the inverse Mill's ratio from the first model is added to $\boldsymbol{x}_2$, the list of regressors in the Censored model. The first-stage model, again, is routinely a Logit or a Probit.[6] Finally, the explanatory variables for both the adoption and intensity models, $\boldsymbol{x}_1$ and $\boldsymbol{x}_2$, are likely to be similar, though they need not be. In the empirical estimation that follows, we will also assume that $\boldsymbol{x}_1$ and $\boldsymbol{x}_2$ are equivalent, mainly because we have no prior reason to believe that

[4] Several other commodities not typically grown in Pennsylvania (or the Northeast) also had a high percentage of production value sold under contract. These include sugar beets (95.5 percent), tobacco (54.8 percent), peanuts (53.3 percent), rice (51.8 percent), and cotton (51.4 percent),

[5] For example, MacDonald and Korb (2006) note that only 19.9 percent of farms with gross sales less than $250,000 use contracts. However, 31.3 percent of farms with sales between $250,000 and $500,000 use contracts, as do 42.6 percent of farms between $500,000 and $1 million, and 53.4 percent of farms over $1 million.

[6] In the results section, we present results for the Logit adoption model because the coefficients are more easily interpreted. However, we present results for the censored regression model that uses a Probit for the sample selection equation. We chose the Probit in this case so that the error structures of both first- and second-stage models are based on the normal distribution. The choice of Logit or Probit does not affect our results described in the next section.

any one particular variable would help explain one decision but not the other.

Data

A written survey instrument of 32 multi-part questions was developed that asked background information about processing firms' structure, size, and other demographic attributes. This instrument, however, was focused primarily on firms' competitiveness concerns, including issues related to firms' locations. Among other questions in this instrument were questions asking if firms used contracts to buy agricultural inputs or other ingredients directly from farmers and, if they answered affirmatively, what percentage of agricultural inputs were purchased through contracts.

The survey instrument was aimed at the entire population of food processors located in Pennsylvania that met three criteria: (i) using data from the PA ES-202 Dataset for 2003, the company had an NAICS code of 311 (food manufacturing) or 3121 (beverage manufacturing); (ii) the company had more than four employees; and (iii) at least one of the two (potentially) available addresses was located in Pennsylvania. Based on these criteria, we identified a total sample of 1,180 names and addresses of Pennsylvania food processing businesses.

The first step in administering the survey, which began in October 2004, was mailing the initial cover letter, survey, and business reply envelope to all 1,180 businesses in the Pennsylvania food and beverage manufacturing population. Two weeks later, a reminder postcard was sent to all of the addresses. To increase the response rate, a third mailing was administered to all non-respondents in early November 2004. This third mailing was composed of a follow-up letter, another copy of the survey, and a business reply envelope. This mailing was sent to 921 identified non-respondent businesses.

At the completion of the mailings, in early December 2004, 312 surveys were completed and returned, resulting in an overall response rate of 26 percent. A question at the beginning of the food processor survey was used to filter out those businesses that were not a food processing or food making facility. Seventy-eight of the returned surveys (6.6 percent) indicated they were not a food processing facility.[7] Ultimately, we obtained a data file containing 234 food processor survey respondents; however, only 208 firms answered the specific question on contract use. Since the survey was primarily focused on other issues, we do not feel respondents were biased relative to the contracting questions.

Two separate concerns arise over how representative the data are. First, there is a potential concern that Pennsylvania food processors are not representative of U.S. food processors. And second, given the low response rate, there is a potential concern that the response data from the population survey are not representative of Pennsylvania food processors. To address these concerns, we compare in Table 1 data from the Census of Manufacturers for the United States as a whole with Census data for Pennsylvania, and then the Census data for Pennsylvania with the food processor survey data.

In general, Pennsylvania firms, on average, have much in common with other U.S. firms. Comparing Census data for the United States and Pennsylvania, one can see that Pennsylvania food processors, on average, are just slightly smaller than the U.S. average. For example, Table 1 shows that Pennsylvania firms averaged $16.2 million in shipments, compared to $17.0 million for the United States, and 51 employees per firm compared to 53. The distribution of firms among sub-industries is fairly similar to that of the United States as a whole (e.g., within 1 percent), except that Pennsylvania has proportionally more sugar and confectionary firms and bakeries and fewer fruit/vegetable and seafood firms. Pennsylvania grain and animal processing firms are smaller than the national average; alternatively, confectionary and fruit/vegetable firms, and other food manufacturers (including snack food manufacturers), are larger.

