The Effect of Seed Market Concentration on Farmers: The Case of Cotton and Corn in 1986-1998

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Abstract

Concentration in the seed industry has been precipitously rising for almost fifty years to the point where it is one of the most concentrated parts of the agricultural market. The paper looks at the effect of that concentration on outcomes to farmers to assess whether there are serious monopoly concerns from seed concentration or whether the claims for higher efficiency from mergers can be substantiated in the data. I use a difference-in-differences methodology along with county level cotton seed and national level corn market share data. Shocks to market share are identified using mergers during period to assess farmer output and yield. I conclude that mergers have a slight negative impact on yield and no impact on output.

1 Introduction

The agricultural industry as a whole is notorious for lacking serious competition in significant chokepoints in the production and distribution pipeline. [19] While the country is covered by small grower operated farms that raise animals and grow produce, most of the yields in growing are increasingly being dominated by large agribusinesses that are not family owned and do substantially more volume than any family operated could ever dream of. [13]

The seed market, despite being relatively young, is no exception to this trend. For thousands of years, seeds were harvested from the crop and replanted to form the next year's crop. Crop characteristics would change slowly as ideal seeds were selected for replanting. The seed industry revolutionized this model of farming. Since the beginning of the 20th century, the seed market mostly consisted of small firms with sparse product offerings focused on one seed stock. These companies were akin to the biotech companies of today with their diminutive size and focus on R&D. This environment created a rather competitive atmosphere for seed development both in the US and across the world. [10] This changed during the 90s. While the market for seeds was very competitive, the small size of the firms meant that it was difficult to achieve horizontal integration with other synergistic industries like agro-chemicals or to exploit firm knowledge by financing a product line in a new seed type. Based on these justifications, the major players in the seed market have spent the past 30 years buying up their competitors or merging with each other. [10] This process hasn't quite been an unstoppable accumulation of market power for the dominant firms (competition authorities generally force divestments during mergers), however, the result is a global seed market where almost all business is conducted by 6 firms. This process of mergers and acquisitions has recently reached what is most likely the final form of the market for the near future. [17] The past five years have seen the acquisitions of Monsanto by Bayer, Syngenta by ChemChina, and the merger of Dow and DuPont. [9] These blockbuster mergers have had massive impacts on the market structure of a variety of seeds and will likely guide many of the dynamics in farming for decades.

It is hard to create a theoretical framework for how to evaluate this increase in concentration. For one, it is very likely that seed growers exercise substantial market power over growers. Most growers in the US are small family farmers who have limited resources and understanding of the seed industry itself. The difference in size and complexity between farmers and seed companies could very easily allow said companies to leverage market power far beyond what they would usually get away with in a more competitive market structure. Simultaneously, seed development is a very R&D heavy industry where there are serious efficiency benefits to allowing firm concentration due to high fixed costs. Concentrated firms can better withstand shocks to the business and can engage in more innovation that might be helpful to customers. Which of these effects prevails in the current US seed market is hard to ascertain.

This paper focuses on the experience of the corn and cotton markets in 1986 through 1998. To attempt to estimate a causal effect of seed market structure

on downstream variables, I employ a difference-in-difference methodology using a time-crop difference. I identify mergers in the seed market and use them as exogenous variation in market concentration. Using county level, per company concentration data about cotton seeds, I perform a difference-in-difference regression where counties who had an increase in seed market concentration due to the merger are compared to those who didn't. A second crop-crop-time difference specification is used to try to estimate the effects of concentration on corn. There is no county level data available for corn, so I use national concentration level data and difference out county level trends in cotton to try to estimate local effects of concentration changes.

2 Background

2.1 History

Seed companies in the US have been around since the early 20th century: however, in their initial stages, they were focused on distributing well established seed stock to farmers who didn't want to harvest their own seed as opposed to developing new types of crops. [5] The 70s and 80s saw the rise of a new model of seed corporation which focused on research and development of new seed products as their primary products. These companies generally focused on a single crop and used new advances in biotechnology to create seeds that were more reliable, cheaper to produce, or more resilient than the alternatives. Common innovations were pesticide, drought, or flood resistance. Hybrid seeds (those with various genetic alterations created exogenously) are not guaranteed to develop the same traits when seeds from the parent crop are replanted. [25] This fact means that seed companies could sell the same seeds to farmers every year thus guaranteeing a steady cash flow which could be used to finance further R&D.

Intense technological change over the past 100 years has created a fundamental shift in how agriculture is practiced all over the globe. Mechanization, fertilizer, and an increasingly competent distribution network have increasingly incentivized scaling agriculture to an extent that hardly could have been imagined in ages past. Seeds have been central to this evolution. Early discoveries in genetics were first demonstrated in plants and, by the 1930s, new companies were sprouting up that were trying to use these discoveries to breed and then sell improved versions of popular crops (corn was the first big target for these companies). The main strategy for improving crops during this period was cross-breeding different varieties of the target crop. By selecting the best performing specimens of certain desirable varietals and cross pollinating them, one could theoretically create a crop that had a large concentration of desirable mutations. The problem with this approach was that it took a long time to produce a seed that could be competitive with the top varieties on the market and it was difficult to exclude undesirable traits from developing which weren't there previously during the breeding process. [5]

Despite these barriers, seeds played an important role in the development of agriculture during this period. The biggest goal was to increase yields for farmers and the new seed varieties were fantastic at this. Yields have risen persistently since the beginning of the 20th century: research has attributed about half of this increase to advances in the quality of seeds. [7] Likewise, seed manufacturers focused on producing crops that were resistant to common causes of crop loss such as drought or pests. The appeal of custom bred seeds was obvious and their prevalence in the US saw a gradual increase through the 20th century until they dominated the market for most crops in the 80s. It wasn't only seed companies engaging in this kind of research either. Public research universities employed many of the foremost experts in the development of new seed crops and came out with seed varieties that very successfully competed with the private companies of the time. In many markets, seeds whose development was funded by public dollars actually held the majority of the market share. [19]

As custom crops achieved almost universal penetration in the US, genetic modification technologies were also maturing to a point where they were useful in creating custom seeds. Due to the time consuming nature of breeding different strains of plants and evaluating their offspring for traits, companies were always looking for a way to more easily develop new traits. Gene insertion provided a much easier way to do this than the previous methods. Instead of breeding, scientists could now use genes from any arbitrary source and insert them into the genome of a seed if it provided a beneficial trait. The new possibilities that genetic modification offered reinvigorated competition in the seed market. A plethora of new companies popped up around the world that breed novel seeds using the new techniques. Many of them were successful and gained substantial market share. Coincidental with this increase in private interest in seed development was a commensurate decrease in the market power of public institutions in the seed market. Universities simply couldn't compete with a newly invigorated private sector, and while popular seed brands from powerhouse agricultural universities like Texas AM still hold substantial market share in regional markets, the 70s represented the high point of influence for public institutions in the market.

