University of Hawai`i at Mānoa
Department of Economics
Working Paper Series

Saunders Hall 542, 2424 Maile Way,
Honolulu, HI 96822
Phone: (808) 956 -8496
www.economics.hawaii.edu

Working Paper No. 15-07

Who Really Benefits from Agricultural Subsidies? Evidence from Field-level Data

By
Barrett Kirwan
Michael Roberts

June 2015

Who Really Benefits from Agricultural Subsidies? Evidence from Field-level Data

Barrett E. Kirwan and Michael J. Roberts

April 10, 2015

Summary: If agricultural subsidies are largely capitalized into farmland values then expanding support for agriculture may not benefit farmers who rent the land they farm. Suddenly reducing subsidies may be problematic to the extent that land values already embody expectations about future subsidies. Existing evidence on the incidence of subsidies on land values is mixed. Identification is obscured by unobserved or imprecisely measured factors that tend to be correlated with subsidies, especially land quality and time-varying factors like commodity prices and adverse weather events. A problem that has received less attention is the fact that subsides and land quality on rented land may differ from owned land. Since most farms possess both rented and owned acreage, farm-level measures of subsidies, land values and rental rates may bias estimated incidence. Using a new, field-level data set that, for the first time, precisely links subsidies to land parcels, we show that this bias is considerable: Where farm-level estimates suggest an incidence of 20 to 79 cents of the marginal subsidy dollar, field-level estimates from the same farms indicate that landlords capture just 10–25 cents. The size of the farm and the duration of the rental arrangement have substantial effects. Incidence falls by 5–15 cents per acre when doubling total operated acres, and the incidence falls by 0.1–1.2 cents with each additional year of the rental arrangement. Low incidence of subsides on rents combined with the farm-size and duration effects suggest that farmers renting land have monopsony power.

> "The more the inhabitant was obliged to pay for the tax , the less he would be inclined to pay for the ground; so that the final payment of the tax would fall altogether on the owner of the ground."
>
> –Adam Smith, 1776

Introduction

In the twenty-first century, subsidized American farmers have gleaned, on average, $8,824 annually in subsidy payments, making agricultural subsidies one of the largest per-capita transfer programs in the U.S.[1]

But farmers might not fully benefit from modern-subsidy payments, which are decoupled from production, if, as is widely believed by economists and non-economists, decoupled subsidies ultimately are capitalized into land values, benefiting farmland

[1] Authors' calculations from USDA Farm Services Agency administrative data, statistics published by the Social Security Administration, and the House Ways and Means Committee's Green Book (U.S. Congress. U.S. House of Representatives. Committee on Ways and Means 2014).

owners.[2] Farmers in the U.S. own only about 55 percent of subsidized farmland—non-farmer landlords own the remaining 45 percent. If full capitalization holds, almost 43 percent of all farm subsidies end up in the pockets of non-farmers.[3]

To determine the effect of farmland-specific subsidies on farmland values, this paper focuses on the incidence of U.S. farmland-specific agricultural subsidies on farmland cash rental rates.[4] The main novelty of this study is that it is the first to obtain and analyze data that precisely connects subsidy payments to the land being subsidized.

Roberts, Kirwan, and Hopkins (2003) lay out the basic theory of subsidy incidence. The theory distinguishes between coupled and decoupled subsidies. The conditions for coupled payments to be fully reflected in the rental rate are extreme: rental rates reflect the full value of coupled government payments "if the supply curve were perfectly inelastic and prices for inputs besides land did not change." These conditions were first formalized by Floyd (1965) and further developed by Gardner (1987) and Alston and James (2002). The theory for decoupled subsidies is more straightforward. According to Alston (2010), "a pure decoupled transfer should have little (if any) effect on input use or output and, if that transfer is tied to land, it should be reflected in land rents and should accrue entirely to landowners."

Here we focus on Direct Payments in the U.S., which ostensibly are decoupled from production and theoretically should be fully reflected in higher farmland rental rates. Myriad research has shown, however, that a minority of decoupled subsidies are reflected in farmland rental rates. In the U.S. Roberts, Kirwan, and Hopkins (2003), Kirwan (2009), and Hendricks, Janzen, and Dhuyvetter (2012) find an ad-

[2]Hal Varian, in his microeconomics textbook, teaches, "the market price of the rents depends on the generosity of the Federal subsidies.The higher the subsidies, the higher the equilibrium rent the large farmers receive. The benefits from the subsidy program still falls on those who initially own the land, since it is ultimately the value of what the land can earn—either from growing crops or farming the government—that determines its market value" (Varian 2010). The Washington Post echoed that sentiment when it reported, "The farm payments have also altered the landscape and culture of the Farm Belt, pushing up land prices and favoring large, wealthy operators" (Morgan, Gaul, and Cohen 2006). And Robert Reich echoed popular sentiment when he wrote in the Wall Street Journal that, "The lavish farm subsidies contained in the new farm bill won't make the nation more secure. They will only stimulate even more production, inflate land values, and make it more difficult for developing nations to export food to us, perpetuating world poverty" (Reich 2001).

[3]Farmers rarely rent land to other farmers. According to the 1999 Agricultural Economics and Land Ownership Survey (the most recent source of information on landlord characteristics), 94 percent of landlords are retired or employed in non-agricultural industries. The 1996 Agricultural Resource Management Survey (ARMS) provides the only information on the percent of *subsidized* acres that are rented: 45 percent. If the share of subsidized, rented land owned by non-farmers is the same as all rented farmland (94 percent) then 42.5 percent of subsidized land is owned by a non-farmer.

[4]Farmland-specific agricultural subsidies are typically paid to a fixed number of qualifying acres—in the U.S., these are called *base* acres. Some examples of farmland-specific subsidies are Direct Payments and Counter-Cyclical Payments under the 2002 and 2008 farm bills and Price Loss Coverage under the 2014 farm bill.

ditional direct-payment dollar per acre causes rental rates to increase by 12–37 cents. Similar results have been found in the E.U. Breustedt and Habermann (2011), Ciaian and Kancs (2012), Kilian et al. (2012), and Michalek, Ciaian, and Kancs (2014) find rental rate incidence in the range of 6–38 percent in various E.U. countries.

The vast divergence of the empirical results from the theoretical predictions suggests either so-called decoupled payments are not actually decoupled from production or the theory's simplifying assumptions fail to hold in reality. Bhaskar and Beghin (2009) and Weber and Key (2012) review the literature on the production effects of decoupled subsidies. Four pathways between decoupled subsidies and production effects have been examined: risk mechanisms (cf. Hennessy 1998; Femenia, Gohin, and Carpentier 2010; Serra, Goodwin, and Featherstone 2011), credit constraints (cf. Goodwin and Mishra 2006; Roe, Somwaru, and Diao 2002; Gohin 2006), labor participation (cf. El-Osta, Mishra, and Ahearn 2004; Key and Roberts 2009) and policy expectations (cf. Lagerkvist 2005; Coble, Miller, and Hudson 2008). The evidence reveals that although decoupled payments appear to affect production, the effects are small. Using credibly exogenous variation in decoupled payments due to the 2002 farm bill, Weber and Key (2012) examine the cumulative effects through all four channels and fail to reject the null hypothesis that decoupled payments do not affect production.

In this paper, we estimate the incidence of agricultural subsidies on land rents using a new nationally representative data set of field-level rental rates and subsidies, which contrasts with well-identified estimates of agricultural subsidy incidence that typically rely on farm-level data. Michalek, Ciaian, and Kancs (2014) employ four consecutive years (2004-2007) of farm-level data from the European Commission's Farm Accountancy Data Network (FADN), and find a six to ten-percent incidence rate of the European Union's Single Payment System. Ciaian and Kancs (2012) use a two-year panel (2004-2005) to examine the incidence of European Union Area Payments in new member countries and find ten-percent incidence.

In contrast, no nationally representative data in the U.S. follows the same farm or field over time. Hendricks, Janzen, and Dhuyvetter (2012) employ annual panel data on Kansas farmers from 1990-2008 and find a 38-percent incidence. Kirwan (2009) creates a nationally representative panel of U.S. farms from the micro-files of the Census of Agriculture and finds a 21-percent incidence. The Census of Agriculture, however, only occurs every five years, so the sample is necessarily limited to farms that neither entered nor exited during the intervening years, which excludes about 25 percent of the farms in each census.

