Assessing Innovator and Grower Profit Potential under Different New Plant Variety Commercialization Strategies

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Abstract: This research is motivated by the sharp increase in the number of patented fruit varieties developed by breeding programs at public universities in the United States. Such varieties are licensed to growers as a way to generate revenue for universities through the use of fees and royalties. Although the use of fees and royalties for patents has been well discussed in the economic literature, there is very little empirical work that examines these questions for varietal innovations in agriculture. Horticultural variety innovations are particularly interesting as they typically involve a demand-enhancing innovation rather than a cost-inducing innovation, and because, in most cases, the new varieties are only intended to replace a small share of production dedicated to existing varieties. We found evidence that fixed-fees under an exclusive contract was the most profitable for growers. For the innovator, the most profitable scheme was the exclusive per-box royalty contract. Our findings on potential profits for both adopters and innovators signal that exclusive contracting would outperform the non-exclusive licensing schemes. Given that the innovations are occurring at land-grant universities and that the technology is largely being distributed to U.S. growers, further work might consider the net societal impacts of the various licensing strategies; this would extend our analysis to consider the economic effects from licensing for the innovator as well as the effects for producers.

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I. Introduction

Developing and marketing new varieties is essential to sales and profit growth of U.S. crops, including apples. Traditional varieties of most crops can be improved from either the product quality side or from a production/cost-reducing side. Consumer expectations for quality are increasing and, at the same time, consumers expect increasingly customized products. In response to heterogeneous consumer preferences, many simple commodity markets have evolved into highly differentiated market products. For certain products, such as Washington apples, the collective reputation depends on the development and sales of tasty new differentiated varieties that can compete on world markets. Once these new varieties are developed, they must be commercialized. If the innovations are not commercialized or commercialized in a sub-optimal way, then the benefits of the research are greatly reduced.

Federal and state support for research and development (R&D) at public universities has been down over the last few decades (Alston et al. 2010). This trend fits spans all agricultural sectors, but is particularly acute in horticulture (Cahoon et al. 2007; Alston and Pardey 2008). Decreasing government support imposes a reliance to develop alternative ways to fund R&D activities at public universities (Huffman and Just 1999; Just and Huffman 2009). One way to accomplish this is through the use of intellectual property rights (IPRs) embodied in government-sanctioned patents for innovations introduced by public universities made possible by the passage of the Bayh-Dole Act in 1980. The Bayh-Dole Act gave universities the ability to claim IPRs from the federal government for university-conducted research, where the revenue flows from the patents are used to support the universities' R&D efforts. However, the use of patents by universities and the subsequent licensing issues raise questions about the best mechanism for funding research investments and maximizing industry revenues.

The traditional arguments for public funding of research are that knowledge spillovers and imperfect IPR protection cause innovators to not realize the economic value of their discoveries, leading to private sector underinvestment in basic research. Public land grant universities are a special case of government funding of academic research. The land grant mission of research and extension faculty is to deliver and apply research and new knowledge to positively impact communities. U.S. Land Grant University agricultural research is funded in many ways, sometimes including required assessments on growers. An open research question is then, given political and funding constraints, what is the optimal way to commercialize publically developed innovations?

To date, universities such as Cornell University and the University of Minnesota have developed licensing schemes wherein cooperatives of growers are able to obtain exclusive access to a variety – a "managed variety" – for a fee that is levied both on the initial planting (a fixed fee) and on every box sold there forward (a per-unit royalty). This approach is extremely controversial, and other states are committed to providing the industry with equal access to its new crop varieties, such as a lottery that is open to all growers.

There are many economic issues to resolve in order to maximize the long-run revenues to the overall industry and to universities' research programs. These issues include how to best generate funds to offset upfront costs before royalties are received. IPRs for new varieties offer incentives for investment, and new institutional arrangements can be put in place for the transfer of new plant varietal technology from the university to growers willing to pay royalty fees for new varieties. If a royalty scheme could be designed to maximize the industry's long-run revenues with the adoption the best new varieties, then all parties would benefit, including consumers.

Issues surrounding the commercialization of new crop varieties have changed significantly since the passage of the Bayh-Dole Act of 1980, which gave the IPR from innovations created by university faculty to universities. This potentially creates additional sources of funding for research.[1] It also has generated questions about the appropriate institutional arrangements for universities to transfer technology to producers. A case in point is varietal innovations in the fruit and vegetable industry. IPRs for new varieties offer some incentives for investment in this area, and new institutional arrangements have arisen for the transfer of new plant varietal technology from research universities to consortia or cooperatives of growers. The creation of collective action organizations funded by commodity levies with matching government support, such as the Research and Development Corporation model employed in Australia is one way to revitalize agricultural innovation in a public-private partnership. Another way is to use formal IPRs such as patents. Each alternatives brings with it questions about the appropriate mechanisms for funding the investment in research and for pricing the products of that investment.

