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4

Supply and Effects of Specialty Crop Insurance

Ethan Ligon

4.1 Introduction

The federal government has played a role in providing crop insurance to producers of particular sorts of crops across the United States since 1938, soon after Franklin Delano Roosevelt announced the creation of an institution to provide such insurance. Roosevelt's rationale for the program had explicitly to do with smoothing supply, as "neither producers nor consumers are benefited by wide fluctuations in either prices or supplies of farm products."[1]

The original system Roosevelt proposed was for wheat and allowed payment of both premiums and indemnities in either cash or in kind, at least in part because in-kind payments by farmers could be used to establish buffer stocks of wheat. What became the Federal Crop Insurance Corporation (FCIC) no longer accepts or makes in-kind payments, and the federal government no longer makes any effort to reduce variation in prices by managing buffer stocks of wheat or other commodities. It seems that the original motivation for the program—to smooth food supply and prices—

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1. See *New York Times,* February 19, 1937.

has changed. The motivation now has to do with providing an orderly way to improve producer welfare by providing payments to producers in states of nature when either yields or prices are low.

It's been possible to purchase policies to cover low yields of wheat in many states since federal crop insurance began in 1938. However, both the areas and the crops for which policies are available have expanded over time. Insurance to cover low yields of "program" crops other than wheat emerged in many states in the years subsequent to 1938 and expanded beyond the program crops with the passage of the 1980 Federal Crop Insurance Act. Only since the late nineties, however, have policies become available for insuring against losses associated with the production of most fruits and vegetables. The number and variety of such products have expanded dramatically over the last decade, following legislative changes made in 1994, 1996, and 2000 designed to encourage the use of crop insurance by farmers.

To grasp the scale of the change, consider just the case of California, where a predominance of fruit and vegetable crops are grown. A given insurance product is specific to a particular crop and county of production. Figure 4.1 shows both the number of county-crops in a given year according to the National Agricultural Statistics Service (NASS) and the number of county-crop insurance products offered. From the figure, one can see that in 1981 there were just a handful of contracts offered (twenty-eight; for almonds, citrus, grapes, raisins, and processing tomatoes). There was a sharp increase in 1989, to nearly 500 products, and then an explosion in 1990, followed by an even larger explosion in 1995. The number of products has

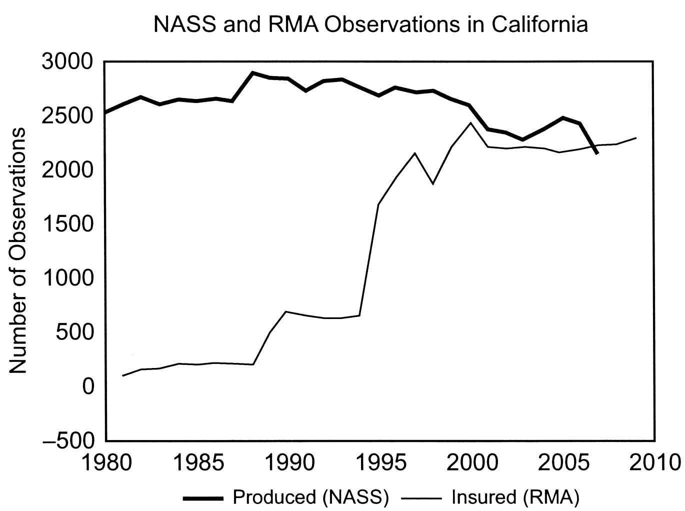


Fig. 4.1 Number of county-crop observations and frequency of county-crop insurance contracts, by year

grown since and now amounts to about 2,300 products across California's fifty-eight counties.

There are two types of justifications typically offered for the provision of crop insurance. The first has to do with concern for producers' welfare. This is not a trivial concern, especially for fruits and vegetables, because these commodities may involve much more risk than do cereal crops. The second has to do with consumer welfare—the idea is that by providing insurance to a risk-averse producer, one can induce those individual producers to act as though they were more nearly risk-neutral and more willing to make production and management decisions consonant with the interests of consumers. Further, such programs could be expected to encourage entry by new producers as insurance should lower the costs of production by risk-averse producers and, thus, lower prices.

Specialty crops, particularly fruits and vegetables, differ in several important respects from traditional commodity crops in ways that may affect both demand for insurance and the difficulty of supplying insurance. Let us first consider some demand-side issues. First, prices for many perishable fruits and vegetables have much greater variation than do prices for storable commodities. One might expect this to create increased demand for crop insurance that could deal with this price risk. However, second, a predominance of fruits and vegetable crops in California are marketed via vertical contracts with intermediaries, and, in many cases, these contracts already play an important role in the producer's risk management (Wolf, Hueth, and Ligon 2001). The existence of these alternative arrangements for managing risk ought to tend to reduce demand for federal crop insurance. Third, because production of many specialty crops is concentrated within a relatively small geographical area, spatial (e.g., weather) shocks that affect production in this area will have a much larger effect on aggregate supply than would a similar shock for a commodity with more geographically dispersed production. As a consequence, negative shocks to yield will cause positive shocks to price—it's not even clear that the average producer will be harmed by such production shocks because the increase in price may easily exceed the decrease in aggregate production. Thus, demand for yield insurance for any commodity with a combination of geographic concentration of production and inelastic short-run demand should be expected to be very low.

Turning to the supply side, the sheer diversity of specialty crops both across commodities and across space for a particular commodity makes the design of appropriate insurance products more demanding than it may be for commodity crops. Further, the well-developed organizations that serve, for example, wheat farmers in other states, and that may serve as an important channel for identifying and marketing to relevant producers will be absent for many (though not all) specialty crops. Related, to the extent that designing an insurance product for a particular crop involves some level of fixed costs (e.g., the costs of the five-year feasibility and pilot programs the

Risk Management Agency [RMA] conducts), then the return to the investment made in these fixed costs may be lower in a state where there are many diverse crops with geographically concentrated production.

If the extension of federal crop insurance programs to cover fruit and vegetable production has affected either producer or consumer welfare, then we would expect to see this reflected in output and prices. We have high frequency (weekly) data available for wholesale prices of a wide range of fruits and vegetables in California and elsewhere in the country. We have monthly production data for many crops by California county. And then, finally, we have data on the expansion of crop insurance programs across counties, years, and crops.

This chapter uses data on crop insurance policies to explore the variation in the timing of their introduction in different locations for different crops. Aside from simply seeking to describe the data, we're interested in using these data to try and understand something about the supply of insurance (the topic of section 4.3). In section 4.4, we tackle the central question of the chapter: what effect does the introduction of crop insurance programs have on output of the insured crops and on prices of those crops? Section 4.5 concludes.

4.2 Data on Insurance for Specialty Crops in California

4.2.1 Data Sources

For the results and discussion of specialty crop insurance in California found in this chapter, we rely principally on two different sources of data. First, data on agricultural production and prices collected by the National Agricultural Statistics Service (NASS), which maintains a database of agricultural production and prices since 1980.[2] These data include information for produce as well as for livestock and other crops. Second, the Risk Management Agency (RMA) that administers the FCIC insurance policies maintains a database of insurance policies sold for qualifying agricultural products.[3]

Using data from these two sources, we construct a database that matches data on insurance supply and demand with data on production and prices. The unit of observation in the resulting data set is a county-crop-year: because the number of California counties hasn't changed over the period 1981 to 2007 (the period our analysis covers) and the crops NASS has collected data on haven't much changed, we have a balanced data set of 190 crops over twenty-six years and fifty-seven counties (only urban San

2. See http://www.nass.usda.gov/Statistics_by_State/California/Publications/AgComm/indexcac.asp.

3. See http://www.rma.usda.gov/data/sob/scc/.

Francisco County is missing). However, as not all crops are grown in every county, the total number of crop-county pairs is 1,053, and the total number of crop-county-year observations is 29,485. Because NASS and RMA use slightly different methods of identifying crops, we had to construct a concordance to match up data from these respective sources: details may be found in appendix A.