New seed varieties aimed to solve the same problems towards which old seed breeding techniques had been directed, but with much more specificity. The most popular varieties had custom traits that enabled greater drought and pesticide resistance than had previously been possible because of the novel nature of the genes to be inserted. For example, the most influential trait in cotton was the Bt trait, named after the bacteria Bacillus thuringiensis. This bacteria produces a variety of toxins which are toxic to common cotton pests (varieties of moths, beetles, etc) but have no negative health effects on anything else. Implanting parts of the bacteria's DNA into cotton seeds enables it to also produce these toxins and gain substantial resistance against pests. [5]

The new specificity with which new seeds could be manufactured created new opportunities in the industry for horizontal integration. Monsanto's most popular product for much of the 90s and beyond was a Roundup-Ready line

of crops that were specifically tailored to be resistant to its signature pesticide, Roundup. This early experiment in integrated product lines presaged the growth of the industry for the next 30 years.

Indeed, increasing concentration has been a fact of life across many parts of the agricultural industry over the past few decades. The economies of scale that can be realized by uses of new technology in the growing phase of production have led to a diminishment of the role of small farmers in the US. While the majority of farms in the US are still small and family owned, the majority of the production is sourced from substantially larger farms - a reality that was not true 30 years ago. While it is clear that there are prevailing technological forces that have pushed towards concentration in the growing layer of agriculture, it is rather unclear how large other factors are. One drastic change in the past 30 years has been a concurrent, and much more precipitous, concentration in the seed market. This period has been one of constant mergers and acquisitions by major companies such that by 2015 the markets for all major seeds were dominated by 6 major players. In the seven intervening years, there have been two pairs of mergers between them (Dow-Dupont and Bayer-Monsanto) such that the market is even more concentrated than it was before. This drive towards concentration has been driven by two different concerns. For one, seed R&D using modern techniques is very expensive and small firms simply don't have the capital to absorb the failure of a product they've spent substantial resources developing. Secondly, mergers through firms that are well positioned in sectors other than seed development allows seed companies to exploit the horizontal synergies mentioned earlier. For example, Bayer was one of the biggest agro-chemical producers while Monsanto was one of the biggest seed producers before their merger. Theoretically, this concentration should allow seed companies to exert greater market power over farmers, especially in a system like the US where the farmers these seed companies are doing business with are often small local family farms. Indeed prices seed prices have consistently trended up over the past decades - in 2020, combined chemical and seed prices accounted for about 29 percent of farmers expenditures. [23] It's hard to tell whether this is a symptom of rising development costs in seed or an attempt by the seed industry to extract rents or a bit of both. Thus, the question of whether concentration in the upstream market benefits growers hinges on the question of whether better products and interfacing with customers outweighs the increases in price.

2.2 Market Structure

Indeed, the structure of the seed market poses unique challenges for analyzing its impact. The agricultural industry as a whole is divided into several distinct levels: providers of intellectual property (such as seed companies) often supply the raw inputs to growers who sell to intermediate companies that do refining and distribution of the raw products. [1] From there, products are sent on for further refining or packaging and then sent to the consumer level distribution. This description is only a vague overview of how the market actually works, but it does show that growers interface with both downstream and upstream

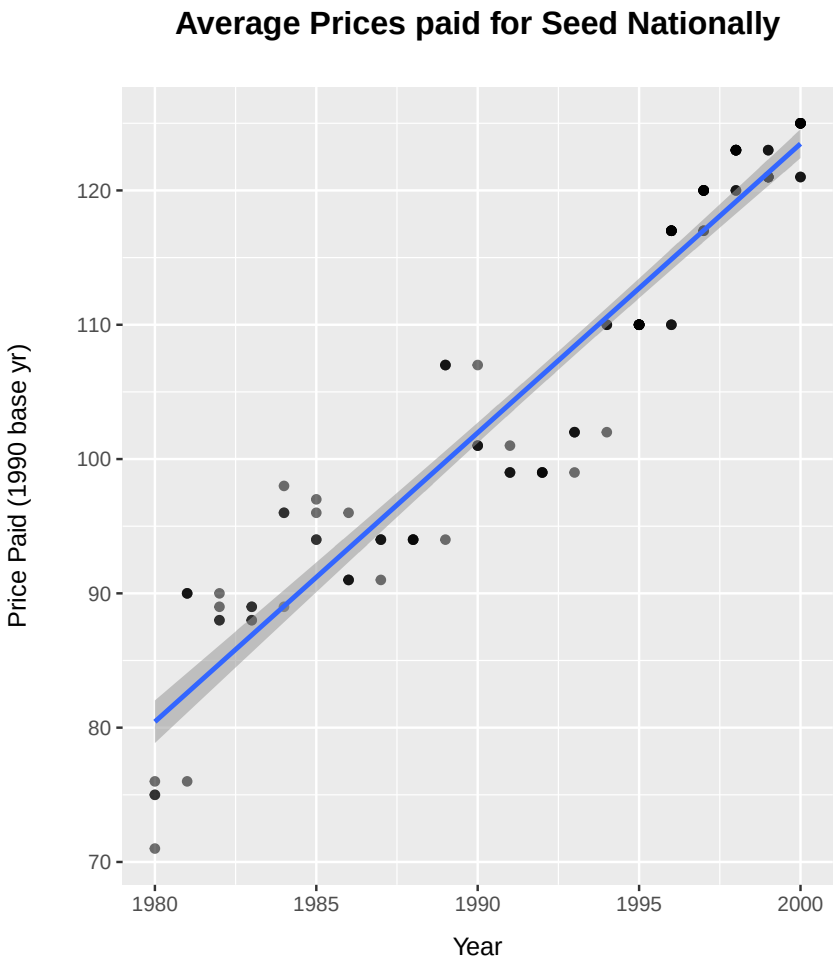

Figure 1: Average price for US nationally over the study period. Index year is 1990.

markets.