Proprietary innovations, whether in agriculture or elsewhere, are used under a license issued by the inventor, which is paid for using either fixed fees, that do not depend on the number of the innovation used by the licensee, or per-unit royalties, where the total royalty payment depends on the number of units used (in the case of end-point royalties, such as on Australian wheat, the payment is based on the number of units produced and sold and not on the amount of seed used, whereas in the case of proprietary seed for corn, soybeans, or canola in the United States, the payment is per unit of seed). Whereas the early theoretical literature found that fixed fees are optimal (Arrow, 1962), per-unit royalties are more often observed in practice (Sen and Tauman, 2007).

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[1] As Federal and State government support for investments in agricultural research and development has diminished in recent years, universities increasingly rely on the development of new institutional arrangements to fill the gap. Such trends are common across many sectors in agriculture, including horticulture (Alston and Pardey 2008).

The importance of universities' role in generating commercially-relevant research has risen sharply in recent years. In fact, Lach and Schankerman (2008) report that universities conduct 53% of all basic research and that the number of U.S. patents awarded to university inventors annually increased from 500 in 1982 to 3255 in 2006. The Bayh-Dole Act gave universities new incentives to engage in specific types of R&D, and in some cases, an additional source of revenue (Jensen and Thursby 2001; Thursby and Thursby 2003; Bhole 2006; Bulut and Moschini 2009).

Questions remain, however, regarding the extent to which university research is transferred to industry stakeholders (Henderson et al, 1998), and the appropriate institutional arrangements for transferring technology to producers (Lach and Schankerman 2008). New institutional arrangements have arisen for the transfer of new plant varieties from research universities to consortia or cooperatives of growers willing to pay for licenses for new varieties (Cahoon et al. 2007), but pricing mechanisms in these markets have been inefficient and not conducive to the rapid growth of research and development in new fruit varieties.

Here we focus specifically on the use of fees and royalties to price patents on innovations created by university-based researchers. We frame our analysis using the example of research into new apple varieties. Specifically, the primary question is whether the licensor, in our case a university technology transfer office (TTO), should use fixed fees, royalties, or a combination of fees and royalties (a two-part tariff) in contracts characterized as either exclusive (one licensee) or non-exclusive in order to maximize licensing revenue.[1]

We discuss background details regarding patents and licenses used for perennial fruit crop varieties in the United States. The following section presents an overview of literature that has studied innovation and the optimal use of fees and royalties for patents. In the section that follows, we provide a description of the experiment we used to study university revenues for a patented innovation. We then present the results from our econometric analysis, and interpret how our findings inform the licensing process from a TTO perspective. In the final section we provide the implications of our findings for university innovators more generally, and discuss avenues for additional research related to the licensing of innovations generated by university plant breeding program

Our research is motivated by the rapid increase in the number of patented fruit varieties released by university breeding programs (Brown and Maloney 2009; Bareuther 2011; Gallardo et al. 2012), and consumer preferences for higher quality fruit varieties (Yue and Tong 2011; Rickard et al. 2013). Licensing mechanisms for patented fruit varieties are typically established via negotiations between a TTO and grower-based licensees. These negotiations typically begin with a request for bids from potential licensees. The bids are evaluated based on financial and management considerations by the TTO with a focus on initial payments, annual payments, quality control issues, contracts with individual growers, and marketing plans. A successful bid for a new variety may allow the licensee the first right of refusal on subsequent varietal introductions. The licensees may include growers or grower-packers, a grower-owned cooperative, or a management company acting on behalf of a group of growers.

In practice, varieties are licensed to individual growers and the licensing mechanisms involve some combination of upfront fixed fees and output royalties that require annual payments based on the quantity of fruit that is marketed. In the case of perennial fruit crops, we consider the upfront fees to include the one-time charges applied per unit of land or per tree. *Ad valorem* or per-unit output royalties have not been widely used for patented fruit varieties, but are becoming more common (Brown and Maloney 2009).

There is a large theoretical literature that studies innovator revenue when licenses are financed by fees or royalties. Rickard et al (2016) examines the fee versus royalty characteristics of licensing with greater than two licensees. They then analyze an experiment that captures many of the important conditions facing fruit growers considering an investment in patented varieties. The question about exclusivity of the contract is particularly relevant to the case of patented fruit varieties because of recent legal action by growers that were denied full access to a patented apple variety released by the University of Minnesota (see Lehnert 2010; Milkovich 2011). As a result of this litigation, administrators at other land grant universities now appear reluctant to employ exclusive contracts.

II. Fees Versus Royalties in Patent Licensing

Arrow (1962) showed that it is welfare maximizing if the innovator is perfectly competitive. With oligopolistic innovators, Kamien and Tauman (1986), Katz and Shapiro (1986) and Kamien, Oren, and Tauman (1992) found that licensing via a royalty system generates less revenue for an external (i.e., not an incumbent) innovator than if a fixed fee were used. However, most of the empirical research finds that royalties, or combinations of fees and royalties, yield the greater profits for innovators (Sen and Taumann 2007). Subsequent research sought to reconcile the predictions of theory with what was observed in industry.