Table 1 also presents a comparison of the survey data to Census data for Pennsylvania. In general, the survey data overstate the size of the average Pennsylvania food processor. Sales per firm survey figures are more than double the shipment figures from the Census, and employee figures

[7] Of the 1,180 businesses in the original mailing, 131 were returned due to an invalid address or a business no longer operating (11 percent). Three businesses refused to participate by returning their surveys to us blank or returning the letter with a note indicating they did not want to participate (0.25 percent).

Table 1. A Comparison of the U.S. and Pennsylvania Census Figures to the Pennsylvania Food Processor Survey

		US—2002 Census			PA—2002 Census			PA Food Processor Survey—2004		
		Shipments			Shipments			Sales		
NAICS		[# of Firms]	$/firm		[# of Firms]	$/firm		[# of Firms]	$/firm	
Code	Description	% of Firms	($1000s)	Empl./firm	% of Firms	($1000s)	Empl./firm	% of Firms	($1000s)	Empl./firm[a]
	Food mfg. (311 and 3121)	[30,823]	17,029	53	[1,501]	16,204	51	[234]	33,230	66
3111	Animal food mfg.	5.9%	15,475	26	6.9%	14,640	31	5.6%	16,608	39
3112	Grain & oilseed milling	2.8%	56,152	65	2.0%	31,313	31	2.1%	4,025	16
3113	Sugar & confectionary prod. mfg.	6.0%	13,834	44	10.1%	26,909	67	8.1%	10,471	62
3114	Fruit & veg. presrv. & spec. food mfg.	5.7%	30,738	102	3.3%	33,923	134	7.3%	15,146	60
3115	Dairy product mfg.	5.5%	39,367	77	6.6%	30,104	76	13.7%	105,172	89
3116	Animal slaughtering & processing	12.9%	30,939	127	11.8%	21,417	82	14.5%	37,930	119
3117	Seafood prod. prep. & packaging	2.4%	11,762	55	0.6%	13,535	43	---	---	---
3118	Bakeries & tortilla mfg.	37.1%	4,292	27	39.2%	5,443	29	27.4%	17,040	27
3119	Other food mfg.	12.4%	14,876	42	11.1%	23,665	64	12.0%	38,572	131
3121	Beverage mfg.	9.4%	22,729	47	8.3%	16,372	47	9.4%	4,429	20

[a] Employment figures for the Pennsylvania Food Processor Survey represent full- and part-time employees.

are about 30 percent greater. The size of surveyed grain, fruit/vegetable, and beverage firms are substantially below the Census averages, while the size of surveyed dairies, bakeries, meat processors, and other food manufacturers (i.e., snack food firms) are substantially above the Census averages. Comparing the distribution of firms in industry sub-sectors, confectionary processors and bakeries are substantially underrepresented (e.g., greater than a 1.5 percent difference), while fruit/vegetable processors, dairies, and meat processors are overrepresented. While substantial at times, these discrepancies therefore do not in general appear to be systematic across industry sub-sectors.

Investigating firms' contracting behavior is a secondary use of the survey data. The survey instrument was originally developed to gauge firm concerns and attitudes about the current business environment in Pennsylvania for food processors and the outlook for business development and expansion. Nonetheless, a number of the 32 multi-part questions in the survey instrument are pertinent to our investigation of contracting. Appendix A presents the wording of the survey's two-part question on contract use as well as other questions used in the analysis that follows.

Examining the sample of processors who responded to the question on contracting reveals that 42 of 208 Pennsylvania food processing firms (20.2 percent) use contracts. Table 2 shows how the contracting response is related to the firms' estimated total annual sales.[8] For all firms in the survey (that answered the question on contracting), total annual sales average just over $34 million. Notably, average annual sales for firms that contract are 2.5 times greater than the overall average. Comparing sales for firms that do contract versus those that do not, the difference is even greater: contracting firms have over $85.5 million in average sales, nearly four times greater than the non-contracting firms' average of $21.6 million. When the firms are categorized by their self-identified main product, the relationship between contract use and sales is even more pronounced. As Table 2 shows, average sales are much higher for contracting firms that claimed fruit or vegetables as their main product, as are sales for firms that said their main product is a combination of multiple categories or a category other than one listed in the survey. On the other hand, average sales are lower for contracting firms with meat or grain as their main product. Table 2 also shows the distribution of contracting responses based on the firm's self-identified main product. One can see that contracting appears to be most prevalent in the "other/multiple products" category. However, firms whose main product is fruit or vegetables have the highest incidence of contract use, while meat firms have the lowest. The survey results from Pennsylvania processing firms are largely consistent with findings from MacDonald and Korb (2006) and MacDonald et al. (2004). Finally, Table 2 shows that of firms using contracts, dairy firms use them most intensively, i.e., buy the highest proportion of inputs under contract. Contracting fruit/vegetable firms and firms in the multiple product category also use contracts very intensively.