As suppliers, seed companies have slightly different types of concentration concerns than are traditionally analyzed when looking at agricultural markets. The effect of concentration in the distribution and processing level has long been a central concern for agricultural economists and policymakers. This concern is more pronounced in certain livestock markets like broilers where most producers don't actually own the chickens they are raising and instead lease them from the distributors on contract with a certain payment for weight put on per chicken. [14] This situation is a result of concentration in the distribution and refining industry due to large economies of scale and due to the relative localization of markets because of the difficulty transporting livestock. [15]

While there is nothing quite as severe as the broiler market in any of the crop markets, there are similar concerns about distributor market power for similar reasons. For example, processing corn requires large facilities to store it and machines to remove husks, clean the corn itself, etc. Corn is also relatively perishable and difficult to ship en-masse which makes it difficult for most farmers to find more than one or two distributors to whom they can sell the majority of their product. [1] The result of downstream concentration is that distributors can exert substantial market power over growers.

However, it is doubtful whether distributors actually use their market power to extract surplus or decrease output by growers due to the structure of the market. A common narrative goes as such: distributors have massive specialized capital investments in receiving, processing, and shipping goods meaning they incur substantial economies of scale. These economies of scale both mean that they have very little incentive to reduce output or raise prices as doing so would increase their average costs and that they prize reliability upon all else in a relationship with a grower so as to maintain their scale economies. [20] It seems reasonable that distributors would then be willing to give growers a substantial part of the surplus to make sure that they don't exit the market and the distributor doesn't need to incur the substantial transaction cost of finding a new supplier. Traditional concerns about vertical integration are thus also assuaged; if the distributor extracts most of their surplus by keeping costs low through scale they have no incentive to discriminate in the upstream market because doing so would lower output.

While this is all well and good for farmers who interface with these distributors, none of these mitigating factors apply to the seed market which makes concentration therein more dangerous than in other parts of the market. Crucially, seed companies are not dependent on farmers for their inputs and are thus do not need them to maintain their cost basis. Instead, most costs are paid up-front during seed development and companies can only start recouping investment after R&D is completed. Seed market outputs are also highly heterogeneous - many companies have vastly different market shares in different regions partly because they tailor their seeds to address different local climatic or biological issues (Tamcot, discussed later, is a good example of this). Both these facts imply that the seed market is well modeled as a monopolistically competitive industry (indeed previous attempts to model seed prices have used

this assumption). [21] Importantly, this means that the primary way they have of increasing their surplus is increasing price over the socially optimal point and decreasing output in the growing market.

Information asymmetry is also a much larger concern in the seed market than elsewhere. Whereas growers are selling largely homogeneous products in the grower-distributor relationship, seed companies are selling differentiated products which take high amounts of technical knowledge to properly evaluate and understand - something the small farms which predominate in the growing industry are unlike to have. Traditional evaluations of information asymmetry in agriculture have focused on a lack of knowledge about product specifics by distributors. In that scenario, information asymmetry is an efficiency enhancing rational for vertical integration because it allows distributors to more closely monitor product quality. The same cannot be said of the seed industry who cares about product quality only insofar as their customers will complain if its bad. Instead, the type of information asymmetry between seed and growing companies is about the efficacy and suitability of the different types of seeds available in the market. Farmers are unlikely to want to pay the transition costs of moving to a new type of seed unless they are relatively certain of the benefits. They are unlikely to obtain such certainty in the current situation which gives seed companies the opportunity to raise prices above equilibrium.

In contrast to the previous discussion about distributors, seed companies have relatively few concerns about vertical integration simply due to the fact that seed companies aren't vertically integrated. There have been brief flashes in the market where seed companies have been owned by broader agricultural conglomerates (for example, Cargill had a seed division in the 90s), but those divisions were all eventually divested. Today, modern seed companies either do exclusively seed companies like Limagrain or part of a larger conglomerate that does chemicals or other sorts of manufacturing products like Bayer-Monsanto or ChemChina (which owns Syngenta). It's not entirely clear why seed companies choose not to pursue vertical integration. It is entirely possible they view it as too risky given the substantial amount of antitrust scrutiny that they already receive. Alternatively, they are unwilling to pay the substantial upfront costs of entry into the growing market given that they can already wring most of the surplus out of it with their substantial market power. Whatever it may be, the lack of vertical integration means discrimination isn't a concern like it is for most suppliers with market power.

While discrimination in the downstream market isn't a concern for seed companies, tying in the horizontal market is a greater concern. As mentioned above, most modern seed companies are horizontally integrated with a chemical company and many package their seed products with their pesticide or herbicide offerings (Monsanto with Roundup-Ready seeds is the canonical example of this). There is evidence that pesticides prices are a way companies extract rents from downstream buyers. [8, 12] Tying in the seed industry could exacerbate this problem. However, this study predates much of the horizontal integration that has become so emblematic of the industry today and thus, isn't a direct subject of the analysis.

All of this aside, one shouldn't discount that there are substantial benefits to increased concentration, especially when producers pay high fixed costs like in the case of the seed industry with R&D. Seed companies are exposed to high risk whenever developing a product because costs are all paid upfront. For smaller companies, the failure of a seed product can mean bankruptcy. [6] This reality creates a large incentive for concentration so companies can actually survive. Concentration can also improve product quality insofar as having larger revenues allows companies to invest in projects that are more speculative or which are more tailored to the needs of a specific market without worrying about the potential risk. Likewise, larger companies can invest in other sorts of fixed costs that allow them to better communicate with farmers how to use their products to be more efficient in a best-practices sense.