By including more realistic institutional characteristics of an industry, including product differentiation (Muto 1993; Fauli-Oller and Sandonis 2002), asymmetric information (Gallini and Wright 1990; Sen 2005), risk aversion (Bousquet et al. 1998), moral hazard (Choi 2001), incumbency (Shapiro 1985; Kamien and Tauman 2002; Sen and Tauman 2007) or strategic delegation (Saracho 2002), researchers were able to reconcile their findings with what appeared to be a paradox in the data. However, in all of theoretical work, the innovation is cost-reducing, while the bulk of applied research in the horticultural industry aims to improve fruit quality.

Li and Wang (2010) examine the profits an inventor can realize by using an exclusive or a non-exclusive contract (under different licensing schemes). They focus on a vertical product innovation, and this is the type of innovation that describes new fruit varieties with better eating qualities. Li and Wang (2010) show that, in the case of a duopoly, licensing by means of a two-part tariff generates greater profits for the innovator compared to licenses that are financed through royalties or fees alone. By setting the license price such that both downstream firms license an improved product, the licensee is able to raise industry profit, and then extract much of the resulting surplus via a fixed fee.

In this study, we focus on Washington apple growers' preferences for commercialization mechanisms. Although we observe that growers were willing to pay more to engage in a contract that uses an exclusive license, it is not clear that such a licensing scheme is the best for the university or for the growers. In fact, recent research at Cornell University found that a non-exclusive contract that relies solely on fruit royalties would generate the greatest total revenue flow to the university.[2]

III. Experimental Design

To investigate on Washington apple growers' values for different licensing arrangements we conducted experimental auctions. Apple growers were invited to participate in auctions during the 2014 Washington State Horticultural Association Annual Meeting (hereinafter WA Hort Show). Growers who agreed to participate signed a consent form stating that participation was voluntary and that all individual-level information provided during the experiment would be kept strictly confidential. Each individual was compensated between \$10 and \$30, depending on the profits they earned during the auction.

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[2] We understand that there are limitations to the types of contracts that can be used for new varieties being released by the Washington State University (WSU) tree fruit breeding programs as the aim of the WSU apple breeding program is to provide new varieties that are available to all Washington apple growers.

The experiment consisted of simulating a situation in which participants were contemplating the possibility of growing a new promising apple variety. For such, participants would buy the 1450 trees, that is the number of trees that would grow in one acre of land, following a modern tree fruit wall architecture. We provided additional information to growers for them to make their decision: the likely horticultural management costs (we used 'Honeycrisp' costs as a proxy, following Galinato and Gallardo, 2012), and the expected market prices (we use as a reference 'Honeycrisp' market prices). The new apple variety was offered under three different licensing schemes: (1) a fixed fee, (2) a per-unit royalty, and (3) a combination of a fixed fee and a per-unit royalty, as well as an outside option in which individual could not purchase the new apple variety. For each licensing scheme, participants had to choose in between the option of signing an exclusive and a non-exclusive contract. The difference in between contracts –besides the number of acres or farms that could grow the variety- was the expected market price, under the exclusive contract the expected market price for the new apple variety was \$54/40-lb box and under the non-exclusive contract, it as \$47/40-lb box. A total of 32 apple growers participated in the auctions. On average, the participants had 23 years of experience in apple production. Collectively, they operate on a total of 26,080 acres representing 16% of all apple acreage in Washington State. Table 1 presents descriptive statistics of the grower participants.

We conducted Becker-DeGroot-Marschak (BDM) auctions (Becker, DeGroot, and Marchak, 1964). At the beginning of the experiment, we explained the BDM auction mechanism to the participants and we conducted a practice round with a practice item, so that participants became familiar with the auction mechanism. With the BDM auction, each participant places a bid on the item in question. In this study, there were in total six items: three licensing schemes under two types of contracts. After the six bids were placed, the participant was asked to randomly select one of the six bids, the binding bid. Once the binding licensing scheme and the type of contract was known, the facilitator randomly drew a clearing price, corresponding to the binding licensing scheme and the type of contract for each individual. There were six random lists of clearing licensing prices, each list was created using a Monte Carlo simulation. To simulate the lists of clearing licensing prices we used as a reference the means for each licensing scheme under the two contracts used in Rickard et al. (2015) and Rickard et al (2016). See Table 2 for summary statistics of the clearing prices. If the participant's bid for a licensing scheme was greater than or equal to the exogenous clearing price, then the participant was enabled to purchase the item. Otherwise, the participant did not get to purchase the product and did not pay anything. The benefits of using a BDM auction was that it was incentive compatible because participants had the incentive to bid their true willingness to pay, in order to be able to win and get the opportunity to grow the new apple variety. Also, the BDM approach does not require a specific number of participants or even a group since the market price is exogenous and randomly drawn.

To enable comparisons across net profits to be realized under the six licensing schemes, considering the different time horizons of each licensing scheme: a one-time per tree fee, a per box royalty during the whole life cycle of the orchard, profits were calculating using the net present value (NPV) over 20 years, the assumed lifespan of an apple tree. To estimate costs and profits a 'Honeycrisp' cost of production study was used as reference (Galinato and Gallardo, 2012).