4.2.2 Brief Descriptive History

Crop Insurance in California

Though a program of federal crop insurance began in the United States in 1938, until 1981, the operations of the FCIC were extremely limited in two ways. First, prior to 1981, the FCIC only insured program commodities such as grains, dairy, and oilseeds, and, second, crop insurance consisted mainly of free disaster coverage. However, 1980 saw the passage of the Agricultural and Food Act, which was meant to replace free coverage with an experimental buy-up insurance, which required participants to pay an insurance premium for coverage and which was to be made available for a much broader variety of crops (beyond commodity crops).

Demand in California for the insurance products offered in the eighties was weak. Demand everywhere was weak—despite subsidies that made the expected return to insurance policies large and positive for the average enrolled producer, only 25 percent of eligible acreage was enrolled by 1988 (Glauber 2004). But because of inadequate data with which to rate policies for specialty crops, insurance products simply didn't exist to cover more than a very small share of agricultural production in California. Figure 4.2 shows a time series of the number of crops for which policies were offered in California by year: in 1981, there were only thirteen such crops (basically, the program crops plus policies for almonds, citrus, grapes, raisins, and tomatoes).

Further, prior to 1985, insurable yields for a particular farm depended on average yields in the county, and adequate data to estimate the distribution of county-level yields even for the small number of insurable crops were limited to a handful of California counties.

After the passage of two ad hoc disaster bills (in 1988 and 1993: Risk Management Agency 2009), Congress passed the Federal Crop Insurance Reform Act of 1994 (FCIRA). The principal goals of the Act were to expand coverage to cover more (especially specialty) crops, and to increase participation by creating a new category of mandatory.[4] Prior to 1994, the insurance policies available offered varied levels of coverage as a function

4. A list of specialty and nonspecialty crops can be found in appendix B. More precisely, having at least cat insurance became a criterion for producer eligibility for a range of other federal programs.

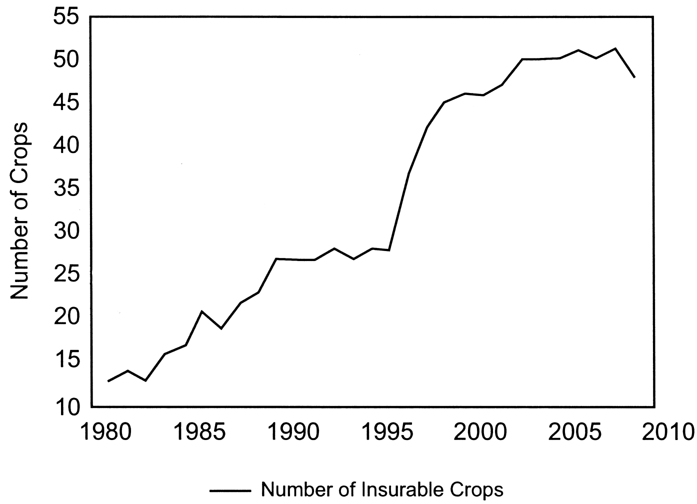


Fig. 4.2 Number of insurable crops in California, by year

of the premium amount paid. The catastrophic (cat) coverage offered in 1994 established a low baseline level of coverage with no premium (though producers were charged a flat nominal administrative fee).[5] The results of this legislative change for use of crop insurance in California can be seen in figure 4.3. In 1995, there was no very large change in demand for the buy-up policies, but a huge increase in demand for the new quasi-mandatory cat policies. This huge increase went a considerable way toward achieving the goal of increasing overall producer participation. However, the increase in participation evident in figure 4.3 for California was almost entirely due to the new mandatory cat insurance—no policy for new California crops was developed by the RMA between 1991 and 1997, at which time programs for apricots and nectarines were developed (see table 4.1).[6]

A second act of Congress, the Federal Agriculture Improvement and Reform Act of 1996 (FAIR), gave the option of forgoing cat insurance in exchange for forfeiture only of eligibility for federal disaster benefits. The Act also created the RMA, whose function was to administer FCIC crop insurance, including researching crops to make insurance available on more crops.

5. Compensation was for "losses exceeding 50 percent of an average yield paid at 60 percent of the price established for the crop for that year."

6. Of the many specialty crops that aren't covered (in at least some counties), some disaster insurance is available based on countywide production, rather than on a given producer's production history. These specialty crops are instead covered by the "Noninsured Crop Disaster Assistance Program," which was also created by the 1994 act.

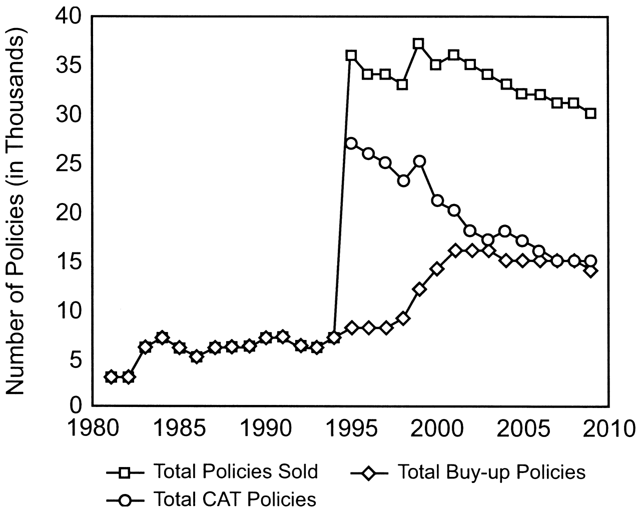


Fig. 4.3 Number of policies sold in California, by category and year

Notable Features of California Agriculture

Among the important agricultural states, California is notable for the very large share of specialty crops in the total value of its agricultural production. As an examination of figure 4.4 makes clear, fruits and vegetables collectively accounted for over half the total value of California agricultural production in 2007, with a collective value of roughly twenty billion dollars. It's not only that the nominal value of fruits and vegetables have been increasing sharply since the 1980s; their share in the total value of California agricultural production has also increased over time and has exceeded half of total value since about 2000. The only other class of agricultural commodities to increase its share over this period of time is dairy, so between figure 4.4 and figure 4.5, we see a picture of increasing specialization, with the three highest value categories of agricultural commodities accounting for an increasing share of total production over time.