The only annual, farm and field-level, nationally representative data available in the U.S. come from the Agricultural Resource Management Survey (ARMS). The ARMS sampling procedure, however, is explicitly designed to prevent farms from being surveyed in multiple years (Perry, Burt, and Iwig 1993). Even with this limitation, ARMS is a widely used dataset. To capitalize on the strength of ARMS, we worked directly with the U.S. Department of Agriculture (USDA) to add questions to the 2006 and 2007 ARMS to elicit the expected subsidy, the rental rate, and the underlying productivity of specific plots of land growing soybeans, rice, or cotton across the U.S. This paper works to use these nationally representative, explicitly cross-sectional, *field-level* data in a way that reduces bias and accurately estimates subsidy incidence.

The primary concern with using cross-sectional data to estimate subsidy incidence is the difficulty of accounting for land productivity, which is commonly unobserved. Unobserved land productivity, however, confounds the estimated relationship between subsidies and the rental rate because, as we explain below, both directly depend on the land's productivity.

The problems of not accounting for land productivity can be seen in the approaches taken by Goodwin, Mishra, and Ortalo-Magné (2011) and Patton et al. (2008). Goodwin, Mishra, and Ortalo-Magné (2011) employ multiple cross sections from ARMS Phase III to estimate the subsidy incidence on rental rates, but they do not account for land productivity. Patton et al. (2008) employ farm-level panel data from 1994-2002 in Northern Ireland, but decoupled farmland payments—Less-Favored Land Payments—aren't introduced until 2001. By treating these payments as zero until 2001, and by taking first-differences to account for unobserved heterogeneity, they include the *level* of the 2001 subsidy in their analysis and effectively undo the benefits of having panel data. Among the burgeoning literature on subsidy incidence the findings from these studies stand apart. Patton et al. (2008) find an incidence of 1.2, and Goodwin, Mishra, and Ortalo-Magné (2011) find 0.73. Both estimates are substantially larger than the findings cited above. But since we know subsidy rates derive from land productivity, these estimates have an unknown degree of upward bias.

We deal with this problem using field-level data. ARMS collects practices and underlying productivity, which allows us to directly control for this confounding characteristic. Once we control for field productivity, we estimate a subsidy incidence of 0.137 for soybeans, 0.103 for rice, and 0.249 for cotton. In other words, landlords extract 13.7 cents of the marginal subsidy dollar from soybean fields, 10.3 cents of the marginal subsidy dollar on rice fields, and 24.9 cents of the marginal subsidy dollar on cotton fields. These results fall in line with those found in the U.S. and the E.U., even though they are obtained with different data and a different identification strategy than those currently in the literature.

We explore the representativeness of these findings by exploring the variation in the incidence estimates over the farm-size distribution and the length of the landlord-tenant relationship. We find the incidence falls by \$0.05–\$0.15 per acre when doubling total operated acres. And the subsidy incidence falls by 0.1–1.2 cents for each additional year of the landlord-tenant relationship. These findings are consistent with tenants who have bargaining power through size and informational advantages.

We develop these arguments further below, but first we explain the institutional setting and provide the relevant details needed to appreciate the identification strategy. Before we elaborate on the sources of identification, we provide more detail about the unique dataset we employ. We then explain our identification strategy and illustrate it by contrasting our estimates with the estimates one would obtain in the absence of our identification strategy. Finally, we use the data to shed light on the reasons for low incidence rates.

The Setting

In this section we explain the institutional details that must be taken into account to obtain unbiased incidence estimates. We first explain the relevant details of the subsidies. Then we provide an overview of the farmland rental market.

U.S. Farmland-Specific Agricultural Subsidies

Although farmers receive support through many mechanisms, we focus our analysis on Direct Payments (DP) and Counter-Cyclical Payments (CCP) because these are farmland-specific subsidies. Direct and Counter-Cyclical Payment policies have their roots in the 1973 farm bill, which was "designed to encourage increased production of basic food and fiber crops" (Youde 1974). This began the reversal of 40 years of supply-control policies. The bill introduced an "income support" program designed to reward farmers by providing a guaranteed income based on their "typical" production of the targeted crops. The '73 farm bill defined the income guarantee as the product of the farmer's acreage allotment for the subsidized crop and the *projected yield* established for the farm. A similar formula exists today. To effectively estimate the incidence of the subsidy, we must understand these two parameters.

Acreage Allotment Throughout the 1950s and 1960s the Secretary of Agriculture used the *acreage allotment* to limit the supply of a crop. Each year the USDA determined a farmer's crop-specific allotment—the number of acres he could plant to a specific crop and still qualify for subsidies. If land was sold (or rented), the seller's (landlord's) allotment was reduced commensurately while the buyer's (renter's) was increased. In that way, the allotment was a characteristic of the land. Since the income support was limited to pre-defined acres and because the right to receive the subsidy payment transferred with the land, the income support was a *de facto* land-specific subsidy. Today acreage allotments are known as "base acres."

Projected/Program Yield The policy rewarded farmers if they were more productive by connecting the subsidy to a farmer's "projected yield." The projected yield—renamed *program payment yield* in the 1977 farm bill—was usually determined by a farmer's average productivity in previous years. Congress began to divorce income-support subsidies from production in the 1985 farm bill, which defined the program yield as an Olympic average of the five previous years' (1981–1985) program yields. After 1985, the program yield was frozen at the value calculated in 1985. Today, subsidies continue to be calculated as a function of the 1985 program yield. Because more productive land commands a higher rental rate *and* receives higher subsidies, the subsidy's effect on the rental rate will be confounded with the land's underlying productivity. To accurately estimate the incidence, it is crucial to disentangle the subsidy effect from the productivity effect.

Decoupled Subsidies Congress' drive to end supply controls, which began in 1973, culminated in the 1996 "Freedom to Farm" bill. Farmers were no longer limited by their base acres; they could plant as much or as little of the subsidized crops without penalty. After 1996, a farmer received direct payments equal to a legislated subsidy rate multiplied by the farm's 1996 crop-specific base acres and the 1985 crop-specific program yield.[5] This had the effect that farms could completely change their crop mix but continue to be subsidized for the crops grown in 1996.

The upshot is that in 2006 and 2007, the years of our analysis, Direct Payments were pre-determined, farmland-specific subsidies, which could directly impact farmers' willingness to pay to rent subsidized land.

The Farmland Rental Market

In the U.S., farmers rent 355 million acres of farmland, an area equal to 38 percent of all farmland and comparable to all the farmland in the Midwest. Table 1 reports statistics on the farmland rental market from the 2002, 2007, and 2012 Censuses of Agriculture. In 2012, farmers paid $21 billion in cash rent, a 58% increase from 2007. This expense accounted for 10.2 percent of total production expenditures by renters. At the same time the number of tenants fell 0.8 percent while their farm sizes increased 3.6 percent. The farmland rental market is considerable in size.

The farmland rental market is also an important market for subsidized land. Data from the 1996 Agricultural Resource Management Survey (ARMS) indicate that 45 percent of *subsidized* acres are rented Table 2 reports owned and rented acres by farmland type. The table reports that only 44.2 percent of farmland is cropland—the only

[5] Direct and Counter-Cyclical Payments were extended to soybeans and other oilseeds in 2002 with the acreage allotment and program yield based on the land's 1998–2001 yields scaled by the ratio of the national-average 1981–1985 yield and the national-average 1998–2001 yield (Direct Payment Yield for Soybeans and Other Oilseeds 2002).