All participants received a participation payment of $20 as compensation for their participation. Those participants who become eligible to produce the patented variety could receive an additional payment based on their profits from the simulation exercise. At the completion of each session, the participants completed a survey to collect demographic and production information and measures that attempt to capture their overall risk return preferences.

IV. Economic Framework

We consider a single innovator, such as a university, who develops a product with a vertical quality, demand-enhancing innovation, such as a new apple variety, which is subject to fully enforceable intellectual property protection. We assume the innovator wishes to license the innovation to multiple producers, who will grow the innovation and sell to downstream buyers. Rickard et al (2015) showed that when there were more than two potential licensees, the profit-maximizing innovator would prefer to license her technology using a nonexclusive two-part contract that consists of both a fixed fee and a per-unit royalty. We tested this prediction empirically with our auctions conducted with apple growers.

Empirical Model

We used the growers' bids in the auction to obtain their willingness to pay (WTP) for an acre of trees of the new apple variety. Bids under fixed fee scheme were defined in terms of payments for an acre of fruit trees, whilst those under per-box royalty and two-part schemes first need to be converted to equivalent payment units. We calculated total payments under per-box royalty scheme that subjects would incur from owning an acre of tree fruits by summing the present value of twenty years of payments for production of apples from one acre of land:

$$(1) \qquad WTP_{i,PBR} = \sum_{t=1}^{20} \delta^{t-1} \left(B_{i,PBR} \cdot Y_t \right).$$

where $WTP_{i,PBR}$ is the present value of payments by grower i under per-box royalty scheme; δ is the discount rate, which is set at 5%; $B_{i,PBR}$ is grower i's per-box royalty bid; and Y_t is the yearly production of apples (in boxes) from an acre of land, for $t = 1, 2, \ldots, 20$ years. The assumed yearly production of apples is presented in Table 3, based on Galinato and Gallardo (2012).

Since the two-part scheme had both fixed and per-box royalty components, we derived the present value of payments arising from the ownership of an acre of trees of the new variety by adding the fixed fee and the present value of the per-box royalty payments:

$$WTP_{i,COMB} = B_{i,FF} + \sum_{t=1}^{20} \delta^{t-1} \left(B_{i,PBR} \cdot Y_t \right), \tag{2}$$

where $WTP_{i,COMB}$ is the present value of the payment by grower i under combination scheme; and $B_{i,FF}$ is grower i's fixed fee bid, which is defined in terms of per acre payments.

First, we estimated a linear regression for the bid equation separately for each type of licensing mechanisms (i.e., fixed fee, per box royalty, and two-part licensing). The WTP of grower i under the contract type j, for $j = \{\text{exclusive, non-exclusive}\}$, is specified as:

$$WTP_{ij} = \alpha + \beta excl + \boldsymbol{\gamma}\mathbf{z}_i + \boldsymbol{\omega}\mathbf{x}_i + \upsilon_i + \varepsilon_{ij}. \tag{3}$$

In equation (3), $excl$ is an indicator variable that is equal to one if the contract is exclusive and zero otherwise; $\mathbf{z}_i$ is a vector of grower i's orchard characteristics; $\mathbf{x}_i$ is a vector of grower *i*'s demographics; υ_i is an individual-specific error term; and ε_{ij} is the normally distributed overall error term with mean zero. Since individuals under each licensing arrangements provided bids for two types of contracts (i.e., exclusive or non-exclusive), we clustered the standard errors by individual in order to account for the panel nature of the data.

Second, we examined the joint effect of three licensing arrangements and two types of contracts on individual's WTP, using data for all auctions. In this context, the WTP of subject i under the licensing mechanism k, for $k = \{\text{FF, PBR, COMB}\}$, with contract exclusivity j is specified in the following way:

$$WTP_{ijk} = \alpha + \beta excl + \sum_k \varphi_k scheme_k + \sum_k \eta_k excl \times scheme_k + \boldsymbol{\gamma}\mathbf{z}_i + \boldsymbol{\omega}\mathbf{x}_i + \upsilon_i + \varepsilon_{ijk}. \tag{4}$$

In the model specified above, $scheme_k$ is an indicator variable that is equal to one if the contract type is k and zero otherwise; and $excl \times scheme_k$ is the interaction between the licensing mechanism and exclusivity. Since the subjects submitted bids for six different contractual arrangements in the experiment, the standard errors of the parameter estimates are clustered at the individual level.