All this analysis implies that the effect of seed companies is hard to ascertain. The evidence on the impact of concentration is also mixed. Several studies have looked at the effect of concentration on prices and found different results. [**?**, 16, 2, 21] That said, the positioning of the seed industry as a supplier to growers means that it is much more likely to extract rents from downstream participants than distributors. We would expect that to manifest as decreased production in areas that are more concentrated. However, if there is an efficiency benefit from seed concentration, that would lead to an increase in yields (it also could be the case that decreased competition from concentration leads to a commensurate decrease in yields as companies are less incentivized to add value for farmers). I evaluate both these pathways next.

3 Data

Data is the fundamental problem with all research on the seed market. Seed companies undoubtedly have their own estimates of the concentration and market shares in the various kinds of seeds that they sell. However, this data is rarely made public, and when it is, it is never in a form that is comprehensive enough to do serious analysis (the types of disclosures are generally slides in investor presentations and such that are hard to trust in the first place). There have been some attempts to measure the market shares in the global seed market by using financial disclosures to investors in documents like 10-Ks from all the major international seed markets. The sum of revenues in the seed divisions of these companies is used to represent the size of the global market and the share of a specific company is their revenue over the total market size. [**?**] The problem with this approach is that it only generates one observation per company per year which is hardly enough to do serious analysis given the short existence of the modern seed market and that the methodology of summing declared revenues seem to imply results about the size of the global seed market that cohere poorly with other types of estimates.

There have been some attempts to collect data on market shares in the US, however, this data tends to be either hard to come by or only for specific seeds in specific years. The most widely cited dataset is from dmrKyntec in the 90s

who did phone surveys of different farms across the US to try to estimate market share. However, this is only a smaller sample of certain types of seeds and it is a paid dataset and thus, beyond my reach. There have been studies, mostly stemming from researchers at agricultural colleges, that attempt to measure market shares of certain crops per state over periods of certain years. Collating these can lead to a reasonably comprehensive view of the distribution of certain types of seed markets during short periods of US history. I use one such collation from Fernandez-Cornejo [5] as an estimate for market shares in corn from 1988 to 1998. He uses several studies and publicly disclosed estimates from companies to estimate the shares of the top 8 firms as well as the concentration ratios and HHIs. Obviously, this is not high quality data. Preferably data would be collected using similar methodologies to avoid bias. However, one must use what one has.

Luckily, data on cotton is substantially more uniform. To estimate cotton market shares, I use the Cotton Varieties Planted Report which is a survey gathered by the USDA every year starting in 1970.[22] While the data was pared down in 1996 to stop including county level data, prior to that point, the USDA reported county level area planted data collected from each of the regional classification offices. Usually, seeds are named after the company who owns them, but when they aren't, I use another dataset from the USDA to identify the owner of the listed seed.[3] Note that this dataset doesn't provide a direct measure of market share because it measures area planted instead of revenue which means measures of area planted will underestimate the market power of seed companies that have more expensive seeds or sell seeds as part of a more expensive platform. This concern is more prominent during our study period because seeds owned by public institutions still make up a substantial fraction of the market. For example, a good portion of the Texas cotton producers during this period were growing a variety called Tamcot which was designed by researchers at Texas AM. While we don't have direct price data for different types of seeds, it seems likely that privately owned seeds are more expensive than those owned by non-profit organizations and thus the market power of public institutions is overrated in these measures. These concerns are somewhat alleviated by the fact that we're looking at changes in market power rather than market power overall. Thus, differential changes in concentration between high and low price are the only type of movement that might create bias.

Data on growers is substantially easier to obtain because most of it is tracked by the National Agricultural Statistical Service (NASS). The NASS conducts a survey of growers every year and a census every five. The census tends to have more data with greater granularity but doesn't occur regularly enough to be useful here. So, county level data is pulled off the NASS portal and merged with the coded Cotton Varieties data to obtain final per county data.

An initial examination of the data shows that the seed market for cotton in the US is concentrating and there is a concurrent expansion of production for growers. The concentration increase is inline with our general narrative about concentration in the US seed market more generally during this period. Likewise, production is expanding locally. There isn't granular enough data

