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ECONOMIC IMPACTS OF THE CALIFORNIA ONE-VARIETY COTTON LAW

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October 24, 1993

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Abstract

The California One-Variety Cotton Law is an important example of technological regulation, in this case intended to serve both as a *de facto* quality control and to mitigate externalities in production that can arise from the mixing of cotton seed at the gin. This paper describes and interprets the economic history of the law, presents a theoretical model of its economic effects, and provides quantitative estimates of the impacts on output, prices, and economic welfare, following a partial deregulation under a 1978 amendment to the law. The analysis shows that large social costs have arisen from concentrating control over the genetic base for California cotton production in the hands of a single government cotton breeder, and restricting production to the use of a single selection of a single variety. Some of these costs have been eliminated by the partial deregulation in 1978 to permit private breeders to compete in the provision of genetic material, but production is still restricted to the *Acala* variety of cotton. While the regulation has benefited some, perhaps even a majority, of the industry participants it has been increasingly harmful to some other growers and costly overall. The persistence of this costly regulation may be due to the distribution of its impacts: the partial deregulation yielded large increases in aggregate producer surplus but many growers experienced small losses.

Key Words: California cotton; technological regulation; genetic diversity

Introduction

Government interacts with science and industrial technology in a number of ways, both to mitigate distortions and market failures and to create them. Some of these impacts arise indirectly from the effects of government actions (or failure to act) on incentives for private-sector agents to invest in research and development (R&D) or to adopt new technologies (e.g., through introducing price distorting policies or not providing effective property rights over inventions); some of them arise more directly, through the important role of government as a producer of scientific knowledge. A third type of impact is through technological regulation.

Some of these aspects have been studied at length in general, and in the context of agricultural R&D in particular, but there has been relatively little analysis of the economic impacts of technological regulation in agriculture. Technological regulation is becoming increasingly a feature of agricultural production, with regulations being imposed for a diverse range of reasons including (a) phytosanitary and food safety objectives (e.g., requirements for refrigeration of milk on farms), (b) animal welfare objectives (e.g., requirements for housing of livestock), (c) environmental objectives (e.g., regulations over the use of agricultural chemicals or the disposal of effluent), or (d) nonspecific consumer protection (e.g., regulations prohibiting the use of growth hormones in milk production).[1]

A somewhat separate, but related, matter is the increasing (and increasingly vocal) public concern with biological diversity. This concern is often expressed in terms of the undesirable impacts of unregulated private-sector activites on the public good of a diverse genetic resource base, the implications of which may be government intervention aiming to ensure preservation of genetic diversity. Such intervention might involve technological regulation that encourages a greater range of private variety choices. More often, however, government intervention to restrict technology choices has led to a narrowing of the genetic base. An extreme example of this type of technological regulation is the

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[1]Wilcox provides an analysis of the economic impacts of animal welfare regulations; Zepeda, Butler and Carter analyse the potential impacts of deregulating to allow the introduction of *bovine somatotropin*; Lemieux and Wohlgenant analyse the potential impacts of deregulating to allow the introduction of *porcine somatotropin*.

regulation of cotton variety choices in California during the past seventy years.[2] The California One-Variety Cotton Law (OVL) has been used to dictate the planting of cotton in six counties in the San Joaquin Valley since 1925. From 1925 to 1978, cotton producers were permitted to grow only one variety of cotton—*Acala* cotton—from only one type of seed produced by a single seed breeder, the United States Department of Agriculture (USDA) experiment station at Shafter in Kern county, and sold by a single distribution agency, the California Producing Cotton Seed Distributors (CPSCD).

Underlying the introduction of the regulation in the 1920s was the belief that textile mills, the primary consumers of cotton, would be willing to pay a *price premium* for cotton originating from a one-variety district. At the time, cotton quality could not be detected objectively and economically prior to ginning and textile mills would therefore be expected to pay a premium if they could be guaranteed a uniform (high) cotton quality because their grading and processing costs would be lower.[3] In addition, it was argued that to ensure high and uniform quality (and avoid "mongrelization" of seed) over time, seed from different qualities of cotton should not be mixed at the gin (where seed was recovered for the next crop), and that therefore different varieties should not be mixed prior to ginning. This is an externality argument that pertains to the effects of mixing of seed at the gin on average quality over time.

Ostensibly, then, by regulating the variety that could be grown, the law provided a guarantee of cotton quality—information that was of value to buyers and that was therefore expected to result in a higher price per pound to producers for a given quality of cotton—and also served to maintain quality

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[2]Another example of this type of varietal regulation is wheat in Canada (e.g., Ulrich, Furtan, and Schmitz; and Carter, Loyns, and Ahmadi-Estafini). Similar regulations have also applied in Australia.

[3]Traditionally, cotton was hand-graded which yielded estimates of the fiber's staple length, grade (trash content and color), and micronaire (fiber fineness and maturity). Other important characteristics (especially fiber length uniformity and fiber strength) were not discernible by hand grading, but now can be measured objectively, along with the other characteristics, accurately and cheaply, using the recently developed *high volume instrument*. Acala cotton has relatively high strength and uniformity characteristics that make it relatively valuable. Under current conditions, where all of these quality aspects are objectively measureable, the premium for this aspect of Acala is additional to any premium arising from the one-variety district's guarantee of quality.

over time. However, the regulation forced some producers to grow a lower-yielding, higher-cost cotton than they would have produced otherwise. Even if the official variety were better "on average" throughout the whole San Joaquin Valley it could not be best for all growers because the diversity of growing conditions in California demands a diversity of genotypes.

Between 1950 and 1975 opposition to the law increased. In 1975, in response to grower complaints, the U.S. Department of Justice initiated an investigation of the monopoly in seed breeding and distribution created by the OVL; but no action was taken until 1978 when the law was amended to permit cotton growers to use more than one type of Acala seed. The 1978 amendment to the OVL only partially deregulated cotton planting in the San Joaquin Valley: cotton growers are still banned from producing non-Acala cotton, and new Acala seed must be approved by a new licensing authority, but private seed companies can now develop and market new Acala varieties. The OVL has recently been criticized on the fundamental ground that because of innovations in cotton grading and handling, it no longer serves the purpose of providing a quality guarantee for which it was created. Examining the consequences of abolishing the law is therefore a particularly relevant exercise.[4]

This paper examines the economic impacts of the OVL as an example of technological regulation aimed at achieving social objectives. First, we provide a brief history of the OVL that shows how this type of regulation, introduced for plausible reasons and apparently with the public interest in view, can become progressively more costly and unfair, and less successful at achieving its original objectives, over time. As a part of that history, we document the consequences of having relied on only one breeder and

[4]Indeed, there has been legal action in 1993 over whether colored cotton may be grown in the San Joaquin Valley. Such cottons are easily distinguishable—so the issue is not one of quality measurement—but the concern remains, apparently, that the colored cotton could contaminate white cotton either in the field or at the gin. In 1991, the law was relaxed to permit the planting of *Pima* cotton in the San Joaquin Valley. But this provided little relief to the growers in Madera, Merced or Tulare (eastside) counties who had complained against the law because Pima cotton has been grown mainly in the westside counties. In 1991, of 63,400 acres of Pima in the San Joaquin Valley only 900 acres were in Madera, Merced or Tulare counties. (Pima is a much higher-quality, higher-valued cotton than Acala but requires a longer growing season; it had been produced in California before 1991 but outside the one-variety district).

one genotype for cotton when disease infestations worsened unequally throughout the valley, and we note some specific instances where the beneficiaries from the law acted effectively to forestall reform.

Following the review of the history of the law, we present a theoretical model of the economic effects of the original regulations (restricting technology choice to one selection of Acala cotton bred by the government breeder) relative to both a partial deregulation (that allows for private breeders but continues to restrict varieties to be Acala cotton) and a totally unregulated choice of cotton varieties (including Acala and non-Acala varieties). Then, we estimate the quantitative impacts of the partial deregulation involved in the 1978 amendments to the law and examine whether the OVL has led to a premium for California cotton. The evidence strongly suggests that the returns were very high from allowing competition in cotton breeding and in developing and introducing new Acala types, and that the 1978 amendment created both winners and losers among San Joaquin Valley cotton producers but yielded significant net benefits in aggregate. In addition, the evidence for a OVL premium is weak, and the available evidence on experimental yields suggests it is likely that there were further losses to producers due to the prohibition of non-Acala varieties.