Table 1: Farmland Rental Market Descriptive Statistics

		2002	2007	2012
Number of Renters	Total	719,143	686,437	680,952
Number of Farms (1,000)	Total	2,174	2,197	2,109
Farm size—All Producers (acres)	Mean	435	419	434
Farm size—Renters (acres)	Mean	816	844	849
Acres Rented by Renter	Mean	501	517	529
Proportion of Farm Rented	Mean	63.3%	63.1%	60.7%
Cash Rent Expenditures	Total ($ billion)	11.20	13.27	21.00
	Share of Total	10.0%	6.4%	5.5%
Number of Rented Acres	Total (million)	323	308	355
Proportion of U.S. Farmland Rented		38.4%	38.8%	38.8%

Notes: 2002 and 2007: Authors' calculations from Censuses of Agriculture. 2012: Census of Agriculture, Table 70. Summary by Tenure of Principal Operator and by Operators on Farm: 2012.

type of farmland that is subsidized.[6] The table also reveals that cropland is much more likely to be rented than non-cropland. Of the land eligible to receive subsidies, 51.3 percent is rented, compared to 41.5 percent of farmland overall.[7]

Table 2: Owned and rented acres by farmland type

Farmland Type	Owned		Rented		Total	
	Acres	Percent	Acres	Percent	Acres	Percent
Cropland	207,990	48.72	218,921	51.28	426,911	44.24
Pastureland	260,264	68.57	119,315	31.43	379,579	39.33
All Other	96,371	60.80	62,142	39.20	158,513	16.43
Sum	564,625	58.51	400,378	41.49	965,003	100

Data Source: Agricultural Economic and Land Ownership Survey. Table 74.

Table 3 reports farm characteristics by tenure of the farmer from the 2012 Census of Agriculture. The average farm size for part owners is 922 acres, the average for full tenants is 588 acres, while full owner-operator farm size is just 235 acres on average. Part owners and full tenants are also more profitable on average; both earn $117/acre compared to $74/acre for full owners. Farmers who rent land are also more likely to receive subsidies; 56.8 percent of part owners and 43.4 percent of tenants receive subsidies, but only 31.1 percent of full owners receive subsidies.

[6]It is possible that land formerly cropped but now uncropped could be subsidized. Unfortunately, we are aware of no data quantifying this transition.

[7]Table 2 excludes non-private landlords, e.g. Indian Reservations, because the AELOS does not disaggregate these rented acres by farmland type. Once included, the overall share of farmland acres that are rented rises to 45 percent, as reported in the Introduction.

Table 3: Farm Characteristics by Ownership Status

Item	Total	Full Owners	Part Owners	Tenants
Farms (number)	2,109,303	1,428,351	533,070	147,882
Farms (percent)	100.0	67.7	25.3	7.0
Land in farms (acres)	914,527,657	336,233,189	491,292,824	87,001,644
Average size of farm (acres)	434	235	922	588
Receive government payments (farms)	811,387	444,317	302,875	64,195
Govt payments (1,000 dollars)	8,053,346	2,577,273	4,610,481	865,593
Net cash income (1,000 dollars)	92,281,080	24,932,770	57,142,564	10,205,745
Average Net cash income per farm	43,750	17,456	107,195	69,013
Net cash income per acre	100.91	74.15	116.31	117.31
Share of farms receiving subsidies	0.38	0.31	0.57	0.43

Data Source: Agricultural Economic and Land Ownership Survey. Table 74.

Taken together, these data underscore the importance of subsidized land in the farmland rental market, and highlight the distinction between producers who farm rented land and those who do not.

Data

This paper uses novel, field-level data from the USDA's Agricultural and Resource Management Survey (ARMS). According to the USDA, "ARMS is a nationally representative survey administered using [three] phases—sample screener, field-level, and farm-level phases—targeting about 5,000 fields and 30,000 farms each year" (Morehart 2014b). We employ data from the second phase of the 2006 and 2007 ARMS. This phase is dubbed Phase II—Production Practices and Costs (PPC). The ARMS Phase II questionnaires are "only directed to operations producing the survey year's target crop(s)" (Morehart 2014a). A limited number of crops are targeted each year. In 2006 the target crops were soybeans and rice, and in 2007, apples and cotton were targeted. The analysis consequently employs three Phase II data sets, the set of soybean fields in 2006, the set of rice fields in 2006, and the set of cotton fields in 2007 (apples are unsubsidized).[8] These crops represent three of the eight primary, subsidized crops.[9] To limit the influence of outliers we winsorize the variables at the 99th percentile and

[8]The survey questionnaires are available at the following url: `http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/questionnaires-and-manuals.aspx`

[9]The remaining subsidized crops are barley, corn, oats, sorghum, and wheat. Minor oilseeds also receive Direct Payments.

we drop fields in the highest percentile of subsidies per acre. The soybean-field sample has 586 cash-rented fields in 19 states. The rice-field sample has 152 cash-rented fields in 6 states—primarily California, Texas, and the Mississippi Portal.[10] And the cotton-field sample has 275 cash-rented fields in 11 states. To account for the diverse environments in which these crops are grown we include state fixed effects in the empirical model below.[11]

To collect production practices and costs for the target crop, the ARMS Phase II enumerator randomly chooses only one of the respondent's fields where the target commodity is growing, and the the survey focuses on the costs and production practices on *that field only*. This procedure ensures that a respondent reports on a single target commodity even if they produce more than one of the ARMS-targeted crops on the whole farm.

The advantage of these data for the current analysis is that in 2006 and 2007 we added questions to the ARMS Phase II survey that elicited information on rent paid and subsidy payments received on the randomly chosen field. These data are unique because they link subsidies to the *specific* cash-rented parcels being subsidized.

Importantly, the ARMS Phase II survey obtains production practices and costs for the same field. This allows us to carefully and accurately control for the field's underlying productivity, which is often mis-measured or omitted altogether (see, e.g., Goodwin, Mishra, and Ortalo-Magné 2011). To account for the land's underlying productivity we use the producer's *fertilizer-decision yield goal* as reported in the Fertilizer section of the survey. Rather than an aspiration to be achieved, the fertilizer-decision yield goal is a common parameter used to determine fertilizer application rates. According to the USDA, "recommended fertilizer application rates are often based on the *yield goal* of the producer" (U.S. Department of Agriculture 2006), which is why the question is asked in the Fertilizer section of the survey along with early season field-specific production costs and indicators for crop-rotation pattern.[12] Producers have an incentive to set an accurate yield goal; an overly optimistic goal, for instance, leads to higher costs due to greater fertilizer use, but not higher revenue. The reported

[10] The Mississippi Portal is one of nine "resource regions" defined by the USDA, ERS (U.S. Department of Agriculture, Economic Research Service 2000).

[11] The exact states in each of the datasets can be seen at the following USDA, ERS website: http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/documentation.aspx#Scope.

[12] "Recommended fertilizer application rates are often based on the yield goal of the producer. Estimates of producer yield goal compared with actual yield gives some indication of how realistic producer's expectations are. It also gives an indication of how unexpected conditions, such as droughts or pest infestations, may have affected yields. Furthermore, assessing the impact of adopting different nutrient practices requires information on the producer's pre-season expected yield or yield goal which can be much different from actual yield." From 2006 Agricultural Resource Management Survey (ARMS) Phase II – Field Crop Chemical Usage and Production Practices Interviewer's Manual

yield goal, therefore, provides an accurate reflection of the field's underlying productivity.[13] Early season seed, fertilizer, and chemical costs reveal another dimension of soil fertility; more fertile fields can be farmed more intensively with lower fertilizer expenses. Information on historical rotations also serves as a powerful control for land quality and production practices that influence rental rates.

In the analysis below we contrast the field-level analysis with results obtained by analyzing farm-level data from the farms associated with each field. To accomplish this, we merge the field-level data with data from the ARMS Phase III—Farm Business and Farm Household Information. Each of the Phase II respondents is asked to complete an expanded Phase III survey, which collects detailed farm and household-level information. Because many Phase II respondents fail to complete the Phase III survey, our sample sizes fall to 441 soybean farms in 19 states, 83 rice farms in 5 states, and 215 cotton farms in 11 states when we combine data sets.

Table 4 contains summary statistics for the soybean, rice, and cotton fields in our dataset, and table 5 reports summary statistics for the corresponding farms. For both tables columns 2 and 3 report the means and standard deviations, respectively, for fields/farms in the soybean dataset. Columns 4 and 5 report means and standard deviations for rice fields/farms, and columns 6 and 7 report the means and standard deviations for cotton fields/farms.

