Benefits and Beneficiaries from U.S. Farm Subsidies

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Introduction

This paper provides an overall review of product market effects of U.S. agricultural policies in aggregate, and analyzes consequences for gains and losses, with special attention to landowners as recipients of rents generated by programs. Ideas and evidence are presented, based on a combination of past studies and new work, to draw inferences about the consequences of agricultural commodity programs for commodity markets and factor markets. The main findings are summarized in this introduction.

As discussed in the next section of the paper, a host of conceptual and measurement issues are involved in estimating and interpreting measures of the consequences of agricultural policies. These issues are sometimes subtle, with implications that are not always appreciated. In addition to differences in measures intended for a given concept and purpose, differences are found because different measures are appropriate for different purposes. For these types of reasons, there is no single set of widely accepted estimates of consequences of farm subsidy policies, or even of the parameters of the underlying economic relationships that determine the consequences. Indeed, the views among economists on these matters are diverse, even among those who are comparatively specialized and regarded as expert in the relevant subject matter, and so are the corresponding measures. An important challenge is to make sense of this diversity and attempt to narrow the likely range.

These observations notwithstanding, a simple and popular theoretical model of the consequences of farm program policies yields clear qualitative results on some aspects of the question, as shown in the third section of this paper. Specifically, using a simple two-factor model—after Floyd (1965)—it can be shown that output subsidies benefit both consumers of agricultural products and suppliers of other inputs used by farmers, not just landowners, unless extreme assumptions are made about the nature of demand for agricultural products (it is perfectly elastic); (b) the supply of land to agriculture (it is fixed), and (c) the technology of production (land and other inputs are used in fixed proportions). Under more realistic assumptions, the issue is not whether all subsidy benefits go to land, but rather what *share* of the benefits go to land. To say more than this about the distribution of benefits from output subsidies requires empirical work, and empirical results on this issue are mixed.

Theoretical analysis also suggests that 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 land owners.[1] Significant elements of U.S. farm program payments implemented in 1996, and still employed, are widely regarded as essentially decoupled payments tied to land. According to the mainstream theory, the benefits from those "direct payments" should be mostly if not entirely reflected in land rents and land values. A range of recent empirical work, however, shows that when direct payments change, only a fraction of those changes in benefits—possibly as low as one-quarter—is reflected in changes in land rents in the current period (see, for example, Kirwan 2007). Hence, at least in the short run, the payments do not entirely accrue to land. One rationale for this finding is that land rents are specified in multiyear contracts, and it may take some years for the market for land to fully adjust to a change in farm program payments (or any other factor affecting farm profitability). However, direct evidence is not yet available showing that the payments are fully capitalized into land, even in the long run. The finding that changes in direct payments are not fully reflected in

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[1] By definition, "decoupled" transfers are meant not to have any effects on input use and production and therefore should not have any effects on markets for factors or products.

1

changes in land rents might also mean that they are not fully decoupled (that is, that they have some effects on input use and output). Some econometric and other evidence supports that view.

These econometric findings, summarized and reviewed in the fourth section, are at odds with the predictions from our simple static model, and must weaken our confidence in predictions from such models more generally until we understand more about why the particular prediction was rejected. At the same time it is appropriate to question both forms of evidence—from statistical and econometric models versus calibrated theoretical or simulation models—as we attempt to resolve the difference. Certainly the simple static model does not allow for the multiyear nature of cash-rent contracts, and that fact alone may be sufficient to resolve the issue. At the same time, econometric estimates are always open to some questioning; indeed, the range of published estimates reminds us that the estimates are imprecise.

At another level, however, the two sets of findings agree. Many economists have argued that all farm subsidies are ultimately capitalized in land values. This viewpoint is comprehensively rejected both by theoretical analysis and econometric estimates. Careful review of the econometric evidence and consideration of the implications of the simple static model lead me to conclude that the truth is likely to lie in between the results from the two approaches to evaluate the effects of commodity subsidies. Taking that perspective, the range of results is reasonably narrow: perhaps in the range of 40 to 60 percent of subsidy payments accrues as benefits to landowners, half to farmers who own the land they farm and the other half to absentee landlords. Of the remaining amount, perhaps 20 percent accrues as a benefit to consumers and some—say 5 percent—is wasted as a deadweight loss, leaving 15 to 35 percent that accrues as a benefit to farmers as a return to their management and labor.

The fifth section presents a more disaggregated set of estimates to show the effects, commodity by commodity, of a comprehensive reform of U.S. farm programs. These results, from ABARE (McDonald and others 2006), indicate that for most of U.S. agriculture, the complete elimination of U.S. farm commodity programs would result in fairly modest changes in production, prices, and value of production. The ABARE results are supplemented with a sector-model of farm program crop production, based on 2005 data and using an approach developed by Sumner (2005a) for partitioning the different elements of farm program policies into two components: a fully coupled subsidy equivalent, and a fully decoupled residual. This model yields comparable results to those from the ABARE model, though larger effects. It indicates that eliminating policies for program crops would result in a 7.3 percent decrease in output of program crops. In addition, the same model indicates that the output-reducing consequences from the Conservation Reserve Program (CRP) having removed land from production have partially offset the output-enhancing effects of the subsidy programs. Eliminating both the CRP and program crops policies would result in a net 5.0 percent decrease in output of program crops.

The results from these models are used to develop some "back-of-the-envelope" estimates of deadweight losses associated with U.S. commodity program policies. In addition to the conventional "Harberger triangles" that measure deadweight losses associated with distortions in production and consumption of farm commodities, attention is paid to some less-conventional sources of deadweight loss, including costs of enforcement, and compliance and costs of resource distortions associated with the application of taxes to raise the revenues to finance subsidies. Since the subsidies have mostly only modest implications for production and consumption, for the most part only modest net national benefits would be achieved by eliminating the net social costs (or deadweight losses) associated with distortions in resource use and production and consumption of agricultural commodities. Program crop subsidies generate a

deadweight loss in the range of 2 to 5 percent of the total transfer, or about $400–800 million per year given subsidy expenditure of $16.5 billion in 2005. The social costs of distortions from taxation to finance the transfers are likely to be five to ten times greater than this amount, such that the overall social cost is around $4 billion. The opportunity cost of that money might be higher again. (For instance, it could be used to finance an increase in agricultural research, which has a very high benefit-cost ratio.)

General Issues in Analysis of the Incidence of Agricultural Policy

A number of conceptual and empirical issues arise in developing appropriate measures of policy impacts for a specific purpose and in interpreting the evidence from previous studies. Measures of policy impacts are inherently uncertain, owing to uncertainty about key aspects of the agricultural economy and how policies affect it. Measures can also differ because they are based on different assumptions about parameters or because they refer to different questions. Moreover, even when policies are fixed, their consequences change over time as markets and other institutions change; but the policies themselves also change. Thus particular quantitative findings have a temporary, time-specific, historical relevance, as well as a particular contextual relevance determined by the question to which they were directed.

In addition, particular findings are typically to a significant extent subjective, individual, and open to challenge. To infer consequences of policy changes involves the use of a model, assumptions, and indirect inference; only in very special circumstances and for very narrow policy questions can we make direct inferences from econometric analysis. The elements of policy models, many of which are represented by elasticity measures, may be the outcome from direct estimation. More often, however, these elements are themselves the result of a combination of theoretical models and assumptions, conditioned by the modeler's introspection about the relevance of particular estimates and the implications of the alternatives. These characteristics of the determinants of particular findings are not always transparent, more particularly with larger and more complex models; thus the findings themselves often are not easy to understand let alone validate or replicate. More often, rather than validating, we find ourselves having to take on faith the results from particular studies, and the strength of that faith is often determined more by our confidence in the modeler than in the model per se.

Critical Questions. This paper includes evidence from previous studies as well as some new results. As noted, results from policy models depend on values for elasticities, among other model specifics. It is perhaps surprising to learn that economists are far from having reached consensus about several key and basic characteristics of agriculture reflected in the parameterization of policy models—and thus about the implications of policies—even though these characteristics have been the subject of a great deal of research. Among these characteristics, there is substantial disagreement among agricultural economists and in the literature over the answers to the following questions:

- Is the competitive market model a reasonable approximation for U.S. agriculture?
- Is the overall demand for U.S. agricultural output elastic or inelastic?
- Is the effective supply of land to U.S. agriculture essentially fixed?
- To what extent is it possible to substitute other inputs for land (that is, is aggregate agricultural supply largely fixed, to the extent that land is fixed)?

- Are the so-called decoupled subsidies to farmers really decoupled or do they affect use of land, other agricultural inputs, and production?
- Is the Conservation Reserve Program a concomitant of farm subsidy programs that would change when farm programs change, or an independent environmental policy?
- Are agricultural subsidies mostly, if not fully, capitalized into land rents and values? Answers from policy models to this last question, which is the focus of much of this paper, depend on the answers to the others. The literature also includes some direct evidence related to the effects of subsidies on land markets, which in turn has indirect implications for the other questions.

An important point to recognize from the outset is that the answers to these questions and other questions that depend on them are uncertain. The literature contains a range of estimates of the key elasticities, and other forms of evidence about them. Consequently, we necessarily find a range of inferences for policy impacts based on models that involve these parameters. The range of findings is wider than we would wish because the range of estimates of underlying parameters is wide, even after we adjust for differences that reflect different concepts. In writing this paper, I have made an effort to narrow the range of findings by making informed interpretation of the evidence and by adjusting for some sources of differences. Even so, the range of findings is uncomfortably wide. This is a fact of life and is useful to keep in mind when reading the findings from any study of the consequences of agricultural policy.

Defining the Relevant Counterfactual. When someone asks about the effects of policies, before we can give a useful or meaningful answer we must clarify the question and define some terms. First, are we looking backward and asking a counterfactual question of the form: "If such and such a policy had been different, what would have been the consequences?" Or are we looking forward and considering alternative hypothetical futures: "What would be the effect if in the future we have this hypothetical policy versus that alternative policy?" In either case, we are comparing sets of outcomes under alternative hypothetical policy regimes. Second, which factors are being held constant, by assumption, in the analysis and which ones are being allowed to change as part of the proposed policy change or as part of the response to the policy change? Third, what effects are of interest, on whom, over what time period, and at what level of aggregation? This section elaborates on these points and provides a foundation for the discussion that follows.

Many policy analyses have an undated, timeless quality, but the real world does not. The baseline scenario can have profound implications for the analysis. In an ex post facto, backward-looking analysis, the natural baseline is the actual past policy and it can be compared with a hypothetical counterfactual alternative in which the analyst chooses which aspects will be allowed to differ from their actual past values. In an ex ante, forward-looking analysis, both the baseline and the alternative are objects of choice.

One dimension of the choice of the counterfactual is whether to contemplate a large change or a marginal change. Much of the empirical literature on the incidence of farm program policies is explicitly or implicitly partial (referring to changes in specific elements of farm programs) and marginal (such as econometric studies that measure consequences from changes in spending within existing programs). The resulting estimates may not be appropriate as measures of response to larger-scale changes if the relationships are significantly nonlinear, such that the implications are different for different-sized changes. For instance, some have suggested that decoupled subsidies enable some farmers to remain engaged in agricultural production who

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could not afford to do so otherwise—such that complete elimination of the subsidies would cause a substantial restructuring of the industry, even though marginal changes in subsidies might have no appreciable effect on resource allocation.[2] This possibility is not easily reconciled with our standard static model of competitive profit maximization, but it might be more relevant in a setting in which farmers have more complex objective functions and where resource adjustment is costly.