The survey also contains information on firms' input expenditure. We estimate that 44.8 percent of inputs, based on their dollar value, are purchased under contract by Pennsylvania food processors.[9] This estimate is slightly higher than MacDonald and Korb's (2006) finding that 39 percent of agricultural commodities for the United States as a whole, based on value, were produced or marketed under contracts between growers and processors.

Based on risk-sharing and transaction cost rationales for contracting, as well as other findings from MacDonald et al. (2004), we identified 16 variables in the Pennsylvania food processor survey or other available sources that might be expected to positively or negatively influence the likelihood of a firm's decision to contract for agricultural inputs. These variables are listed and

[8] In the survey instrument, firms were given a choice of answering an open question of total sales and/or choosing a sales category. In all, 210 firms answered one or both of these questions. More specifically, 116 firms provided a total sales figure and 128 chose a sales category. To investigate the issue of how total sales might be related to contract choice, we assigned firms answering only the sales category question to the midpoint of the sales category. Firms choosing the highest sales category (> $20 million) were assigned a sales figure based on the number of employees they had and sales per worker estimates (by NAICS codes) obtained from secondary sources. This extrapolation was made for 19 firms in the highest sales category.

[9] The survey asked firms to choose one of 12 input expenditure categories. Firms were assigned the midpoint of the expenditure range. Expenditures for those firms in the maximum input expenditure category (i.e., input expenditures greater than $15 million) followed an extrapolation that involved calculating the average sales-to-input expenditures ratio for all other firms and applying this calculation to the high expenditure firms' sales.

Table 2. Extent of Contracting and Average Sales for Pennsylvania Food Processors (2003)

Self-Identified Sector	Contracts or No Contracts	# of Firms	Average Sales ($)	Contracting Intensity (%)[a]	# of Responses
Fruit or vegetables	contracts	9	35,698,034	65.9%	8 of 9
	no contracts	6	1,825,000		
Dairy	contracts	4	41,944,800	99.8%	4 of 4
	no contracts	23	35,188,261		
Meat	contracts	3	33,500,000	37.0%	3 of 3
	no contracts	26	38,016,007		
Grain	contracts	10	3,601,111	6.7%	10 of 10
	no contracts	13	56,269,231		
Other/multiple products	contracts	16	174,997,375	66.1%	15 of 16
	no contracts	98	10,200,994		
Total	contracts	42	85,484,358	53.7%	40 of 42
	no contracts	166	21,599,318		
	all firms	208	34,249,821		

[a] Here, contract intensity refers to the percentage of inputs purchased under contract. In the econometric model, this variable is measured as a proportion and bounded above by 1.

described in Table 3. Some of the variables, particularly those in the risk-sharing category, are at best weak proxies for theoretical rationales for contracting. For example, the number of full-time employees reflects a firm's ability to share risks only to the extent that firm size, as measured by employees, accurately captures this ability. The percentages of output sales leaving the Pennsylvania region and leaving the country are certainly weak proxies, as well, for risk-sharing ability. Though unavailable, better measures would reflect a firm's output diversity or the availability of financial markets. Conditional on these limitations, Table 3's variable categories represent our attempt to provide a link to theoretical rationales for contracting.

Table 3 also lists the anticipated impact that firm-level factors may have on contracting decisions. Based on theoretical explanations for contracting, we expect variables that reflect firm size, such as expenditures on inputs and number of employees, to be positively related to contracting variables because size may be one indication of a firm's ability to share risks with growers. We also expect that firms that target their sales outside the Pennsylvania region or outside the United States may also be more able to share risks, and hence expect a positive impact on contracting. Many of the other variables can be associated with the level of transaction costs between processors and growers. For example, we expect that two variables are negatively related to contracting variables. In the case of percentage of sales staying within a county, we believe a negative relationship may indicate higher potential transaction cost savings; i.e., firms that sell close to home benefit less from contracting, all else equal. For profitability concerns relating to a firm's proximity to inputs, a negative relationship stems in part from the variable definition. Smaller values of this categorical variable translate to increased concerns. Therefore, we believe that firms with increased concerns are more likely to contract due to potentially high search costs or costs associated with ensuring production capacity. On the other hand, we expect that several other variables are positively related to transaction cost savings and therefore positively related to the contracting variables. These variables include concerns about required inputs not grown or not grown enough in Pennsylvania, and concerns about product quality. Here again, lower values of the categorical variables for food safety regulations and food labeling reflect increased concerns. Therefore, we expect that these variables will have a negative relationship with contracting. Because MacDonald and Korb (2006) note that contracting is