What accounts for this increased specialization? The increased specialization evident in these figures occurs over the same period in which insurance for specialty crops is introduced. In a study of program crops, O'Donoghue, Roberts, and Key (2009) find that the expansion of crop insurance associated with the 1994 FCIRA led to modest increases in on-farm specialization, either because producers substituted toward crops whose expected returns increased with the introduction of subsidized insurance or because insurance reduced demand for crop diversification for risk-management reasons. One possibility is that similar mechanisms are at work here and that with

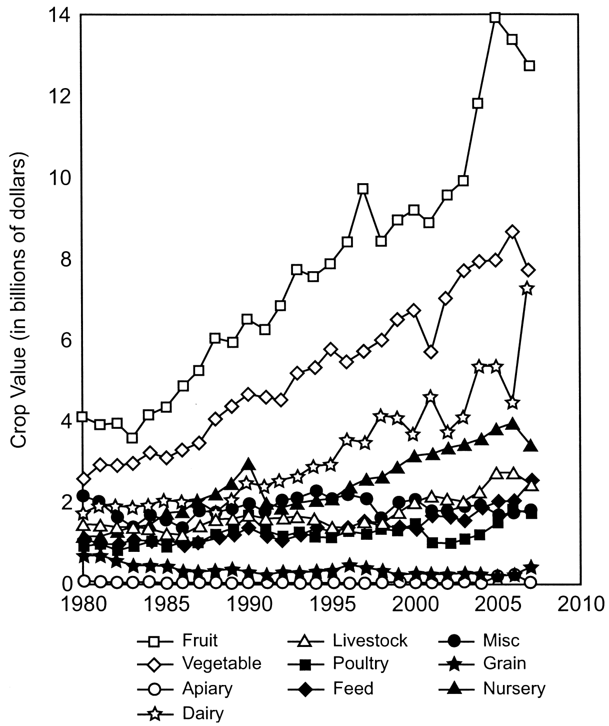


Fig. 4.4 Total market values for California agricultural production

the introduction of insurance, the improvement in the (insured) distribution of returns to growing fruits and vegetables led farmers to substitute toward these commodities.

This hypothesis is consistent with figure 4.6, which shows not only a steady increase in the total value of Californian agricultural production over time, but also that this increase in value is essentially entirely attributable to the increase in the value of insurable crops (i.e., crops produced in a county where insurance is available for that crop). So one might be tempted to infer that the expansion of crop insurance to cover specialty crops over this period led to an increase in the value of these crops.

However, this inference is not so straightforward. The problem is that an increasing number of crops became insurable at an increasing number of locations over this period. Furthermore, as discussed in section 4.3, insurance was wasn't randomly assigned to new crop-counties over time; rather, the total value of the crop in a particular location was the key variable that led the RMA to create or expand new programs. So the increase in the value of insurable crops evident in figure 4.6 could easily be entirely a consequence of the way the *supply* of insurance changed over time and not have anything

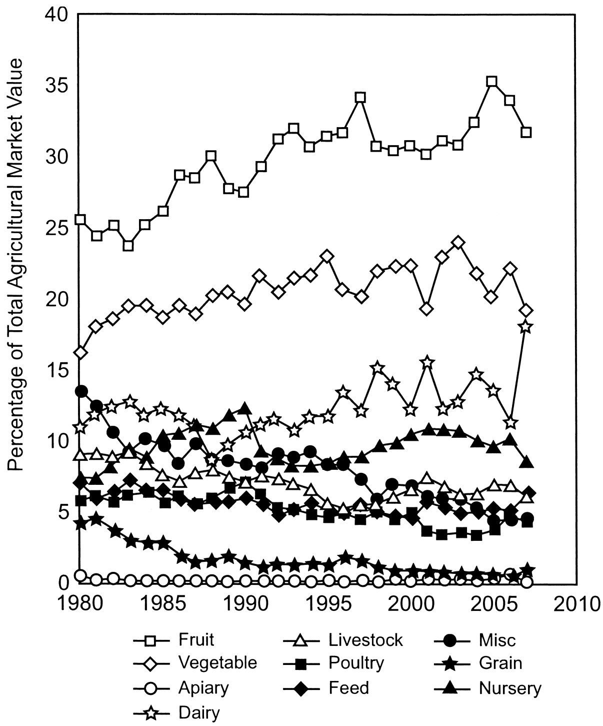


Fig. 4.5 Market shares of California agricultural production

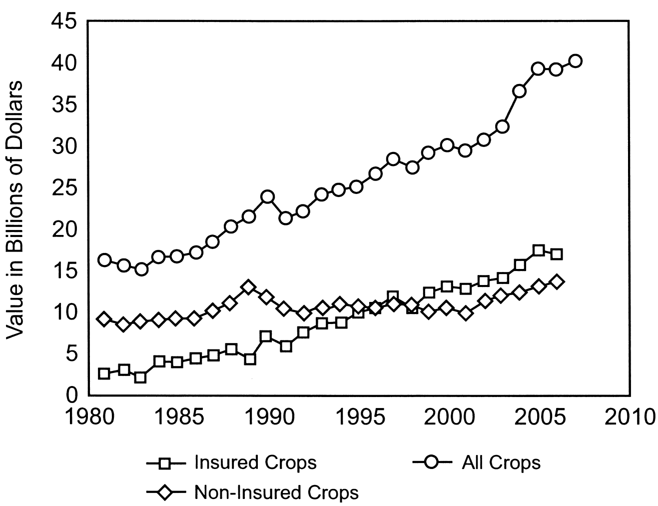


Fig. 4.6 Total market value of California agricultural production

to do with either demand for that insurance or with the effects of insurance on crop specialization or production. Sorting out these different possible reasons for the increase in the value of insurable crops is the central goal of this chapter.

4.3 Supply of Insurance for Specialty Crops in California

We have data on a total of 190 different agricultural commodities. These are all produced in California and result from merging of NASS and RMA data sets. Of these 190, the RMA classifies all but seventeen as "specialty" crops.

There are 173 fruit and vegetable specialty crops grown in California. Of these, twenty-seven are covered by a crop-specific insurance program in one or more California counties.

Table 4.1 shows how new insurance policies are offered for different crops at different times. The numbers that appear in each cell indicate the number of California counties (of which there are fifty-eight in total) for which insurance policies are offered for a given crop. So, for example, we see that insurance for walnuts was first offered in 1985, debuted in ten counties, and by 2007 was offered in twenty-five counties.

If the decision to offer insurance for a particular crop in a particular region was left to competitive firms, each seeking to earn a profit through the development of new policies, then we'd expect the supply of insurance to depend on the equilibrium price. However, for crop insurance in the United States, the decision to offer insurance for a particular crop in a particular county is a bureaucratic one, made not by the insurance firms that sell the product, but rather by the RMA. It's not entirely clear what the objectives of the RMA are, but it does seem clear that maximizing profits from the provision of insurance is not among its principal objectives: the net cost of crop insurance to the U.S. Treasury is well in excess of 3.5 billion dollars per year (General Accounting Office 2007).[7]

Regardless of the RMA's objectives in creating new insurance products, we know quite a lot about their decision rule as they have developed a rather clear procedure for determining whether to offer insurance for a particular specialty crop in a particular region (General Accounting Office 1999, appendix III).

7. It's possible that the RMA weighs the costs of this subsidy against what the costs of disaster relief would be in absence of crop insurance. In 2002, when insured acreage nationwide was roughly 80 percent of the total, with average coverage of roughly 60 percent, Congress allocated $2.1 billion in supplemental disaster assistance. Had the crop insurance program not existed, the costs of providing the same levels of compensation to growers as those that they actually received would have been roughly $4.4 billion; thus, in 2002, the crop insurance program saved the U.S. Treasury about $2.3 billion dollars. But because disasters of this scale seem to occur less often than every other year, it's not at all clear that ad hoc disaster relief is less cost-effective than are existing crop insurance programs.