Other dimensions of choice for the modeler concern which prices are endogenous and which policies are held constant. Individual agricultural commodities interact with one another both in demand (through competition for consumers' dollars) and supply (through competition for the use of productive factors). To understand the full consequences of policies for individual commodities, it may be necessary to work through the implications for other commodities, through the interactions of supply and demand, and ultimately for final consumers and for owners of land, labor, and other factors of production. To do this involves going beyond partial equilibrium analysis and considering agricultural policies in multi-market partial equilibrium or an economy-wide general equilibrium. We can expect that the results will be different when we allow for "general equilibrium" feedback of induced price changes in interrelated markets. In many cases, the implication of this feedback will be to make the effective elasticities of supply and demand less elastic for a commodity of interest than would be appropriate in a partial equilibrium analysis in which the prices of the related commodities were held constant. Thus when we change policy for a single commodity of interest, the incidence in its market can be expected to be different if we allow for all the consequences in related markets.[3]

In addition, for some questions it is necessary to go beyond the analysis of single policies in isolation. Some policy questions involve scenarios in which policies for several (or perhaps all) agricultural commodities change together, with very different implications from a scenario in which all other policies are held constant, while only one policy changes. For instance, should the Conservation Reserve Program be seen as part of the set of commodity programs, and thus something that offsets the output-enhancing effects of subsidies, or as an entirely separate environmental policy that should be regarded as exogenous and constant when we evaluate the effects of commodity programs per se? Definition of the relevant counterfactual policy set has important implications for findings, such as whether we can expect the ultimate consequences of commodity programs to be reflected primarily in land rents and prices versus markets for other specialized factors and how quickly we can expect adjustment to occur.

In this paper, in particular, the interest is in the overall impact of U.S. farm program policies. I choose to interpret this in a forward-looking way to consider the implications of continuation of the current farm programs compared with an alternative in which those programs are eliminated—either instantaneously or in some phased-out fashion. I assume explicitly throughout that the policies of other countries are exogenously fixed, even though it would be more reasonable to think that any substantial reform of U.S. farm program policies would be accompanied by changes in other countries, either as a response to the effects of U.S. policies or as part of an agreement among nations to change policies together. Since the analysis involves

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[2] Tweeten and Hopkins (2003) discuss economies of farm size and government payments. They suggest that elimination of farm programs might cause a significant restructuring of agriculture.

[3] At the same time, when we extend the scope of the model to accommodate multiple commodities or other complications, we usually lose some flexibility in terms of the representation of details of markets and policies and other institutional details for particular commodities, and thus we are engaged in a trade-off between accuracy in particulars and comprehensiveness in coverage.

joint elimination of multiple policies affecting multiple commodities, emphasis is paid to making proper allowance for the multi-market interaction effects of own- and cross-commodity policy changes.

Concepts and Measures of Economic Incidence. Alston and James (2002) discuss the consequences of agricultural policy in terms of the implications of alternative policies for the functional distribution of income: the net incomes (or producer surpluses) accruing to suppliers of various factors of production, the net benefits from consumption or economic surplus of consumers, and the costs of the associated government expenditure that are ultimately borne by taxpayers. This approach is based on the view that—while we may be interested in the consequences of policies for prices and quantities of commodities produced and consumed, and prices and quantities of inputs used in agriculture—the more fundamental interest is in what is implied for net benefits to consumers, taxpayers, and factor owners. This functional distribution of income is different from the personal distribution of income, which also may be of interest but is not the focus of this paper.[4] Alston and James (2002) used a simple competitive model of the market for an agricultural commodity, and the same type of model is used here for a similar purpose.

In the literature on the incidence of taxes, an important distinction is drawn between the initial incidence of the policy (from whom is the tax collected) and the final incidence of the policy (who bears the burden ultimately after markets have adjusted, causing changes in prices that result in shifts of the incidence). The same concepts are relevant for any policy, including agricultural subsidies. It is often argued, for instance, that regardless of the initial incidence of farm subsidies, the ultimate final incidence will all be on landowners, who supply a fixed factor that earns Ricardian rent. The same simple competitive market model can be used to examine and illustrate the conditions under which agricultural subsidies accrue entirely to landowners, and to conjecture about the likely share of subsidies accruing to landowners versus others. That is done in the next section. Related questions concern the implications of the form of agricultural policy, and the different contractual arrangements within agriculture such as share-farming arrangements, for the final incidence. For instance, by definition, "decoupled" transfers are meant not to have any effects on input use and production and therefore should not have any effects on markets for factors or products. What are the determinants of the ultimate incidence of such payments? Do the benefits accrue exclusively to landowners? Are the benefits capitalized into the value of the land? Legal definitions of the details of the policies may have important implications for the answers to these questions, which are the focus of much of what follows.

Models of Agricultural Policy, Land Rents, and Land Values

It is commonly suggested by agricultural economists that the benefits from agricultural subsidies will ultimately be capitalized mostly, if not entirely, into land, as the fixed factor.[5] However, this view depends on the use of assumptions that are extreme and likely to be inappropriate for most

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[4] Other studies may go into the incidence in terms of differences among types of farms according to their size, geographic location, or product mix, for instance, or among individuals according to their wealth or other socioeconomic characteristics.

[5] For example, see Rosine and Helmberger (1974); Gisser (1993).

applications; and, as pointed out by Alston and James (2002), the questions about the appropriate assumptions are entangled with some other issues about the definition of the relevant counterfactual policy scenarios. For the moment let us set those issues aside and revisit the model presented by Alston and James (2002, pp. 1715–21) to consider the implications of subsidies for land rents.

A Simple Model of Subsidies and Land Rents. The model as described in appendix A and in more detail in Alston and James (2002) includes a final demand equation; two factor supply equations; a production function (or cost function) to represent the technology for the production of a homogeneous product, using two factors of production; and equations imposing competitive market clearing.[6] The solutions to the model are equations for proportional (or percentage) changes in the endogenous quantities and prices of the product and the two factors, each as a function of a set of fixed parameters, and exogenous shift parameters representing the effects of policies. The supply and demand shift parameters can be used to represent a subsidy on an input or output. In either case, for moderate rates of subsidy the benefits to consumers are approximately proportional to the percentage change in quantity consumed, and the benefits to suppliers of each factor are approximately proportional to the percentage change in the use of the factor.

As demonstrated by Alston and James (2002), the benefits from the subsidies are shared between landowners, other factor suppliers, and consumers even when the quantity of land (input 1) is fixed, unless key parameters take on extreme values: either the price of non-land inputs (input 2) is fixed and there is no producer surplus for its suppliers, or the factor proportions are fixed. Under any other circumstances, the total benefit to factors will be shared between land and other inputs; and, if output changes and the output price is not fixed, consumers will benefit, too. In general, then, we expect the benefits from subsidies to be distributed among consumers and factor owners, with the proportions depending on parameters, which in turn depend on the details of the policy, as discussed by Alston and James (2002).

This simple model illustrates some key determinants of the extent to which farm program payments accrue to landowners versus others, treating the output from agriculture as a single homogeneous product, produced using homogeneous land, and with a given subsidy applying to all of land or all of the output. U.S. agriculture is more complicated than that, with heterogeneous land used to produce many different outputs that are subject to a variety of complex policies involving multiple instruments. As a crude approximation, however, we can apply the simple model to U.S. agriculture in aggregate and look at the incidence of output or input subsidies on landowners.

What might be reasonable values for the parameters in this case? Useful direct econometric evidence is not available for any of the parameters, but subjective estimates can be made given some knowledge of the relevant econometric literature and the nature of the application. First, demand for U.S. agricultural output is probably elastic but not very elastic, reflecting highly elastic demand for some traded goods and inelastic demand for some nontraded goods. Second, the supply of land in total may be essentially fixed, but the supply to agriculture is variable, as it can be allocated between agriculture and forestry and other nonagricultural uses. Third, the supply of "other" inputs to agriculture is more elastic than that of land but less than perfectly elastic, reflecting the specialized nature of some agricultural inputs, including

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[6] An equivalent model was used by Floyd (1965) for a similar purpose; see, also, Gardner (2003).

managerial inputs and some capital. In view of these arguments, and based on further arguments and econometric evidence presented in appendix B, the following values seem reasonable for the key parameters of the model:

- Elasticity of demand for U.S. aggregate farm output, $\eta = 1.0$
- Elasticity of supply of land, $\varepsilon_1 = 0.1$
- Elasticity of supply of the aggregate "other" input used in agriculture, $\varepsilon_2 = 1.0$
- Cost share of land in total costs of agricultural production, $k_1 = 0.20$
- Cost share of "other" inputs in total costs of agricultural production, $k_2 = 0.80$
- Elasticity of substitution between land and the aggregate "other" input, $\sigma = 0.10$.

Using these values in the model solutions, landowners would receive 39 cents per dollar of output subsidy expenditure and 68 cents per dollar of input subsidy expenditure applied to land. Holding the other parameters constant but assuming a fixed supply of land ($\varepsilon_1 = 0$), the landowner would receive 58 cents per dollar of output subsidy expenditure but 100 percent of the land subsidy expenditure. Table 1 shows how benefits to landowners as a percentage of subsidy expenditure change as we change some key parameters (the elasticities of demand, factor substitution, and supply of land) holding the other parameters constant. In addition, this table includes corresponding estimates of benefits to consumers as a percentage of subsidy expenditure. The residual amount approximates the share of benefits to suppliers of non-land inputs (after due allowance for deadweight loss). The results are intuitive. The share of benefits going to land from either an output subsidy or an input subsidy on land increases with reductions in the elasticity of supply of land or with increases in either the elasticity of substitution between land and non-land inputs or the elasticity of demand for agricultural output, either of which implies an increase in the elasticity of the derived demand for land. In the extreme case of a fixed supply of land, landowners receive 100 percent of the benefits from an input subsidy but only 33 to 62 percent of the benefits from an output subsidy. Allowing for some elasticity of supply of land (with $\varepsilon_1 = 0.1$), land owners would receive 60 to 80 percent of the benefits from an input subsidy on land or 24 to 44 percent of the benefits from an output subsidy, depending on the values for the other parameters.

Table 1. Implications of Key Parameters for Incidence of Farm Programs

Elasticity			Economic surplus change as a share of subsidy expenditure			
			Input subsidy		Output subsidy	
ε_1	σ	η	Consumers	Landowners	Consumers	Landowners
			Percent			
0.0	0.2	0.5	0	100	44	33
		1.0	0	100	29	43
		1.5	0	100	21	47
	0.1	0.5	0	100	35	48
		1.0	0	100	21	58
		1.5	0	100	15	62
0.1	0.2	0.5	24	71	52	24
		1.0	16	75	35	32
		1.5	12	77	27	37

η	σ	ε_1				
	0.1	0.5	30	62	49	30
		1.0	20	68	32	39
		1.5	15	70	24	44
0.2	0.2	0.5	37	56	57	19
		1.0	26	60	40	26
		1.5	20	63	30	30
	0.1	0.5	43	45	55	21
		1.0	30	51	38	30
		1.5	23	54	29	34

Source: Prepared by the author using the model in appendix A.