For the analysis of profits under the different licensing schemes, we first determined which growers bid high enough to participate by randomly drawing a market price and comparing it against the grower's bid. Following the BDM auction approach, if a submitted bid was greater or equal to the market price, the bidder "purchases" the tree under that licensing arrangement. Using these market prices, we simulated grower profits following using the spreadsheet in Galinato and Gallardo (2012). Profits were based on producing a new fruit variety on either 10% of grower's total apple land or 10 acres of land, whichever is higher, over ten-, fifteen-, and twenty-year horizons. Second, we estimated the adopter and the innovator profits in the following way:

$$\pi_{ijk} = \alpha + \beta excl + \sum_k \varphi_k scheme_k + \sum_k \eta_k excl \times scheme_k + \gamma land_i + \upsilon_i + \varepsilon_{ijk}. \tag{5}$$

In equation (5), π_{ijk} describes the benefits received by the innovator from a contractual arrangement with adopter i. Because of fewer degrees of freedom offered by the sample of eligible bidders, we did not include all orchard and demographic controls in the above regression equation. Hence, only the size of total apple land ($land_i$) of each grower is included in the model. Finally, we used cluster-robust standard errors in our estimations and inference.

V. Results and Analysis

The bids across all licensing arrangements are presented in the descriptive statistics in Table 1. As expected, within each licensing arrangement, the growers were willing to pay significantly more for exclusive contracts than non-exclusive contracts. Tables 4, 5, and 6 present regression results for how specific factors affect bids for fixed fee, per-box royalty, and two-part licensing, respectively. Across all three estimations, the exclusive contract was the largest non-constant statistically significant factor. Grower demographic variables were not statistically significant in any estimation. Some of the grower acreage variables have significantly negative effect in some of the models, but the magnitude is small.

Table 7 presents estimation results of factors affecting all bids. As in earlier results, the exclusive contract variable had a statistically positive effect on the bid. The grower demographic variables were not statistically significant. Holding increased current acreage of the Honeycrisp variety had a statistically negative impact on bids.

Table 8 reports the summary statistics for the eligible bids (those greater than the market-clearing price in the BDM auction) for each licensing arrangement, including the mean acreage that each bidder holds. Tables 9 provide mean producer profits based on ten-, fifteen-, and twenty-year present value simulations. The fixed-fee exclusive contract was the most profitable for growers[3] in our simulations. Of the non-exclusive contracts, the fixed fee contract also performed the best, on average, in the simulations. Table 10 presents simulated mean profits for the innovators. The highest mean innovator profit comes from the exclusive per-box royalty contract. Of the non-exclusive contracts, the per-box royalty contract also results in the highest innovator profits. Finally, Tables 11 and 12 present regressions of simulated grower and innovator profits, respectively. After the constant term, the exclusive nature of the contract has the largest effect on profits.

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[3] Note that exclusive contracts are most profitable for those who are included, but those not included, do not benefit.

VI. Conclusions

This article considers the issue of how university plant breeding programs should commercialize a new plant variety. Three different licensing schemes under two types of contracts (exclusive versus non exclusive) were evaluated in terms of expected profits. Results prove evidence that the fixed-fee exclusive contract was the most profitable for growers. Of the non-exclusive contracts, the fixed fee contract also performed the best. For the innovator, the most profitable scheme was the exclusive per-box royalty contract. Of the non-exclusive contracts, the per-box royalty contract also results in the highest innovator profits. Our findings on potential profits for both adopters and innovators signal that exclusive would outperform the non-exclusive licensing schemes. However there are limitations to the contracts that can be used for new varieties being released by the Washington State University (WSU) considering that the aim of the WSU apple breeding program is to provide new varieties that are available to all Washington apple growers. Findings from these studies warrants further in depth research of this complex and contrasting situation.

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Table 1. Descriptive statistics

Variables			Units/Description	Mean	Standard deviation
Bids					
Fixed fee	Exclusive		Dollars per one acre of apples	5,207.58	4,909.85
	Non-Exclusive		Dollars per one acre of apples	3,368.75	3,714.13
Per box royalty	Exclusive		Dollars per one box of apples	2.02	2.14
			Present value of 20-year payments for one acre of apples at 5% interest	21,135.31	22,352.37
	Non-Exclusive		Dollars per one box of apples	1.10	1.95
			Present value of 20-year payments for one acre of apples at 5% interest	11,544.08	20,346.91
Combination	Exclusive	Fixed fee	Dollars per one acre of apples	2,905.53	3,919.64
		Per box royalty	Dollars per one box of apples	1.34	2.00
		Combined payment	Fixed fee + present value of 20-year payments for one acre of apples at 5% interest	16,513.51	21,621.30
	Non-Exclusive	Fixed fee	Dollars per one acre of apples	1,588.20	2,157.13
		Per box royalty	Dollars per one box of apples	0.71	1.48
		Combined payment	Fixed fee + present value of 20-year payments for one acre of apples at 5% interest	8,808.56	15,502.31
Orchard characteristics					
Total land			Acres	1,246.13	2,018.01
Total apple land			Acres	841.31	1,677.41
	Red delicious		Acres, entire sample (Acres, growers only)	9.19 (18.38)	11.19 (8.82)
	Gala		Acres, entire sample (Acres, growers only)	10.31 (13.75)	7.54 (5.23)
	Honeycrisp		Acres, entire sample (Acres, growers only)	4.13 (7.33)	4.58 (3.65)
Demographic characteristics					
Age			Years	49.17	12.24
Ethnicity	Caucasian/white		Percent	90.32	30.05
	Hispanic		Percent	9.68	30.05
Income	>$500,000		Percent	64.52	48.64
	≤$500,000		Percent	35.48	48.64
Education	Bachelor or higher		Percent	70.97	46.14
	High school/some college		Percent	29.03	46.14
Experience			Years in apple production	22.64	13.82