Table 4.1 **Number of counties with insurance products for different crops**

First insured	Crop name	1981	1985	1990	1994	1995	1996	1997	2002	2007
1981	Almonds	4	15	16	16	16	16	16	16	16
	Citrus fruit	3	4	8	8	11	12	12	15	15
	Grapes	8	15	16	17	24	26	26	31	31
	Raisins	7	7	6	6	6	6	6	6	6
	Tomatoes	6	14	11	11	15	15	15	14	12
1982	Dry beans		15	15	15	18	16	18	16	3
1984	Walnuts		10	15	16	25	25	25	24	25
1985	Potatoes		2	1	3	6	5	5	5	13
1986	Peaches			11	13	13	13	11	12	11
	Prunes			10	11	12	14	14	14	13
1988	Apples			2	1	9	10	12	17	12
	Figs			3	3	3	3	3	2	2
1989	Pears			3	4	8	7	7	7	5
1990	Fresh market tomatoes			2	3	6	5	6	5	4
	Fresh plums			6	4	7	8	8	7	6
1997	Apricots							11	11	10
	Nectarines							7	7	6
1998	Avocados								6	5
	Sweet potatoes								1	5
1999	Cherries								2	2
	Wild rice								3	3
2000	Strawberries								2	3
2002	Raspberry and blackberry								1	
2003	Nursery									3
	Onions									1
2007	Alfalfa seed									1
2008	Pecans									2

Notes: On the left is the first year the crop was introduced; generally, policies were sold every year following. Selected years afterward (on the right) are simply a snapshot of subsequent years, including more detail around the Federal Crop Insurance Reform Act of 1994 and Federal Agriculture Improvement and Reform Act of 1996. Each entry for a year and crop represents only the number of counties in which policies were sold for that year and crop.

There are three basic criteria that must all be satisfied for a product to be developed. First, the crop must be "economically significant"; second, there must be "producer interest"; and third, offering the product must be "feasible" (General Accounting Office 1999, appendix III).

The FCIC regards a particular crop economically significant in a particular area only if the total market value of the crop is at least one of the following:

1. $3 million in the agricultural statistics district (of which there are nine in California) where it will be covered.
2. $9 million in the state where it will be covered.

3. \$15 million in the RMA administrative region (of which there are ten nationwide).
4. \$30 million nationally.

Producer interest in insurance is considered to be indicated by high levels of noninsured disaster payments as well as recommendations by RMA regional offices. For a pilot program to be initiated, projected producer participation in the program must be at least 10 percent.

Offering an insurance product may be infeasible if, for example, there are inadequate data to evaluate the actuarial soundness of the product; if mechanisms to market the product are lacking; or if the proposed product itself is too complicated (General Accounting Office 1999).

Once the RMA has decided to try to develop a new insurance product, the process of development takes about five years to complete, including two years of feasibility studies and three years to carry out a pilot program.

Operationally, the criteria for economic significance described in the preceding don't offer sufficient guidance about what crops to develop programs for, as very many crops in many locations satisfy those criteria, and the RMA presumably lacks the resources to develop programs for all of these at once.[8] To deal with these constraints, the RMA has developed a list of crops ranked according to market value. We understand from conversations with analysts within the RMA that this list provides primary guidance about what crop to focus on next and that the RMA seldom initiates new programs for more than a single crop per year.

We wish to test the hypothesis that the RMA's decisions regarding what crops to insure in what counties depend on the value of the crop in different counties. Our approach is to model the probability of a policy being offered for a particular crop-county-year. Let d_{ijt} be equal to one if a policy for crop j is offered in county i in year t, and equal to zero otherwise.

We imagine that there are characteristics of counties or crops that are essentially fixed in the short run but that may affect the probability of a crop policy being introduced in that county. Obvious features of counties that could matter include the overall importance of agriculture in that county or the effectiveness of insurance salespeople operating in that particular area. Features of crops that are fixed and may affect the probability of policy introduction may include features of the commodity itself, which may make it infeasible to introduce insurance, or involve commodity-specific grower associations, which are more or less enthusiastic about the introduction of insurance policies for their particular crop (a correspondent at the RMA tells us that lettuce growers in California have resisted the introduction of crop insurance).

8. Over the period 1982 to 2008, there has been, on average, less than one new California crop program developed per year, and in no year have there been more than two new crop programs introduced.

Table 4.2 **Factors affecting the probability of new crop insurance programs across different counties**

	Specification			
Variable	(1)	(2)	(3)	(4)
County fixed effects	Yes	Yes	Yes	Yes
Crop fixed effects	No	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes
Value rank-year interactions	No	No	No	Yes
Log-likelihood	–14,061.02*	–6,627.50*	–4,382.37*	–4,341.32*
Degrees of freedom	57	162	24	27

*Significant at the 95 percent level.

Let R_{jt} denote the RMA's ranking of the crop value in year t (with the lowest-value crop receiving a ranking of 1). We estimate

$$\text{(1)} \qquad \text{Prob}(d_{ijt} = 1) = \alpha_i + \gamma_j + \eta_t + \left(\sum_{s=1980}^{t} \delta_s \right) R_{jt} + \nu_{ijt},$$

where the $\{\alpha_i\}$ are a collection of county fixed effects, the $\{\gamma_j\}$ are a collection of crop fixed effects, and the $\{\eta_t\}$ are a collection of year effects. The term $(\Sigma_{s=1}^{t}\delta_s)R_{jt}$ allows there to be a time varying but cumulative effect of crop ranking on probability of a policy being offered.

We use a logistic model to estimate equation (1), with results reported in table 4.2. Each successive column adds an additional collection of variables and reports the resulting log-likelihood so that column (1), for example, presents a measure of fit for a regression of policy offerings on just a set of county fixed effects, column (2) adds crop fixed effects, and so on. The reported log-likelihood ratios allow us to construct likelihood ratio tests of the null hypothesis that the coefficients associated with the newly added variables are all equal to zero.

Each of the collections of county, crop, and year effects jointly are significant and explain a great deal of variation in whether a policy is offered. Though no individual term in the rank-year interactions is statistically significant, these are collectively extremely important in terms of explaining variation. We interpret this as evidence that even *after* throwing out variation at the level of the county, the crop, and the year that our characterization of the RMA's supply decision is useful in predicting what crop-counties will have insurance products developed for them.

4.4 Effects of Insurance on Output and Prices

The consequences of crop insurance programs for consumer welfare can be presumed to depend on two different channels: first, the cost of the programs to taxpaying consumers; and second, via the effect the programs have on prices and quantities of agricultural commodities purchased by consumers.

It's reasonably straightforward to document the direct costs of FCIC programs for U.S. taxpayers. From the General Accounting Office report cited in the preceding (General Accounting Office 2007), we have a figure of roughly \$3.5 billion per year, or roughly \$30 dollars per year for each U.S. household. There are numerous elaborations on these costs available in the literature and on estimates of the welfare losses involved in having the government involved in effecting these transfers from taxpayers to producers (e.g., Gardner and Kramer 1986; Wright and Hewitt 1994; Glauber 2004).

In comparison, the literature on the ultimate effects of crop insurance on prices and quantities is surprisingly small, and small relative to the literature on demand for crop insurance or its effects on farmer behavior. Young, Vandeveer, and Schnepf (2001) is an exception: using a computable general equilibrium model, they estimate the effects of crop insurance subsidies on prices and supply of eight program crops. They find a small shift (a 0.4 percent increase in planted acres) toward production of those crops, but because demand for those same program crops is inelastic, prices tend to fall by a much larger proportion. Overall, they compute that the roughly \$1.5 billion dollars spent in crop insurance premium subsidies led to an increase in farm income of roughly one billion dollars.