Note: The parameters varying here are the elasticity of demand for U.S. agricultural output, η, the elasticity of substitution between land and non-land inputs, σ, and the relevant elasticity of supply of land, ε_1; other parameters being held constant are the elasticity of supply of non-land inputs, $\varepsilon_2 = 1.0$, and the share of land rent in total cost of production, $k_1 = 0.20$. The incidence shares for the input subsidy are computed using the equations in appendix A

A more realistic view of the incidence of U.S. agricultural subsidy programs might be obtained by modeling program crops that receive the bulk of subsidy expenditure, as opposed to all of agriculture. Even if the total supply of land were fixed, the supply of land to the cropping industries would not be so. If we reinterpret the model above as representing the program crop sector of U.S. agriculture rather than agriculture as a whole, the main implied difference would be to increase the elasticity of supply of land to the sector (say 0.2 rather than 0.1 or zero).[7] The other parameters may be about the same. Using these alternative parameters ($\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), landowners would receive 30 cents per dollar of output subsidy expenditure and 51 cents per dollar of input subsidy expenditure applied to crop land.[8]

Implications of Rental Market Institutions. As well as simplifying the nature of supply of land to agriculture or to the cropping sector, the analysis presented above has been based on some simplifying implicit assumptions about the function of the land rental markets and farm program policies. Almost half of all U.S. farmland is leased, and U.S. policy specifies how farm program payments—such as direct payments or countercyclical payments—may be distributed in the first instance between farm operators versus farm owners. Sherrick and Barry (2003) reported that in 1999, 45.3 percent of farmland was leased and, of that amount, 59.4 percent was for cash rent. If a lease arrangement meets the technical definition of a "cash" lease under federal regulations, then the farm program payments must go entirely to the farm operator; the landlord is not eligible to receive any payments. Otherwise, under a share lease arrangement, the same subsidy payments *must* be divided between the landlord and the tenant. Thus, if subsidy payments increase unexpectedly in the presence of preexisting leases, tenants holding cash leases will capture all of the benefits (and their landlords will receive none), whereas tenants holding share leases will share the same benefits with their landlords. Of course these regulations govern only the initial distribution (or incidence) of the subsidy payments between landlord and tenant, which is almost surely different from the final incidence after markets have adjusted in response to the subsidies. Ultimately, other things equal, one would expect the rates of cash rent eventually to adjust to equivalence with the corresponding share lease rate, reflecting the government subsidies and other determinants of income.

The competitive market model implicitly has rental markets for farmland clearing continuously. However, rental arrangements are typically multiyear in nature (for example, typical contracts may fix a rental rate that will apply every year for a three-year term) and may reflect long-term personal relationships, often among members of the same family. Competitive pressures might not take full

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[7] An elasticity of supply of land to crop production of 0.2 would indicate that a 50 percent increase in cropland rents in agriculture would induce a 10 percent increase in the quantity of land in crop production, coming from other uses such as grazing, the CRP, which holds 35 million acres compared with 442 million acres of cropland (in 2002), or nonagricultural use such as forestry.

[8] These parameters imply an elasticity of supply of program crops of 0.62. The same elasticity is implied if, alternatively, we assume land has an elasticity of supply of 0.3, and a cost share of 0.3.

and immediate effect in such a setting. It should be clear to anyone who has ever attempted to explain the theory of policy incidence that tenant farmers and landlords may not have the same understanding as economists do about it; and thus it might not be immediately obvious to the parties to a cropland lease contract that it is fair to increase (or decrease) rent immediately by one dollar for every dollar increase (or decrease) in direct payments, say, even if that is the final incidence that would come about in a fully competitive process.[9] Further, the fact that information on crop yields and sales prices is incomplete and held asymmetrically may mean that landlords do not always have good knowledge of how much their tenants are receiving in government payments or what would be their fair share. In these circumstances, rental payments to landowners (as landlords) may adjust incompletely and sluggishly to changes in farm program payments. Thus the short-run may differ from the long-run incidence, with less of the incidence on land than predicted by our simple model, and the difference between the short run and the long run may take several years to work through.

Capitalization Questions. The issue of capitalization is not necessarily the same as the issue of functional distribution, though often they are treated as though they are equivalent. Benefits may flow to landowners but not be capitalized into land values if they are not expected to continue into the future. On the other hand, benefits may be capitalized effectively into land values even if the benefits themselves do not flow to land per se. For instance, if the right to a stream of income is freely transferable separately from land or other assets, then the value of that stream will be capitalized into the right per se: a piece of paper (see, for example, Sumner and Wolf 1996). However, if that piece of paper is attached to a piece of land, and cannot be used or transferred separately from that land, then the value of the stream is likely to be capitalized effectively into the value of the land or the farm as a whole (like the benefits from direct payments, for example). Alternatively, if a right to a stream of income is assigned to an individual, separate from land or any other assets and not in any way transferable, it will not be capitalized into any physical assets. Thus in principle, totally decoupled transfers might be fully capitalized into land or not capitalized into land at all, depending on the details of the rules determining eligibility to receive the future stream of transfers. In addition, capitalization rates will depend on the determinants of the incidence of the subsidy and perceptions of the future duration of subsidy benefits.

Consider a farm that is operated by a tenant who rents the land for cash, at a rate R_0 per acre per year in the absence of any policy. Suppose the government pays an input subsidy of IS per acre per year on all such land and the total quantity of land is fixed, at A acres, such that the total subsidy expenditure is $A \times IS$. Competition will drive the rent up to $R_0 + IS$ per acre per year, such that the entire amount of the subsidy accrues to the landowner, as demonstrated in the models above for an input subsidy with a perfectly inelastic supply of the input.

Similarly, if the government made a decoupled, direct payment to the landowner of DP per acre per year, once again, the entire amount of the subsidy would accrue to the landowner, and the total subsidy expenditure would be $A \times DP$. If the payment is made direct to the landowner regardless of whether the land is rented to a tenant for cash, the rent would be unaffected by this policy. In the

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[9] Uchtman (2006), and Johnson, Prosch, and Raymond (2006) illustrate the reality of complications with farmland leases and how they may be renegotiated when circumstances change, and, reading between the lines, how rental contracts may be expected to adjust sluggishly to changes in the market.

United States, however, direct payments of this type are paid to the farmers who use the land, whether they own it or rent it for cash. Therefore, in long-run competitive equilibrium, the payments are expected to be fully reflected in cash rents. In short, decoupled payments based on land ownership may or may not be reflected in land rents, depending on the policy rules, but in either case they will accrue ultimately to landowners.

As a third alternative, suppose the government pays an output subsidy of OS per bushel on production, which gives rise to changes in production and the input mix. In this case only a fraction of the total subsidy amount accrues as an increase in land rent, which increases to $R_1 = R_0 + s_L (OS \times Y_1)$, where Y_1 is the yield in bushels per acre in the presence of the output subsidy, such that multiplying by yield converts the payment per bushel into a payment per acre, and s_L is the fraction of the total subsidy that accrues as increases in land rents. In this case, the total subsidy expenditure is equal to $A \times OS \times Y_1$, but only a fraction of that expenditure ($s_L < 1$) accrues to landowners through effects on land rents.

In appendix C, a present value model of land values is used to model these different types of subsidies and illustrate the roles of various other elements in influencing the extent to which farm program payments may be capitalized into the price of land. In sum, we have different rates of capitalization of different types of subsidy payments into land values depending on (a) the eligibility rules for decoupled transfers, which do not have any incidence in commodity or factor markets but may nevertheless be linked to farm assets; (b) the determinants of the incidence of the subsidy in the case of input and output subsidies, including the nature of the subsidy and whether it applies to all or only a subset of land or outputs, and the market conditions in terms of elasticities of factor supply, product demand, and factor substitution; and (c) perceptions about the extent of policy risk or other factors that might influence the rate of capitalization of a given stream of expected income and may differ among subsidy instruments.

The observation of a different rate of capitalization of income from the market compared with income from the government may reflect any or all of these factors at work, which makes any specific interpretation hazardous. As a corollary, information about the extent to which program payments are capitalized into land values alone may not be sufficient to determine the extent to which the program payment is decoupled, or the incidence is on land rental income per se. These issues have not always been made clear in studies that sought to use findings concerning the observed relationships between farm commodity programs and land values to draw inferences about the rate of capitalization or the extent to which programs are decoupled. In the next section, empirical work on modeling effects of policy on land values is reviewed in light of these types of considerations.

Evidence on the Incidence of U.S. Farm Program Policies in Land Markets

The recent published literature includes a number of econometric studies of impacts of farm commodity policies on land markets, mainly in the United States. This section reviews the evidence from these studies to draw conclusions about the extent to which transfers from the government are decoupled from production and capitalized into land prices, and what that and other evidence means in terms of the extent to which farm program payments accrue as land rents rather than to other factor suppliers or consumers. An overview of key points that are relevant in interpreting the published work is provided first, followed by a summary of the main

findings and their implications as they pertain to the purpose at hand. Appendix D provides a more complete discussion of the published work.

Key Points. Some of the following points relate to what our theoretical models suggest about the relationships between policies and land markets. Others relate to the econometric problems likely to be encountered in looking for evidence about those relationships using typical methods.

First, the details of policies matter. Real-world farm program policies tend to be complicated, involving multiple instruments working in concert, none of which is exactly the same as the stylized textbook counterparts presented here. Hence, as noted in the third section, even when payments are fully decoupled, whether the payments are fully reflected in land rents or capitalized into land values may depend on other details of the policy. But real-world policies for the most part are not fully decoupled, and their final incidence will also depend on the extent to which the incidence is shifted through changes in input use and output, which will depend in turn on details of the policies and parameters of supply and demand and so on. As a consequence we have to be careful in generalizing about the likely transmission of subsidies into land rents and land values. Econometric studies often require some aggregation across different types of subsidies in ways that may cause problems if the nature of the subsidies varies across the observations (for example, the mixture of forms of subsidies varies in a cross section or the details of the instruments change over time). To what extent are results influenced by how policies are represented in the models?

Second, formal and informal land rental contracts mean that the transmission of changes in policy into rental prices and asset prices for land is not instantaneous. Sluggish adjustment of rental rates means that the short- and intermediate-run incidence of policies (and the extent to which subsidies are decoupled) will be different from the long-run outcome with complete adjustment. Even without contracting, the market involves lags and dynamics, uncertainty and expectations, from which our simple models typically abstract. Because contracts are established well in advance of market realizations, some of our measures do not precisely correspond to the theoretical constructs they are meant to represent. For instance, our theoretical model might correspond to the relationship between land rents and expected values of subsidies under risk neutral preferences or certainty, but the land rents are set ex ante and the subsidies we observe are ex post. Further, data on land rents and land values are often based on expert assessments rather than the direct evidence from market transactions. These assessments are likely to understate the true movements in rental prices associated with year-to-year variations in income received from the market or the government. Both these factors will mean that short-term movements in observed rental prices will tend to understate the long-term impact of a permanent change in subsidies. How well have studies dealt with unobservable expectations and what are the implications for their findings?