Number of participants = 32 Observations = 192

Table 2. Summary Statistics for Randomly Generated Market Prices under Different Licensing Arrangements

	Fixed fee		Per box royalty		Two-part licensing scheme			
					Exclusive		Non-exclusive	
	Exclusive	Non-exclusive	Exclusive	Non-exclusive	Fixed fee	Per box royalty	Fixed fee	Per box royalty
Mean	2,264.5	1,558.1	2.416	1.806	1,148.1	1.435	632.7	1.124
Std. dev.	882.37	327.74	0.8690	0.7047	387.11	0.4163	215.18	0.3241

Table 3. Assumed Per-Acre Production of Apples (in boxes), Used in Calculations

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6 to 20
0	0	222.75	668.25	965.25	1039.5

Table 4. Factors Affecting Bids for a New Variety of Apple, *Fixed Fee*

Variables	(1) Coefficient	(1) Standard error	(2) Coefficient	(2) Standard error	(3) Coefficient	(3) Standard error
Exclusive contract	1,838.83***	305.63	1,811.42***	338.80	1,823.88***	365.76
Total apple land			-0.0257	0.1536	0.3524	0.2516
Red delicious			-142.66**	65.45	-104.70	76.42
Gala			-237.96**	106.92	-183.83	114.74
Honeycrisp			-192.34*	109.12	-300.44*	170.89
Years in apple production			-77.64*	42.77	-86.48	89.44
Age					49.46	157.17
Ethnicity (Hispanic)					2,763.03	2,214.15
Education (≥ Bachelor's)					-1,540.18	1,768.38
Income (>500,000)					-2,399.77	1,844.01
Constant	3,368.75***	661.85	9,473.64***	2,009.76	8,968.13*	5,275.71
Clusters	32		30		29	
Observations	64		60		58	
R^2	0.044		0.410		0.479	

Note: Standard errors are clustered at the individual level. * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$.

Table 5. Factors Affecting Bids for a New Variety of Apple *Per-box Royalty*

Variables	(1)		(2)		(3)	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Exclusive contract	9,591.22***	2,102.52	9,795.22***	2,336.06	9,772.64***	2,523.74
Total apple land			-0.6529	1.5752	-0.5417	1.5819
Red delicious			-163.11	247.31	-171.36	252.08
Gala			-750.33*	428.34	-701.66*	369.56
Honeycrisp			418.12	828.60	1,203.56	1,728.67
Years in apple production			-483.78	316.47	-473.35	320.73
Age					122.95	278.43
Ethnicity (Hispanic)					-8,119.82	11,463.85
Education (≥ Bachelor's)					8,673.01	14,596.60
Income (>500,000)					-4,421.64	11,959.20
Constant	11,544.08***	3,625.75	31,021.73**	12,888.30	16,942.28	12,446.55
Clusters	32		30		29	
Observations	64		60		58	
R^2	0.049		0.191		0.211	

Note: Standard errors are clustered at the individual level. * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$.

Table 6. Factors Affecting Bids for a New Variety of Apple, *Two-Part Scheme*†

Variables	(1)		(2)		(3)	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Exclusive contract	7,704.91***	1,923.65	8,211.90***	2,112.95	8,495.07***	2,259.88
Total apple land			-1.4203	1.4607	-1.0881	1.5415
Red delicious			-34.05	216.77	-198.80	249.78
Gala			-436.56	400.71	-289.25	309.67
Honeycrisp			564.98	716.94	1,274.70	1,650.39
Years in apple production			-334.29	275.94	-125.85	290.49
Age					-375.75	281.64
Ethnicity (Hispanic)					624.05	10,316.85
Education (≥ Bachelor's)					5,147.87	13,518.48
Income (>500,000)					-7,158.22	10,977.15
Constant	8,808.59***	2,762.46	20,105.96*	10,095.94	31,733.67***	9,981.30
Clusters	32		30		29	
Observations	64		60		58	
R^2	0.042		0.144		0.223	

Note: Standard errors are clustered at the individual level. * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$.

†A "two-part scheme" is a combination of a fixed fee and a per-unit fee.