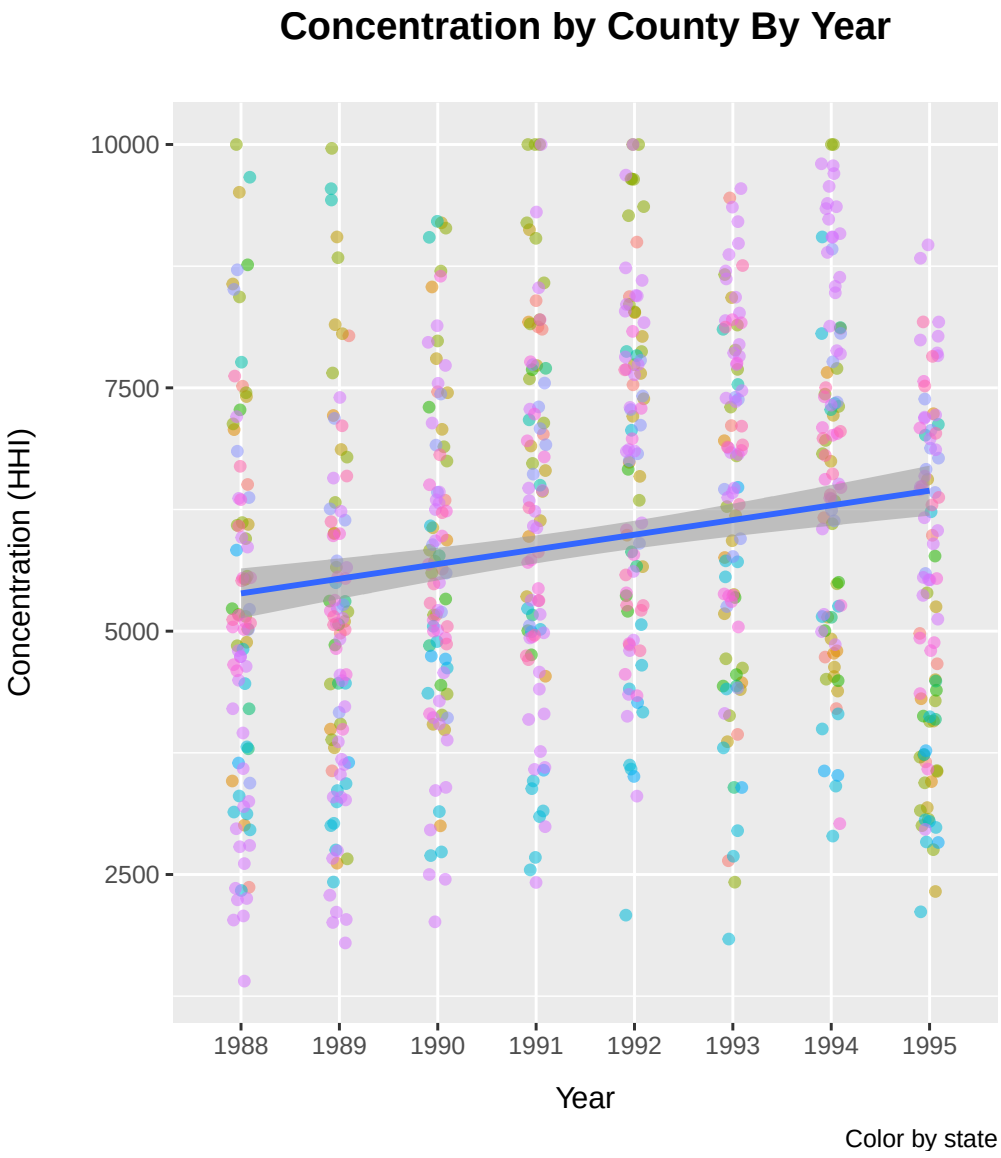

Figure 2: Concentration of seed companies per county as measured using HHI. Data is measured annually and jitter is applied to the data to make the graph legible.

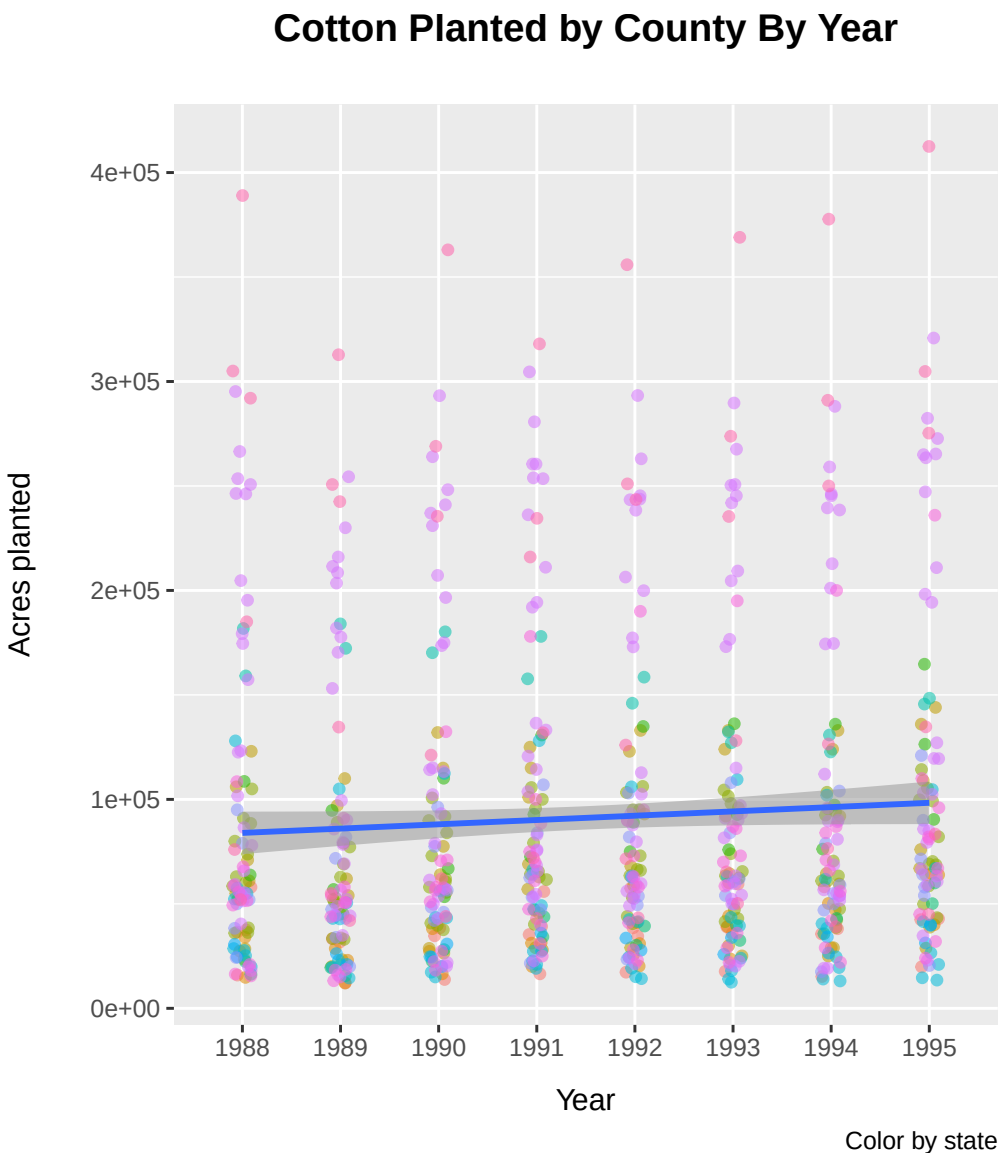

Figure 3: Amount of cotton planted by county measured in bushels. Jitter applied for legibility.