Table 3. Descriptive Statistics and Expected Signs for Data Used in the Empirical Models

Variable	Variable Description/Units	Min.	Mean	Max.	Anticipated Impact
Dependent Variables					
Contract (1 if firm uses contracts)	0, 1	0	0.202	1	
Contracting intensity (proportion of inputs bought under contract)	(0,1]	0.01	0.511	1	
Factors Related to Processors' Ability to Share Risks					
Input expenditure[a]	$	5,000	4.5 mil.	295 mil.	+
Full-time employees	#	1	66.4	973	+
Percentage of sales outside the region	%	0	16.9	100	+
Percentage of sales outside the country	%	0	1.1	30	+
Factors Related to Processors' Transaction Costs					
Percentage of sales within the county	%	0	37.7	100	–
Concerns—inputs not grown in PA	0–1	0	0.4	1	+
Concerns—not enough grown in PA	0–1	0	0.2	1	+
Concerns—quality	0–1	0	0.1	1	+
Profitability factors—proximity to inputs	1–5 Scale: 1 = Critical, 5 = Not important	1	3.2	5	–
Profitability factors—food safety regulations	1–5 Scale: 1 = Critical, 5 = Not important	1	1.8	5	–
Profitability factors—labeling requirements	1–5 Scale: 1 = Critical, 5 = Not important	1	2.2	5	–
Other Factors					
Fruits or vegetables	0, 1	0	0.07	1	+
Meat	0, 1	0	0.12	1	+
Grain	0, 1	0	0.14	1	–
Dairy	0, 1	0	0.11	1	–
No. of farms in county > $100,000 in sales	From 2002 Census of Ag.	1	297.2	2,095	+

[a] This variable was constructed using the midpoints of input expenditure categories presented to survey participants. See footnote 8 for additional explanation of how this variable was constructed.

more frequent in some sectors (such as poultry, beef, and fruits and vegetables) than others, we also expect that firms that identified their primary product as meat or fruits and vegetables should be positively predisposed to contracting. Alternatively, firms whose primary product is (non-specialty) grain or dairy may be negatively predisposed to contracting.

Finally, MacDonald et al. (2004) also find that larger farms have higher rates of contracting than smaller farms. Because we surveyed processors instead of producers, we have no direct information on the size of processors' contracting partners. However, we can match up a processor's home county to the 2002 U.S. Census of Agriculture information to reflect the proximity to larger farms (which are more likely to contract). To do this, we include the number of farms within a processor's home county larger than $100,000 in sales.[10] When estimating the con-

[10] MacDonald et al. (2004) note that farms with sales larger than $250,000 are more likely to contract with processors. Data on farms above this sales threshold are not available from the Census of Agriculture. According to the Census data, 9,597 farms in Pennsylvania (16.5 percent of all farms) have more than $100,000 in sales.

tracting adoption and intensity models, we try including and excluding this variable. When it is included, we expect it to be positively related to contracting.

Results

Using the two decision models specified in (1)–(5), we estimated two model variations using the variables from Table 3. Models 1a and 1b are used for the contract adoption Logit model, where the binary variable equals 1 if a firm uses contracts at all and 0 if it does not. Models 2a and 2b are used for estimating the Censored model with sample selection, where the dependent variable is contracting intensity, the proportion of inputs purchased under contract. Models with the "a" suffix include all 16 variables from Table 3; models with the "b" suffix exclude the number of county farms with over $100,000 in sales.

Results for the contract adoption Logit model are presented in Table 4, where Models 1a and 1b differ only by the farm-size variable. This variable does not have a significant impact on contract adoption, and therefore results for Models 1a and 1b are very similar. Both models have a high degree of success predicting contract adopters (94 to 95 percent correct), but do a poorer job of predicting non-adopters (47 percent correct). These results, however, are not surprising given the high rate (just under 80 percent) of non-adoption. Overall, Models 1a and 1b are only moderately successful at identifying factors that significantly affect a firm's likelihood to use contracts. Only six factors were estimated to be significantly different from zero in impacting this likelihood: a firm's self-identified primary product was often significant, as were the firm's level of input expenditures, the percentage of sales outside the region, and the stated importance of being in close proximity to its inputs. We had expected to identify more factors that have a significant impact on the contract use decision. In particular, we thought that several variables listed in the category of transaction cost factors, such as quality concerns, and the importance of food safety regulations and food labeling requirements, would be significant factors because they were cited as important reasons for contracting in previous surveys of processors and handlers. The fact that these variables were not significant in Table 3 results suggests at least three possible explanations: (i) these factors may not be as important for Pennsylvania food processors as they are in other areas of the country or in more narrowly defined sectors of the agricultural economy, (ii) quality concerns or other factors have become less important in the contracting decision since some of the earlier studies were completed, or (iii) our survey questions did not do an adequate job of representing these factors.