Table 7. Factors Affecting Bids for a New Variety of Apple, *All Bids*

Variables	(1)		(2)		(3)	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Exclusive contract	1,838.83***	307.24	1,811.42***	330.47	1,823.88***	346.44
Per box royalty	8,175.33**	3,633.82	8,996.19**	3,890.38	7,704.66*	3,835.84
Combination	5,439.84*	2,836.66	5,804.17*	3,031.47	6,204.31*	3,150.88
Per box royalty × Exclusive contract	7,752.40***	2,011.16	7,983.80***	2,161.62	7,948.76***	2,267.47
Combination × Exclusive contract	5,866.078***	1,807.57	6,400.48***	1,916.95	6,671.19***	1,989.75
Total apple land			-0.6996	0.9746	-0.4258	0.9803
Red delicious			-113.27	147.86	-158.29	162.62
Gala			-474.95*	260.17	-391.58*	215.13
Honeycrisp			263.59	485.63	725.94	1,065.45
Years in apple production			-298.57	184.03	-228.56	191.39
Age					-67.78	165.45
Ethnicity (Hispanic)					-1,577.58	6,748.64
Education (≥ Bachelor's)					4,093.57	8,743.10
Income (>500,000)					-4,659.88	7,395.71
Constant	3,368.75***	665.34	15,266.99***	5,032.52	14,578.37***	4,905.89
Clusters	32		30		29	
Observations	192		180		174	
R^2	0.125		0.218		0.233	

Note: Standard errors are clustered at the individual level. * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$.

Table 8. Descriptive statistics for eligible bids

Licensing arrangement			Number of eligible bidders	Market price ($)		Land (acres)	
				Mean	Standard deviation	Mean	Standard deviation
Fixed fee	Exclusive		25	1,935.28	500.02	121.17	186.25
	Non-Exclusive		19	1,449.89	363.84	127.85	199.77
Per box royalty	Exclusive		13	2.12	0.91	166.76	239.14
	Non-Exclusive		8	1.25	0.30	115.75	237.57
Combination	Exclusive	Fixed fee	12	1,170.50	376.91	173.20	248.69
		Per box royalty		1.41	0.45		
	Non-Exclusive	Fixed fee	6	720.33	235.46	31.00	39.27
		Per box royalty		0.92	0.36		

Table 9. Descriptive statistics for grower profits (in $)

Licensing arrangement		10-year PV		15-year PV		20-year PV	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Fixed fee	Exclusive	74,009.86	5,193.69	132,902.81	7,377.45	179,046.98	9,089.96
	Non-Exclusive	44,826.80	5,182.68	86,572.60	7,434.85	119,281.53	9,200.32
Per box royalty	Exclusive	64,271.40	8,623.92	116,471.46	12,883.93	157,371.57	16,231.41
	Non-Exclusive	40,747.39	5,687.76	79,160.03	8,079.72	109,257.33	9,956.93
Combination	Exclusive	65,965.66	6,037.84	119,903.85	8,555.33	162,165.83	10,540.06
	Non-Exclusive	43,482.55	1,257.08	83,601.81	2,125.56	115,036.30	2,813.13

Table 10. Descriptive statistics for innovator profits (in $)

Licensing arrangement		10-year PV		15-year PV		20-year PV	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Fixed fee	Exclusive	247,333.77	370,660.92	247,333.77	370,660.92	247,333.77	370,660.92
	Non-Exclusive	166,882.52	260,042.97	166,882.52	260,042.97	166,882.52	260,042.97
Per box royalty	Exclusive	1,959,372.77	2,779,699.59	3,036,756.02	4,308,148.81	3,880,913.99	5,505,728.77
	Non-Exclusive	599,944.76	1,037,157.76	929,831.16	1,607,450.67	1,188,305.78	2,054,290.08
Combination	Exclusive	1,287,000.17	1,830,663.90	1,863,006.90	2,670,413.59	2,314,323.24	3,330,470.47
	Non-Exclusive	139,380.66	127,648.92	202,101.51	178,732.78	251,244.93	218,814.23

Table 11. Model of grower profits for a new variety of apple

Variables	10-year PV		15-year PV		20-year PV	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Exclusive contract	29,010.25***	258.65	46,084.33***	325.98	59,462.32***	378.81
Per box royalty	-4,392.47***	615.59	-7,858.03***	956.54	-10,573.38***	1,224.67
Combination	-3,849.75***	672.36	-6,535.82***	1,094.71	-8,640.43***	1,427.02
Per box royalty × Exclusive contract	-4,166.61**	1,725.56	-6,895.22**	2,706.21	-9,033.15**	3,475.38
Combination × Exclusive contract	-2,848.51***	722.41	-4,548.04***	1,190.45	-5,879.66***	1,560.78
Land	-25.87***	1.1747	-36.81***	1.8712	-45.38***	2.4186
Constant	48,134.26***	249.67	91,278.71***	356.22	125,083.50***	441.39
Clusters	27		27		27	
Observations	83		83		83	
R^2	0.975		0.975		0.975	

Note: Standard errors are clustered at the individual level. * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$.

Table 12. Model of innovator profits for a new variety of apple

Variables	10-year PV		15-year PV		20-year PV	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Exclusive contract	114,080.7	84,992.79	128,641.4	127,184.1	140,050.1	161,118.3
Per box royalty	493,988.8***	150,374.9	850,254.9***	258,979.5	1,129,399***	347,453.3
Combination	460,099.3**	170,842.4	733,939**	267,68236	948,499.6***	343,696.8
Per box royalty × Exclusive contract	988,529.3**	470,714.5	1,610,270**	745,806.9	2,097,420**	962,234.4
Combination × Exclusive contract	317,631.7	200,739.7	506,387.3	326,434.4	654,282.3	425,523.2
Land	5,034.51***	467.68	7,214.32***	721.84	8,922.26***	921.15
Constant	-476,788.4***	168,565.4	-755,481.5***	264,186.4	-973,844.8***	339,245.4
Clusters	27		27		27	
Observations	83		83		83	
R^2	0.678		0.638		0.622	

Note: Standard errors are clustered at the individual level. * denotes $p < 0.10$, ** denotes $p < 0.05$, *** denotes $p < 0.01$.