Here, by exploiting variation in the timing of the introduction of crop insurance policies across crops and counties and then combining this with county-level data on prices and output, we're in a position to try to deliver some tenative estimates of the effects of crop insurance on the observable variables most germane to consume welfare. The findings of O'Donoghue, Roberts, and Key (2009) lead us to expect that the introduction of crop insurance programs will, other things equal, lead to some substitution toward the insured crop and, hence, produce an increase in output. Some crops we examine may be produced only in very limited areas and have no close substitutes, and for these crops, we might expect increased supply to have a large effect on price. However, most of the different crops we examine are highly disaggregated and most have close substitutes or can be grown in other counties, states, or countries. Accordingly, we'd expect demands to generally be highly elastic. If this is correct, then increased supply will have at most a modest effect on prices.

We begin by considering a simple reduced-form supply relationship, which takes the form

$$\log q_{ijt} = \alpha_i + \gamma_j + \eta_t + \beta d_{ijt} + \varepsilon_{ijt}, \tag{2}$$

where (as before) the $\{\alpha_i\}$ are county dummies; the $\{\gamma_j\}$ are crop dummies; and the $\{\eta_t\}$ are year dummies. A couple of features of this equation are worthy of note. First, in a supply equation, we'd ordinarily expect prices to feature prominently on the right-hand-side of the equation, but prices do not appear explicitly in equation (2). The reason is that we implicitly assume that prices will vary only across crops, counties, and time, and so any variation in price will be captured by some combination of the dummy variables that appear prominently in equation (2).

Second, the crop dummies are particularly important here as they allow us to avoid the problem that the output of different crops are measured in different units. So long as these incommensurate units (e.g., cartons of mature green tomatoes, pounds of almonds) are unchanging over time, the combination of taking logs and adding crop-specific dummies allows us to compare the dimensionless percentage changes output across crops.

However, the key coefficient of interest for us is β, which captures the effects of introducing crop insurance for a given county-crop on supply. This coefficient can be interpreted as an elasticity—the introduction of insurance for a particular crop in a particular county can be expected to increase production by a factor β.

The problem with estimating equation (2) as it stands, of course, is that the introduction of crop insurance is endogenous. Indeed, making the point that crop insurance depends importantly on observables such as value rank was the main point of section 4.3. However, we can use the results of section 4.3 to address the problem of endogeneity here. In particular, if one were to take the estimates the conditional probabilities of a program being introduced for a given crop-county from the estimation reported in table 4.2, we could treat this as a sort of first stage in a two-stage-least squares estimator of the effects of crop insurance on supply. For this strategy, we would let $\hat{d}_{ijt}$ denote the estimated probability of introduction and then use these estimates in a second stage:

$$\log q_{ijt} = \alpha_i + \gamma_j + \eta_t + \beta\hat{d}_{ijt} + \varepsilon_{ijt} \tag{3}$$

In effect, the interactions between rank and years that appear in equation (1) would act as instruments for the endogenous introduction of crop insurance.

In practice, using a logit-first stage with a least-squares second stage would make inefficient use of the information contained in the first-stage right-hand-side variables and complicate estimation of standard errors. Accordingly, we adopt a generalized method of movements (GMM) or three-stage-least-squares (3SLS) approach to estimation. A nice consequence of this approach is that because we have more excluded instruments than coefficients to estimate, we can also test the specification and validity of our instruments as well as remain quite agnostic as regards the covariance structure of residuals.[9]

9. This flexibility does come at a price: with a full set of rank-year interactions, the GMM optimal weighting matrix can't be reliably estimated using our finite sample. Accordingly, we use a smaller set of decade-rank interactions as excluded instruments in the estimates presented here.

Table 4.3 **Estimated average supply response to crop insurance and the average of the reciprocal of price elasticity of demand for crops grown in California**

Variable	(1)	(2)
Policy available	1.38*	
	(0.23)	
Policy × nontree		0.50
		(0.49)
Policy × tree		1.64*
		(0.27)
Excluded instruments	d	d
χ^2	11.12	6.80
p-value	(0.05)	(0.13)
Estimator	GMM	GMM

Note: d = decade-rank interactions. The top panel presents generalized method of moments (GMM) estimates of coefficients in column (2). County, crop, and year fixed effects are included but not reported. Figures in parentheses are standard errors.

*Significant at the 95 percent level of confidence.

Our estimate of the value of β in equation (2) appears in the first column of table 4.3. We find that the introduction of insurance for a given crop has a highly significant effect on the quantity supplied—there's no doubt great variation across commodities in terms of this supply response, but our estimate is that, on average, there's a 138 percent increase in output for crops with crop insurance, compared with uninsured crops. However, our ability to test the underlying specification is useful here: we're able to *reject* the hypothesis that our instruments are valid in this specification at a 5 percent level of confidence.

In a search for the reasons for the rejection, it was suggested to us that the effects of crop insurance on supply might differ dramatically between annual and perennial crops, on the logic that sunk costs for perennial crops implied that producers of such crops would have to bear considerably greater risk in the absence of insurance. We explore this idea by introducing an interaction between whether a crop was a "tree crop" or not.[10]

The second column of table 4.3 shows the result. In place of an indicator for "Policy available," we interact a pair of indicator variables for tree and nontree crops with the policy availability indicator; the pair of coefficients associated with these variables then become estimates of the elasticities we seek. And, indeed, introducing this heterogeneity of response makes a remarkable difference. For tree crops, the estimated supply elastic-

10. Not all California crops can be unambiguously identified as annual or perennial because, for some crops, this depends on location. However, all tree crops are perennial, and so we've used this as a method of distinguishing effects.

ity increases somewhat, to 164 percent. But for nontree crops, the estimate (while still positive) is not statistically distinguishable from zero.

The estimated elasticity of 1.64 is not very precisely estimated—a 95 percent confidence interval about this estimate is [1.11, 2.17]. But, even if imprecise, the elasticity tells us that in counties where crop insurance for tree crops was introduced it stimulated a doubling or tripling of production over the twenty-seven years for which we have production data. But note that this should *not* be interpreted as evidence of an overall increase in output across all crops—equation (2) doesn't allow us to distinguish between increases in total output across crops and substitution between crops. It's entirely possible that the introduction of subsidized insurance actually leads producers to substitute away from higher-value crops (or perhaps lower-value crops better suited to a particular farm), reducing the total value of production.[11]

We won't pursue the issue of the effects of crop insurance on the total value of agricultural output here for want of data (our analysis here relies heavily on variation across crops, and so aggregating across these has a high cost in terms of both the statistical power and size of any tests we might conduct). Instead, we'll return to a consideration of the demand side, on the grounds that any positive effect of crop insurance on consumer surplus must come via a reduction in the prices of insured commodities.

Accordingly, we specify an inverse demand function for produce of type j from county i in year t according to

$$\log p_{ijt} = \alpha_i + \gamma_j + \eta_t + \beta \log q_{ijt} + \varepsilon_{ijt}. \tag{4}$$

There's some abuse of notation here, as we're reusing variables that entered the supply equation (2). Hopefully, context makes it clear that these are all in fact different quantities. Only the quantity supplied q_{ijt} is common across equations (2) and (4). As in our specification of the supply equation, we have a set of county fixed effects, a set of crop fixed effects, and a set of time effects.

As in equation (2), the crop dummies γ_j are critical allowing us to make comparisons of price across crops measured using different units. The time effects play an even more important role here than previously because they capture changes over time in the value of the dollar—we've left the values of prices p_{ijt} in nominal terms, so that the $\{\eta_t\}$ terms capture the effects of inflation on prices.