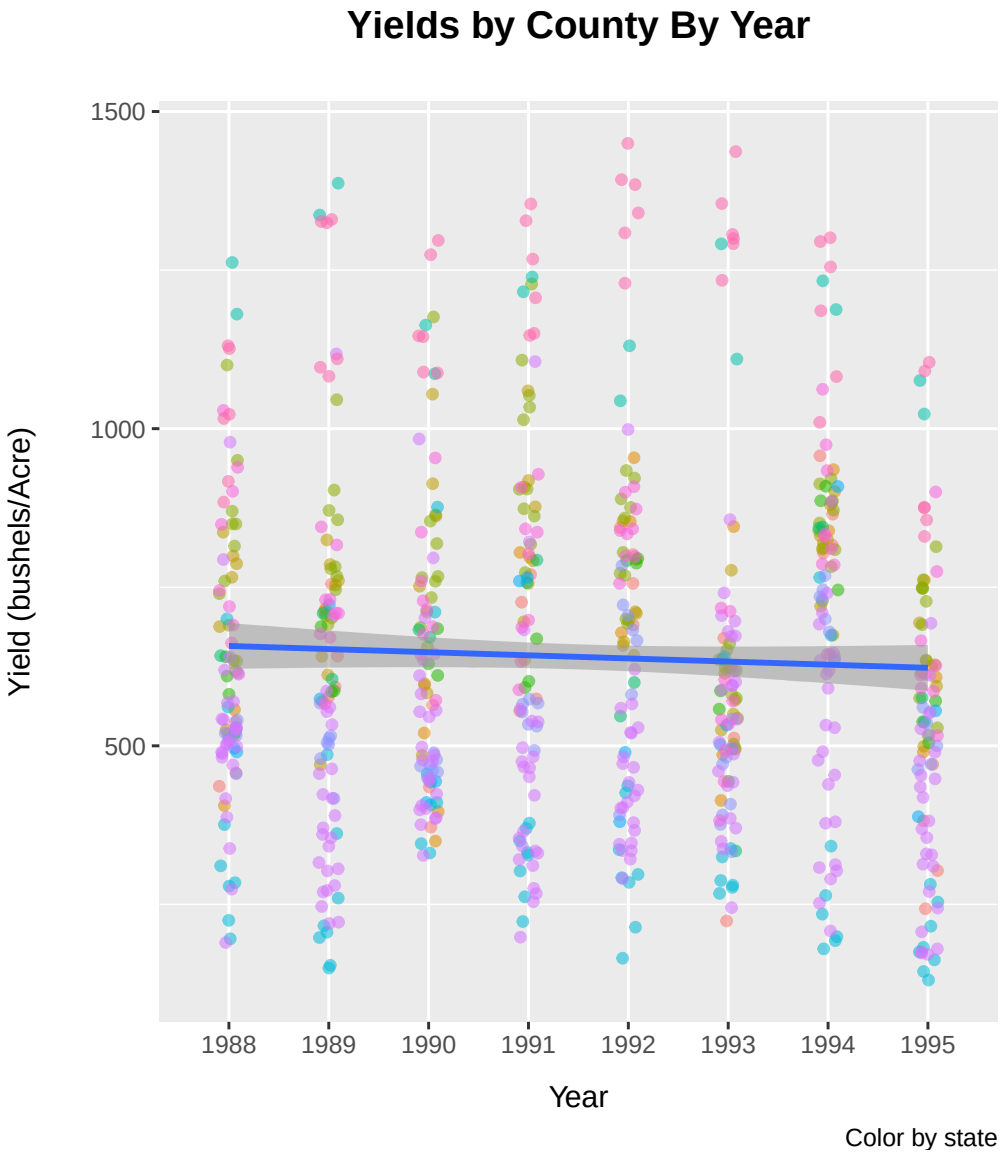

Figure 4: Yields per county per year measured in bushels per acre.

during this period to measure concentration in the growing industry so this could either be new entry or expansion in production - obviously many things could motivate this, but expansion to eliminate information asymmetries between upstream suppliers is one of the possible explanations. Contrary to this, cotton yields are mostly flat during this period. However, the question remains if there's a differential effect between counties that experience exogenous increases in concentration.

4 Methods

This paper employs several methods by which to measure outcomes of downstream growers in response to concentration. The lack of solid data for growers during this period or solid concentration data limits our ability to assess outcomes and makes it so that one must employ some less than ideal analytical structures in order to assess causality in this case.

The main source of exogenous variation I exploit in this paper is mergers in the cotton industry. There are a few arguments about why this variation is exogenous. For one, merger timing is unpredictable as they are often subject to antitrust scrutiny. For example, Monsanto attempted to acquire Delta Pine Land in 1996 and was only able to do so in 2004 after the initial attempt failed. This example is extreme, but it illustrates that mergers are unlikely to be an attempt by firms to exploit any shock to an outcome variable because timing of the actual merger is unknown at the point the merger is started.

Furthermore, seed preferences in the US are both regional and persistent. Sans any corporate acquisitions, market shares per seed, and per seed company, change relatively slowly. I run a regression of lagged market-share per company per county per year and find that the market share in a specific county in a previous year explains about 75 percent of the variation in a company's share.