Third, models that attempt to measure the extent to which subsidies are capitalized into asset prices of land combine the problems associated with modeling impacts of subsidies on land rents with the (probably more serious) econometric problems that arise in modeling the asset price of land. On the other hand, the sluggish short-term adjustment of land rents that confounds the rental market models may be less of an issue in land market models since land prices should reflect longer-term expectations.

Fourth, econometric studies of land-market implications of agricultural subsidies have involved either aggregative time-series

data (where the unit of analysis is a state or a nation) or disaggregated cross-sectional data (where the unit of analysis is a farm firm). Both approaches involve some general problems. In aggregate time-series studies, the fundamental problem may be simply lack of data, which compounds a lack of confidence over whether the model structure is right or whether the empirical proxies for theoretical constructs are reasonable, and thus how to interpret the estimated model. In cross-sectional studies, the primary econometric issues appear to be related to dealing with the roles of unobserved factors (such as farm-specific weather and soil fertility that determine the farm's history and thus its eligibility for subsidies as well as its current production mix and productivity) in jointly influencing land rents and land prices, and agricultural subsidies, manifested as identification problems.

Many of these aspects are discussed by various authors who have studied impacts of farm programs on land markets, such as articles by Goodwin, Mishra, and Ortalo-Magné (2003); Lence and Mishra (2003); and Roberts, Kirwan, and Hopkins (2003); and others that were presented in the same conference session and published in the same issue of the *American Journal of Agricultural Economics*. Much of the work in the literature has been concerned with finding solutions to these conceptual and measurement problems, or with drawing inferences for the interpretation of findings. The main findings from these and other studies are discussed next. Appendix D reviews the empirical literature on the effects of U.S. agricultural subsidies, in each instance showing the main features of the study and findings about decoupling and the effect of subsidies on land rents or land prices or both. The two sets of findings are related but separate and will be treated separately here, beginning with the results on decoupling.

Evidence on Farmer Responses to Decoupled Payments. A variety of approaches have been applied to the problem of estimating the impact of decoupled payments on farmer decisionmaking, including simulation models and direct econometric estimation using various types of data. The general conclusion from the relevant empirical literature appears to be that decoupled program payments— such as direct payments—have statistically significant effects on farmer behavior. The magnitude of these effects varies from study to study, however, and econometric issues remain. The crux of the problem is that non-program farms will not likely serve as a valid comparison group in any investigation of program impacts, and it is unclear to what extent analysts are able to control for unobserved heterogeneity. Fixed-effects models are certainly an improvement on ordinary cross-sectional regressions, but their conclusions are valid only to the extent that differences between program and non-program farms are time invariant; it is not clear that this will be the case.

Although the evidence generally indicates that decoupled payments do have some effects on farmer behavior, the evidence is mixed on the size of the effects. In the fifth section, some specific parameterizations are used to represent these effects, drawing on this literature. These parameterizations allow for comparatively large effects of decoupled payments, more consistent with the findings of Key, Lubowski, and Roberts (2006).

Effects of Program Payments on Land Rents and Land Prices. The attempts made by analysts to estimate the impact of program payments on land rents and land prices can be broken down into two broad categories. In the first approach, the present value (or asset

price) of land is modeled as a function of government payments and other explanatory variables.[10] While estimated elasticities of land prices with respect to program payments from these studies are often small, the total share of land value determined by support payments can be quite large.

The second approach uses farm-level variation in government payments and farm revenues to explain variation in land rents, controlling for observable covariates and fixed effects when panel data are available.[11] The studies using this approach face the same hurdles as the nonexperimental, cross-sectional studies of decoupled payments outlined above: econometric problems associated with unobserved heterogeneity, errors in variables, and other potential sources of bias.

In sum, the literature on the incidence of farm subsidies on land values indicates that while landowners certainly benefit from support programs, they do not appear to capture the full value of subsidies, at least in the short to medium run. That this is so is not surprising in relation to subsidies generally. However, much of the econometric work relates to forms of subsidies that we would expect to have most if not all of their final incidence on land, and those studies generally have found a surprisingly small share of subsidy benefits going to landowners. The work by Roberts, Kirwan, and Hopkins (2003) and by Kirwan (2005, 2007) is a good example. The authors have made exhaustive attempts to identify and address potential sources of econometric bias, but their estimates of the multiplier for decoupled subsidies are still well less than half what theory would predict.

One possible interpretation is that the authors are estimating an intermediate-run effect, which is smaller than the long-run effect, because of fixity associated with contracts or because of roles played by expectations or other dynamics. An implication may be that the so-called decoupled subsidies are much less decoupled than is commonly thought: that is, the subsidies are being transmitted to other non-land inputs or consumers with consequences for production and consumption. Alternatively, the estimates may be biased because, notwithstanding the comprehensive efforts of the authors, they have not fully resolved the econometric issues that they identified. Perhaps the only way to obtain different types of answers is to use different types of data, such as farm-specific time-series.

Consequences of the Elimination of U.S. Farm Program Policies

This section presents some quantitative results on the potential implications of comprehensive reform of U.S. farm program policies. ABARE (McDonald and others 2006) simulated the consequences of elimination of U.S. farm program policies. This section provides an overview of their results and some discussion of the order of magnitude of deadweight losses associated with the programs, and the efficiency of the transfers. The ABARE results are supplemented with a sector-model analysis of farm program crop production based on 2005 data and using an approach developed by Sumner (2005a) for deriving a fully coupled subsidy equivalent of the different elements of farm program policies.

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[10] Examples of this approach include Goodwin and Ortalo-Magné (1992); Weersink, Clark, Turvey, and Sarkar (1999); and Shaik, Helmers, and Atwood (2005).
[11] Examples include Gardner (2003); Goodwin, Mishra, and Ortalo-Magné (2003a, 2003b); Lence and Mishra (2003); Roberts, Kirwan, and Hopkins (2003); and Kirwan (2005, 2007).

ABARE Analysis of Omnibus Reforms. ABARE (McDonald and others 2006) published an ex ante analysis of the implications of a phased elimination of U.S. farm program policies over ten years, 2007 to 2016. They considered various scenarios relative to changes in policies in other countries. For simplicity, consideration here is limited to the scenario in which policies remained at the status quo in all other countries, and in which the reform did not engender enhanced productivity growth. The published report does not include full details of the results for the scenarios simulated. However, ABARE staff generously provided unpublished details on the implications for prices and quantities produced and consumed. The key features of the analysis and the main results are summarized in table 2.

Table 2. ABARE Results on Consequences of Elimination of U.S. Policies, 2007–20

Percent difference in output, price, and gross value of production (relative to the reference case)

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Soybeans	Output	0.00	-0.31	-0.61	-0.89	-1.17	-1.44	-1.72	-1.99	-2.27	-2.56	-2.86	-2.54	-2.20	-2.17	-2.15
	Price	0.00	-0.12	-0.24	-0.37	-0.50	-0.62	-0.74	-0.86	-0.96	-1.06	-1.14	-1.37	-1.62	-1.64	-1.65
	GVP	0.00	-0.43	-0.85	-1.26	-1.66	-2.06	-2.45	-2.83	-3.21	-3.59	-3.97	-3.88	-3.78	-3.77	-3.76
Wheat	Output	0.00	-0.62	-1.27	-1.94	-2.64	-3.38	-4.15	-4.95	-5.79	-6.67	-7.58	-6.10	-4.55	-4.64	-4.73
	Price	0.00	0.06	0.14	0.23	0.34	0.47	0.63	0.81	1.02	1.25	1.52	0.96	0.37	0.41	0.46
	GVP	0.00	-0.56	-1.13	-1.71	-2.31	-2.92	-3.54	-4.18	-4.83	-5.50	-6.18	-5.20	-4.20	-4.25	-4.30
Maize	Output	0.00	-0.39	-0.78	-1.17	-1.54	-1.92	-2.29	-2.67	-3.04	-3.41	-3.79	-3.60	-3.39	-3.37	-3.35
	Price	0.00	-0.05	-0.10	-0.13	-0.15	-0.15	-0.13	-0.08	-0.01	0.11	0.26	-0.24	-0.79	-0.75	-0.71
	GVP	0.00	-0.45	-0.88	-1.30	-1.69	-2.07	-2.42	-2.75	-3.05	-3.31	-3.54	-3.83	-4.15	-4.10	-4.03
Rice	Output	0.00	-1.33	-2.59	-3.80	-4.98	-6.12	-7.24	-8.36	-9.47	-10.59	-11.71	-11.96	-12.23	-12.25	-12.27
	Price	0.00	-0.33	-0.67	-1.02	-1.39	-1.78	-2.17	-2.58	-3.00	-3.43	-3.87	-3.75	-3.63	-3.76	-3.89
	GVP	0.00	-1.65	-3.24	-4.79	-6.30	-7.79	-9.26	-10.72	-12.18	-13.65	-15.13	-15.26	-15.42	-15.55	-15.68
Cotton	Output	0.00	-1.55	-3.05	-4.52	-5.94	-7.34	-8.70	-10.03	-11.33	-12.62	-13.88	-14.04	-14.22	-14.13	-14.04
	Price	0.00	-0.50	-1.03	-1.59	-2.17	-2.77	-3.40	-4.05	-4.72	-5.40	-6.10	-6.08	-6.05	-6.24	-6.43
	GVP	0.00	-2.04	-4.05	-6.03	-7.98	-9.91	-11.80	-13.67	-15.51	-17.33	-19.13	-19.27	-19.41	-19.49	-19.56
Cane and beet	Output	0.00	-2.15	-4.73	-7.72	-11.05	-14.63	-18.38	-22.20	-26.01	-29.73	-33.31	-32.86	-32.42	-31.88	-31.37
	Price	0.00	-0.95	-2.06	-3.32	-4.74	-6.29	-7.95	-9.71	-11.54	-13.41	-15.30	-15.35	-15.39	-15.70	-15.99
	GVP	0.00	-3.08	-6.70	-10.79	-15.26	-19.99	-24.87	-29.76	-34.55	-39.15	-43.51	-43.17	-42.82	-42.58	-42.34
Fruit and vegetables	Output	0.00	0.32	0.67	1.04	1.45	1.88	2.34	2.82	3.33	3.87	4.42	4.33	4.23	4.37	4.51
	Price	0.00	-0.45	-0.93	-1.42	-1.92	-2.44	-2.97	-3.51	-4.05	-4.60	-5.16	-5.03	-4.90	-5.02	-5.13
	GVP	0.00	-0.14	-0.27	-0.39	-0.50	-0.61	-0.70	-0.78	-0.86	-0.92	-0.96	-0.92	-0.88	-0.87	-0.85
Beef cattle	Output	0.00	0.11	0.23	0.36	0.49	0.64	0.79	0.95	1.11	1.27	1.44	1.42	1.40	1.48	1.55

	Price	0.00	-0.28	-0.57	-0.89	-1.22	-1.56	-1.91	-2.26	-2.62	-2.97	-3.31	-3.27	-3.23	-3.37	-3.51
	GVP	0.00	-0.17	-0.35	-0.53	-0.73	-0.93	-1.13	-1.33	-1.53	-1.73	-1.92	-1.90	-1.87	-1.95	-2.02
Pigs and poultry	Output	0.00	0.02	0.05	0.09	0.12	0.17	0.21	0.26	0.31	0.36	0.41	0.42	0.44	0.49	0.53
	Price	0.00	0.00	-0.01	-0.02	-0.02	-0.03	-0.04	-0.04	-0.04	-0.03	-0.01	-0.03	-0.06	-0.10	-0.14
	GVP	0.00	0.02	0.04	0.07	0.10	0.13	0.17	0.22	0.27	0.33	0.39	0.39	0.38	0.39	0.39
Milk	Output	0.00	-0.05	-0.09	-0.14	-0.18	-0.22	-0.26	-0.31	-0.35	-0.40	-0.45	-0.44	-0.43	-0.41	-0.39
	Price	0.00	0.00	0.00	-0.01	-0.02	-0.04	-0.05	-0.06	-0.05	-0.04	-0.01	-0.05	-0.09	-0.16	-0.24
	GVP	0.00	-0.05	-0.10	-0.15	-0.20	-0.26	-0.31	-0.36	-0.40	-0.44	-0.46	-0.49	-0.52	-0.57	-0.63

Source: Table was provided by Vernon Topp, ABARE, December 2006, personal communication. Effects refer to elimination of U.S. farm programs as represented in ABARE (2006) Research Report 06-10, Scenario 1.