In this case, the key variable of interest is quantities—what we'd like to

11. A casual investigation of this hypothesis involves substituting total crop value for total crop production in equation (2). This yields estimates suggesting that the introduction of insurance results in an increase in tree-crop value smaller than the increase in tree-crop production, while the value of nontree crops actually falls significantly in response to the introduction of insurance. However, tests of the overidentifying restrictions result in a rejection of this specification; further investigation is left for future research.

know is how changes in the quantity supplied affect prices. But, of course, these quantities are endogenous—if we didn't already know this from examination of equation (2), we could see that we're contending with the classic problem of separately identifying supply and demand relationships. But our estimation of equation (2) suggests a strategy to address this endogeneity: by using predicted values of (log) quantities from equation (2) in place of actual quantities, we obtain

$$\log p_{ijt} = \alpha_i + \gamma_j + \eta_t + \beta \widehat{\log q}_{ijt} + \varepsilon_{ijt} \tag{5}$$

Then estimates of the coefficient β can be interpreted as the average of the reciprocal of price elasticities (thus, values close to zero imply high elasticities). Because this is the only parameter of interest, we don't need a table to report it: we estimate an inverse demand elasticity of –0.056, with a standard error (computed using the heteroskedasticity-consistent method of White [1980] of 0.003). Thus, we find a negative elasticity, consistent with the law of demand, and significantly different from zero. Indeed, our estimate is reasonably precisely estimated—a 95 percent confidence interval about the estimate is [–0.050, –0.062], suggesting that demand is quite elastic. This is consistent with the hypothesis that such highly disaggregated commodities are likely to permit a great deal of substitution. As before, recall that this is an *average* reciprocal elasticity—for commodities that are only grown in a few counties in California or which possess no close substitutes, price elasticity may be much smaller.

4.5 Conclusion

In this chapter, we've gathered evidence on the process by which crop insurance programs are created and used this evidence to estimate the supply of crop insurance programs across counties, crops, and years. We've found that an administrative rule that gives priority to crops with the highest ranking value has considerable predictive power, though crop- and county-specific variables also play an important role.

We've used our predictions regarding the introduction of crop insurance to deal with issues of the endogeneity of the supply of crop insurance programs and estimate the effects of the introduction of crop insurance programs on both the supply of and demand for different crops.

Our estimates regarding the effects of crop insurance on the supply of and demand for insured crops indicate that effects differ for tree and nontree crops, perhaps as a consequence of the much larger investments at risk in crops of the former type. We find what we think is a rather large effect on supply for tree crops but no significant effect for nontree crops. However, we can't say whether the large effect of insurance on tree-crop production is principally due to more efficient production or substitution away from other crops.

We find a significant negative effect of crop insurance on prices for insured crops, though the magnitude of the effect is small compared to the effect on supply (around –5 to –6 percent). This last finding is consistent with the view that demand for such highly disaggregated commodities is likely to be highly elastic. A consequence is that crop insurance for these specialty crops has little benefit for consumers, *even* if it generates a large supply response.

Appendix A
Detailed Data Description

The production and insurance data obtained from the NASS and RMA websites are organized differently.[12] First, the production data (which date from 1980) use a unique commodity, county and year as the unit of observation, while the insurance data group data by crop, year, county, and insurance plan. Second, the RMA definitions of crops are less specific (and broader reaching) than the NASS definitions; thus, there are many more production commodities than insurance crops. (See figure 4A.1.)

Production

Output information is reported as acres harvested, tons produced, and total market value, as appropriate for the commodity type (animal commodities, for example, only include information for total market value). The number of counties with production data stayed primarily constant year over year, ranging from fifty-seven counties (1980 to 1988) to fifty-nine counties (2004 to 2007).

Production Types

The raw data have been further organized by an external classification by broad production type (see figure 4A.2):

1. Fruit
2. Vegetable
3. Apiary
4. Dairy
5. Livestock
6. Poultry
7. Feed
8. Miscellaneous
9. Grain
10. Nursery

12. This appendix was written with Alana LeMarchand. Additional details and discussion may be found in her Berkeley undergraduate honors thesis of 2009.

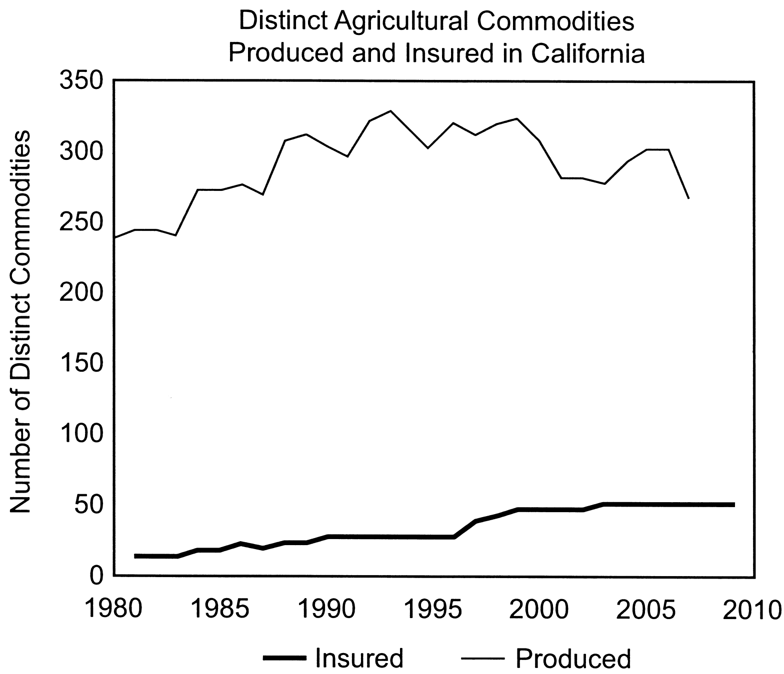


Fig. 4A.1 Number of distinct commodities in the California agricultural market, as defined by the National Agricultural Statistical Service (NASS)

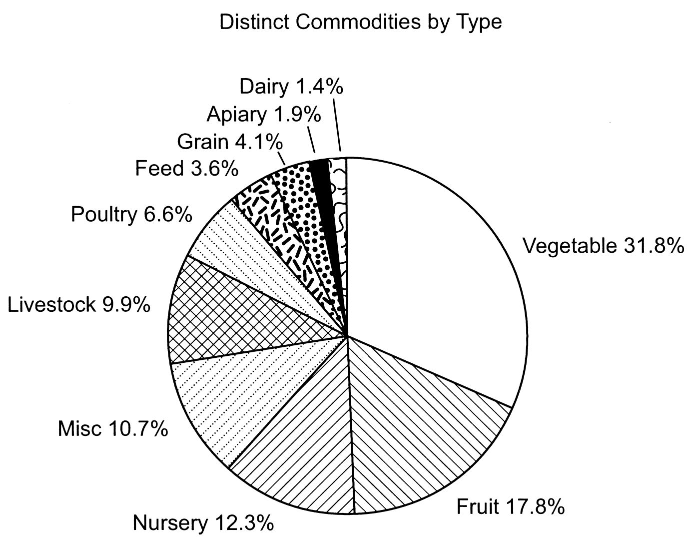


Fig. 4A.2 Distinct agricultural commodity names in California, as defined by the National Agricultural Statistics Service (NASS), grouped by type

There are many more unique commodities in the fruit and vegetable categories than in the other categories although this is not necessarily related to the actual aggregate market value of goods of different types. Analysis of the share of actual market value of each production category indicated that the number of commodities in each category is not correlated with market share.