The relevant rental rate for the analysis is the field-specific cash rental rate. The first row of each table reports the cash rental rate at each level of aggregation. In table 5 the reported farm-average cash rental rate is constructed by dividing total rent expenditures by total rented land. Across all three crops the farm-average cash rental rate is lower than the field cash rental rate, although the difference is only statistically significant for soybeans (p=0.001). Since only cropland is subsidized, the farm-average rental rate will be too low for farms that also rent less-valuable, unsubsidized pasture and rangeland. And it will be too low for farms that have crop-share agreements in addition to cash leases. We discuss the influence this has on the incidence estimates in the Measurement Error section below.

The second row of each table reports direct payments per acre, which are greater at the field level than the farm level for soybeans, but not for cotton and rice. For soybeans, the average field-level subsidy is $1.22 greater than the average farm-level subsidy. The rice field-level subsidy is $14.56 less than the average farm-level subsidy, and for cotton the difference is $12.10.

[13]The accuracy of the yield goal can be seen by regressing realized yield on yield goal. This analysis results in the following intercepts and slopes (respectively): -4.06 & 1.03 (soybeans), -152.89 & 1.01 (cotton), and 25.14 & 0.61 (rice). The slope coefficient of 1 for soybeans and cotton show the yield goal is an extremely good predictor of actual yield, although the negative intercepts suggests slight optimism in the yield goal. The rice coefficient, 0.61, shows a high, but less than perfect, relationship between yield goal and realized yield.

Table 4 reports statistics on several field characteristics that influence the amount a renter would be willing to pay to rent the land. The cost of seed, fertilizer, and chemicals measure the operating cost of the field. A field's environmental sensitivity has been found to be correlated with its productivity (Claassen, Lubowski, and Roberts 2005), so we capture these effects with variables indicating whether the field is highly erodible and if it's in a conservation program. Expected returns of other crops in the crop rotation also matter. If these unobserved crop yields respond to land attributes in a way that is correlated with Direct Payments, even after accounting for current crop yield and field operating costs, then the incidence estimate may be too large. Although yields of rotated crops are unavailable, we account for this somewhat with variables indicating the crops being rotated with the target crops.

The financial variables listed in table 5 are whole-farm gross revenues, whole-farm non-land expenses, net returns, assets and debt. From these summary statistics we learn that mean rice-farm revenue per acre ($658.22) is about 84 percent greater than mean soybean-farm revenue ($357.05); mean cotton-farm revenue ($569.35) is about 56 percent greater than mean soybean-farm revenue. Both mean rice and cotton non-land expenses are about 60 percent greater than soybean-farms'. In contrast net returns for rice farms ($149.95) in 2006 was nearly three times that of soybean farms ($53.04), while cotton farms ($124.22) in 2007 received about two and a half times higher net returns than soybean farms did in 2006.

Table 5 reports that rice and cotton farmers operate twice as many acres as soybean farmers—1,634 and 1,682, respectively, versus 804—although rice farmers own just 25-percent more acres (257) than soybean farmers (199), and cotton farmers own just 50-percent more (298). The table shows that farmers' demographic characteristics are similar across farm types. Finally, the table reports statistics on the type of crop-rotation employed on the surveyed fields.

Table 4: Summary Statistics—Field Level

	Soybeans (N=586)		Rice (N=150)		Cotton (N=275)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Cash rental rate	86.75	40.19	114.45	52.93	70.88	42.31
Direct payment (/acre)	15.43	23.45	48.37	50.08	15.78	17.59
Field size (acres)	49.72	49.70	72.04	48.34	44.54	45.74
Yield goal	46.87	9.12	78.83	12.56	988.52	239.73
Expect a counter-cyclical payment	0.40	0.49	0.39	0.49	0.72	0.45
Total Seed Cost	33.75	9.67	31.04	24.60	66.65	27.69
Total Fertilizer Cost	17.93	19.63	69.84	44.94	90.45	41.94
Total Chemicals Cost	14.89	9.44	61.89	43.35	82.22	43.79
Irrigated	0.05	0.22	–	–	0.24	0.43
Classified as highly erodible	0.17	0.37	0.01	0.04	0.05	0.21
In a conservation program	0.09	0.29	0.12	0.33	0.06	0.24
Corn-soy rotation	0.77	0.42	–	–	–	–
Soy-soy rotation	0.13	0.34	–	–	–	–
Rice-rice rotation	–	–	0.42	0.49	–	–
Rice-soy rotation	–	–	0.40	0.49	–	–
Rice-idle rotation	–	–	0.12	0.33	–	–
Cotton-cotton rotation	–	–	–	–	0.50	0.50
Cotton-peanuts rotation	–	–	–	–	0.14	0.35
Cotton-corn rotation	–	–	–	–	0.09	0.28
Cotton-soy rotation	–	–	–	–	0.08	0.28
Cotton-wheat rotation	–	–	–	–	0.04	0.20

Source: Agricultural Resource Management Survey, Production Practices and Costs (Phase II): Soybeans (2006), Rice (2006), Cotton (2007). Excludes observations in the top percentile of the per-acre subsidy distribution.

The Challenge of Identification

The literature grapples with three sources of bias: non-random measurement error in the dependent variable, measurement error in the expected subsidy measure, and omitted-variable bias (e.g., see Kirwan 2009). We attempt to address all three problems with our unique dataset.

Measurement Error

A benefit of using field-level data is the ability to accurately measure the rental rate. Studies using farm-level data have calculated the farm-average rental rate by dividing the farm's total rental expenditure by its total acres rented. When farms have both cash and crop-share rental agreements, this approach results in a rental rate that is

Table 5: Summary Statistics—Farm Level

	Soybeans (N=441)		Rice (N=100)		Cotton (N=215)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farm-average cash rental rate	77.82	40.39	103.08	75.88	63.99	59.85
Farm-average direct payment (/acre)	14.21	10.63	62.93	62.62	27.88	20.34
Target-crop yield	44.55	11.48	73.08	11.19	789.93	348.09
Total acres operated	803.82	934.72	1,634.49	1,673.98	1,681.73	1,886.46
Total cropland	715.33	848.37	1,425.56	1,534.25	1,362.63	1,320.31
Total acres owned	198.80	309.20	256.81	451.60	297.88	415.59
Proportion of Acres Cash Rented	0.69	0.29	0.73	0.30	0.70	0.29
CCP per Acre	9.08	9.18	14.84	34.39	21.56	17.79
Loan Deficiency Payments (total)	1,513.13	4,916.71	1,291.20	7,511.96	2,173.50	12,146.93
Whole-farm gross revenue (/acre)	357.05	215.38	658.22	486.63	569.35	414.97
Crops' Share of Revenue	0.77	0.34	0.97	0.16	0.93	0.16
Whole-farm non-land expenses (/acre)	247.45	155.63	409.78	190.38	395.84	277.68
Net Returns (/acre)	53.04	136.89	149.95	305.06	124.22	217.47
Assets ($1,000)	1,108	1,278	1,241	1,284	1,964	2,271
Debt ($1,000)	194	298	259	437	210	429
Operator's age	50.15	11.59	54.49	11.54	51.96	11.82
Operator's gender	0.98	0.12	0.99	0.11	0.99	0.12
Operator has high school diploma or less	0.34	0.47	0.39	0.49	0.47	0.50
Operator has some college	0.38	0.49	0.26	0.44	0.26	0.44
Operator has a college degree	0.23	0.42	0.34	0.47	0.22	0.41
Operator's primary occupation is farming	0.73	0.44	0.97	0.17	0.88	0.33
Operator is retired	0.03	0.16	0.02	0.13	0.02	0.14

Data Source: Agricultural Resource Management Survey, Cost and Returns Report (Phase III): Soybeans (2006), Rice (2006), Cotton (2007). Excludes observations in the top percentile of the per-acre subsidy distribution.

lower than the farm-average cash rental rate—the measurement error is systematically negative for these farms. If farmers are more (less) likely to use cash contracts with higher subsidies, the measurement error will be positively (negatively) correlated with the subsidy, leading to an over (under) estimate of the subsidy incidence. Qiu, Goodwin, and Gervais (2011) find that as farmland-specific subsidies increase, farms switch from share contracts to cash contracts, which would result in positively-biased incidence estimates. Field-level cash rental rates avoid this type of measurement error-induced bias.