A Brief History of the California One-Variety Cotton Law[5]

California is the second largest cotton-producing state in the United States, partly because of exceptionally high yields.[6] Prior to 1925, when the OVL was enacted, large-scale commercial cotton production was almost unknown in California. Based primarily on a national security argument, USDA officials actively promoted the western region's irrigated valleys as areas with the potential to produce high-quality cottons

[5]A comprehensive account of this history, which includes detailed documentation of sources, is provided by Constantine. In addition, Musoke and Olmstead provide some further details on the rise of the cotton industry in California in contrast with the Cotton South.

[6]In 1992, California produced 2.8 million bales (1.4 billion pounds) of cotton, representing 17.8% of total U.S. production. California's lint yield was 1,351 pounds per acre, almost twice the U.S. average of 695 pounds per acre.

used to produce defence-related products such as vehicle tires, heavy cordage and airplane wings. The USDA initiated a California seed-breeding program in the early 1900s and became the major cotton breeder in the region.

In 1916, USDA personnel began to explore the possibilities of producing high-quality cotton in the San Joaquin Valley. By 1924, the USDA had identified an Acala cotton variety for the San Joaquin Valley and proposed that all other varieties be legally banned. The USDA argued that such a ban would preclude inadvertent mixing of high-quality and low-quality fibers at the cotton gins and therefore textile mills would receive a quality guarantee for which they would be willing to pay a price premium. In 1925, the OVL was enacted with little opposition.

The 1925 OVL required all cotton growers in the San Joaquin Valley to plant the same Acala cotton variety. Six counties were affected by the law; three on the valley's westside (Fresno, Kern and Kings) and three on its eastside (Madera, Merced and Tulare). The San Joaquin Valley currently accounts for about 95% of all California cotton production, of which about 80% is grown on the westside and 20% on the eastside. Farms tend to be larger on the westside and growing conditions differ substantially across the valley. In particular, the growing season in the northern eastside counties (Madera and Merced) is 20 to 30 days shorter than in the westside counties, and Tulare county is heavily infested with *verticillium wilt*, a soil-borne fungus that reduces fiber quality and yields.

The varying agroclimatic conditions would not be an issue except that the one-variety law forced *all* growers to produce an identical Acala variety of cotton. Growers were unable to choose either Acalas adapted to their different situations or non-Acala varieties. Critics argued that the USDA Acala varieties performed well in the westside counties (with their long, hot, growing season), but did poorly in northern counties (with their shorter, cooler, growing season) and on the wilt-infested soils of Tulare county.

Under the 1925 OVL, a state law in California, the USDA controlled all cotton breeding in the San Joaquin Valley under a monopoly that continued until 1978.[7] During this fifty-four year period, innovations in seed breeding were controlled entirely by USDA seed breeders at the westside *Shafter* experiment station in Kern county. While Shafter was responsible for breeding seed, it was not allowed to increase seed or sell it.[8] Thus, the 1925 OVL created a grower-based non-profit organization, the California Producing Cotton Seed Distributors (*CPCSD*), to perform those operations. The CPCSD also was authorized to collect and distribute seed tax revenues that provided up to 50% of the funding for the USDA breeding program and supported other research activities. The composition of the CPCSD board was determined by each county's share of total San Joaquin Valley production and thus its membership included a majority of westside growers. The composition of the CPCSD board was important because it meant that the the pattern of R&D, as well as the choice of one-variety cotton, were likely to be oriented toward westside growing conditions. At any time during 1925-78 there was only one cotton breeder and one variety of cotton available to growers, and only nine varieties were released by the four breeders between 1925 and 1978 (see table 1).

In the mid-1950s, a group of growers and specialists in the eastside county of Tulare complained of persistently declining yields, attributing the problem to *verticillium wilt*. They also pointed out that yields were typically 20-40% higher in Kern county than Tulare county and argued that the seed developed by the Kern county Shafter station was not suitable for land infested by *verticillium wilt*. Tulare growers asked the USDA breeders to develop a variety more suitable to their growing conditions. In the

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[7]Until the 1978 amendment was introduced, the USDA was the sole breeder. The original 1925 OVL made no mention of who could breed Acala cotton in the San Joaquin Valley. The USDA became the sole breeder by default. By the late 1950s there appeared to be some interest in non-USDA varieties (e.g., from the Delta and Pine Land Company) for San Joaquin Valley production but a 1961 amendment stipulated that all Acala seed planted in the San Joaquin Valley must originate from the USDA Shafter breeding station, assuring the USDA and CPCSD's control over the San Joaquin Valley cotton industry.

[8]"Increasing" seed refers to growing a crop from the original seed and harvesting for seed, and then repeating the process until commercial quantities of pure seed are available.

early 1960s, growers in Madera and Merced also protested against the USDA breeding program on the grounds that the Acala variety developed by the USDA breeder was unsuitable for their shorter growing seasons. Yields in both counties were also typically 30% to 40% lower than in Kern county (Constantine). The repeated requests for help from eastside growers were consistently ignored by the State of California, the USDA and the CPCSD board. In 1975, in direct response to Tulare grower complaints that USDA and CPCSD were maintaining a seed monopoly, the U.S. Department of Justice initiated an anti-trust investigation which continued for three years.

In 1978, the California legislature responded to the threat of action by the Department of Justice by amending the law to relax seed-breeding and distribution provisions. The 1978 amendment abolished the USDA seed-breeding program and permitted private companies to develop Acala varieties, but any new Acala varieties released to growers had to meet minimum quality standards and the Acala Cotton Board was established to enforce them. The structure of the Acala Cotton Board was very similar to that of the CPCSD, which reorganized itself as a private seed breeding company and hired most of its breeders from the now defunct USDA breeding program. The amended OVL required that any new Acala seed would have to be tested on experimental plots for a minimum period of three years before the Acala Cotton Board could determine whether the new variety met required quality standards.

The first year when any such new variety was eligible for acceptance by the Acala Cotton Board was in 1983. In that year two companies presented Acala varieties: the CPCSD and the Delta and Pine Land Company (*DPL*). The Board accepted the CPCSD variety but rejected the DPL variety and subsequently DPL (the largest cotton seed company in the United States) withdrew its breeding program from the San Joaquin Valley, asserting that the Board was using its authority to protect the CPCSD breeding program. These events raise the possibility that, initially, the partial deregulation may have been only partially effective. The CPCSD variety approved in 1983 was commercially unsuccessful.

The first variety released by a new, private breeder—*Germain's Seed Company*—was not approved until 1985. Once new privately-bred Acala varieties became available, they were adopted rapidly by growers throughout the San Joaquin Valley. However, as can be seen in table 2, there were dramatic differences in adoption rates among counties, reflecting the differences in impacts of the technological regulation among counties. These differential impacts among different counties, with differing agroclimatic and resource endowments, are captured in the economic model developed below.

A Model of the Impacts of Variety Regulation

The original law restricted production to be the Acala cotton variety and further regulated that only one USDA selection of Acala be grown. The 1978 amendment to the law was a partial deregulation that allowed private breeders to compete in the production of different selections of Acala seed. Our theoretical analysis considers first the movement from one Acala variety to multiple Acala varieties (the deregulation that has happened) and then considers the implications of a further deregulation, to permit the planting of non-Acala cottons (a counterfactual analysis since this deregulation has not occurred).

A Partial Dergulation—Private Breeders of One-Variety Cotton

In the analysis of the 1978 amendment, we assume that any premium arising from the one-variety regulation would not be affected by allowing more than one breeder of one-variety cotton.[9] Therefore the only price effects being considered are those that arise from changes on the supply side—i.e., the effects of increased output of a homogeneous product. When we analyse the possibility of non-Acala varieties we must consider demand-side responses along with supply-side response to changes in the regulations.

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[9]The 1978 amendment required that any new Acala cotton meet the minimum quality standards set by the Acala Cotton Board, thus ensuring the preservation of any premium.

The production possibility locus for two varieties of Acala cotton, A1 (USDA-CPCSD Acala) and A2 (private breeder Acala), is represented by a_0b_0 in figure 1, assuming that a fixed bundle of resources is available for the production of cotton in the six San Joaquin counties of interest. The OVL forces cotton producers to operate at a_0 where they specialize in a single cotton variety, A1. The products from the two Acala cotton varieties are assumed to be sold for the same price in the market, initially p_A. Thus the slopes of lines P_0 and P_1, which show the price of A1 relative to A2, are both -1. A partial deregulation of the law to permit the use of A2 (the 1978 OVL amendment) would allow cotton producers to shift from a_0 to x on the production possibility locus and Acala cotton output would increase from a_0 to a_1. If the price of Acala cotton, p_A, remains unchanged there is a welfare gain for producers equal to $p_A*(a_1-a_0)$. However, if Acala producers face a downward sloping demand curve, the benefits from expanded production will be mitigated by lower prices. Still, if demand is price elastic (as we expect will be the case for Acala), total revenues from Acala cotton sales will rise and, because resource use is unchanged, producer surplus will increase.[10]

Relaxing the OVL also can have distributional effects among different groups of producers. If p_A remains constant, producers who continue to specialize in the original cotton variety, A1, experience none of the producer surplus gains that result from the relaxation of the law. If p_A falls, then they suffer welfare losses. All of the gains are concentrated among producers who find it optimal to adopt the new seed. In the San Joaquin Valley, after 1985 over 50% of cotton acreage continued to be planted to the original Acala varieties so that over 50% of growers (by acreage) did not gain and might have lost. Thus, although (as we show later) the 1978 OVL amendments resulted in a large increase in aggregate producer surplus, it is easy to understand why many growers resisted the changes.