Much of this persistence can be attributed to the qualities or recognition of a certain seed. For example, Tamcot, a variety of seed developed at Texas AM is very popular in Texas but has very little market share outside the state itself. This is also true of DES which was developed at UMiss and has similar popularity in its home state. The fact that the same can be said of many other varieties of seeds suggests that seed brands either make use of their local reputation to enhance their market power in certain regions or that certain seed brands are much better designed for specific climates or types of regional pests and are suboptimal in other regions besides the ones for which they have been designed. This regional persistence in seed concentration allows us to exploit mergers in the cotton market as an exogenous source of per county variation. Say that Delta Pine Land bought Paymaster with the intention of trait stacking and expanding their market share. There are going to be some markets in which Paymaster and Delta Pine Land had preexisting market share that are particularly suited for their technology and those where either one of them had no market share that are going to face little new competition as a result of the merger. In other words, the fact that a merger happened is unlikely to change

Table 1: Cotton MS stationarity

	Dependent variable:
	Market Share Per Company
Lagged share	0.857***
	(0.004)
Constant	0.418***
	(0.048)
Observations	20,870
R^2	0.731
Adjusted R^2	0.731
Residual Std. Error	6.738
F Statistic	56,787.650***
Note: Years from 1988 to 1995	*p<0.1; **p<0.05; ***p<0.01

the market share of any individual seed initially - the year after the merger, concentration mostly increases by virtue of one company now owning more seed brands. Because the merger happens nationally and market concentrations are measured by county, one can compare the counties where all companies had market share pre-merger and experienced a rise in concentration to the counties where one of the merging companies didn't have a share. The latter counties experience the same changes in global demand and national regulation that the treated counties do and therefore serve as a robust control for many types of outcome variables.

4.1 Cotton

I use 2 cotton mergers between 1988 and 1995 as sources of variation in cotton market share: the Paymaster-Delta & Pine Land merger in 1993 and the acquisition of Coker and McNair by Stoneville in 1990. Delta Pine Land was by far the biggest supplier of cotton seed in the US in the 80s with some presence in almost every market. Paymaster, on the other hand, was a smaller company with substantial share in some isolated pockets of the US South.

The basic specification of the regression is as follows:

$$OUT_{ijk} = \beta_0 + \beta_1 HHI_{ijk} + \beta_2 MergerIntensity_{ikm} + \beta_3 YR + \beta_4 StateFE_k + \beta_5 X_{ijk} + \epsilon_{ijk} \quad (1)$$

where i, j, k, m are county, state, year, and merger indicators, MergeIntensity is an index that measures how much merger concentration increased that is zero before the merger and the index value for all years after (the index takes the value zero if one of the merging firms had zero market share in the county and

increases as the market share of either increases), HHI is a measure of market concentration per county, Yr is a time trend, StateInd is a state fixed effect, and X is a vector of controls. The quantity of interest is MergeIntensity which is the treatment effect of a specific merger.

Outcomes variables are selected to test the hypotheses outlined above and align with the presentation in the data section.

4.2 Corn

The regression for corn is slightly more problematic as there isn't the granular level of data that exists for cotton. Like cotton, I use mergers as a source of exogenous variation. There are two mergers that happen in the corn market in this period. The first is the acquisitions of DeKalb and Asgrow by Monsanto in 1996 and the second is the acquisition of Cargill's seed business by AgroEvo in 1997. The same methodology is used to generate changes in market share, just on a national level.

Instead of using local controls for corn HHI, I use local cotton outcome data and HHI as a proxy for corn local concentration. If there is a trend in concentration that occurs as a result of national economic trends or state based regulation that affects agriculture in general, the changes in the cotton data should be correlated with those in corn. Counties are filtered for those which have over 15% corn and cotton so the results aren't spurious.

The regression specification is similar to the case of cotton.

$$\text{OUT}_{ijk} = \beta_0 + \beta_1 CottonHHI_{ijk} + \beta_2 MergerIntensity_{km} + \beta_3 YR + \beta_4 StateFE_k + \beta_5 X_{ijk} + \epsilon_{ijk} \tag{2}$$

5 Results

5.1 Cotton

Summary statistics for the variables of interest are reported below.

The first question I investigate is whether increases in seed concentration leads to higher prices or other impediments which cause them to decrease production. One of the broader questions about mergers is whether they actually help create a better product or whether they are solely to allow larger corporations to exercise market power over smaller participants in the market. I run several specifications of the main regressions. Regressions one and two report just the 1990 and 1993 mergers separately. Regression three reports both together and adds a time trend. Regression four adds a time interaction term. As one can see, none of the non-control variables end up being statistically significant. To test another related hypothesis, I then look at yields in response to increases in concentration. Theoretically, mergers should create corporations

Table 2: Summary Stats

Statistic	N	Mean	Min	Max	St. Dev.
HHI	704	5,915.600	1,404.680	10,000.000	1,928.180
Cotton Planted	704	91,155.840	12,100	412,500	75,540.580
Paymaster Share (1993)	88	22.021	0	98	36.754
Delta Share (1993)	88	46.313	0	97	37.019
Stoneville Share (1990)	88	9.289	0.000	65.900	13.050
Coker Share (1990)	88	1.350	0	64	7.595
McNair Share (1990)	88	0.997	0	21	3.874
Cotton Yield	704	640.216	131	1,450	267.166
Total Cotton Prod	704	117,535.400	3,600	958,000	133,982.700

that have much greater knowledge about their customers and greater knowledge about their own capacities. This either means that they can create new products that are more aligned with the needs of their customers or provide better guidance for their customers about how to use their products. It was justifications like these that would underlie many of the chem-agro mergers of the next 20 years after the study period. Regardless, either of these should effects should lead to higher yields to farmers who use their products. Empirically, we do not observe this result in the study period. Regression specifications are the same as above:

5.2 Corn

I run the same regressions for corn. Tables 5 and 6 report the results.

6 Discussion

In both studies I don't find a relationship between production and production and concentration increases due to mergers. This fact is comforting in the sense that the most serious threat of concentration is that seed companies will decrease output by raising prices in a manner that flows down to the consumer market.

However, yields decreasing as a result of increasing concentration is slightly perplexing. Theoretically, higher concentration should allow companies to invest in services that allow customers to better use their products or to invest in more speculative innovations that yield greater returns in the future. One possible interpretation comes from the fact that this effect was detected as a result of the 1993 merger and not the 1990 much smaller one. This suggests that when seed companies achieve substantial share in a market they can use that as an opportunity to lower the quality of service in order to save money. Obviously, this is just a hypothesis and some story about how this happens empirically would be needed to fully justify it.