In addition to identifying significant factors in the contracting decision, we attempted to link these factors to the risk-sharing and transaction cost saving rationales. Table 4 results, however, support our hypotheses in only a few cases. We associated four variables with the risk-sharing rationale, but found that only one of the estimated coefficients, input expenditures (logged), was significant and had the anticipated positive sign. In this case alone, the results support our hypothesis that increased input expenditures may proxy a firm's risk-sharing ability and lead a firm to be more likely to use contracts to purchase inputs. Two other coefficients in the risk-sharing category, full-time employees and the percentage of total sales made outside the country, were positive as hypothesized, but they were not found to be significantly different from zero. The negative and significant estimated coefficient for the fourth risk-sharing variable, the percentage of sales made outside the region, contradicts our hypothesis. We had expected that firms that increasingly sold to a national customer base would be more able to share risks with producers and be more likely to use contracts.

For variables we associated with transaction cost factors, we had hypothesized that three of the coefficients would be positive and four would be negative. Table 4 results also show that our expectations of the coefficients' signs were correct in five of seven cases. In only one case, however, is a coefficient significantly different from zero. Firms that are more concerned with being in close proximity to their purchased inputs are more likely to contract, presumably because these firms have high search costs for acquiring inputs (or ensuring capacity).

Table 4. Logit Results for Pennsylvania Food Processors' Use of Contracts (t-stats in parentheses)

Independent Variable	Model 1a	Model 1b	Model 1b Elasticities[a]
Constant	-7.554**	-7.188	
	(-2.707)	(-2.633)	
Risk Sharing Factors			
Input expenditures (log)	0.537**	0.511**	0.454
	(2.872)	(2.796)	
FT employees	0.001	0.001	0.084
	(0.693)	(0.669)	
Percentage of sales outside the region	-0.036**	-0.035**	-0.566
	(-2.565)	(-2.524)	
Percentage of sales outside the country	0.075	0.069	0.070
	(1.060)	(0.938)	
Transaction Cost Factors			
Percentage of sales within the county	0.001	0.001	0.032
	(0.155)	(0.109)	
Concerns—inputs not grown in PA	0.153	0.124	0.049
	(0.284)	(0.231)	
Concerns—not enough grown in PA	0.506	0.405	0.110
	(0.904)	(0.744)	
Concerns—quality	0.436	0.441	0.044
	(0.622)	(0.631)	
Profitability factors—proximity to inputs	-0.525**	-0.534**	-1.522
	(-2.816)	(-2.879)	
Profitability factors—food safety regs.	0.306	0.286	0.445
	(1.140)	(1.076)	
Profitability factors—labeling requirements	-0.099	-0.091	-0.175
	-0.358)	(-0.332)	
Other Factors			
Fruits or vegetables	2.504**	2.378**	0.278
	(2.946)	(2.900)	
Meat	-1.889*	-1.874*	-0.142
	(-1.885)	(-1.871)	
Grain	1.182*	1.183*	0.170
	(1.730)	(1.728)	
Dairy	-1.222	-1.248	-0.109
	(-1.416)	(-1.449)	
No. of farms in co. > $100k	-0.000		
	(-0.780)		
Number of observations	182	182	
Pseudo R-squared	0.3431	0.3397	
Percentage correct predictions: 1's	47.4	47.4	
Percentage correct predictions: 0's	95.1	93.8	
Percentage correct predictions: 1's and 0's	85.2	84.0	

[a] For continuous variables, the elasticity is interpreted as the percentage change in the probability of contracting due to a 1 percent increase in the explanatory variables, expect for logged input expenditures where total, not logged, expenditures are used. For dummy variables, the elasticity calculation reflects a change in the explanatory variable from 0 to 1.

Note: * = significant at the 0.10 level, ** = significant at the 0.05 level.

Three of the estimated coefficients in the "Other Factors" category in Table 4 are significant. Only one of these estimates, however, is consistent with our expectations: the positive and significant coefficient for firms with fruits and vegetables as a primary product. Because Mac-

Donald and Korb (2006) find higher rates of contracting among livestock producers and lower rates of contracting among grain producers, we expected a positive sign for the coefficient of firms with meat as a primary product and a negative sign for the coefficient of firms with grain as a primary product. A possible explanation for these results stems from our choice of using firms choosing the "other" or "multiple combinations" category as our base group for comparisons. As Table 2 shows, while this group has a low incidence of contract adoption on a proportional basis, it does contain a high number of firms (16) that contract. A second explanation for the positive sign on the grain coefficient is that Pennsylvania grain processors may be purchasing specialty grains, which are thought to have higher rates of contracting. Unfortunately, our data provide no additional information on this subject.