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[10]The analysis of figure 1 pertains to a situation in which total resources used in cotton production are fixed and thus represents a lower bound on the total benefits from the change. If the price of Acala cotton remains unchanged additional resources will flow into cotton production when yields (and profitability) increase. However, if the price of Acala falls as a result of greater output, resources allocated to the production of Acala cotton could fall, though not sufficiently to reduce total output below its initial level of a_0 (otherwise the price of Acala would rise).

Further Deregulation—Non-Acala Cotton Varieties

Non-Acala cotton varieties are still prohibited in the San Joaquin Valley and associated regulations over breeding and testing non-Acala varieties remain in force. We now turn to an examination of the consequences of totally eliminating the law. Such a deregulation would allow free choice of cotton varieties, free enterprise in the production and distribution of cotton seed, and freedom of scientific endeavor in the development of varieties, in California as is now true in other states.

Potential effects of permitting free choice of cotton variety—both Acala and non-Acala varieties with seed produced commercially—are illustrated in figure 2. In figure 2, the production possibility locus, a_0n_0, represents the alternative mixes of Acala and non-Acala cotton that could be produced using the fixed amount of resources currently used to produce Acala cotton. California non-Acala cotton is assumed to be similar to other U.S. non-Acala cotton and its price, p_{NA}, is assumed to be exogenous to the region.[11] The initial relative price ratio of Acala cotton to non-Acala cotton is given by the slopes of P_0 and P_1. Note that this ratio is no longer equal to one as p_A is assumed initially to be greater than p_{NA}. If the prices of both types of cotton remain constant, as long as resources devoted to cotton are fixed, elimination of the law will result in a shift along a_0n_0 from a_0 to z_0. Given that p_{NA} is fixed and (for convenience in measuring welfare effects) equal to unity, the resulting aggregate producer surplus welfare gain is equal to the distance n_2-n_1 on the vertical axis of figure 2.

The above analysis assumes that the price of Acala is independent of the quantity produced and the existence of the OVL. In fact, two countervailing forces are at work with respect to the price of Acala cotton. If the OVL does provide a premium for Acala cotton because it reduces handling and grading charges at textiles mills, this premium would disappear if the law were eliminated, and the price

[11]This is a reasonable assumption as California produces only about 15% of total U.S. cotton output but enjoys a much greater share of the high-quality (Acala) markets. Thus there are some grounds for believing that there is some slope to the demand curve for California's Acala cotton but that, as a group, California growers are price takers in the non-Acala market.

of Acala cotton (p_A) would fall. In contrast, if California's producers face a downward sloping demand curve for Acala cotton, the reduction in Acala output would lead to a rise in p_A. Which of these effects would dominate is an empirical question. In figure 2, the relative price line, P_2, is constructed under the assumption that there would be a net decrease in the price of Acala cotton while, by assumption, the price of non-Acala cotton (p_{NA}) does not change. Holding total resource use constant, the effect of revoking the OVL is then to shift the region to z_1 on its initial production possibility locus. The net effect of relaxing the constraint on variety choice is to increase the value of cotton production from n_1 to n_3, a smaller increase in producer surplus than would be obtained if the Acala cotton price remained fixed.

It is conceivable that the quality premium associated with the OVL is so large that abolition of the law would cause p_A to fall enough to completely, or more than completely, offset any producer surplus gains from reorganizing production. This possibility is illustrated by the relative price line P_3. In this case, the externality effects on quality premia justify the law, at least in terms of aggregate producer interests.

Whether total resources allocated to cotton production in the region would rise or fall if the OVL were abolished is an empirical question. The answer depends on the size of the quality premium, elasticities of supply and demand for agricultural inputs, the technologies used in cotton growing, and the elasticity of demand for San Joaquin Valley Acala cotton. Again, there would be distributional effects among cotton producers. Growers who wanted to switch to non-Acala cotton at pre-abolition prices would unambiguously gain as would farmers who would have planted land currently in other uses to non-Acala cotton if non-Acala varieties had been permitted. Producers who continued to specialize in Acala cotton would gain if the positive effects on p_A of reduced Acala production outweighed the negative effects of foregoing the quality premium; otherwise they would lose.

Empirical Results—Impacts of the 1978 Amendment

The economic welfare effects of the partial deregulation of cotton to permit multiple varieties of Acala depend on the adoption responses, the impacts on yields, and changes in resource allocation in cotton production. In addition, on the demand side, there may be price responses to changes in production.[12] However, since it is assumed that all Acala cottons are identical there would be no demand response to changes in the mix of production and no impact on any quality premium attributable to the implicit quality guarantee provided by the regulation. First we look at the adoption response and yield effects, then we use the results from that part to measure the economic welfare impacts.

Acala Variety Adoption and Yields in the San Joaquin Valley

Once new privately-bred Acala varieties became available, they were adopted rapidly by growers throughout the San Joaquin Valley. Table 3 (column H) shows that during 1985-91 (the post-amendment period) new private varieties typically were planted on almost 50% of total cotton acreage in four of the six San Joaquin Valley counties. However, there were dramatic differences in adoption rates among counties, ranging from 19% in Kern County to 70% in Merced County. The adoption rates tended to be much higher in the eastside counties (Madera, Merced, and Tulare) and in Fresno, which straddles both sides of the valley. In addition, a comparison of columns B and C in table 3 (which report county-wide average yields for the periods 1979-84 and 1985-91) shows that differences in yields among counties almost disappeared after 1985. As no other major changes occurred between 1985 and 1991, it is

[12]The welfare effects on society as a whole also depend on a range of other considerations, including implications for taxpayer outlays through the federal cotton program, the effects of changes in cotton quality on consumer surplus, and the social costs of irrigation and other changes in agricultural input use in the San Joaquin Valley. In the empirical analysis of the 1978 amendment we assume that the social costs of existing cotton farm program provisions, irrigation policy in California, and other policies, are not affected significantly by any changes in cotton production in response to changes in the one-variety cotton law. So long as the overall distortions associated with those other policies are constant in relation to the analysis, they can be ignored (Alston and Martin).

reasonable to attribute almost all of the changes in San Joaquin Valley yields since 1985 to the 1978 OVL amendments.[13] This assumption is utilized in the empirical analysis.

The yield data in table 3 (column D) also suggest that after the introduction of private varieties in 1985 yields rose more substantially in the eastside counties of Madera, Merced and Tulare than in the westside counties of Kern and Kings. The legitimacy of eastside grower complaints about consequences for them of the pre-1978 version of the OVL is also borne out by a statistical analysis of yield changes.[14]

The effects of the 1978 OVL amendments on per acre cotton yields in each of the six San Joaquin Valley counties were examined using regression analysis. Plots of historical yield data for the period 1945-1991 indicated that yields rose sharply in each county during the 1950s but thereafter exhibited no long-run trends.[15] However, yields did appear to increase in all of the counties except Kings during the late 1980s after new private commercial seeds were released in 1985. A simple ordinary least squares regression of per acre average annual yields (measured as pounds per acre of cotton) on a trend variable (TREND) and a dummy variable (DUMMY85), set equal to 0 prior to 1985 and 1 thereafter, was estimated for each county using data for the period 1960-1991. Results are reported in table 4. The

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[13]The period 1985-91 includes the beginning of the five-year drought that afflicted California from 1988 to late 1992. Whether that drought had any direct or indirect impact on cotton yields remains moot. Since cotton is grown under irrigation (relying almost entirely on irrigation as a source of water during the growing season) in California, any effects of drought are likely to be through the supply of irrigation water. Water supply for cotton irrigation was not limited until the latter part of the drought and water restrictions were not likely to have affected production or yields much before 1991. In 1990 and 1991 there were some effects of water restrictions on acreage planted. One might expect the effect (if any) of a drought on yield to be negative so that (if anything) ignoring the drought could lead us to *understate* the effect of the deregulation on cotton yields. However, while less water per acre would reduce yields, a reduction in acreage would tend to increase yields so that the net effect is ambiguous. Since we are comparing five-year averages, it is reasonable to ignore any such effects in the one year when they may have been important, 1991.