The results reflect assumptions about the baseline of world prices and U.S. policies, and thus the extent of the U.S. market adjustments that would be required to accommodate the elimination of the programs. They also reflect modeling details such as elasticities of supply and demand response to price changes, elasticities of price transmission, and the specific mathematical representation of policies (in many cases, I suspect, as ad valorem tariff or subsidy equivalents) with corresponding assumptions about the extent to which elements of subsidies are decoupled. These details are not known to me. However, the estimated changes in quantities and prices in table 2 seem plausible enough, given a baseline that was established in 2006 and before the more-recent commodity price increases. The baseline is crucial. If the baseline had been set based on an extrapolation out to 2020 of market prices for commodities in 2007, which are above support prices because of high oil prices and the enhanced demand for use of program crops for biofuels, then the measured consequences would be negligible. The ABARE baseline apparently reflects market conditions that had applied reasonably recently, but not currently, and which may well be an appropriate view of "normal" conditions in the longer-term future to which their estimates apply.

The results in table 2 have some interesting patterns. First, beginning in 2007, as the programs are progressively phased out over the ten years ending in 2016, the consequences for percentage changes in prices, quantities produced, and the value of production increase monotonically (and roughly linearly) in each case, so the results in 2016 can be used to indicate the nature of the results generally over that period of transition, recognizing that the effects are greatest in that year. Second, after 2016, with no further changes in policies, the pattern of percentage changes relative to the baseline is fairly constant over time, albeit with some movement (perhaps reflecting the path of the baseline or dynamic adjustment to previous changes), such that results for 2016 can be used to represent the long-term "steady-state" effects.

Table 3 includes the results for 2016 from table 2. Looking across commodities, the pattern of results for 2016 is consistent with expectations based on general knowledge of the U.S. farm program policies. For most of the commodities the effects of elimination of farm programs on price, quantity, and value of production would be modest: less than 5 percent of the baseline for corn, soybeans, fruit and vegetables, and all of the livestock products. The effects would be larger for wheat (but still modest, a reduction of less than 10 percent in quantity and value of production). Only the heavily supported rice, cotton, and sugar industries would experience changes in quantity and value of production greater than 10 percent of the baseline— and only sugar, more than 15 percent. The directions of changes in quantity are plausible: reductions in output for all crops except fruit and vegetables; increases in output for livestock products except dairy. The withdrawal of support would result in lower prices as well as lower quantities produced for rice, cotton, sugar, and milk. Some of the other price changes are less obvious, reflecting complex cross-commodity effects as well as own-commodity policy effects in the multi-market setting. For instance, the movement of resources into the fruit and vegetable industry, in response to lower relative profitability of program crops, would result in an increase in production and consequently a lower price of fruit and vegetables; similar patterns apply for beef, pigs, and poultry but for less clear reasons; the converse is the case for wheat and maize.

Table 3. Consequences of Elimination of U.S. Policies, 2016
(percent difference from baseline)

	Output	Price	GVP
Soybeans	-2.86	-1.14	-3.97
Wheat	-7.58	1.52	-6.18
Maize	-3.79	0.26	-3.54
Rice	-11.71	-3.87	-15.13
Cotton	-13.88	-6.10	-19.13
Cane and beet	-33.31	-15.30	-43.51
Fruit and vegetables	4.42	-5.16	-0.96
Beef cattle	1.44	-3.31	-1.92
Pigs and poultry	0.41	-0.01	0.39
Milk	-0.45	-0.01	-0.46

Source: See table 2.

The ABARE study included alternative simulations that allowed for other factors that would tend to moderate the changes in the United States. First, based on evidence from New Zealand in its period after reform, the ABARE authors argued that liberalization of farm program policies might give a boost to the underlying rate of productivity growth in U.S. agriculture. This effect would somewhat offset the effects of removal of subsidies on U.S. production, by enhancing U.S. competitiveness. Second, some simulations allowed for concomitant reductions in agricultural subsidies by other countries, as might be a more realistic scenario in which to see such substantial U.S. policy reform, and in these scenarios the gains to U.S. agriculture resulting from liberalization by importers and competing exporters would offset to some extent the losses from withdrawal of U.S. government support.

A Sector-Model Analysis of Farm Program Consequences. An alternative approach to evaluating the impact of subsidies is to use a sector model approach. In this section that approach is applied to the main program crops, using data on program payments for 2005 combined with an approach developed by Sumner (2003, 2005a, 2005b) for representing different elements of program payments as equivalent amounts of revenue from the market (or fully coupled output subsidy equivalents) in terms of their production incentive effects. For both corn and upland cotton, Sumner has reviewed, case by case, the types of incentive effects different elements of farm program payments would have, and derived multipliers to be applied to the different forms of subsidy to represent their differential incentive effects relative to revenue from the market (or, equally, in the application at hand, a fully coupled subsidy).

The case of corn provides a useful introduction to the approach. In this case, Sumner (2005a) argued that loan program payments (including loan deficiency payments, marketing loan gains, and certificate exchange gains) are closely tied to production, and could be treated as equivalent to a pure output subsidy. In contrast, direct payments are significantly decoupled from production, but Sumner offers four reasons for why direct payments have effects on production: through lowering a recipient's cost of capital; through increasing a recipient's tolerance of market risk; because of limitations on what may be grown on program acreage; and because of the expectation that payment bases will be updated. He derived a multiplier of 0.40 for direct payments to corn growers, which means that a dollar of direct payments has the same effect on production as 40 cents from the market. In other words, in our models we can represent a dollar of direct payments, equivalently, as a decoupled payment of 60 cents and an output subsidy of 40 cents. Countercyclical payments fall in between these two, a hybrid between direct payments and loan program payments, and Sumner suggested a multiplier of 0.50 to be applied to countercyclical payments for corn. In each instance, he argued that the multiplier was conservatively small. In what follows, the same multipliers are applied to the other program crops as well.

Table 4 shows details crop by crop and in total of government subsidy payments to program crops in 2005. Total government payments in 2005 of $24.3 billion included a range of payments (such as ad hoc and emergency program payments or tobacco transition payments) that we would not include in our measure of subsidies in the current context. Subsidies to producers of program crops included $5.25 billion in the form of direct payments (DP), $4.82 billion in the form of countercyclical payments (CCP), and $6.44 billion in the form of loan program payments (LPP —including loan deficiency payments, marketing loan gains, and certificate exchange gains), together totaling $16.5 billion. Production of program crops had a value in 2005 of about $58 billion and used 318 million acres such that the payments were equal to 28.6 percent of the value of production, or $52 per acre of program crops nationally.

Table 4. Commodity Program Payments in Crop Year 2005, by Commodity—Subsidy Rates

Program crop	Crop acres[a] (A)	Crop value (V)	Subsidy payments[b]					Subsidy rate	
			DP	CCP	LPP	TS_1	TS_2	$(100*TS_1/V)$	$(100*T$
	millions		*$millions*					*percent*	
Corn	75.11	21,041	2,109	2,948	4,600	9,657	6,918	45.9	
Soybeans	71.25	16,928	598	0	19	617	258	3.6	
Upland cotton	13.53	5,204	611	1,376	371	2,358	1,303	45.3	
Wheat	50.12	7,140	1,136	0	1,036	2,172	1,490	30.4	
Rice	3.36	1,789	425	87	130	642	344	35.9	
Other[c]	104.43	5,696	375	414	288	1,077	645	18.9	
Total[d, e]	317.80	57,798	5,254	4,824	6,444	16,522	10,958	28.6	

Source: Compiled by the author with assistance from Henrich Brunke using data from the USDA NASS Agricultural Statistics Database (http://www.nass.usda.gov/#top), the USDA Economic Research Service Farm Income Database (http://www.ers.usda.gov/Data/FarmIncome/finfidmu.htm), and the Commodity Estimates Books for the 2007 President's Budget (http://www.fsa.usda.gov/FSA/webapp?area=about&subject=landing&topic=bap-bu-ce).

DP=Direct payments
CCP=Countercyclical payments
LPP=Loan deficiency payments, marketing loan gains, and certificate exchange gains

a. Harvested acres
b. LPP is "loan program payments" which includes loan deficiency payments, marketing loan gains, and certificate exchange gains.
TS_1 is the simple sum: $TS_1 = DP+CCP+LPP$ and $TS_2 = (0.4*DP)+(0.5*CCP)+(1.0*LPP)$ is the weighted sum, where each weight represents an estimate of the equivalent rate of output subsidy per dollar of payment.
c. Other includes other program crops: feed grains (barley, oats, grain sorghum), peanuts, oilseeds (sunflower seed oil, other minor oilseeds, canola, rapeseed, mustard seed, safflower seed, crambe, sesame), lentils, chickpeas, dry edible peas, wool, mohair.
d. The U.S. total given here is slightly different from the total in table 6 because of a difference in sources.
e. The total crop value figure includes the U.S. value of production data for food grains, feed crops, cotton, and oil crops, as reported by USDA.

In addition to the simple sum of program payments, the total subsidy (TS$_1$), the table includes a weighted sum of payments (TS$_2$), given by applying the weights (0.4, 0.5, and 1.0) to the respective elements of payments (DP, CCP, and LPP): TS$_2$ = 0.4*DP+0.5*CCP+LPP. These subsidy amounts are expressed relative to the value of production in the last two columns of the table. The entries in the final column, 100*TS$_2$/V, represent the percentage output subsidy equivalent of the payments. The last entry in that column represents the average rate of subsidy equivalent, in terms of the incentive effects, for the commodities in the table: 19.0 percent.