The field-level analysis, combined with novel questions placed on ARMS Phase II, also resolves a measurement error problem on the subsidy rate, one that could create a different kind of bias. Subsidy rates are typically elicited at the farm scale, not the field scale. Since many farms, particularly large ones, usually own a portion of their land and rent another portion, the subsidy rate for the farm likely differs from that of rented fields. Furthermore, the difference between field- and farm-level subsidy rates may well be systematic. For example, large farms with market power may successfully seek out land to rent that has particularly high subsidies relative to land productivity. Moreover, farms with greater market power may well have lower incidence. If so, measurement error would be systematically correlated with heterogeneous effects. This kind of non-random measurement error could cause considerable unknown bias, especially when combined with measurement errors in rental rates described above.

Note, in particular, that this kind of measurement error is quite unlike classical measurement error, in which the observed explanatory variable has a greater variance (signal plus random noise) than the true explanatory variable. Classical measurement error is well known to bias coefficients toward zero, since the covariance of the observed variable is expected to be correct while variance is too large. In the present case, even if the error were random and not associated with latent heterogeneous effects, one would obtain bias opposite from the classical case, ie., away from zero. The reason is that farm-level subsidies necessarily encompass more acres of land than just rented acres. Thus, even if within-farm variation in subsidy rates were purely random and not associated with quality, tenancy or incidence, the variance of the observed farm-level subsidy rate would be *less* than the variance of the true rate. Thus, even random within-farm errors would bias incidence too large, not too small.

Another form of measurement error identified in the literature is measurement error in the expected subsidy measure, dubbed "expectation error" (see, e.g., Roberts, Kirwan, and Hopkins 2003). Direct Payments were known with certainty beforehand and were not directly subject to expectation error. But Direct Payments are closely related to Counter-Cyclical Payments because they both are proportional to the farm's program yield and paid only on base acres, and the CCP is subject to expectation error because it depended on how far below a fixed price—the Target Price—the market price fell. The influence this might have on the incidence estimate depends on the relationship between the DP and the expected price. Although we lacked the resources to collect the expected price distribution from every surveyed farmer, we did ask whether the farmer expected to receive a CCP. On average, farmers who expected to receive a CCP received a 22% higher-than-average DP, which suggests a positive relationship between the DP and the expected CCP. In other words, not accounting for the expected CCP would lead to upward bias of the incidence estimate.

Although we don't know the farmer's expected price, we do know whether they expected the price to be less than the Target Price. We use this measure, albeit crude, to control for the effect of expected subsidies on rental rates. But since we don't know the size of the expected CCP, the coefficient on this variable will be attenuated due to classical measurement error. This is an important control, however, because if Direct Payments and expected CCP payments are positively correlated, the coefficient on Direct Payments would pick up some of the effect of expected CCP payments. Including this indicator variable in the analysis below ameliorates some of this upward bias to the incidence estimate.

Omitted-Variable Bias

Failure to account for the land's underlying productivity is an important source of bias in incidence estimates. The productivity of the land obscures the effect of subsidies on farmland rental rates because both the subsidies and the rental rate depend on the land's productivity. More productive land commands a higher rental rate; for example, fertile soil that retains moisture requires fewer inputs, which increases the returns to the land and, hence, increases farmers' willingness to pay to farm the land. And since 1973, the land's historical productivity has determined farmland-specific subsidies. The farmland's productivity, therefore, is a fundamental reason that land commanding a high rental rate also receives high subsidies. Incidence estimates that fail to account for the underlying farmland productivity will be too large because they suffer from positive omitted-variable bias.

The econometrician rarely observes the underlying productivity of the farmland. Recent attempts to estimate the effect of subsidies on farmland values have tackled the problem with panel data, using fixed effects to account for the farmland's presumably fixed underlying productivity (Ciaian and Kancs 2012; Hendricks, Janzen, and Dhuyvetter 2012; Michalek, Ciaian, and Kancs 2014). In this case, identification of incidence comes from changes over time in subsidy rates, or because farms rent more, less or different land over time. In the former case, some have argued that it may take time for changes in subsidies to be reflected in land rents (Alston 2010). In the latter case, even fixed effects may not fully account for land productivity, since land associated with the farm changes over time.

In the analysis below, we address omitted-variable bias by capitalizing on one of the strengths of the data we employ: the data contain the farmer's estimate of the field's underlying productivity. The farmer has much more information about the field's characteristics than does the econometrician, and are thus better equipped to accurately estimate the field's underlying productivity. And while farmers may be optimistic, or otherwise make systematic assessment errors, we see little reason why farmers' systematic errors ought to be associated with productivity or subsidy rates.

Empirical Strategy

The model we use to estimate the incidence of agricultural subsidies on farmland rental rates is

$$Rent_i = \alpha + \gamma Subsidy_i + \beta X_i + State_j + \varepsilon_i, \tag{1}$$

where $Rent_i$ is the rental rate for field or farm i, depending on the level of analysis. The per-acre Direct Payment subsidy is $Subsidy_i$. X_i is a vector of field-level observable covariates. Differences in production practices and state policy regimes are accounted for by $State_j$, a fixed effect for state j.

Since rental rates and direct payments are both a function of the field's productivity, simply regressing $Rent_i$ on $Subsidy_i$ would yield an upwardly biased estimate; $\hat{\gamma}$ would capture both the incidence and the positive relationship between $Rent_i$ and $Subsidy_i$ due to field productivity. To overcome this difficulty and identify the subsidy incidence parameter in equation (1), we attempt to exploit an element of randomness in how U.S. farmland subsidies are determined. U.S. farmland subsidies are based on an acre's historical, *realized* productivity (see section). Because it is based on *actual* production, the program yield is partly determined by the land's underlying productivity, and partly determined by exogenous, idiosyncratic shocks (e.g., weather and pests) during the reference period. This random variation is a key component of the variation needed to identify the subsidy incidence.

To isolate the random component of the program yield, we control for the land's inherent productivity with the fertilizer-decision yield goal as reported in the Fertilizer section of ARMS, with field-specific operating costs, and by indicating the crop rotation. Armed with this information, we explicitly control for the fundamental characteristic that confounds the incidence analysis, namely each field's inherent productivity. The remaining cross-sectional variation in the subsidy, after we have "partialled out" the underlying productivity, is the random variation outlined above. We use the random component of subsidy variation to determine the causal effect of subsidies on farmland rental rates.

Results

Field-level Rental Rate Incidence

We report primary findings for soybean, rice, and cotton fields in tables 6, 7, and 8, respectively. Each table reports estimates from four different specifications. The first column reports the result of a simple bivariate OLS regression between the cash rental rate and per-acre Direct Payments. The second column adds the yield goal as a control variable, and the third column adds the remaining covariates—whether the respondent expected to receive counter-cyclical payments; seed, fertilizer, and chemical costs; dummy variables for reported crop rotations; whether the field is classified as highly erodible; and whether it is in a conservation program. Finally, the fourth column adds state fixed effects to the specification from column 3—this is our preferred specification.

In first column of the tables, we see that before controlling for any field characteristics, the field level incidence estimate is low. For soybeans, column 1 reports an incidence of 0.296; in other words, rental rates increase by 29.6 cents with the marginal subsidy dollar. The estimate is an insignificant 0.108 for rice and a statistically significant 0.471 for cotton.

Adding the yield goal reduces the point estimate across all three crops. As we had suspected, the positive correlation between rental rates and direct payments is driven in part by the land's underlying productivity. Controlling for the yield goal reduces the incidence estimate from 0.296 to an insignificant 0.104 for soybeans, from 0.108 to 0.082 for rice, and from 0.471 to 0.373 for cotton. The yield goal alone accounts for a substantial share of the variation in rental rates. The point estimate on the yield goal is strongly significant for all three crops, and the R^2 increases substantially between the Bivariate and Yield Goal specifications for soybeans and cotton and somewhat for rice.