[14]In table 1, the period 1979-84 is chosen as a benchmark period against which yield increases after 1985 are compared because, during that period, very little technical innovation occurred and weather conditions were relatively normal.

[15]This can be traced in part to the history of cotton breeding and cotton breeders at Shafter (see Constantine).

pattern of results across counties is remarkably consistent. In no case is the trend variable's coefficient significant. In contrast, the DUMMY85 coefficient is positive and significant at the 5% confidence level in five of the six counties. For Kings County, in which only 26% of cotton acreage was planted to the new varieties after their introduction in 1985, the DUMMY85 coefficient is not significant.

The coefficients for the DUMMY85 variable provide point estimates of the effects of the OVL amendments on county-wide yields. These estimates range from 133.98 pounds per acre in Kings County to 290.82 pounds per acre in Fresno County and correspond closely to actual increases in average yields between the years 1979-1984 and 1985-1991, which are reported in column D of table 3. The actual average yield changes between these two periods are slightly smaller, ranging from 80 pounds per acre in Kings County to 230 pounds per acre in Madera County. The latter, therefore, provide more conservative estimates of the effects of the 1978 OVL amendments on average yields than those implied by the regression models.

Economic Welfare Impacts[16]

Market data were combined with data from test-plot experiments to estimate changes in producer surplus under the assumption that resource use and production costs remained fixed. The results show that the 1978 OVL amendment resulted in substantial increases in aggregate producer surplus among San Joaquin Valley cotton growers. Growers who did not switch lost, while those who adopted the new (privately-bred) varieties of Acala gained. The empirical analysis compares two time periods, the pre-amendment period 1979-84 and the post-amendment period 1985-91. Resources devoted to cotton, including land, are assumed to be identical in both time periods. In fact, the amount of land actually used for cotton production in the San Joaquin Valley has fallen slightly since the 1979-84 period.

[16]Complete details on the calculations reported here are provided by Constantine.

An important question is whether the increase in San Joaquin Valley Acala output in the post-amendment period affected the price received by San Joaquin Valley producers for their cotton. Lack of suitable data precluded direct estimation of a demand function for San Joaquin Valley Acala, but a rough estimate may be deduced from information on the overall elasticity of demand for U.S. cotton and information on the fraction that is produced in the San Joaquin Valley. For example, if the total elasticity of demand for U.S. cotton is -0.3, then dividing by the ratio of San Joaquin Valley output to total U.S. cotton production (typically about 15%) indicates that the own-price demand elasticity for San Joaquin Valley Acala cotton is about -2.0. This is almost certainly an underestimate, as over 50% of all San Joaquin Valley Acala cotton is exported. Thus welfare effects are computed for elasticities of -2, -5, -10 and infinity. Point estimates of the slope of the demand curve were obtained from the assumed elasticities of demand using average San Joaquin Valley output for the 1979-84 period and an estimate of the 1984 Acala price (adjusted to 1991 dollars) of $1.027 per pound.[17]

Using market data on production and estimates of the price changes based on the above range of demand elasticities, changes in average annual producer surplus (and total revenues) from Acala production for the periods 1979-84 and 1985-91 were calculated. The estimates were obtained as follows. The average change in total annual output was multiplied by the estimated slope of the demand curve under each elasticity assumption to calculate the change in the price of Acala cotton and the new price for Acala cotton. The change in producer surplus (and total revenues) was then obtained by subtracting the initial average Acala output multiplied by the initial price for Acala cotton from the new average Acala output multiplied by the new price for Acala cotton. These estimates are reported in table 5. Table 5 shows that, in the aggregate, each county realized gains in producer surplus with the enactment of the amended law. In table 5, as the price elasticity of demand increases, aggregate producer surplus

[17]This estimate was obtained using a simple linear trend forecasting model for cotton prices. Other functional forms did not perform as well as the linear model.

gains increase because cotton prices fall by less. Estimates of total producer surplus gains to growers in the San Joaquin Valley range from $78 million to $181 million per year, depending on the assumed elasticity of demand for San Joaquin Valley Acala cotton. In some counties, depending on the assumed elasticity of demand, the estimated increases in producer surplus exceed 20 percent of initial (1979-84) average total revenues from cotton sales.

Estimates of changes in consumer surplus, calculated under the assumption of a linear demand curve for Acala cotton, are presented in table 6 for each assumed elasticity of demand.[18] The estimates of the increase in consumer surplus range from $97 million per year (for $\eta_D = -2$) to zero (for $\eta_D = -\infty$). As the elasticity of demand increases, and correspondingly the absolute size of the implied price change decreases, the size of the consumer surplus increase falls. Estimates of the aggregate change in total economic welfare, the sum of the changes in producer surplus and consumer surplus, are also presented in table 6. These estimates of total welfare effects increase only slightly as the elasticity of demand increases (because producer surplus increases by slightly more than consumer surplus decreases when demand becomes more price-elastic). However, as was shown above, the share of the aggregate welfare effects that accrues to producers is sensitive to the elasticity assumption.

Estimating the disaggregated welfare effects of the amendment on growers who switched and growers who did not requires estimates of the effects of the amendments on yields for the two groups. Data were available on actual county-wide average annual yields for the pre- and post-amendment periods, 1979-84 and 1985-91, and the share of county acreage planted to new private Acala varieties and original varieties during 1985-91 (see table 7). In addition, for each county, experimental-plot data on the performance of both new and original varieties were available for the period 1983-90. The ratios of

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[18]The formula used to compute the increase in consumer surplus, Δcs, is $\Delta cs = \Delta p.q_0 + 0.5\ \Delta p.\Delta q$, where q_0 is the initial output level, Δp is the absolute change in price, and Δq is the change in output. This represents changes in the welfare of everybody involved in the textile chain from the gin and beyond, as well as final consumers of goods involving cotton.

the experimental-plot yields of the new varieties relative to the original variety were assumed to be equal to the ratios of actual commercial yields for the two types of cotton in each county. In addition, average yields on land that continued to be planted to the original pre-1985 Acala varieties after 1985 were assumed to remain constant over the entire period of 1979-91. These assumptions permitted the estimation of average yields on land planted continuously to original Acala varieties and land switched to new varieties in both the pre-amendment and post-amendment periods.[19] These yield estimates, reported in table 7, are combined with the county-level data in table 3 on average planted acreage and the share of acreage planted to new varieties after 1985, to obtain disaggregated county-level estimates of the welfare effects of the 1978 OVL amendments. Estimates of welfare effects are given in table 8.

The 1978 amendment had two countervailing effects. First, the new Acala varieties led to increases in average per acre yields and total Acala production. Second, as noted above, as total production increased the price of Acala decreased. Because the size of the price effect is uncertain, in table 8, results are presented for price elasticities of -2 and -10. Recall that we assumed that all Acala cottons are of identical quality so that they all obtain the same price.

The welfare gains from changing to a different Acala variety arise from greater yields for those whose agroclimatic situation makes it profitable to adopt the new variety, but greater total Acala output will lead to lower prices received by both adopters and nonadopters. Thus the results show that in all cases producers who adopted the new Acala varieties in the post-amendment period were net gainers and producers who continued to plant the original varieties were net losers. Growers who continued to plant original Acala varieties lost an estimated producer surplus of between $60 million and $12 million (about

[19]The data and related calculations are reported in Constantine. Constantine demonstrates that relative experimental yields (new relative to old Acala) provide a very conservative estimate of the relative commercial yields since the experimental conditions were held constant with agronomic practices chosen to be optimal for the USDA varieties whereas under commercial conditions the agronomic practices would be expected to be optimized for the actual variety being grown. This implies that the estimates of welfare impacts may also be conservatively low.

$10 per acre of cotton, assuming an elasticity of -10). Producers of original varieties in Kern and Kings counties (in which less than 30% of total acreage was switched to new varieties) lost relatively more (losses of $4.15 million or $14/acre in Kern county and $2.98 million or $12/acre in Kings county, assuming a demand elasticity of -10). In contrast, growers who switched to new Acalas enjoyed aggregate welfare gains of between $138 million and $172 million per year. In Fresno, Madera, Merced and Tulare counties, gains to producers who switched to new, private varieties of Acala were large relative to the losses incurred by the non-adopters.