Insurance

While the insurance data include such supplementary information as premium and coverage level, the most pertinent information is which commodities are insured and the type of insurance plans offered. The total number of commodities insured since 1989 is sixty-three, but there have never been more than fifty-one commodities insured in a single year. The number of insured crops began at twenty-three and increased with time, including an abrupt jump in the year 1997 (twenty-eight crops in 1996, thirty-seven crops in 1997).

Insurance Plan Types

There are seven insurance plan types offered. The following description is adapted from material available on the RMA website, including information for less-traditional pilot programs.[13]

AGR: Adjusted Gross Revenue: insures revenue of the entire farm rather than an individual crop by guaranteeing a percentage of average gross farm revenue, including a small amount of livestock revenue. The plan uses information from a producer's Schedule F tax forms and current year expected farm revenue to calculate policy revenue guarantee.

APH: Actual Production History: insure producers against yield losses due to natural causes such as drought, excessive moisture, hail, wind, frost, insects, and disease. The farmer selects the amount of average yield he or she wishes to insure; from 50 to 75 percent (in some areas to 85 percent). The farmer also selects the percent of the predicted price he or she wants to insure; between 55 and 100 percent of the crop price established annually by the RMA. If the harvest is less than the yield insured, the farmer is paid an indemnity based on the difference. Indemnities are calculated by multiplying this difference by the insured percentage of the established price selected when crop insurance was purchased.

ARC: Avocado Revenue Coverage: pilot since 1998.

ARH: Actual Revenue History: pilot for dry beans in 2009.

CRC: Crop Revenue Coverage: provides revenue protection based on price and yield expectations by paying for losses below the guarantee at the higher of an early-season price or the harvest price.

13. See http://www.rma.usda.gov/policies/ and http://www.rma.usda.gov/pilot/2010pilot.html.

DOL: Dollar Plan: provides protection against declining value due to damage that causes a yield shortfall. Amount of insurance is based on the cost of growing a crop in a specific area. A loss occurs when the annual crop value is less than the amount of insurance. The maximum dollar amount of insurance is stated on the actuarial document. Amount of insurance is based on the cost of growing a crop in a specific area. A loss occurs when the annual crop value is less than the amount of insurance. The maximum dollar amount of insurance is stated on the actuarial document.

GRP: Group Risk Plan: policies use a county index as the basis for determining a loss. When the county yield for the insured crop, as determined by the NASS, falls below the trigger level chosen by the farmer, an indemnity is paid. Payments are not based on the individual farmer's loss records. Yield levels are available for up to 90 percent of the expected county yield. GRP protection involves less paperwork and costs less than the farm-level coverage described in the preceding.

PRV: Pecan Revenue: since 2005, began as a pilot.

Qualitative Distribution of Plans in the Data

AGR: Adjusted Gross Revenue: This plan is not crop specific and applies only to the entire production of a farm.

ARH: Actual Revenue History: This plan is sold only beginning in 2009 as a pilot for dry beans.

GRP: Group Risk Plan: This plan is indexed on county production and comprises an insignificant percentage of policies sold.

APH: Actual Production History: This plan is by far the most common plan type and is linked most directly with production volume.

CRC: Crop Revenue Coverage: This plan protects a farmer's crop based on yield and price. It is also more significant in terms of numbers than the AGR, ARH, or GRP plans.

DOL: Dollar Plan: This plan protects against yield shortfall below a certain dollar amount. It is the second most common plan, after the APH.

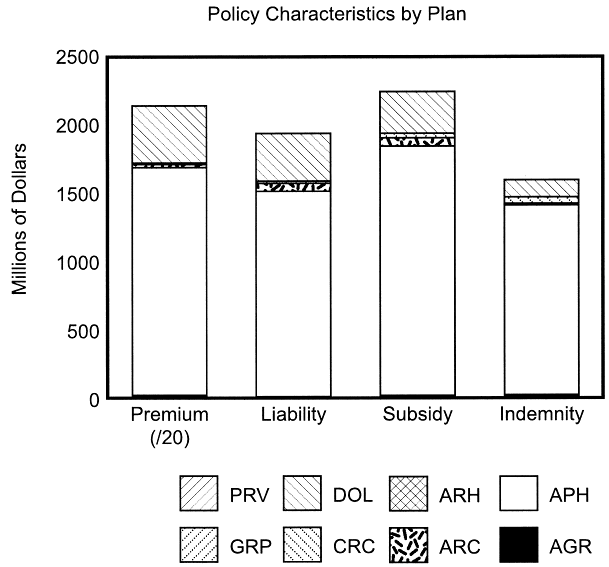
PRV: Pecan Revenue: This plan applies only to pecans and could only be useful in regressions where policies are linked specifically to crops.

ARC: Avocado Revenue Coverage: This plan applies only to avocados and could only be useful in regressions where policies are linked specifically to crops.

Graphical Presentation of Insurance Plan Distribution

Figure 4A.3 presents data on premiums, liabilities, indemnities, and subsidies for each RMA insurance plan category. Raw data are included below each bar chart in figure 4A.3. "Premium" and "Net Reported Acres" are scaled so as to be more readable.

Figure 4A.4 simply indicates the number of policies offered by plan. It is



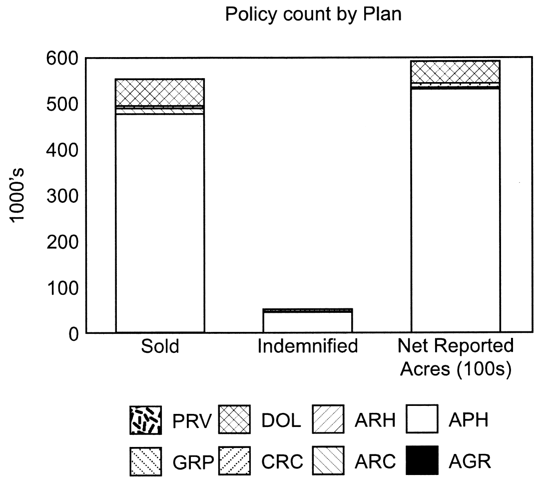
	Premium (/20)	Liability	Subsidy	Indemnity
AGR	20414486	10505392	19159537	15887803
APH	1659060935	1495594411	1814842705	1246254816
ARC	22667433	57480517	60759206	12261077
ARH	0	0	0	0
CRC	10956630	16760355	32684597	45808888
DOL	415679117	346684026	303883600	124826248
GRP	16408	4629	7847	11010
PRV	340908	314858	546990	161099

Fig. 4A.3 Distribution in California, by Risk Management Agency (RMA) insurance plan category, of cumulative monetary value of total premiums, liabilities, subsidies, and indemnities

clear from this data that traditional APH policies comprise the great majority of RMA insurance plan activity, with the DOL plan a very distant second. After that, the most significant share of policies comes from the AGR, ARC, and CRC plans. As mentioned, AGR insurance is not crop specific and, thus, is inappropriate for a crop-specific analysis; ARC insurance is only for avocados; CRC is crop specific and applicable to many different crops. ARH, GRP, and PRV are insignificantly small. However, ARC, ARH, and PRV plans may be included in regressions where policies are linked specifically to crops. They might also be studied later on for their influence on the avocado, dry bean, and pecan markets, respectively.