Column 3 shows the importance of further adding covariates; the incidence estimate for all three crops is affected. The model's explanatory power continues to rise; each table reports an R^2 just greater than 0.4.

Column 4 reports the incidence and covariate estimates after using a state fixed effect to account for state-level characteristics, such as policies and/or large weather shocks that affect all farmers in the state. The tables report that adding one more dollar of direct payments per acre increases a soybean-field rental rate by 14.2 cents, rice-field rental rates increase by 11.4 cents, and the rental rate for cotton fields increases by 21.6 cents. These estimates are in line with what others have estimated, and they bolster the argument that farmland rental markets do not operate the way basic models of a competitive market would predict.

Table 6: The Incidence of Field-level Subsidies on Field-level Rental Rates: Soybeans

Dependent Variable	Cash Rental Rate			
	Bivariate	Yield Goal	Controls	State FE
Direct Payments	0.296**	0.104	0.142	0.142
	(0.149)	(0.114)	(0.095)	(0.086)
Yield Goal		2.342***	2.080***	1.179***
		(0.185)	(0.205)	(0.183)
CCP Expected			3.095	3.225
			(3.013)	(2.364)
Total Seed Cost			-0.433***	-0.219**
			(0.158)	(0.107)
Total Fertilizer Cost			-0.032	0.025
			(0.098)	(0.076)
Total Chemicals Cost			-0.455***	-0.091
			(0.138)	(0.095)
Corn-Soy Rotation			15.130***	6.085
			(4.458)	(3.809)
Soy-Soy Rotation			2.499	3.915
			(4.070)	(3.830)
Proportion Irrigated			5.554	18.089**
			(9.307)	(8.775)
Highly Erodible			6.598	-1.786
			(4.888)	(4.110)
In Conservation Pgm			-0.582	-0.958
			(4.006)	(3.959)
Observations	586	586	586	586
R^2	0.015	0.345	0.410	0.612
State FE	No	No	No	Yes

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard error (in parentheses) clustered by crop reporting district. See the footnote in table 4 for data source.

Aggregation and Measurement Error Biases

An advantage to using field-level data in the analysis is the ability to explore the bias induced when field-level data is aggregated to the farm level or higher. A general concern when using aggregated data (farm- or county-level) is whether the parameter estimates from the aggregated data accurately represent the fundamental, structural parameters that characterize individual behavior (see Blundell and Stoker (2005) for a general treatment of this problem). In the current problem, these aggregation issues are exacerbated by the subsidy-rate measurement error described above, where farm-level subsidy rates may not reflect subsidy rates on rented fields. When it comes to agricultural subsidy incidence, the primary unit of analysis is the field-level tenant-

Table 7: The Incidence of Field-level Subsidies on Field-level Rental Rates: Rice

Dependent Variable:	Cash Rental Rate			
	Bivariate	Yield Goal	Controls	State FE
Direct Payments	0.108	0.082	0.103*	0.114*
	(0.086)	(0.082)	(0.056)	(0.060)
Yield Goal		0.888*	0.394	0.389***
		(0.445)	(0.279)	(0.140)
CCP Expected			8.967	12.747
			(9.388)	(7.677)
Total Seed Cost			0.046	0.145
			(0.206)	(0.123)
Total Fertilizer Cost			-0.203**	-0.051
			(0.085)	(0.069)
Total Chemicals Cost			0.116	0.046
			(0.073)	(0.059)
First Crop			-10.330	-17.165
			(13.174)	(10.350)
Rice-Rice Rotation			36.539***	19.030*
			(12.149)	(10.269)
Idle-Rice Rotation			-32.897***	15.352
			(10.318)	(9.771)
In Conservation Pgm			10.576	2.027
			(9.045)	(6.962)
Open Discharge Irrigation			-17.340	-20.502
			(22.435)	(12.672)
Portal System Irrigation			-1.706	-13.488
			(24.691)	(11.959)
Poly Pipe Irrigation			-32.254	-24.160
			(24.313)	(15.092)
Observations	152	152	152	152
R^2	0.015	0.065	0.398	0.655
State FE	No	No	No	Yes

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard error (in parentheses) clustered by crop reporting district. See the footnote in table 4 for data source.

Table 8: The Incidence of Field-level Subsidies on Field-level Rental Rates: Cotton

Dependent Variable	Cash Rental Rate			
	Bivariate	Yield Goal	Controls	State FE
Direct Payments	0.471***	0.373**	0.203*	0.216*
	(0.123)	(0.155)	(0.122)	(0.114)
Yield Goal		0.088***	0.028**	0.007
		(0.014)	(0.013)	(0.010)
CCP Expected			-1.399	2.607
			(5.449)	(5.334)
Chemical Cost per Acre			0.192***	0.084
			(0.059)	(0.061)
Fertilier Cost per Acre			0.092	0.074
			(0.059)	(0.057)
Seed Cost per Acre			-0.028	-0.057
			(0.093)	(0.083)
Cotton-Cotton Rotation			13.418**	12.699
			(5.162)	(10.547)
Cotton-Wheat Rotation			13.753	7.797
			(12.060)	(4.796)
Cotton-Corn Rotation			-1.442	-0.696
			(6.328)	(5.999)
Cotton-Soybeans Rotation			6.062	9.647*
			(6.095)	(5.522)
Proportion Irrigated			47.550***	44.515***
			(9.501)	(10.992)
Highly Erodible			-5.521	-7.933
			(10.150)	(6.846)
In Conservation Pgm			-2.512	8.631
			(7.659)	(7.261)
Observations	275	275	275	275
R^2	0.040	0.262	0.476	0.596
State FE	No	No	No	Yes

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard error (in parentheses) clustered by crop reporting district. See the footnote in table 4 for data source.

landlord contractual agreement, and this study is the first to estimate incidence at this unit of analysis. This level of analysis circumvents both aggregation and measurement error problems.

Table 9: Incidence Estimates for Three Crops at Three Levels of Aggregation

	Field Level	Field-Level Rent & Farm-Average Subsidy	Farm Level
Soybeans	0.003	0.472***	0.841***
	(0.053)	(0.113)	(0.170)
Rice	0.173***	0.201***	0.569**
	(0.048)	(0.081)	(0.251)
Cotton	0.216***	0.135	0.588***
	(0.094)	(0.157)	(0.215)
Cotton—Mississippi Portal	0.099	0.788**	1.012***
	(0.214)	(0.280)	(0.264)

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard errors are in parentheses. All specifications include state fixed effects, yield goal, expected CCP, field characteristics, and operator demographics. Data source: Agricultural Resource Management Survey, Production Practices and Costs (Phase II) and Cost and Returns Report (Phase III): Soybeans (2006), Rice (2006), Cotton (2007).

Table 9 illustrates the magnitude of bias caused by using aggregate data. Column 1 reports the field-level incidence estimates for all three crops using the same model as before, but limited to farms that responded to both ARMS Phase II and Phase III. Column 2 reports the subsidy incidence when the farm-average subsidy is used as a proxy for the field subsidy. Aggregation clearly leads to substantial bias. The field-level incidence estimate for soybeans is 0.142 in the full sample and 0.069 for this subsample. But when using the farm-average subsidy as a proxy, incidence estimate jumps to 0.414, nearly three times the original estimate. The bias is similar for rice. For this subsample the estimate using the aggregate subsidy measure is three times the actual incidence when estimated at the field level. The nationally representative cotton subsample yields a small, statistically insignificant incidence estimate when using farm-average subsidy.

To illustrate the challenges faced by farm-level data in this setting, we regress the farm-average cash rental rate on the farm-average subsidy rate—using the same subsample and covariates as before—and report the incidence estimates in column 3. The upward bias is substantial. The differences between the biased farm-level estimates and the well-identified field-level estimates are 0.838, 0.396, and 0.372 for soybeans, rice and cotton, respectively. In addition to the bias illustrated in column 2, the field-level controls are inadequate to account for farm-wide productivity, resulting in positive omitted variable bias. And the measurement error inherent in the farm-average rental rate exerts positive bias as described in the Measurement Error section above.