Applying that subsidy rate in the model in appendix A, with parameters representing program crops as a whole (η = 1.0, σ = 0.1, ε_1 = 0.2, ε_2 = 1.0, k_1 = 0.20), the implied effect of eliminating the programs would be a reduction in production of these crops by 7.3 percent.[12] This estimate is comparable to albeit implying larger effects than the corresponding estimates from the ABARE (McDonald and others 2006) model (which ranged from 2.9 to 13.9 percent for the crops considered here, but were only 2.9 and 3.8 percent for soybeans and maize, which represent two-thirds of the value of production). The implications are similar: the total output effects of elimination of subsidies would be modest, even in the most-subsidized parts of the agricultural industry.

The direct net benefit (deadweight loss avoided) is correspondingly small. As shown in appendix E, the deadweight loss from distortions in production and consumption resulting from an output subsidy, expressed as a percentage of the subsidy expenditure, is proportional to the percentage subsidy-induced change in production. Using the same parameters for program crops, and allowing for the role of international trade, the proportion is in the range of 0.5 to 1.0. Thus, if elimination of subsidies at an average rate of 19 percent (in incentive effect) would yield a 7.3 percent increase in production, it would yield net gains to society in the range of 3.6 to 7.3 percent of the amount of effective subsidy expenditure of $10.96 billion in 2005 (that is, in the range of $400 million to $800 million; 2 to 5 percent of the actual subsidy expenditure of $16.52 billion; 0.7 to 1.4 percent of the value of program crop production of $58 billion). Of course, the total deadweight loss is much bigger if we allow for any significant deadweight losses associated with general taxation to raise the government revenues to finance subsidies (or equivalently, a social opportunity cost of government revenues significantly greater than a dollar per dollar spent—say $1.20 per dollar). When these additional deadweight losses are added, applying a conservative rate of 20 percent to the full subsidy expenditure of $16.52 billion in 2005, the total deadweight loss is about $4 billion.

CRP Acreage. Suppose the Conservation Reserve Program was eliminated and an additional 35 million acres of CRP land were added to the 442 million acres used of cropland in 2005, a 7.8 percent increase in crop acreage. Applying that percentage increase in supply of land in the model from section 2, with parameters representing program crops as a whole (that is, once more, η = 1.0, σ = 0.1, ε_1 = 0.2, ε_2 = 1.0, k_1 = 0.20), the implied effect would be an increase in production of these crops by about 2.3 percent. Thus if the CRP were eliminated along with crop subsidies, the net effects on output would be smaller, compared with eliminating the subsidies alone, but still negative—an output reduction of around 5 percent.

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[12] These parameters together imply an elasticity of supply of program crops in aggregate of 0.62.

Table 5. Commodity Program Payments in Crop Year 2005, by Commodity—Equivalent Subsidy Per Acre

Program crop	Crop acres[a] (A)	Crop value (V)	Subsidy payments[b]				Subsidy/Acre	
			TS_1	TS_2	TS_3	TS_4	(TS_1/A)	(TS_4/A)
	millions		*$ millions*				*$/acre*	
Corn	75.11	21,041	9,657	6,918	2,739	4,815	128.58	64.10
Soybeans	71.25	16,928	617	258	359	436	8.67	6.12
Upland Cotton	13.53	5,204	2,358	1,303	1,055	1,446	174.20	106.85
Wheat	50.12	7,140	2,172	1,490	682	1,129	43.34	22.52
Rice	3.36	1,789	642	344	299	402	190.84	119.51
Other[c]	104.43	5,696	1,077	645	432	626	10.31	5.99
Total[d, e]	317.80	57,798	16,522	10,958	5,564	8,852	51.99	27.85

Source: See table 4.

a. Harvested acres

b. As defined in table 6, TS_1 is the simple sum: $TS_1 = DP+CCP+LPP$ and $TS_2 = (0.4*DP)+(0.5*CCP)+(1.0*LPP)$ is the weighted sum, where each weight represents an estimate of the equivalent rate of output subsidy per dollar of payment. $TS_3 = TS_1 - TS_2 = (0.6*DP) + (0.5*CCP)$.
An estimate of the proportion of the subsidy in question that accrues to land is $TS_4 = TS_3 + \mu TS_2$, where μ represents the proportion of an output subsidy that would accrue to land, assumed to be around 30 percent for the cases modeled here (see the second and fifth sections). Combining $TS_4 = TS_3 + \mu TS_2$ with $\mu = 0.3$, $TS_3 = 0.6*DP+0.5*CCP$, and $TS_2 = 0.4*DP+0.5*CCP+LPP$ yields $TS_4 = 0.72*DP+0.65*CCP+0.30*LPP$.

c. Other includes other program crops: feed grains (barley, oats, grain sorghum), peanuts, oilseeds (sunflower seed oil, other minor oilseeds, canola, rapeseed, mustard seed, safflower seed, crambe, sesame), lentils, chickpeas, dry edible peas, wool, mohair.

d. The U.S. total given here is slightly different from the total in table 6 because of a difference in sources.

e. The total crop value figure includes the U.S. value of production data for food grains, feed crops, cotton, and oil crops, as reported by USDA.

Table 6. Program Payments versus Cash Rents in Crop Year 2005, by State

State	Crop acres (A)[a]	Subsidy payments[b]					Subsidy rate[c]		Cash rent (R)
		DP	CCP	LPP	TS_1	TS_4	(TS_1/A)	(TS_4/A)	
	1000s	*$millions*					*$/acre*		
Alabama	2,037	42.7	80.7	62.3	185.7	101.9	91.2	50.0	40.0
Arizona	730	35.2	66.6	4.2	105.9	69.9	145.1	95.7	165.0
Arkansas	7,559	253.9	79.5	168.3	501.7	285.0	66.4	37.7	76.0
California	4,397	167.0	130.5	256.1	553.6	281.9	125.9	64.1	330.0
Colorado	6,245	75.2	38.2	55.8	169.2	95.7	27.1	15.3	61.0
Connecticut	93	0.7	0.7	1.5	2.8	1.4	30.6	15.2	46.0
Delaware	443	5.7	4.2	9.2	19.2	9.6	43.3	21.7	46.0
Florida	1,061	10.9	22.9	3.3	37.0	23.7	34.9	22.4	37.0
Georgia	3,656	100.5	197.2	76.7	374.5	223.6	102.4	61.1	58.0
Idaho	4,219	59.7	10.5	18.4	88.5	55.3	21.0	13.1	104.0
Illinois	23,711	462.1	379.8	743.5	1,585.4	802.6	66.9	33.9	129.0
Indiana	12,330	233.8	193.0	359.5	786.3	401.6	63.8	32.6	109.0
Iowa	24,730	508.5	441.5	983.8	1,933.8	948.2	78.2	38.3	131.0

State									
Kansas	22,711	332.4	139.7	259.2	731.4	407.9	32.2	18.0	42.0
Kentucky	5,425	55.4	43.1	68.0	166.5	88.3	30.7	16.3	73.0
Louisiana	3,365	122.8	93.5	66.3	282.7	169.1	84.0	50.2	66.0
Maine	290	0.9	1.1	1.8	3.8	1.9	12.9	6.6	46.0
Maryland	1,345	17.3	13.0	23.9	54.3	28.1	40.3	20.9	62.0
Massachusetts	113	0.4	0.6	1.0	2.0	1.0	17.7	8.7	46.0
Michigan	6,538	89.8	71.0	135.5	296.2	151.5	45.3	23.2	62.0
Minnesota	19,377	309.5	235.4	549.2	1,094.1	540.6	56.5	27.9	86.5
Mississippi	4,305	125.0	153.4	494.9	773.3	338.2	179.6	78.6	69.0
Missouri	13,524	185.7	115.5	190.2	491.4	265.8	36.3	19.7	79.0
Montana	9,495	103.7	11.0	20.8	135.4	88.1	14.3	9.3	25.0
Nebraska	18,867	338.7	301.4	551.4	1,191.5	605.2	63.2	32.1	97.0
Nevada	479	0.6	0.1	0.1	0.9	0.5	1.8	1.1	62.0
New Hamps.	72	0.3	0.4	0.9	1.6	0.7	22.4	10.4	46.0
New Jersey	323	2.7	2.1	3.0	7.8	4.2	24.1	13.0	47.5
New Mexico	1,138	16.3	16.9	10.5	43.6	25.9	38.3	22.7	62.0
New York	3,088	27.5	25.8	41.1	94.4	48.9	30.6	15.8	41.0
N. Carolina	4,635	66.0	100.3	135.3	301.6	153.3	65.1	33.1	53.0
North Dakota	21,317	224.4	34.0	140.7	399.0	225.9	18.7	10.6	39.0
Ohio	10,103	168.6	118.5	205.1	492.2	259.9	48.7	25.7	82.0
Oklahoma	10,150	125.4	43.6	18.9	187.9	124.3	18.5	12.2	29.0
Oregon	2,169	30.1	2.1	2.1	34.2	23.7	15.8	10.9	100.0
Pennsylvania	3,753	24.5	22.2	43.3	90.1	45.1	24.0	12.0	45.0
Rhode Island	12	0.0	0.0	0.1	0.1	0.0	9.7	2.5	46.0
S. Carolina	1,584	27.2	37.4	22.3	86.8	50.6	54.8	31.9	29.0
South Dakota	16,998	160.6	106.5	243.2	510.3	257.8	30.0	15.2	50.4
Tennessee	4,590	53.0	69.3	140.4	262.8	125.3	57.3	27.3	67.0
Texas	22,265	404.8	513.1	665.0	1,583.0	824.5	71.1	37.0	29.7
Utah	1,003	6.3	2.0	2.4	10.7	6.6	10.7	6.5	65.0
Vermont	335	1.9	2.1	5.5	9.6	4.4	28.6	13.1	46.0
Virginia	2,732	24.0	28.8	26.9	79.7	44.1	29.2	16.1	40.0
Washington	3,615	73.9	7.2	11.4	92.4	61.3	25.6	17.0	190.0
West Virginia	645	1.8	1.6	1.6	5.0	2.8	7.7	4.4	28.0
Wisconsin	8,197	114.0	112.7	191.6	418.2	212.8	51.0	26.0	70.0
Wyoming	1,589	7.1	3.2	4.6	14.9	8.6	9.4	5.4	62.0
United States[c]	317,802	5,198.6	4,074.0	7,020.6	16,293.2	8,497.3	51.3	26.7	78.0

Source: Compiled by the author with assistance from Henrich Brunke using data from the USDA NASS Agricultural Statistics Database (http://www.nass.usda.gov/#top), the USDA Economic Research Service Farm Income Database (Government payments, by state and program) (http://www.ers.usda.gov/Data/FarmIncome/finfidmu.htm), and the USDA NASS 2006 summary on Land Values and Cash Rents (http://usda.mannlib.cornell.edu/usda/current/AgriLandVa/AgriLandVa-08-04-2006.pdf).

DP=Direct payments

CCP=Countercyclical payments

LPP=Loan deficiency payments, marketing loan gains, and certificate exchange gains

a. Harvested acres are for field and miscellaneous crops.

b. Subsidy rates in millions of dollars are divided by millions of acres, whereas the values for A are in thousands of acres.

c. LPP is "loan program payments" which includes loan deficiency payments, marketing loan gains, and certificate exchange gains.