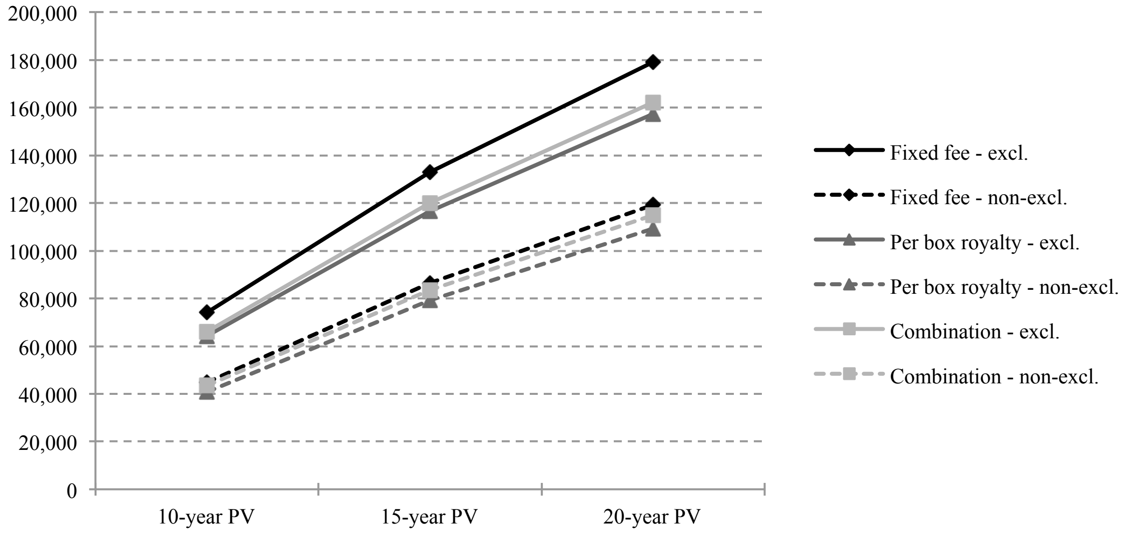

Figure 1. Average grower profits under different licensing arrangements (in $)

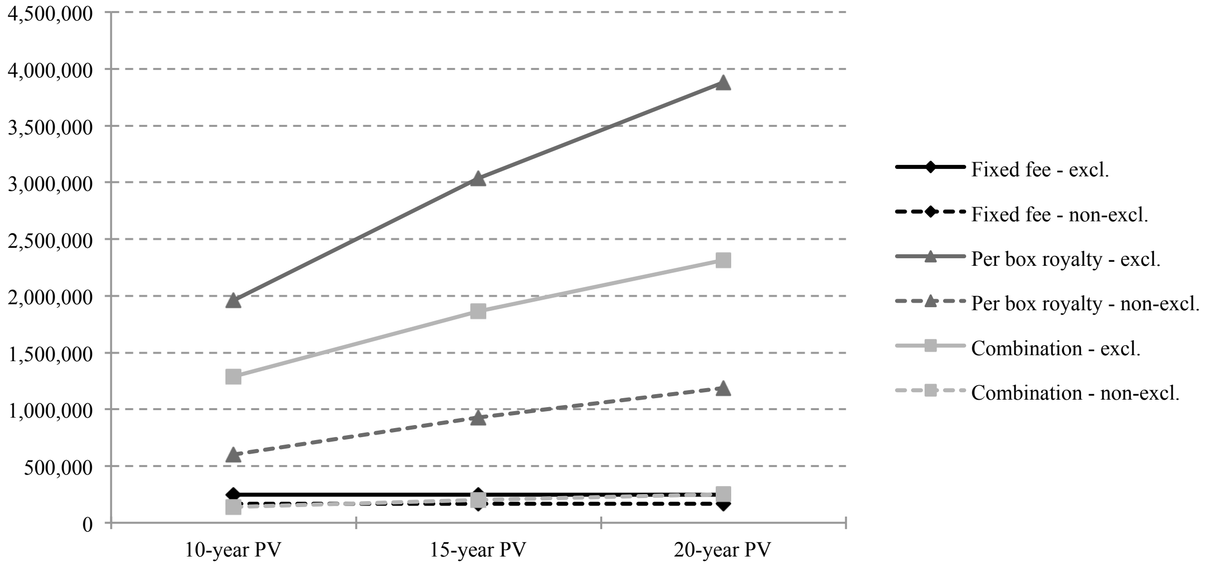

Figure 2. Average innovator profits under different licensing arrangements (in $)