Benefits and Costs of the Prohibition of Non-Acala Cotton

The partial deregulation in 1978 yielded an estimated net benefit of around $180 milllion per year. But this is only a part of the story. The California cotton industry continues to prohibit the production of private or public non-Acala cotton varieties, a more restrictive constraint, perhaps, than the pre-1978 restriction that growers plant only one type of public Acala cotton. To understand why the OVL was introduced and why it endured for so long in its original form, it is necessary to consider all of its consequences, including those associated with the prohibition of non-Acala cotton.

The introduction of the OVL in 1925 was predicated on a belief that there would be a price premium for cotton coming from a one-variety district. It was understood that some growers might not benefit. But it was argued that the overall benefits from eliminating externalities associated with multiple varieties of cotton would outweigh any inefficiencies on the production side; an empirical assertion that has been open to question, especially in more recent years. To evaluate the net benefits would require estimating the premium attributable to the OVL (above any premium due to quality differences that would be available to individual cotton growers and which is independent of whether the cotton is from a one-variety district) and comparing that benefit to the opportunity costs of foregone profits due to the restrictions on varieties (resulting, primarily, from lower yields).

There is insufficient information to allow an accurate assessment of the costs and benefits of this component of the OVL (i.e., the prohibition of non-Acala varieties, as opposed to the part that precluded private Acala varieties given a restriction to Acala). However, some information is available on prices in recent years and on the likelihood of a significant OVL premium in the past. In addition, there is some, albeit incomplete, information on experimental yields that we can use to infer something about the opportunity costs of prohibiting non-Acala varieties.[20]

Price Premiums for California Cotton

In 1924 the OVL was presumed to have the potential to generate a price premium for all producers in the San Joaquin Valley for three reasons. First, farmers would be able to obtain a reputation for high-quality cotton. Second, high-quality seed consisting of only one variety could easily be recovered from the gin. Third, the cotton would be of relatively consistent quality, reducing the need for sorting at the mill. The clearest evidence in support of these arguments would be direct evidence on a premium attributable to the OVL above any premium for quality as such. Prior to the introduction of the law there was no such direct evidence.[21] However, after the law was introduced it is possible to evaluate its price effects by comparing prices for cotton from the one-variety district with prices of cotton from other areas.

Although data are not available for the period immediately after the OVL was introduced, annual average data are available for the more recent 34-year period, 1957-90, on prices for two classes of

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[20]The production of non-Acala cotton varieties, even for experimental purposes, has effectively been disallowed in the San Joaquin Valley. Initially, state and federal cotton researchers were exempted from the law. In the early 1960s, University of California (UC) researchers began experimenting with non-Acala varieties, but an amendment to the OVL in 1965 required UC researchers to obtain the state's permission for non-Acala variety testing in the one-variety district, effectively eliminating the UC testing program. Thus the only non-Acala yield results are for 1966-78 when limited trials were carried out by the USDA and CPCSD.

[21]Proponents of the law pointed to the high prices that had prevailed during World War I for Egyptian (Pima) cotton as evidence of the potential for a premium. This was more likely to have been evidence of a premium for particular quality attributes, valuable for military reasons, with no clear implications for benefits from regulation. In fact the high Pima price was transitory. At the end of the war, Pima prices fell from about 70 to 12 cents per pound (Constantine).

cotton, identified by two characteristics, grade (31 or 41) and staple length (34 or 35), at each of three locations (Fresno in the San Joaquin Valley, Phoenix Arizona, and Memphis Tennessee).[22] These data are presented in table 9. Table 10 includes the measures of the difference between the price paid for cotton in California and the prices for cotton of the same quality class in Arizona and the South.

As can be seen in table 10, over the 34-year period, the California price was greater than the prices in both Memphis and Phoenix for both grades of cotton on average (around 2.5 cents per pound or 5 percent of the California price).[23] Moreover, the California price was greater than the Memphis price in 29 of the 34 years for both qualities, and greater than the Phoenix price in 32 of the 34 years for both qualities. But in no case was the average price difference statistically significant. Thus there may have been a price premium of around 5 percent, but other sources of variation in the data, including variation in the premia for quality attributes, mean that it cannot be detected statistically.[24]

There are other reasons for questioning the importance of a OVL premium if it existed at all. Ethridge and Davis, using data on prices for cotton sold in lots (multiple bales), estimated a hedonic price model in which price was negatively correlated with variation in micronaire. This supports the idea that there might be a premium for uniformity. However, their results suggest that the premium for reducing quality variation within a lot is small, likely to be less than one percent.

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[22]Grade "31" is superior to grade "41"; length "35" is superior to length "34". The two classes considered are 41-34 and 31-35; the latter being superior on both counts.

[23]These price differences might reflect things other than a premium due to California cotton coming from the one-variety district. The cotton from different regions might not be exactly the same quality, since two quality characteristics (fiber length uniformity and fiber strength), were not included in the classification. In any year, the price difference between California and Memphis or Phoenix, for a particular class of cotton, might include a component due to a quality difference and there might be systematic regional differences in these characteristics. As well, there might be a component of price differences attributable to regional transport cost differences.

[24]Using the hedonic procedures developed by Rosen and by Brown and Rosen, Bowman and Ethridge showed that the price of cotton depends on at least six attributes: trash content, color, fiber length, micronaire, fiber length uniformity, and fiber strength. They also showed that the value of each attribute varies over time in response to changes in supply and demand conditions for those attributes, as suggested by Rosen. These results mean that the average quality premium may vary substantially over time.

Moreover, in the early 1950s, in a comparison of the quality of cotton obtained from gins handling one-variety cotton, and gins handling multiple varieties, Campbell found that one-variety production did not guarantee uniformity. He concluded (p. 28):

> "Cotton mill operators usually demand cotton within a range of one grade and staple length combination, but the one-variety gins produced an average of 30 such combinations with ranges in the other fiber properties. California, the one-variety state, produced an average of more than 180 such combinations or about 6 times as many as the one-variety gins studied. Therefore such one-variety cotton would not be uniform enough to meet the usual demand of mill operators and would require about as much sorting as multiple-variety cotton."

Thus there are grounds for questioning the main argument for expecting a premium due to the OVL. In fact the (statistically insignificant) premiums observed in the data reported in table 10 may be due to regional variations in other quality attributes or transport costs.

Similarly, there are grounds for questioning whether the issue of contamination of seed at the gin is important today, although it might have been important in the 1920s. Nowadays over 95 percent of cotton is grown from pure seed produced by commercial seed producers. Only around five percent of San Joaquin Valley cotton is grown from seed recovered from growers' cotton at the gin, and in such cases great care is taken with hygeine. There is no risk of mongrelization of seed at the gin and there is no corresponding benefit from the OVL.

Finally, recent technological developments permit cotton quality to be measured objectively and cheaply. Thus any benefits from ensuring quality and obtaining a reputation for quality can now be secured at the individual grower level; it is no longer true that regulating the genetic base provides a de facto promise of quality that cannot be assured otherwise. The recent development of the *high-volume instrument* for measuring cotton quality means that there can be little virtue in the one-variety regulation as a de facto quality control in the future.

Yields of Acala and Non-Acala Cottons

At the time of its passage in 1925, proponents of the OVL saw its potential to benefit all producers in the OVL district through higher prices for their cotton, but recognized that some producers in the region would suffer lower yields. Test-plot data from different regions in the San Joaquin Valley showed that Acala cotton outyielded all other varieties at one of two locations tried in 1918 and at all four locations tried in 1919; but Acala was only a little better in most cases.[25] In testimony, Camp asserted that Acala outperformed other varieties in varietal tests conducted between 1920 and 1925. However, as Harrison later pointed out, no records of these experiments exist. Nonetheless, the available information indicates that Acala was a reasonable choice given the decision to proceed with a one-variety regulation.

There was limited experimentation with non-Acala varieties in California but only between 1966 and 1978, and the results can be taken with confidence for only the first year, 1966.[26] In that year, non-Acala varieties slightly outyielded the best Acala variety in every case in plots on seven sites across the San Joaquin Valley. Given the diversity of agronomic and climatic conditions in the valley it seems likely that for at least some growers, non-Acala varieties would have done much better than Acala over the past thirty years (recall, the agroclimatic variation is sufficient to generate significantly different responses *among* Acala varieties).

There is some indirect, anecdotal, evidence about the yield potential of non-Acala varieties. On April 20, 1970, Calcot Ltd testified before a special hearing on the One-Variety Cotton District Act. The testimony supported the OVL, but acknowledged its yield-depressing consequences:

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[25]In one trial Acala yielded 2.3 percent below the best variety, in four trials the Acala yield advantage was between 2.1 and 6.6 percent, and in one trial Acala yielded 47.4 percent better than the next-best variety (see Constantine, pp. 44-45). We cannot say whether these yield differences were statistically significant and it is not known whether the cultural practices favored Acala or other varieties.