Table 3: Cotton Production

	Dependent variable: Cotton Planted			
	(1)	(2)	(3)	(4)
Cotton HHI	0.170	0.469	0.025	−1.168
	(0.694)	(0.686)	(0.720)	(1.451)
Year	3.162	327.722	462.779	2,255.967
	(534.361)	(787.541)	(788.737)	(1,579.041)
Merger Intensity	3,057.837*		3,545.446**	−5,718,583.000
(1993)	(1,621.994)		(1,775.939)	(10,682,498.000)
Merger Intensity		−29.540	−23.397	−52,272.000
(1990)		(58.091)	(58.047)	(148,178.100)
Yr:Intensity				26.199
(1990)				(74.350)
Yr:Intensity				2,872.956
(1993)				(5,355.900)
Constant	62,827	−584,105	−851,051	−4,439,460
	(1,064,011)	(1,567,035)	(1,569,338)	(3,141,524)
Observations	704	704	704	704
R^2	0.847	0.847	0.848	0.399
Adjusted R^2	0.844	0.843	0.843	0.381
Residual Std. Error	29,865	29,958	29,893	59,418
F Statistic	224.214***	210.259***	200.271*** (df = 19; 684)	22.662***

*p<0.1; **p<0.05; ***p<0.01

Table 4: Cotton Yield

	Dependent variable: Cotton Yield (bushels/acre)			
	(1)	(2)	(3)	(4)
HHI	0.025***	0.020***	0.025***	0.024***
(county)	(0.003)	(0.003)	(0.003)	(0.003)
Year	−13.142***	−12.440***	−13.551***	−12.499***
	(3.728)	(3.804)	(3.755)	(3.894)
Merger Intensity (1993)	−1.590***		−1.571***	1,510.731
	(0.335)		(0.336)	(1,060.040)
Merger Intensity (1990)		0.094	0.072	184.743*
		(0.079)	(0.078)	(102.303)
Yr:Intensity (1990)				−0.093*
				(0.051)
Yr:Intensity (1993)				−0.758
				(0.531)
Constant	26,580***	25,216***	27,393***	25,317***
	(7,416)	(7,566)	(7,468)	(7,744)
Observations	704	704	704	704
R^2	0.718	0.709	0.718	0.703
Adjusted R^2	0.711	0.702	0.711	0.695
Residual Std. Error	143.639	145.820	143.653	147.624
F Statistic	102.710***	98.461***	97.032***	85.185***

*p<0.1; **p<0.05; ***p<0.01

Table 5: Corn Yield Regression

	Dependent variable: Corn Yield (bushels/acre)			
	(1)	(2)	(3)	(4)
Corn HHI (national)	-0.035^{**}	-0.034^{**}	-0.034^{**}	-0.035^{**}
	(0.014)	(0.014)	(0.014)	(0.014)
Cotton HHI (county)				0.0004
				(0.001)
Year	1.862^{***}	1.690^{**}	1.433^{*}	1.463^{*}
	(0.680)	(0.712)	(0.746)	(0.754)
Merger Intensity	-139.931^{***}	-137.103^{***}	-135.990^{***}	-135.879^{***}
	(34.531)	(34.728)	(34.715)	(34.795)
Cotton Yield (bushels/acre)		0.006	0.008	0.008
		(0.008)	(0.008)	(0.008)
Constant	228.385^{***}	222.950^{***}	228.279^{***}	228.105^{***}
	(41.745)	(42.295)	(42.515)	(42.616)
Observations	209	209	209	209
R^2	0.450	0.452	0.455	0.455
Adjusted R^2	0.436	0.435	0.436	0.434
Residual Std. Error	20.425	20.441	20.425	20.471
F Statistic	33.175^{***}	27.715^{***}	23.982^{***}	20.901^{***}

*p<0.1; **p<0.05; ***p<0.01

Table 6: Corn Production

	Dependent variable: Corn Planted (bushels/acre)			
	(1)	(2)	(3)	(4)
Corn HHI (national)	−10.348	−9.795	−7.962	−4.588
	(10.230)	(10.257)	(8.948)	(8.501)
Cotton HHI (county)				−3.968***
				(0.784)
Year	−756.416	−883.853*	239.047	−402.462
	(487.755)	(510.442)	(466.564)	(486.555)
Corn Merger Intensity	−5,609.157	−3,512.095	−8,386.497	−4,423.416
	(24,755.850)	(24,894.210)	(21,718.610)	(20,711.210)
Cotton Yield		4.768	−2.626	2.061
		(5.590)	(4.961)	(4.782)
Percent Production Corn			72,294.610***	63,615.860***
			(8,994.995)	(8,918.373)
Constant	113,973***	109,942***	86,611***	79,978***
	(29,927.050)	(30,317.900)	(26,598.990)	(25,536.940)
Observations	209	209	209	209
R^2	0.652	0.653	0.738	0.768
Adjusted R^2	0.643	0.643	0.728	0.757
Residual Std. Error	14,642.720	14,652.560	12,778.440	12,083.770
F Statistic	76.056***	63.416***	80.698***	73.053***

*p<0.1; **p<0.05; ***p<0.01

Furthermore, interpretation of these results is made hard by the time period which is being studied and the lack of available data. It is much easier to obtain market share data on a state level than on a county level which would enable studies of much broader swathes of time. However, this strategy dramatically narrows the statistical power of any methodology because there are only about 6 or 7 states that grow substantial amounts of cotton. Furthermore, using state level market share data doesn't even necessarily allow a more robust study of different outcome measures. The NASS measures of statistics like concentration in the growing market can be derived from measures like 'number of farms' which incorporates any farm that grows anything or any livestock operation. Since there isn't any state whose main export is cotton, any variation in cotton would be swamped by variation in other crops.

These difficulties make it challenging to assess core questions about the effect of concentration on farmers. Furthermore, it is not entirely clear to what extent this period generalizes to the following periods. As mentioned earlier, one of the main justifications for mergers in the past 20 years has been to promote seed-chemical synergies which were not characteristic of any of the mergers in this period. The proposition that these types of mergers are uniquely value enhancing for growers seems tenuous due to these results, however, should newly available data for the following 20 years become public, that conclusion could easily be revisited.

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