In Table 4, we also present elasticity estimates for the 16 factors. Among all factors, input expenditures has the highest positive impact. For example, Table 4 shows that a 1 percent increase in input expenditures leads to a 0.454 percent change in the probability that a firm will contract. Alternatively, the percentage of sales outside the Pennsylvania region and profitability concerns about being in close proximity to inputs have high negative impacts. Proximity concerns, for example, have a very large impact: increased concerns, represented by a one-category downward movement in this variable, increase the probability of contracting by 1.5 percent. While profitability concerns about food safety regulations have a high positive elasticity, their impact on the probability of contracting is an inverse one because concerns diminish as this variable increases.

Table 5 presents the results of the Censored model with sample selection where the dependent variable is contracting intensity, i.e., the proportion of inputs purchased under contract, which is bounded above by 1.0. This variable is observed only if processing firms answered affirmatively to the question of contract use; thus there are far fewer observations of this variable. Because of this sample selection bias, we include the inverse Mill's ratio calculated from the selection equation. Our results in Table 5 use a Probit model as the selection equation to facilitate simultaneous maximum likelihood estimation, but we obtain similar results using a Logit for the selection equation. Model 2a differs from Model 2b by the inclusion of the large farm variable. Again, the inclusion of this variable makes little difference in the model results. Overall, Table 5 results show moderate success in achieving our objective of identifying significant factors that affect the contract intensity decision. Nine of the 16 variables from Table 3 play a statistically significant role in Model 2a. However, the results show much less success at linking these factors to theoretical rationales for contracting. Because only half of the estimated coefficients have the anticipated sign, the results are decidedly mixed in our attempt to associate these factors with risk-sharing or transaction-cost rationales. Consistent with our expectations, Table 5 results suggest that higher input expenditures, fewer sales within a home county, and more concerns about being in close proximity to inputs all lead to proportionally more inputs bought under contract.

However, two of the risk-sharing and transaction cost factors are significant with an unanticipated sign. The negative impact of full-time employees on contracting intensity is hard to explain. This coefficient estimate is positive (but not significant) in contracting decision results of Table 4, but negative (and significant) in the contracting intensity decision results of Table 5. One possible explanation is that impact of this variable may be confounded by issues related to vertical integration. For example, a large firm with many employees may own both processing and production facilities. Such a firm may be more likely to use contracts to buy at least some inputs (hence the positive estimate in Table 4), but because it produces some of its own inputs, it may buy proportionally fewer inputs from farmers using contracts (hence the negative estimate in Table 5). Information on the degree to which firms are vertically integrated would certainly be useful here.

The positive sign on the coefficient for profitability concerns arising from complying with food safety regulations is likewise unanticipated. Recall from Table 3 that this categorical variable increases as food safety regulation concerns decrease. The result in Table 5 suggests that decreasing concerns over regulatory compliance lead to proportionally fewer inputs bought under contract from farmers. One explanation is that firms concerned with regulatory compliance may buy inputs from middlemen rather than directly from farmers. This result, and others, highlights

Table 5. Censored Regression Results for Pennsylvania Food Processors' Intensity of Contract Use (%) (t-stats in parentheses)

Independent Variable	Model 2a	Model 2b	Model 2b Elasticities[a]
Constant	-2.263**	-2.458**	
	(-2.792)	(-3.160)	
Risk Sharing Factors			
Input expenditures (log)	0.161**	0.175**	0.325
	(3.401)	(4.014)	
FT employees	-0.0004	-0.001*	-0.136
	(-0.696)	(-1.661)	
Percentage of sales outside the region	-0.004	-0.004	-0.096
	(-1.284)	(-1.38)	
Percentage of sales outside the country	-0.012	0.002	0.005
	(-0.406)	(0.084)	
Transaction Cost Factors			
Percentage of sales within the county	-0.005**	-0.005**	-0.304
	(-2.900)	(-2.926)	
Concerns—inputs not grown in PA	0.015	-0.010	
	(0.145)	(-0.101)	
Concerns—not enough grown in PA	0.141	0.146	
	(1.306)	(1.383)	
Concerns—quality	-0.067	-0.088	
	(-0.532)	(-0.719)	
Profitability factors—proximity to inputs	-0.091*	-0.091*	
	(-1.946)	(-1.927)	
Profitability factors—food safety regulations	0.146**	0.159**	
	(2.155)	(2.409)	
Profitability factors—labeling requirements	0.014	0.005	
	(0.266)	(0.093)	
Other Factors			
Fruits or vegetables	0.431**	0.412**	
	(2.962)	(2.841)	
Meat	-0.523**	-0.539**	
	(-2.104)	(-2.142)	
Grain	-0.364**	-0.357**	
	(-3.044)	(-2.936)	
Dairy	0.441**	0.451**	
	(2.069)	(2.090)	
No. of farms in co. > $100k	- 0.000		
	(-0.019)		
Inverse Mills ratio	0.661**	0.682**	
	(5.011)	(5.043)	
Number of observations	37	37	