[26]In the subsequent yield trials there was a startling change in relative performance. Acala dominated all other varieties everywhere; on the eastside experimental Acala yields were lower, but still higher than non-Acala yields. However, the results from these trials are thought to be unreliable (Constantine).

> "The one-variety one-strain program currently in effect places a definite constraint on the ability to achieve increased yields.... If each area in the Valley could pick their best strain, then a 10 percent increase in yield could easily result." (pp. 4-6)

The comments from Calcot do not distinguish between Acala and non-Acala alternatives. As reported by Constantine (p. 82) a clearer distinction was drawn by Reynolds in testimony before the California Legislative Hearings (1963):

> "We (Imperial County cotton growers) know that a small premium is paid for the Acala cotton but when we compare the small premium to the yield increase of the Deltapine over the Acala, and since we see that the plant itself is better suited for mechanical harvesting, we must conclude that the Deltapine is far above the income of the other variety." (p. 12)

As discussed by Constantine, the Imperial Valley growers were allowed to enter cotton production in 1951, and they planted Acala 4-42 without being required to do so. They joined the one-variety district in 1954 but left almost immediately afterwards, in 1955, never having planted cotton under the OVL. Free from the constraints of the law, growers in Imperial Valley rapidly abandoned Acala 4-42 and planted DPL varieties. By 1958 nearly all growers in Imperial county were planting DPL varieties while Acala was virtually abandoned. Another set of hearings were held in Madera county in 1964, and some growers there expresssed similar ideas, but they were unsuccessful in that their production continued to be subject to the conditions of the OVL.

Perhaps the strongest evidence that some growers have suffered significant economic losses as a result of the prohibition of non-Acala varieties is that, against complaints and opposition, the law has remained in force. Presumably this is because its proponents believe that, without the constraint of the law, some growers would profit by adopting non-Acala cotton varieties.

Conclusion

The history of cotton in California exemplifies the arguments of Becker and Stigler which suggest that changes in deadweight costs tend to change the policy equilibrium and that the deadweight costs of

regulation are likely to increase as the duration of regulation increases. The California One-Variety Cotton Law was introduced in 1925 because it was believed that it would generate a price premium while imposing little yield penalty, and would be to the individual advantage of most growers as well as in growers' collective interest. At that time there may well have been net benefits overall from the regulation but the costs of regulation have risen (with the increasing yield penalty, especially for eastside growers, relative to what might have been) and the benefits have fallen (as technological changes in cotton grading, and institutional changes in seed production have reduced the potential for a premium due to the regulation). Pressure from the eastside growers grew over time, reflecting the rising cost of regulation borne by them, leading eventually to a partial deregulation.

Amending the OVL simply to permit growers to use more than one variety of Acala cotton resulted in large net welfare gains to producers. The total social benefit from this partial reform was around $180 million per year, a significant fraction (over 10 percent) of the gross value of production. This finding raises questions as to why the law, in its original form, endured for over 50 years. At least part of the answer lies in the fact that even the modest 1978 amendment to the law, which allowed the use of more than one type of Acala cotton seed, created both winners and losers among Acala cotton producers. To the extent that increased production resulted in lower prices, those who switched generally gained and those who did not switch lost; those who stood to lose controlled a majority of cotton acreage and had been influential in the breeding of cotton. In addition, the original law created a monopoly supplier of seed, the CPCSD, whose monopoly power would be substantially eroded by the 1978 amendment, and therefore who would be expected to oppose reform. As a consequence, the law was modified only after disadvantaged producers in Tulare county sought relief under federal anti-trust legislation through the Department of Justice.

These results illustrate the general proposition that the regulation of technology to pursue social objectives may have undesirable side-effects. The original proponents of the regulation of California

cotton technology intended to eliminate the social costs of negative externalities arising from unregulated variety choices. They knew that some producers would be disadvantaged by such a law but believed that the benefits would outweigh the costs. However, they did not anticipate (a) that the inflexibility of the centralized system of plant breeding would mean that the costs to those disadvantaged would grow much more rapidly than the benefits to others, (b) that a single selection of a single government variety would be so much inferior to multiple selections of privately-produced varieties under a modified one-variety law, but (c) that vested private interests would resist reforms that would serve the broader interest.

Some other developments, such as the rise of synthetic substitutes for cotton, and the development of high-quality cottons in other U.S. regions, were not anticipated at the time when the law was introduced. In addition, the framers of the policy did not anticipate the development of new technology (the high-volume instrument) that would make the main argument for the law irrelevant—but this change relates more to the prohibition of non-Acala cotton which is still in force.

The justification for the prohibition of non-Acala cotton rested on the expectation that buyers would pay a premium for the implicit quality guarantee and that, although some growers would be worse off due to lower yields, the premium would more than compensate growers in aggregate for any foregone yields. In fact, when the law was introduced, the available experimental evidence indicated that Acala cotton would yield at least as well as other varieties and little or no attention was given to the longer-term consequences for foregone yields; it might have seemed that there would be little yield penalty.

Analysis of price data, and indirect evidence, suggest that, if it existed at all, in recent years the premium for one-variety cotton has been small—certainly less than 5 percent of the price. Direct evidence on yields of non-Acala cotton in California is not available. Trials conducted in the 1960s indicated that other varieties might have yielded as well as Acala or better on average. It seems likely that, as for the within-Acala varieties, agroclimatic diversity among areas within the San Joaquin Valley means that other varieties are significantly economically superior to Acala for some growers, especially

in the eastside. Some support for this view is provided by the experience in the Imperial Valley, where growers were relieved of the one-variety restriction and shifted to non-Acala varieties, and in Merced county where growers sought similar relief but were denied it.

Whether the law will persist for much longer is a question of great interest given that the likelihood of a quality premium has been further diminished by the development of a high-volume instrument that enables quality to be measured objectively and cheaply. It is simply no longer necessary to rely on the implied quality guarantee provided by a one-variety regulation introduced almost seventy years ago.

Table 1

Acala Varieties Planted in SJV: 1925-1978

Year Released	Variety	Breeder[1] (Service)
1925	Acala S-5-4-1	Wofford B. Camp (1925-1928)
1928	Acala P12 and derivatives	
1944	Acala P18C	George J. Harrison (1934-1952)
1949	Acala 4-42	
1967	Acala SJ-1	John H. Turner (1953-1972)
1973	Acala SJ-2	
1974	Acala SJ-3[2]	H. B. Cooper (1972-1978)
1975	Acala SJ-4	
1978	Acala SJ-5	

Note: SJ-2 and SJ-5 remained the only one-variety cottons until 1983 when privately bred varieties were released to SJV growers.

[1]Camp is given credit for the development of Acala S-5-4-1 and the early Acala "P" lines, although it is not certain whose varieties they were. Records of the breeding program in the early years of the OVL are lacking. Beginning with Harrison's 1944 release of Acala P18C there is no question about the lineage and breeder of a variety.

[2]Acalas SJ-3, SJ-4 and SJ-5 did not replace Acala SJ-2, they were meant to give growers a choice based on cultural conditions. Beginning in 1974 growers had the opportunity to plant either SJ-2 or one of SJ-3, SJ-4 or SJ-5, where SJ-4 replaced SJ-3 and SJ-5 replaced SJ-4.

Table 2

Private Companies' Shares of SJV Acala Market by County: 1984-1991 (Percent)

Year	Fresno	Kern	Kings	Madera	Merced	Tulare
1984	0.0	0.0	0.0	0.0	0.0	0.0
1985	27.0	9.0	10.0	40.0	44.0	29.5
1986	61.0	22.0	16.6	55.0	81.0	39.4
1987	57.0	17.0	17.8	44.0	73.0	32.7
1988	66.1	20.9	29.2	56.4	73.3	36.7
1989	58.2	22.3	35.2	52.7	73.2	42.9
1990	63.8	19.8	32.6	66.6	74.3	61.8
1991	53.9	23.9	42.5	49.4	74.6	70.6

Source: United States Department of Agriculture, Agricultural Marketing Service, Cotton Division. *Cotton Varieties Planted*. Various issues.