TS_1 is the simple sum: $TS_1 = DP+CCP+LPP$.

TS_4 is the weighted sum: $TS_4 = 0.72*DP+0.65*CCP+0.30*LPP$, where each weight represents an estimate of the

proportion of the subsidy in question that accrues to land.
d. United States total includes Alaska and Hawaii, which have been left out to reduce the size of the table. The U.S. total given here is slightly different from the total in tables 4 and 5 because of a difference in sources.

Incidence on Land Rents. In 2005, cropland rented for about $80 per acre as a national average (but closer to $120 per acre in the Midwest—see table 6), and cropland rents represented about 20 to 25 percent of the value of production, which is less than the value of subsidies as a percentage of production. Thus if all of the payments had been fully reflected in land rents, income from the market would have accounted for only a small (possibly negative!) share of the income to land; government payments would have accounted for the lion's share. However, we would not expect all of the subsidy payments to go to land.

Table 5 replicates some of the information from table 4. It includes, crop-by-crop, the total subsidy amount (TS_1) and the fully coupled equivalent (TS_2) as well as the difference between these two ($TS_3 = TS_1 - TS_2 = 0.6*DP+0.5*CCP$), which represents the amount of the total subsidy that can be treated as a pure decoupled payment that goes to land. Having partitioned the total subsidies into an element that can be treated as a fully coupled output subsidy (TS_2) and a residual that can be treated as a fully decoupled payment (TS_3), we can analyze the impacts on landowners. The total benefits to land owners are equal to the benefits from the fully decoupled element (TS_3) plus the amount going to land from the fully coupled element ($\mu\,TS_2$, where μ is the share going to land): $TS_4 = TS_3 + \mu\,TS_2$. In the model from appendix A, with parameters representing program crops as a whole ($\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), the implied value for μ is 30.0 percent. This value is used to compute the values for TS_4 in table 5.[13] These amounts are expressed relative to the value of production and per acre. Again, the last row expresses these subsidies summed across the program crops included in the table. Taking this approach, the total of $16.52 billion is equivalent to a decoupled transfer of $5.56 billion, 100 percent of which accrues to land, combined with a pure output subsidy of $10.96 billion, 30 percent of which accrues to land. The overall incidence is therefore about $8.85 billion on land and $7.65 billion on suppliers of non-land inputs and consumers.

We can replicate this kind of analysis at the level of U.S. states, given information on the total government payments, on the value of agricultural production, and on cash rents to land. Table 6 shows the details, state by state and in total. Considering the last three columns, we can compare the cash rent (R) with the total subsidy per acre of cropland (TS_1/A) in the third-last column, or the weighted subsidy per acre of cropland as an estimate of the subsidy accruing to land (TS_4/A) in the second-last column. To facilitate this comparison, figure 1 plots the unweighted (TS_1/A) and weighted (TS_4/A) payments per acre versus cash rents.

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[13] Combining $TS_4 = TS_3 + \mu TS_2$ with $TS_3 = 0.6*DP+0.5*CCP$ and $TS_2 = 0.4*DP+0.5*CCP+LPP$ yields $TS_4 = 0.72*DP+0.65*CCP+0.30*LPP$.

Figure 1. Cash Rent versus Farm Program Payments per Acre, by State, 2005
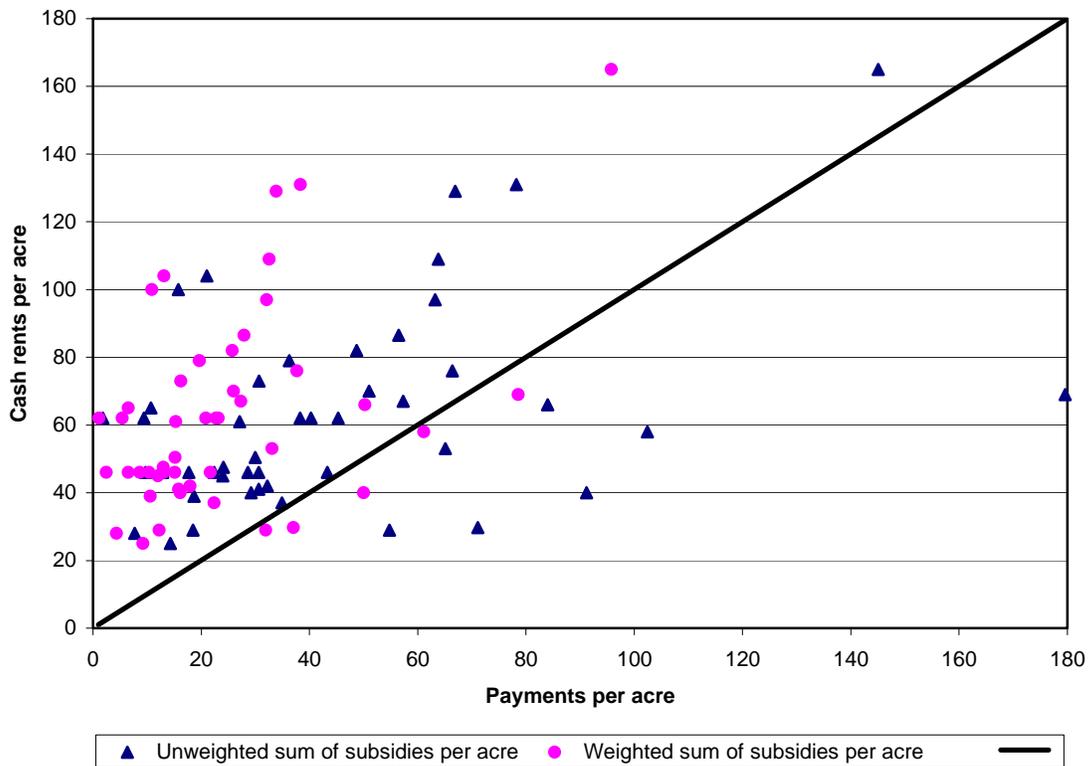
Source: Based on data in the last three columns of table 6.
   Note: Excludes California and Washington.

In most (but not all) of the states, the total subsidy per acre of cropland (TS_1/A) is less than cash rents per acre but often it is large relative to the total cash rents, and sometimes implausibly large as a measure of the incidence of the subsidy on land rents. On that basis, these simple comparisons alone are sufficient to question the view sometimes expressed that all subsidy payments end up in land rents, because surely some rental payments are due to the productive effects of land. On the other hand, the estimate of the subsidy accruing to land (TS_4/A) is typically about one-half to one-third of the total cash rent, which is plausible.

These results provide a useful background for the interpretation of the results from econometric studies that have attempted to draw direct statistical inferences about the effects of farm program payments on land rents or land (asset) prices. Related econometric work has attempted to measure the extent to which farm program payments are decoupled from production, and the results from this body of work are relevant as well. The econometric studies in this area have found that subsidies that we might expect to be mostly if not fully decoupled do have some effects on production and resource use, although the quantitative effects of these responses were fairly small in some cases. Much of this work is consistent with the view that the "so-called" decoupled transfers really do not have much effect on production and would be expected to be distributed for the most part as returns to landowners and in land rents. On the other hand, some studies found larger effects of these subsidies on production and most econometric studies of the land market found surprisingly small effects of subsidies on land rents and land values.

Conclusion

This paper has discussed theory and evidence on the incidence of U.S. farm commodity programs. Specifically, it has attempted to answer the question: what are the impacts of agricultural subsidies on consumers, taxpayers, and landowners—as opposed to farm operators, who may be seen by some as the intended recipients of subsidy payments? The focus of the question is contemporary or forward-looking (that is, rather than a question about past impacts, concerned with economic history that may be relevant for understanding the present); and it is holistic, referring to the full impact of all of the programs together, allowing for the interactions among all the affected markets for agricultural products and factors.

Simple theoretical models following Floyd (1965) can be used to illustrate how different types of subsidy policies have different incidence. Analysis with such models indicates that we should expect a fully decoupled payment attached to land to be reflected entirely in land rents (one dollar of additional land rent paid and earned per dollar of additional subsidy payments) and capitalized fully into land. Under extreme assumptions (such as a fixed supply of land), the same would be true of an input subsidy on the use of land. More generally, however, even a subsidy on land will have some effects on input combinations and output and thus the incidence will be shifted partly to suppliers of non-land inputs and consumers. A subsidy on output is expected to have even less of its incidence on land and more of it on consumers and suppliers of non-land inputs, but still it will have a disproportionate incidence on landowners as the suppliers of the least elastic factor of production. Consequently, with some plausible values for the relevant parameters (see the second section and appendix A), based on theoretical analysis alone we might rank instruments in terms of their approximate incidence on landowners versus others as follows: decoupled direct payment tied to land, 100 percent to landowners; land input subsidy, 45 to 77 percent to landowners, depending on the details of the case; output subsidies, 1 to 45 percent to landowners, depending on the details of the case. The specific details of actual policies matter for incidence, as stressed by Alston and James (2002). Real world policies are typically not pure output subsidies or pure input subsidies; they often combine multiple instruments together, and even the direct payments policies may not be fully decoupled. Nonetheless, the abstract theoretical analysis of stylized policies provides some guidance as to the range of incidence outcomes we might expect from real-world policies, and it gives a basis for

interpretation of the results from empirical work with models of land markets.

Relative to the predictions from these models, the econometric studies generally have found a surprisingly small share of subsidy benefits going to land owners. The work by Roberts, Kirwan, and Hopkins (2003) is a good example. The authors have made exhaustive attempts to identify and address potential sources of econometric bias, but their estimates of the multiplier for decoupled subsidies are still well less than half what the static theory would predict. One possible interpretation is that the authors are estimating an intermediate-run effect, which is smaller than the long-run effect, because of fixity associated with contracts or because of roles played by expectations or other dynamics. A direct analogy can be drawn between this finding and the more general findings about the elasticity of supply response to output prices. Synthetic models based on theory and assumptions about parameters generally yield much larger elasticities of supply response than econometric models do. A reasonable interpretation is that the synthetically estimated elasticities are too high and that the econometrically estimated ones are too low to represent long-run responses; though they might well represent intermediate-run or short-run responses.[14] In the context of supply response, there is not such thing as "the" elasticity; it depends on the length of run. Similarly, perhaps we should not think of "the" multiplier effect of farm programs on land rents and we should identify the relevant length of run for particular estimates.

Combining the results from a review of econometric models in the literature, multi-market simulations, and application of a sector model of U.S. agriculture yields a range of results about the share of subsidy payments going to land. The truth probably lies in between the results from the theoretical models and the general run of the econometric evidence: that a significant share of even the so-called "decoupled" transfers goes to farmers rather than landowners, and that both landowners and farm operators receive a significant share of the net benefits from subsidies. To make matters concrete, the evidence is generally consistent with a view that 40 to 60 percent of subsidy payments accrue as benefits to landowners, 20 percent accrue as benefits to consumers and that 15 to 35 percent accrue as benefits to farmers per se, with a modest amount—say 5 percent—wasted as a deadweight loss.