[a] Here, elasticities are calculated for continuous variables only using their mean values, and are interpreted as the percentage change in the contracting intensity due to a 1 percent increase in the independent variable. For dummy (and categorical variables), the coefficient estimate is interpreted as the change in contracting intensity due to a change in the dummy from 0 to 1 (or from one category to the next).

Note: * = significant at the 0.10 level, ** = significant at the 0.05 level.

some potential ambiguity in the survey instrument and its interpretation.

Other results in Table 5 are only partly consistent with our expectations. Results suggest that fruit and vegetable processors and dairy processors are more likely to contract intensively for inputs, while meat and grain firms are less likely. These results confirm those in Table 2, which shows that nearly 100 percent of dairy input purchases (by value) and 66 percent of fruit or

vegetable input purchases are bought under contract by firms that contract at all. Alternatively, only 6.7 percent of grain input purchases and 37 percent of meat input purchases are bought under contract by contracting firms. These results present an interesting contrast to those in Table 4. Looking at both tables, for example, one sees that dairy firms are less likely to contract, but those that do use contracts intensively. The opposite result holds for grain firms: these firms are more likely to contract, but those that do use contracts less intensively. More detailed follow-up research of dairy and grain firms may be required to better understand contracting behavior in these cases.

Discussion

This study confirms that contracting has become fairly common among Pennsylvania-based food processors. Using a survey of Pennsylvania food processors, we find that 20.2 percent of over 200 surveyed firms use contracts to purchase some agricultural inputs or ingredients directly from producers. This figure is much lower than MacDonald and Korb's (2006) finding that 39 percent of farms use contracts. The important differences between our finding and theirs are that (i) ours comes from a survey of processors rather than farms, and (ii) ours is limited to Pennsylvania rather than including the entire United States. However, using survey information on both contracting and on the value of input expenditures, we find that approximately 45 percent of all inputs are purchased through contracts. Our results suggest, therefore, that overall contracting activity is as high in Pennsylvania as it is for the United States as a whole. This finding is important because it implies that understanding the behavior of food processing firms throughout the United States, even in Pennsylvania and the Northeast, will require a better understanding of contracting.

We also used the survey data to investigate empirically the processing firms' decisions of (i) whether or not to use contracts at all and (ii) how intensively to use contracts. We had only moderate success in identifying firm-level factors and attributes that significantly affect a firm's decision to use contracts, but more success in identifying factors that affect a firm's contract intensity decision. Our study, therefore, helps extend current knowledge of contracting collected from national surveys of farms or specialized processors to a Northeastern state such as Pennsylvania that is highly active in food manufacturing and processing.

But perhaps the most important conclusion to be drawn from our results is that firms' contracting behavior is multifaceted, and may not conveniently fit the theoretical rationales, at least not across all sectors. For example, one of our strongest conclusions is that, on average, larger firms more actively use contracts, a finding that appears to be consistent with the logic that larger, more sophisticated firms are better able to share risks with growers. However, even this simple conclusion is more complicated than it appears. When firm size is measured by sales, we find that contracting firms are four times larger than noncontracting firms. But after using survey information to categorize firms by their primary product, the survey data show that this finding holds for some but not all groups. For the grain sector, contracting firms are dramatically smaller; and for the meat sector, contracting firms are slightly smaller. When firm size is instead measured by input expenditures or the number of full-time employees, we find mixed evidence about contracting behavior. Our results strongly suggest that firms with higher input expenses are more likely both to contract and to buy proportionally more inputs under contract. But we find that the number of full-time employees has virtually no effect on the decision to contract, and that it leads to proportionally fewer inputs under contract.

Furthermore, our findings provide decidedly mixed support for linking firm-level attributes to two common explanations of why firms contract, namely to share risks and to reduce transaction costs. We find some evidence that attributes linked to risk-sharing ability (e.g., total input expenditures) impact contract adoption or contract intensity; we also find only limited evidence that attributes linked to the reduction of transaction costs impact contracting activity. Finally, not all results confirmed our hypotheses: we were most surprised to find that increasing concerns about quality of inputs were not found to play a statistically significant role in firms' contracting decisions. And we were also surprised to find that increased concerns over complying with food safety regulations have a negative impact on a firm's proportional use of contracting. It may be the case that market standards have evolved to the

point where quality and regulatory compliance are no longer important drivers of contracting decisions. Or it may be the case that our survey is not detailed enough to fully disentangle the impacts of these or other variables.