Aggregation bias denotes more than just econometric inconsistency. It refers to whether estimates from aggregate data reflect the true micro parameters (Stoker 2008). In the case of "exact aggregation," every field experiences the same incidence, and consistent aggregate estimates represent the true effect—econometrically $\bar{\gamma} = \gamma$. If the incidence effect is heterogeneous, however, an aggregate estimate would not represent the true effect, even if it were consistently estimated, i.e., $\bar{\gamma} \neq \gamma_i$. For example, large farms might experience lower incidence, or incidence may be lower in long-lived tenant-landlord relationships. We investigate incidence heterogeneity next.

Heterogeneous Effects

We consider two potential sources incidence heterogeneity. First, given the predominantly local nature of farmland rental markets, it is plausible that larger farms may have local market power. The second potential source of incidence heterogeneity stems from asymmetric information due to the length of time a farmer has rented a field. Private information about land quality and disposition is likely to increase with tenancy. This is likely to occur because the farmers have a better idea of (a) how they are managing the land, and events that have affected it, including fertilizer applications, crop rotations, buffer strips, erosion events, pest problems, etc; (b) prices of various crops; (c) changes in technology and how well they suit the particular field. In all respects, the tenant farmer is likely to have an increasingly superior understanding of land quality and this understanding is likely to increase the tenant's bargaining position.

We examine these sources of heterogeneity by augmenting the empirical model in equation (1) by including the source of heterogeneity directly and by interacting it with the subsidy as follows:

$$Rent_i = \alpha + \gamma Subsidy_i + \delta FarmsSize_i + \phi Subsidy_i * FarmSize_i + \beta X_i + State_j + \varepsilon_i, \tag{2}$$

$$Rent_i = \alpha + \gamma Subsidy_i + \delta Duration_i + \phi Subsidy_i * Duration_i + \beta X_i + State_j + \varepsilon_i. \tag{3}$$

$FarmSize_i$ in equation (2) is measured as the log of the total number of acres operated, and $Duration_i$ in equation (3) is the number of years the current operator has farmed the cash-rented field. In both models δ captures the main effect on the rental rate and $\phi \times \ln(2)$ captures the change in the incidence from doubling the farm size (equation (2)) or one year longer duration (equation (3)). Total incidence would be calculated as $\gamma + \phi FarmSize$ or $\gamma + \phi Duration$ evaluated at a given level of $FarmSize$ or $Duration$.

Table 10: Heterogeneous Subsidy Incidence

Dependent Variable	Field Cash Rental Rate		
	Soybeans	Rice	Cotton
Direct Payments	0.966**	0.714*	1.785*
	(0.439)	(0.330)	(1.004)
Acres Operated (log)	4.832***	10.409	9.161**
	(1.510)	(6.002)	(4.094)
DP × Farm Size (log acres)	-0.137**	-0.071	-0.203
	(0.068)	(0.042)	(0.138)
Observations	438	83	215
R^2	0.667	0.549	0.593
State FE	Yes	Yes	Yes
Direct Payments	0.378***	0.167***	0.248
	(0.127)	(0.019)	(0.173)
Duration (years)	-0.071	0.338	-0.195
	(0.124)	(0.591)	(0.229)
DP × Duration (years)	-0.012**	-0.003***	-0.001
	(0.005)	(0.001)	(0.008)
Observations	586	152	215
R^2	0.619	0.661	0.592
State FE	Yes	Yes	Yes

Significance levels: * 10 percent, ** 5 percent, *** 1 percent. Standard error (in parentheses) clustered by crop reporting district. Covariates are the same as in the main analysis.

Table 10 reports the coefficients for the main effects and the interactions for the two sources of heterogeneity. The top panel reports the effect of farm size on the incidence. Two things stand out in this analysis. First, the main effect of Direct Payments is substantially larger than without the interaction term. For soybean fields, the coefficient on Direct Payments indicates that the subsidy incidence would be 0.966 on a one-acre farm (which is obviously outside the support of the data). Second, the interaction term is negative for all three crops, although imprecise for rice and cotton. Consider the interpretation of the coefficients in the results for soybean fields. The interaction term indicates that doubling total operated acres reduces the subsidy incidence by roughly 10 cents. At the mean soybean farm size, 803 acres, the incidence would be 0.966 - 0.137*ln(803) = 0.05, and just under 0.15 for a farm half this size. Rice farms appear to have less market power, with estimated incidence of 0.19

for the average farm and 0.24 for a farm half the average size. Cotton farms have the largest farm-size interaction coefficient across the three crops (-0.203), but it also has the largest standard error (0.138) and the largest intercept (1.785). Incidence for the average cotton farm is an estimated 0.28, and 0.42 for a farm half the average size.

The lower panel of table 10 reports the effect of landlord-tenant relationship duration on the subsidy incidence. As with farm size, the interaction terms are all negative and the main subsidy effect is larger than in the primary regressions—for soybeans it nearly doubles to 0.378, and, according to the interaction term, the rental-rate incidence falls by about 1.2 cents for every year of rental duration on soybean fields. In other words, on average, landlords extract about 38 cents of the marginal subsidy dollar from new tenants, but the incidence decreases by 1.2 cents with each additional year of the tenancy. At the median duration (10 years) the incidence is 12 cents (roughly 33 percent) lower than in the first year of the rental arrangement. The results are similar, but smaller, for rice and cotton.

The evidence presented in this section provides insight into the reason for low subsidy incidence. Larger farms experience lower subsidy incidence, potentially because they have market power in the local farmland rental markets. Longer tenant-landlord relationships also result in lower incidence.

Conclusion

In this paper we show that decoupled agricultural subsidies affect farmland rental rates, but the effect is mitigated by tenant monopsony power. We employ unique, field-level data to precisely connect farmland rental rates with decoupled subsidies. The marginal subsidy dollar causes rental rates increase by 14.2 cents on soybean fields, 11.4 cents on rice fields, and 21.6 cents on cotton fields. Notably, when used as a proxy for field-level subsidies, farm-average subsidies overestimate incidence by two to three times.

Larger farms and farms with in-depth knowledge of the land appear leverage their position to reduce the subsidy incidence. Subsidy incidence falls as both farm size and the duration of the tenant-landlord agreement increase. Doubling the farm size decreases the incidence by about 10 cents, and a one-year increase in duration reduces the incidence by 1.2 cents.

This paper improves on previous analysis by using data at the field level to overcome bias caused by aggregation and measurement error. This paper also overcomes omitted-variable bias by explicitly controlling for each field's fundamental productivity. Subsidies are a positive function of the subsidized land's underlying productivity. Hence, failure to account for this productivity results in an upward-biased incidence estimate. We explicitly control for the farmland's underlying productivity by using farmers' self-reported expected productivity of the field along with field-specific costs of production and information on crop rotations. Using field-level data, which is commensurate with the unit of analysis in standard incidence theory, we find that farmland rental rates for subsidized soybean fields increase by 14 cents, subsidized rice-field rental rates increase by 11 cents, and subsidized cotton-field rental rates increase by 22 cents with the marginal subsidy dollar.

Our findings about the incidence of subsides on land rents could have broader implications. Many articles in the popular press, for example, have informally connected subsidies to land values and growth in large farms (Lynch and Bjerga 2013; Mitchell and Koopman 2013). We provide evidence that the subsidy incidence on rental rates declines as farms get larger. This evidence is consistent with evidence that subsidies contribute to farm-size growth and farm consolidation (Key and Roberts 2006). By capturing the majority of the subsidy, tenant farmers effectively pay less rent on subsidized land. Tenants who face a lower rental rate will rent more subsidized land and, consequently, have larger farms. This mechanism is self-reinforcing: the larger the farms, the greater their market power in the local land market, and the greater tenant farmers' incidence of subsidy benefits.

References

Alston, Julian M. 2010. "The Incidence of U.S. Farm Programs." Chap. 5 in *The Economic Impact of Public Support to Agriculture,* edited by V. Eldon Ball, Roberto Fanfani, and Luciano Gutierrez, 81–105. Studies in Productivity and Efficiency. New York, NY: Springer New York.