Table 3

Average Acala Yield per Acre and Aggregate Acala Cotton Production in the San Joaquin Valley, by County: 1979-84 and 1985-91

County	(A) Total Annual Average Planted Acreage: 1979-91	(B) Actual Average Acala Yield/Acre (lbs): 1979-84	(C) Actual Average Acala Yield/Acre (lbs.): 1985-91	(D) Changes in Average Acala Yield/Acre (lbs.): (C-B)	(E) Estimated Annual Average Acala Production, 1979-84 (million lbs.): (A*B)	(F) Estimated Annual Average Acala Production, 1985-91 (million lbs.): (A*C)	(G) Estimated Change in Annual Average Acala Production (million lbs.): (F-E)	(H) Annual Average Percentage of Total Acreage Planted to New Varieties (1985-91)
Fresno	386,293	1,155	1,345	190	446.90	520.44	73.52	55%
Kern	303,264	1,100	1,215	115	333.59	368.47	34.88	19%
Kings	258,397	1,040	1,120	80	268.73	289.41	20.67	26%
Madera	48,290	860	1,090	230	41.53	52.64	11.11	52%
Merced	63,118	960	1,180	220	60.59	74.48	13.89	70%
Tulare	156,232	960	1,100	140	149.98	171.86	21.87	44%
Total	1,216,224	1,070	1,215	145	1,301.36	1,477.71	176.35	48%

[a] During 1979-84 only two USDA Acala varieties from the Shafter Station were planted in the SJV, Acalas SJ-2 and SJ-5.

[b] During 1985-89 multiple Acala varieties from several private companies were planted in the SJV.

Table 4

Models of Average Cotton Yields for Six Counties, 1960-1991

County	Constant	Trend	Dummies	R^2	Durbin-Watson
Fresno	1,015.60[a] (18.12)[b]	-0.19 (0.05)	290.82[a] (3.46)	0.42	1.57
Kern	1,186.30[a] (19.81)	-6.49 (1.02)	222.44[a] (2.48)	0.12	1.81
Kings	942.94[a] (17.70)	0.35 (0.10)	133.98 (1.68)	0.12	1.63
Madera	796.15[a] (17.80)	1.21 (0.40)	258.57[a] (3.80)	0.52	1.25
Merced	852.63[a] (16.42)	1.63 (0.47)	277.29[a] (3.56)	0.49	0.49
Tulare	786.57[a] (15.30)	3.49 (1.00)	177.30[a] (2.31)	0.37	0.37

[a] Denotes that the coefficient is statistically significant for $\alpha = 0.05$

[b] Student t-statistics are presented in parentheses.

Table 5

Estimated Yearly Average Absolute and Percentage Changes in Total Revenues and Producer Surplus for Acala Cotton by County (millions of dollars)

Assumed Elasticity of Demand	Fresno	Kern	Kings	Madera	Merced	Tulare	Total
$\eta_D = -2$	39.29 (8.5%)	10.19 (3.0%)	1.11 (0.4%)	7.75 (18.2%)	9.08 (14.6%)	10.51 (6.8%)	77.93 (6.0%)
$\eta_D = -5$	61.00 (13.3%)	25.54 (7.5%)	13.18 (4.7%)	9.94 (23.3%)	12.17 (19.6%)	17.68 (11.5%)	139.51 (10.8%)
$\eta_D = -10$	68.23 (14.9%)	30.67 (9.0%)	17.20 (6.2%)	10.67 (25.0%)	13.22 (21.3%)	20.07 (13.0%)	160.06 (12.3%)
$\eta_D = -\infty$	75.46 (16.5%)	35.79 (10.5%)	21.22 (7.7%)	11.40 (26.7%)	14.25 (22.9%)	22.45 (14.6%)	180.57 (13.9%)

Note: The figures in parentheses indicate changes in producers' surplus as a percentage of initial total revenues.

Table 6			
Estimated Welfare Effects of the 1978 Amendment (millions of dollars)			
Assumed Elasticity of Demand	Consumer Surplus Change (A)	Producer Surplus Change (B)	Total Surplus Change (A)+(B)
$\eta_D = -2$	96.57	77.93	174.50
$\eta_D = -5$	38.63	139.51	178.14
$\eta_D = -10$	19.32	160.06	179.38
$\eta_D = -\infty$	0.00	180.57	180.57

Table 7				
Estimated Average Yields by County for 1979-84 and 1985-91 (pounds per acre)				
County	Acreage Planted to the Original Acala Varieties		Acreage Planted to the New Acala Varieties	
	(A) 1979-84	(B) 1985-91	(C) 1979-84	(D) 1985-91
Fresno	1,247	1,247	1,080	1,247
Kern	1,215	1,215	610	1,215
Kings	1,120	1,120	812	1,120
Madera	1,090	1,090	648	1,090
Merced	1,155	1,155	877	1,191
Tulare	1,065	1,065	827	1,145

Table 8

Distribution of Welfare Effects
Among Acala Cotton Producers

County	Original Variety Producer Surplus Change (millions of dollars)		New Variety Producer Surplus Change (millions of dollars)		Total Producer Surplus Change (millions of dollars)	
	$\eta_D = -2$	$\eta_D = -10$	$\eta_D = -2$	$\eta_D = -10$	$\eta_D = -2$	$\eta_D = -10$
Fresno	-15.06	-3.01	54.10	70.93	39.04	67.92
Kern	-20.74	-4.15	30.91	34.80	10.17	30.65
Kings	-14.88	-2.98	15.99	20.17	1.11	17.19
Madera	-1.76	-0.35	9.49	11.01	7.73	10.66
Merced	-1.52	-0.30	10.59	13.52	9.07	13.22
Tulare	-6.48	-1.30	16.97	21.34	10.49	20.04
Total	-60.44	-12.09	138.05	171.74	77.61	159.65

Table 9: Nominal Annual Average Spot Cotton Prices in Memphis (MEM), Phoenix (PHX), and Fresno (FRE) for Two Cotton Classes (41-34 and 31-35), 1957-1990

Year	MEM.41-34	MEM.31-35	PHX.41-34	PHX.31-35	FRE.41-34	FRE.41-34
1957	32.23	36.37	32.69	34.87	31.90	34.89
1958	32.54	37.28	32.28	35.45	32.63	35.96
1959	33.77	37.39	32.16	35.64	32.56	36.00
1960	30.87	34.13	30.31	33.14	31.06	33.16
1961	30.41	33.15	30.10	32.50	31.17	33.26
1962	33.74	32.51	32.40	34.28	32.48	35.08
1963	33.49	35.70	31.72	33.87	34.11	35.93
1964	33.00	35.16	32.21	34.56	35.45	37.84
1965	30.78	33.39	29.65	31.91	35.04	36.45
1966	29.72	32.77	28.87	30.79	32.85	34.94
1967	22.75	25.73	22.67	24.57	31.38	32.95
1968	30.06	33.06	27.95	29.78	33.76	35.17
1969	24.62	28.41	23.72	25.87	25.50	28.45
1970	23.34	25.90	22.35	24.86	24.14	26.16
1971	24.20	26.00	23.92	25.12	26.29	27.44
1972	33.19	34.35	32.58	33.34	34.17	32.15
1973	35.68	38.29	35.73	38.01	38.45	40.30
1974	68.01	70.89	66.26	68.29	71.54	73.83
1975	41.86	44.15	40.52	44.25	42.53	45.61
1976	58.48	59.92	57.20	58.23	58.72	59.99
1977	71.28	72.38	70.12	72.07	71.93	74.50
1978	52.75	54.15	52.71	56.03	56.67	58.59
1979	61.68	63.47	61.98	65.62	67.66	71.89
1980	72.55	74.20	71.98	75.26	73.76	77.04
1981	83.81	85.25	81.70	82.75	82.80	85.65
1982	61.00	62.73	59.93	65.51	61.02	64.78
1983	63.33	65.04	63.17	67.10	64.49	70.61
1984	73.25	75.14	74.13	78.04	77.02	81.08
1985	60.73	62.17	61.57	63.11	61.29	64.19
1986	60.40	61.21	59.84	62.02	60.35	63.48
1987	51.70	53.47	55.38	61.56	60.97	63.99
1988	62.45	64.17	65.69	69.31	66.02	73.24
1989	56.71	58.64	59.67	63.11	63.30	67.71
1990	69.51	71.05	71.19	74.02	73.47	77.14
Mean	46.59	46.30	48.72	48.75	48.97	51.45
St. Dev.	18.13	18.51	18.41	17.66	18.88	19.21

Source: Compiled by the authors from USDA, Agricultural Marketing Service, *Cotton Price Statistics*, various issues.

Table 10: Average Cotton Price Premia for Fresno (California) over Phoenix (Arizona) and Memphis (Tennessee), 1957-1990.