Despite the potential imprecision of the survey instrument, these results are important given Pennsylvania's status as a leading food processing state. While contracting activity continues to grow, only a few studies have investigated it from the processors' perspective. Our results help begin to explain why some processors but not others are contracting with growers, and why some but not others contract intensively. Mainly, however, our results suggest that additional, more narrowly focused research is needed if we are to better understand firms' multifaceted decisions on contracting. Future work of this sort may focus on two issues: fine-tuning survey questions to better test empirical results against theoretical rationales, and focusing surveys on more firms within only a few industry sectors. For example, future survey questions should ask more details about the nature of the product or ingredient that firms are buying under contract. Researchers would want to know whether the ingredients have special qualities or some strategic value. Questions should also be more directly linked to risk-sharing abilities. While it may be impractical to include these narrow questions in a survey targeted to all processors, they will allow for more precise investigations of the firm- and sector-specific factors that affect contracting decisions.

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Appendix A: 2004 Survey of Pennsylvania Food Processors

What follows are selected questions from a 2004 survey of Pennsylvania food processors. These eight multi-part questions form the basis for the empirical analysis in the accompanying manuscript. The original numbering is preserved.

1. What is the **main** product this facility processes? *(Select **only one** answer.)*

   ❍ Fruits or vegetables
   ❍ Dairy
   ❍ Meat
   ❍ Grain
   ❍ Combination of the above
   ❍ Other (specify)

11. What was this business's approximate total sales in 2003, or its most recently completed fiscal year? **(Please be assured that your response will be held in strict confidence.)**

    a. In 2003 this business's total sales was $_____.

    OR: If you are unable to provide approximate information, please indicate the category below that corresponds to your best estimate of total sales in 2003.

    b. ❍ Less than $250,000
    ❍ $250,000 to $499,999
    ❍ $500,000 to $999,999
    ❍ $1 million to $2 million
    ❍ $2 million to $4 million
    ❍ $4 million to $6 million
    ❍ $6 million to $8 million
    ❍ $8 million to $10 million
    ❍ $10 million to $12 million
    ❍ $12 million to $14 million
    ❍ $15 million to $20 million
    ❍ More than $20 million

13. What percentage of your total 2003 sales were made by you to distributors, retailers, consumers, or others in the following geographic areas? Report your answers in whole numbers. *(Please record your best estimates and check to make sure your figures total 100%.*)

a. Within the county				%
d. Elsewhere in the United States				%
e. Outside the United States				%
TOTAL		**100 %**		

14. Which of the following best represents your business's actual expenditures on agricultural inputs/ingredients for the fiscal year 2003?

    ❍ Less than $100,000
    ❍ $100,000 to $249,999
    ❍ $250,000 to $499,999
    ❍ $2 million to $3 million
    ❍ $3 million to $5 million
    ❍ $5 million to $7 million
    ❍ $500,000 to $749,999
    ❍ $750,000 to $999,999
    ❍ $1 million to $2 million
    ❍ $7 million to $10 million
    ❍ $10 million to $15 million
    ❍ More than $15 million

16. If you purchase agricultural inputs/ingredients from outside Pennsylvania, what is the primary reason that you did not purchase them in-state? *(Select **all** that apply.)*

- ❍ Products not grown in the state
- ❍ Not enough is grown in the state
- ❍ Quality concerns

17. Does your business currently purchase agricultural inputs/ingredients under contract with farmers?

- ❍ Yes
- ❍ No *(please skip to Question 18)*.

a. Approximately what percentage of the value of your total agricultural inputs/ingredients are made under contract? [ ][ ][ ] %

21. A region's attributes can have significant effects on a business's profitability. Please fill in the oval that best indicates the relative importance of the following local characteristics to your business, where a 1 means "critical" and a 5 indicates "not at all important."

	Critical 1	2	3	4	**Not at all important** 5
a. Being near agricultural input/ingredient suppliers	O	O	O	O	O

22. Business profitability can also be affected by *costs*. Please rate the following factors in terms of how you perceive their relative importance to your business. Fill in the oval that best reflects the degree of importance to you, where a 1 means "critical" and a 5 indicates "not at all important."

	Critical 1	2	3	4	**Not at all important** 5
p. Complying with food safety regulations	O	O	O	O	O
q. Product labeling requirements	O	O	O	O	O