Production-Insurance Correspondence

As shown in the preceding, there are many more production commodities than there are insurance crops. This is due in part to the nature of the insur-



	Sold	Indemnified	Net Reported Acres (100s)
AGR	1019	117	0
APH	474537	44519	529463
ARC	11984	822	3094
ARH	148	0	0
CRC	5238	907	9065
DOL	58127	4885	47623
GRP	17	1	10
PRV	16	1	36

Fig. 4A.4 Cumulative number of policies of each category sold in California since 1980

ance crop designation (more general, spanning several production commodities) and also in part to the fact that many crops are not insured. Correspondences between production and information have been established using the crop and commodity names of each respective data set. There are 100 production commodities found to correspond to fifty-six insurance crops.

All insurance crop designations encompass one or more production commodity designation, except in a few fruit crops. Tangelos, plums, and apricots have two insurance crop identities corresponding to a single production commodity (usually due to a distinction between fresh and processing grade fruit).

The other notable aspect of the link created between production and insurance information is that there are seven commodities that could not as of yet be linked with production commodities. This is due to ambiguous categories definitions (i.e., four types of insurance categories and six types of production categories for oranges). These unlinked insurance commodities

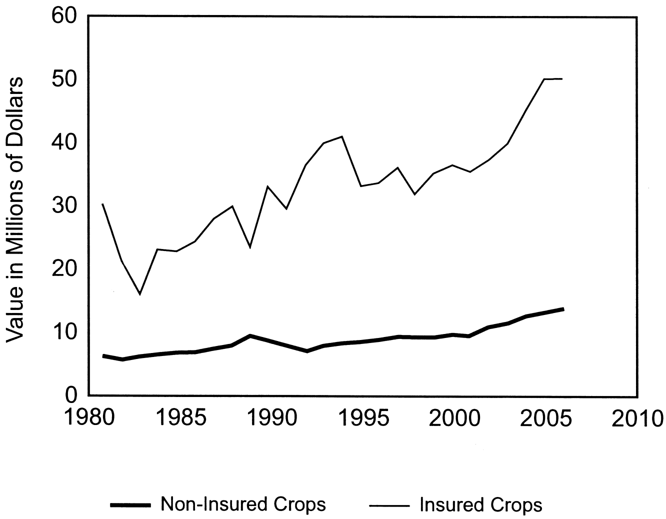


Fig. 4A.5 Mean production value (total market value divided by number of crops) for California agricultural production

include special citrus, processing beans, nursery (container), AGR, stonefruit, and oranges.

This correspondence permits the comparison of production of insured crops to production of uninsured crops. Figure 4A.5 shows that mean production value of insured crops is above that of uninsured crops over the entire thirty-year period analyzed; overall growth of market value of insured crops is also greater than for uninsured crops (although this may not necessarily be true for percent growth).

Appendix B

List of Specialty and Nonspecialty Crops

Specialty Crops

Almonds
Apples
Avocado/mango trees (Florida)
Avocados
Blueberries
Canning beans
Citrus trees

Citrus
Cranberries
Dry beans
Dry peas
Figs
Florida fruit trees
Grapes (table)
Grapes (wine)
Green peas
Macadamia nuts
Macadamia trees
Nursery
Onions
Peaches
Pears
Pecans
Peppers (fresh)
Plums
Popcorn
Potatoes
Prunes
Raisins
Stonefruit
Sweet corn (fresh)
Sweet corn (processing)
Tomatoes (fresh)
Sweet potatoes
Tomatoes (processing)
Walnuts

Nonspecialty Crops

Barley
Canola
Corn
Cotton
Extra long staple cotton
Flaxseed
Forage production
Forage seeding
Grain sorghum
Hybrid corn seed
Millet
Peanuts
Rice

Rye
Oats
Safflower
Soybeans
Sugarbeets
Sugarcane
Sunflowers
Hybrid sorghum seed
Tobacco
Wheat

Appendix C

Integration of RMA Crop Value List

One such list assembled by the RMA using crop value data from 2005 and 2006 was made available by the RMA correspondent for the previously stated research purposes.[14] The list included information on crops at all stages in the insurance policy process, from those at full regulatory status (those already insured) to those not yet being considered for new policies, and everything in between. However, because the informal list contained data for uninsured crops as well as for insured crops, many crops could not be identified with the unique FCIC crop codes that have been previously used to organize crop information in the research database and to define a correspondence between RMA policy information and NASS production and price information. Indeed, no numeric identifiers were used at all in the list provided. In addition, there were several critical discrepancies and complications that must be resolved before integrating the list information into the database:

- The national crop values reported do not correspond to NASS nationwide reported crop values (only a few were checked, and some were off by 50 percent but not by orders of magnitude). Because the list is significant for this research as an indicator of relative crop value as considered by the RMA, this may not be considered significant.
- One third of the listed crops are missing crop value information for 2006. According to the RMA correspondent, the incompletion of some columns can be considered insignificant. In this case, it may be preferable to use only the 2005 crop value data in order to generate a relative ranking of crops by value.

14. This section drawn from the thesis of Alana LeMarchand.

- Three of the crops contained no crop value data whatsoever (for either year). These crops were chicory, collard greens, and kale. The latter two crops are grown in California, so it remains to be determined whether these crops should be thrown out of the list. For now, they will be dropped from the list as insignificant in determining rank by crop value because they comprise less than 2 percent of the 163 observations.
- A few high-value crops were aggregated in the list. Notably, citrus fruit (all oranges, grapefruit, etc.), citrus trees (a pilot in Florida), dry beans (limas, red, navy, etc.), and floriculture (all nonbulb flowers). To appropriately integrate this data into a new table in the existing database, all crops corresponding to each of these categories would need to have the same ranking (or to be aggregated as a single crop to reflect the RMA's consideration of them as a single crop. This is generally typical of RMA reporting compared to NASS reporting: an RMA policy of a certain general crop name will generally correspond to apply to several NASS commodities. It is important to note, however, that there were crops that were subject to aggregation even among varying RMA crop policies, namely citrus fruit and peaches.
- Several crops in the nationwide list are not grown in California and, thus, are not present in the current database. Because these crops will not be significant in the research beyond determining a nationwide crop value rank, they will not be tied or added to the current FCIC and NASS crop lists in the database. Their crop code will be marked null in the database, indicating that they are not California crops.

An initial version of the list has been generated using the preceding modifications. For simplicity's sake, we create a third unique identifier in addition to the NASS and FCIC codes in order to capture the aggregation described in the preceding.

Correspondences were simple to make in most cases, but the following is a list of crops with problematic correspondences, primarily due to lack of specificity of which NASS crops are represented by these RMA crop names because the RMA uses different crop nomenclature than the NASS does (see table 4C.1).

The resulting data have been inserted as three tables with the following fields into the database (see table 4C.2).

The ID field in the first two columns represents the aggregation solution discussed in the preceding. The rank list table may be used to generate crop value rankings (as a temporary auto incremented and indexed table with a MySQL query) based on RMA status, in the event that it would be useful to include or to exclude certain status categories (such as "regulatory," which signifies crops already fully insured).

Table 4C.1

Risk Management Agency crop name	National Agricultural Statistics Service names	codes
Corn	Corn grain	111991
Forage	Pasture forage miscellaneous	194799
Forage seeding	Hay alfalfa, hay green chop	181999, 195299
Hybrid seed corn	Corn seed	171119
Silage: corn/sorghum	Corn silage, sorghum silage, silage	111992, 114992, 195199
Sweet corn (processing, instead of fresh)	Not distinct from "fresh" in NASS data	Null
Trees	No evident correspondence	Null

Note: Null indicates crop not grown in California.

Table 4C.2

Table Name: rank_ID	rank_list	rank_status
ID	ID	codep
ins_code	status	name
prod_code	value	
	name	

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