Grade	Premium Over	Mean Premium	Standard Deviation	t-statistic	Min.	Max.	No. Pos.
			-- nominal cents per pound --				
41-34	Memphis	2.14	2.62	0.82	-1.26	9.27	29/34
	Phoenix	2.42	2.12	1.14	-0.79	8.71	32/34
31-35	Memphis	2.70	3.31	0.82	-2.20	10.52	29/34
	Phoenix	2.49	2.06	1.21	-1.19	8.38	32/34
			-- percent of Fresno price --				
41-34	Memphis	4.60	6.06	0.76	-3.88	27.50	29/34
	Phoenix	5.66	5.88	0.96	-2.48	27.76	32/34
31-35	Memphis	4.60	6.08	0.76	-6.84	21.91	29/34
	Phoenix	5.24	5.34	0.98	-3.70	25.43	32/34

Source: Compiled by the authors using data from table 9.

Notes: The "t-statistic" is computed as the ratio of the mean premium of the price in Fresno over the corresponding price in Phoenix or Memphis (cents per pound or percent of the Fresno price) divided by the corresponding standard error. For the test of whether the premium is significantly different from zero (i.e., a two-tailed test) the calculated statistic should be compared with $t_{33,\alpha=0.05} = 1.96$ and for the test of whether the premium is significantly positive (i.e., a one-tailed test), it should be compared with $t_{33,\alpha=0.025} = 2.24$.

The "Min." and "Max." refer to the minimum and maximum values recorded in the sample and the "no. positive" refers to the number of cases, in the sample of 34, when the premium was positive.

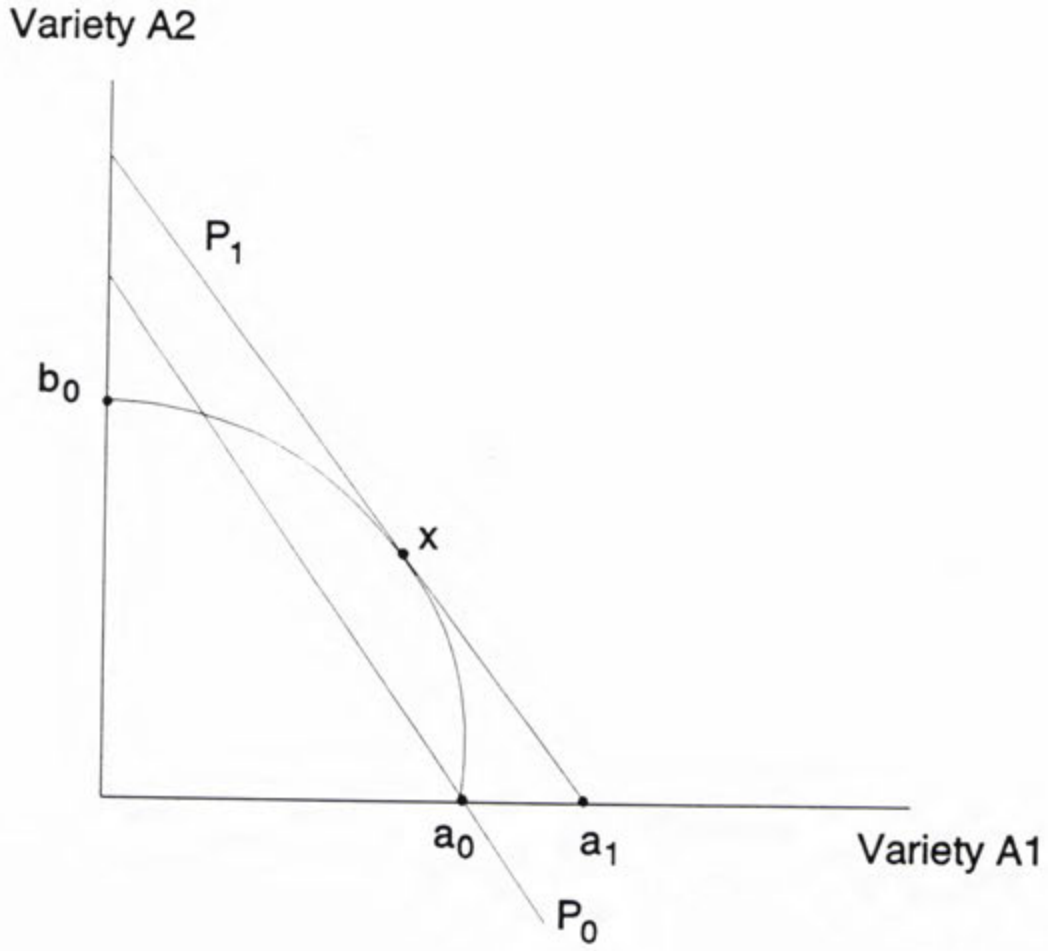

Figure 1

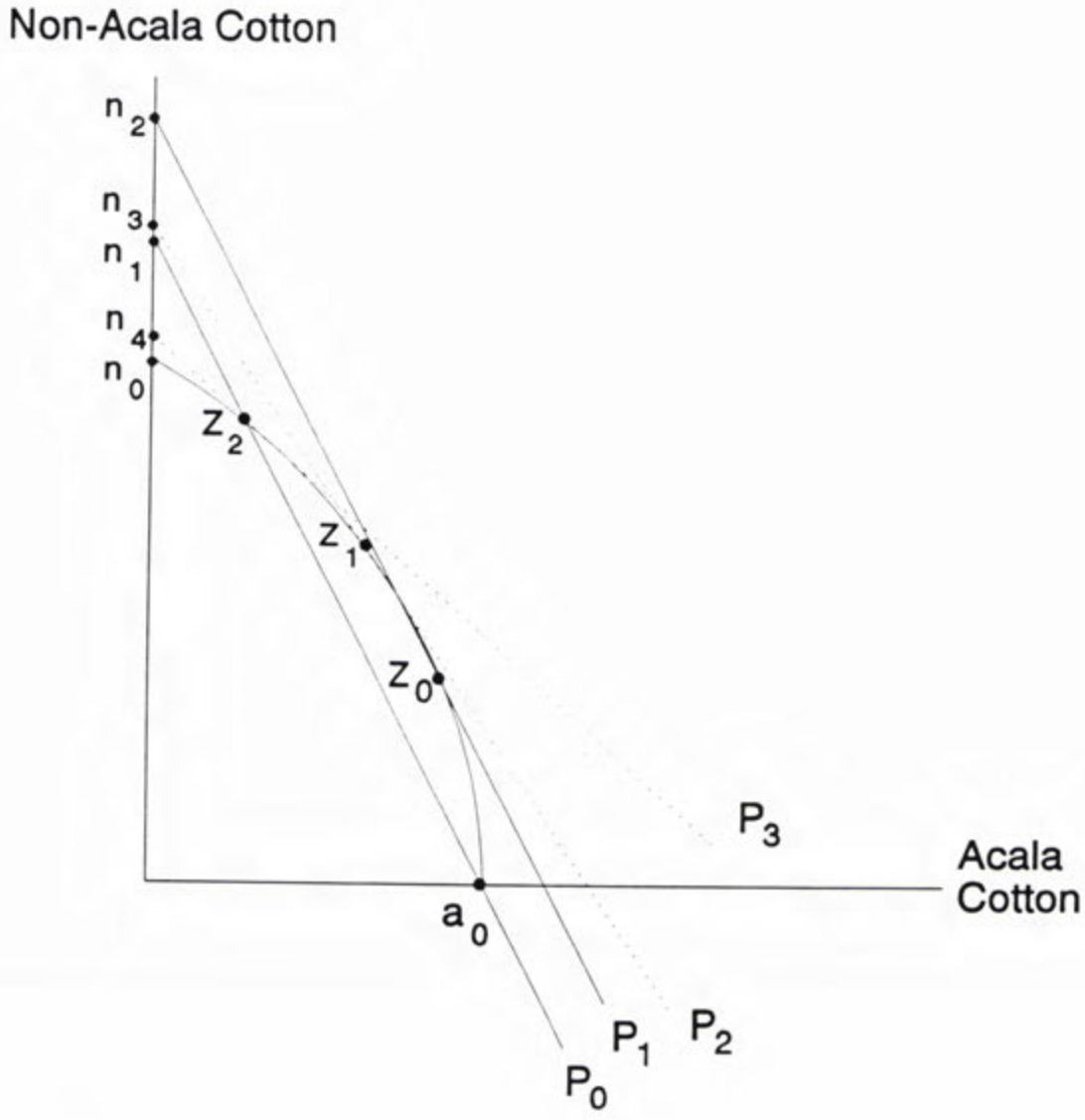
Non-Acala Cotton
n 2
n 3
n 1
n 4
n 0
Z 2
Z 1
Z 0
P 3
Acala Cotton
a 0
P 1
P 2
P 0

Figure 2

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