Alston, Julian M, and Jennifer S James. 2002. "The Incidence of Agricultural Policy." Edited by Bruce L. Gardner and Gordon C. Rausser. *Handbook of Agricultural Economics* 2:1689–1749.

Bhaskar, Arathi, and John C. Beghin. 2009. "How Coupled Are Decoupled Farm Payments? A Review of the Evidence" [in English]. *Journal of Agricultural and Resource Economics* 34 (1): pages.

Blundell, Richard, and Thomas M Stoker. 2005. "Heterogeneity and Aggregation." *Journal of Economic Literature* 43 (2): 347–391.

Breustedt, Gunnar, and Hendrik Habermann. 2011. "The Incidence of EU Per-Hectare Payments on Farmland Rental Rates: A Spatial Econometric Analysis of German Farm-Level Data." *Journal of Agricultural Economics* 62, no. 1 (February): 225–243.

Ciaian, P, and A Kancs. 2012. "The Capitalization of Area Payments Into Farmland Rents: Micro Evidence From the New Eu Member States." *Canadian Journal of Agricultural Economics* 60 (4): 517–540.

Claassen, Roger, Ruben N Lubowski, and Michael J Roberts. 2005. "Extent, Location, and Characteristics of Land Cropped Due to Insurance Subsidies." In *AAEA meetings in providence, RI.* 202.

Coble, Keith H, J Corey Miller, and M Darren Hudson. 2008. "Decoupled Farm Payments and Expectations for Base Updating." *Applied Economic Perspectives and Policy* 30 (1): 27–42.

Direct Payment Yield for Soybeans and Other Oilseeds. 2002. *7 CFR §1412.302.*

Femenia, F, Alexandre Gohin, and Alain Carpentier. 2010. "The decoupling of farm programs: Revisiting the Wealth Effect." *American Journal of Agricultural Economics* 92 (3): 836–848.

Floyd, John E. 1965. "The Effects of Farm Price Supports on the Returns to Land and Labor in Agriculture." *The Journal of Political Economy* 73, no. 2 (January): 148–158.

Gardner, B. L. 1987. *The economics of agricultural policies.* New York: McGraw-Hill Companies.

Gohin, Alexandre. 2006. "Assessing Cap Reform: Sensitivity of Modelling Decoupled Policies." *Journal of Agricultural Economics* 57 (3): 415–440.

Goodwin, Barry K., Ashok K. Mishra, and Francois Ortalo-Magné. 2011. "The Buck Stops Where? The Distribution of Agricultural Subsidies." Cambridge, MA.

Goodwin, BK, and AK Mishra. 2006. "Are "Decoupled" Farm Program Payments Really Decoupled? An Empirical Evaluation." *American Journal of Agricultural Economics* 88, no. 1 (February): 73–89.

Hendricks, Nathan P, Joseph P Janzen, and Kevin C Dhuyvetter. 2012. "Subsidy Incidence and Inertia in Farmland Rental Markets: Estimates From a Dynamic Panel." *Journal of Agricultural and Resource Economics* 37 (3): 361–378.

Hennessy, DA. 1998. "The production effects of agricultural income support policies under uncertainty." *American Journal of Agricultural Economics* 80 (February): 46–57.

Key, Nigel, and Michael J. Roberts. 2006. "Government Payments and Farm Business Survival." *American Journal of Agricultural Economics* 88 (2): 382–392.

———. 2009. "Nonpecuniary Benefits to Farming: Implications for Supply Response to Decoupled Payments." *American Journal of Agricultural Economics* 91, no. 1 (February): 1–18.

Kilian, Stefan, Jesús Antón, Klaus Salhofer, and Norbert Röder. 2012. "Impacts of 2003 Cap Reform on Land Rental Prices and Capitalization." *Land Use Policy* 29 (4): 789–797.

Kirwan, Barrett E. 2009. "The Incidence of U.S. Agricultural Subsidies on Farmland Rental Rates." *Journal of Political Economy* 117, no. 1 (February): 138–164.

Lagerkvist, Carl Johan. 2005. "Agricultural Policy Uncertainty and Farm Level Adjustments-the Case of Direct Payments and Incentives for Farmland Investment." *European review of agricultural economics* 32 (1): 1–23.

Lynch, David J., and Alan Bjerga. 2013. *Taxpayers Turn U.S. Farmers Into Fat Cats With Subsidies,* September.

Michalek, Jerzy, Pavel Ciaian, and d'Artis Kancs. 2014. "Capitalization of the Single Payment Scheme Into Land Value: Generalized Propensity Score Evidence From the European Union." *Land Economics* 90 (2): 260–289.

Mitchell, Matthew, and Christopher Koopman. 2013. *The Growing 'Grain Drain',* September.

Morehart, Mitch. 2014a. "ARMS Farm Financial and Crop Production Practices: Documentation." Accessed February 11, 2015. http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/documentation.aspx.

———. 2014b. "What Is the Agricultural Resource Management Survey (ARMS)?" Accessed February 11, 2015. http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx.

Morgan, Dan, Gilbert M. Gaul, and Sarah Cohen. 2006. *Farm Program Pays $1.3 Billion to People Who Don't Farm* [in en-US], July.

El-Osta, Hisham S, Ashok K Mishra, and Mary C Ahearn. 2004. "Labor Supply By Farm Operators Under "decoupled" Farm Program Payments." *Review of Economics of the Household* 2 (4): 367–385.

Patton, Myles, Philip Kostov, Seamus McErlean, and Joan Moss. 2008. "Assessing the Influence of Direct Payments on the Rental Value of Agricultural land." *Food Policy* 33, no. 5 (October): 397–405.

Perry, Charles, Jameson Burt, and William Iwig. 1993. "Redrawing the 1993 Farm Cost and Returns Survey List Sample to Reduce Overlap with Three Other 1993 Surveys and the 1992 FCRS," 632–637.

Qiu, Feng, BK Goodwin, and JP Gervais. 2011. "An Empirical Investigation of the Linkages between Government Payments and Farmland Leasing Arrangements." *Journal of Agricultural and Resource Economics* 36 (3): 536–551.

Reich, Robert. 2001. *Subsidies Aren't a Wartime Necessity,* October.

Roberts, M. J, B. Kirwan, and J. Hopkins. 2003. "The Incidence of Government Program Payments on Agricultural Land Rents: The Challenges of identification." *American Journal of Agricultural Economics* 85 (3): 762–769.

Roe, Terry, Agapi Somwaru, and Xinshen Diao. 2002. "Do direct payments have intertemporal effects on US agriculture?" *Government Policy and Farmland Markets: The Maintenance of Farmer Wealth:*115–140.

Serra, Teresa, Barry K. Goodwin, and Allen M. Featherstone. 2011. "Risk behavior in the presence of government programs." *Journal of Econometrics* 162, no. 1 (May): 18–24.

Stoker, Thomas M. 2008. "aggregation (econometrics)." In *The New Palgrave Dictionary of Economics,* edited by Steven N. Durlauf and Lawrence E. Blume, 55–63. Basingstoke: Palgrave Macmillan.

U.S. Congress. U.S. House of Representatives. Committee on Ways and Means. 2014. "2014 Green Book, Background Material and Data on Programs Within the Jurisdiction of the Committee on Ways and Means."

U.S. Department of Agriculture. 2006. *Agricultural Resource Management Survey (ARMS) Phase II - Field Crop Chemical Usage & Production Practices: Interviewer's Manual.* Technical report. Washington,DC: National Agricultural Statistics Service.

U.S. Department of Agriculture, Economic Research Service. 2000. *Farm Resource Regions, AIB-760.* Technical report.

Varian, Hal R. 2010. *Intermediate Microeconomics: A Modern Approach.* 8th ed. WW Norton New York.

Weber, Jeremy G, and Nigel Key. 2012. "How Much Do Decoupled Payments Affect Production? An Instrumental Variable Approach With Panel Data." *American Journal of Agricultural Economics* 94, no. 1 (January): 52–66.

Youde, James G. 1974. "Basic Provisions of the 1973 Farm Act." *Calif. Agric.* No. February:5–6.