The fundamental function and purpose of farm commodity policies is to transfer income to agriculture from other sectors of the economy (Sieper 1982). In the case of commodities protected by import barriers like beef, sugar, and dairy products, the transfers come at the cost of domestic and foreign consumers of the food and fiber products those commodities are used to make. In the case of commodities supported by subsidy programs, the transfers are financed from government revenues, ultimately at the expense of taxpayers. The policies involve deadweight losses, in the sense that the costs to taxpayers and consumers exceed the benefits to farmers, landowners, and other agribusiness interests, but the redistributive consequences generally are measured on a larger scale.

Different forms of policy are more or less efficient in the sense that they involve a greater or smaller deadweight loss relative to the amount transferred (see Gardner 1983; Alston and James 2002). Economists sometimes advocate changes in policy instruments with a view to reducing the implications for distortions in domestic resource use or trade, such as the changes introduced in the 1996 U.S. Farm Bill, and more recently in the European Union (EU) and Canada that replaced policies that were tied to production with various types of comparatively

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[14] For instance, see Cassels (1933).

decoupled transfers (see Alston 2007). Such changes, as well as affecting the market distortions associated with transfers to agriculture, will have implications for the distribution of the benefits and costs within the agricultural sector. However, as the work in this paper has shown, our understanding of the redistributive consequences of re-instrumentation of agricultural subsidies is seriously limited.

One argument that has been made for moving in the direction of the so-called decoupled transfers is that they entail a smaller deadweight loss associated with distortions in production and consumption of commodities—depending on the extent to which they are truly decoupled. However, direct decoupled transfers entail other deadweight losses of various types. In comparing instruments, however, it is important to count all the elements of social waste, not just the Harberger triangles, especially in cases where the Harberger triangles are small. The alternative policies, including some that have been proposed for the 2007 Farm Bill, might well engender substantially higher deadweight losses in other dimensions that more than outweigh any savings in Harberger triangles associated with distortions in production and consumption. Of particular concern may be the costs of enforcement and compliance associated with individual farm income support and stabilization programs, possibly subject to individual payment limitations, and the costs of distortions in resource use as farm business are restructured to meet eligibility criteria for certain types of program payments.

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Appendix A.
A Two-Factor Model of U.S. Agriculture, Agricultural Subsidies, and Land Rent

This appendix applies a two-factor model of agricultural production, as used by Alston and James (2002, pp. 1715–21), to consider the implications of subsidies for land rents.

Structure of the Model. The model structure includes a final demand, two-factor supply equations, a production function (or cost function) to represent the technology for the production of a homogeneous product, Q, using two factors of production, X_1 and X_2, and equations imposing competitive market clearing.[15] The solutions to the model are equations for proportional (or percentage) changes in the endogenous quantities and prices of the product and the two factors (Q, X_1, X_2, P, W_1, and W_2), each as a function of a set of fixed parameters, and exogenous shift parameters representing the effects of policies. The parameters of the model are the cost shares of the two factors (k_1 and k_2, where $k_1 + k_2 = 1$), the elasticities of demand for the product and supply of the two factors (η, ε_1 and ε_2), and the elasticity of substitution between the two factors (σ).

  The supply and shift parameters can be used to represent a subsidy on an input or output. In either case, for moderate rates of subsidy the benefits to consumers are approximately proportional to the percentage change in quantity consumed— $\Delta CS \approx (d \ln Q)(PQ/\eta)$ —and the benefits to suppliers of each factor are approximately proportional to the percentage change in the use of the factor— $\Delta PS_i \approx (d \ln X_i)(k_i PQ/\varepsilon_i)$. As demonstrated by Alston and James (2002) the benefits from the subsidies are shared between landowners, other factor suppliers, and consumers even when the quantity of land (input 1) is fixed, unless key parameters take on extreme values: either the price of non-land inputs (input 2) is fixed and there is no producer surplus for its suppliers (that is, $\varepsilon_2 = \infty$) or the factor proportions are fixed (that is, $\sigma = 0$). Under any other circumstances, the total benefit to factors will be shared between land and other inputs; and, if output changes and the output price is not fixed (that is, $\eta < \infty$), consumers will benefit, too.

  In general, then, we expect the benefits from subsidies to be distributed among consumers and factor owners, with the proportions depending on parameters, which in turn depend on the details of the policy, as discussed by Alston and James (2002). Some more-specific results regarding the benefits to landowners can be obtained by transforming results from Alston and James (2002). In the case of an output subsidy at a rate τ_Q, or an input subsidy on land at a rate τ_1, the equations for proportionate changes in quantities of land are:

$$\text{(A-1)} \qquad d \ln X_1 = \frac{\eta \varepsilon_1 (\sigma + \varepsilon_2)}{D} \tau_Q \; .$$

$$\text{(A-2)} \qquad d \ln X_1 = \frac{\left[(k_2 \sigma + k_1 \eta) \varepsilon_2 + \eta \sigma \right] \varepsilon_1}{D} \tau_1,$$

where $D = \varepsilon_1 \varepsilon_2 + \sigma(k_1 \varepsilon_1 + k_2 \varepsilon_2 + \eta) + \eta(k_2 \varepsilon_1 + k_1 \varepsilon_2) > 0$.

  Substituting these results into $\Delta PS_1 \approx (d \ln X_1)(k_1 PQ/\varepsilon_1)$ and then dividing by the cost of the subsidy expenditure (which is equal to $\tau_Q PQ$ for the output subsidy and $\tau_1 W_1 X_1$ for the input subsidy) yields expressions for the benefit to landowners per dollar of subsidy expenditure:

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[15] An equivalent model was used by Floyd (1965) for a similar purpose; see, also, Gardner (2003).

$$\text{(A-3)} \quad \frac{\Delta PS_1}{\tau_Q PQ} = \frac{d \ln X_1 k_1}{\tau_Q \varepsilon_1} = \frac{k_1 \eta(\sigma + \varepsilon_2)}{D} = \frac{k_1 \eta(\sigma + \varepsilon_2)}{\varepsilon_1 \varepsilon_2 + \sigma(k_1 \varepsilon_1 + k_2 \varepsilon_2 + \eta) + \eta(k_2 \varepsilon_1 + k_1 \varepsilon_2)}.$$

$$\text{(A-4)} \quad \frac{\Delta PS_1}{\tau_1 W_1 X_1} = \frac{d \ln X_1}{\tau_1 \varepsilon_1} = \frac{(k_2 \sigma + k_1 \eta)\varepsilon_2 + \eta\sigma}{D} = \frac{(k_2 \sigma + k_1 \eta)\varepsilon_2 + \eta\sigma}{\varepsilon_1 \varepsilon_2 + \sigma(k_1 \varepsilon_1 + k_2 \varepsilon_2 + \eta) + \eta(k_2 \varepsilon_1 + k_1 \varepsilon_2)}.$$

If all of the subsidy benefits go to landowners, these ratios will be equal to one, but in each case the ratio is less than one in general. To see this more clearly, we can consider some limiting cases. First, suppose the demand for output is perfectly elastic such that consumers cannot obtain any of the benefits. Taking the limits of equations (3) and (4) as $\eta \to \infty$ yields:

$$\text{(A-3')} \qquad \frac{\Delta PS_1}{\tau_Q PQ} = \frac{k_1(\sigma + \varepsilon_2)}{\sigma + k_2 \varepsilon_1 + k_1 \varepsilon_2}.$$

$$\text{(A-4')} \qquad \frac{\Delta PS_1}{\tau_1 W_1 X_1} = \frac{\sigma + k_1 \varepsilon_2}{\sigma + k_2 \varepsilon_1 + k_1 \varepsilon_2}.$$

By inspection, these ratios are less than one, in general. In the extreme case where the supply of land is fixed (that is, $\varepsilon_1 = 0$), all of the benefits from an input subsidy on land would accrue to landowners, regardless of the elasticity of factor substitution and regardless of the elasticity of demand. However, in the case of an output subsidy we require both a fixed output price (that is, $\eta = \infty$) and fixed factor proportions (that is, $\sigma = 0$) as well as a fixed supply of land before the subsidy expenditure will accrue entirely as a benefit to landowners.

Implications for the Incidence of Farm Subsidies on Land Markets. This simple model illustrates some key determinants of the extent to which farm program payments accrue to landowners versus others, treating the output from agriculture as a single homogeneous product, produced using homogeneous land, and with a given subsidy applying to all of land or all of the output. U.S. agriculture is more complicated than that, with heterogeneous land used to produce many different outputs that are subject to a variety of complex policies involving multiple instruments.

As a crude approximation, however, we can apply the simple model to U.S. agriculture in aggregate and look at the incidence of output or input subsidies on landowners. What might be reasonable values for the parameters in this case? Useful direct econometric evidence is not available for any of the parameters, but subjective estimates can be made given some knowledge of the relevant econometric literature and the nature of the application. First, demand for U.S. agricultural output is probably elastic but not very elastic, reflecting highly elastic demand for some traded goods and inelastic demand for some nontraded goods. Second, the supply of land in total may be essentially fixed, but the supply to agriculture is variable, as it can be allocated between agriculture and forestry and other nonagricultural uses. Third, the supply of "other" inputs to agriculture is more elastic than that of land but less than perfectly elastic, reflecting the specialized nature of some agricultural inputs, including managerial inputs and some capital. In view of these arguments, and based on further arguments and econometric evidence presented in appendix B, the following values seem reasonable: $\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.1$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$ (and $k_2 = 0.80$).[16] Substituting these values into equations (3) and (4), landowners would receive

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[16] Floyd (1965, p. 155) suggested values for these parameters of $\eta = 0.25$ to 0.50, $\sigma = 0.5$ to 1.5, $\varepsilon_1 = 0$, $\varepsilon_2 = 1.0$ to 3.0, $k_1 = 0.20$ (and $k_2 = 0.80$).

39 cents per dollar of output subsidy expenditure and 68 cents per dollar of input subsidy expenditure applied to land. Holding the other parameters constant but assuming a fixed supply of land ($\varepsilon_1 = 0$), the landowner would receive 58 cents per dollar of output subsidy expenditure but 100 percent of the land subsidy expenditure.

Table A-1 shows how benefits to landowners as a percentage of subsidy expenditure change as we change the key parameters (the elasticities of demand, factor substitution, and supply of land, η, σ, and ε_1) holding the other parameters (the elasticities of supply of non-land inputs and the factor shares, ε_2 and k_1) constant. In addition, this table includes corresponding estimates of benefits to consumers as a percentage of subsidy expenditure. The residual amount approximates the share of benefits to suppliers of non-land inputs (after due allowance for deadweight loss). The results are intuitive. The share of benefits going to land from either an output subsidy or an input subsidy on land increases with reductions in the elasticity of supply of land or with increases in either the elasticity of substitution between land and non-land inputs or the elasticity of demand for agricultural output, either of which implies an increase in the elasticity of the derived demand for land. In the extreme case of a fixed supply of land, landowners receive 100 percent of the benefits from an input subsidy but only 33 to 62 percent of the benefits from an output subsidy. Allowing for some elasticity of supply of land (with $\varepsilon_1 = 0.1$), landowners would receive 60 to 80 percent of the benefits from an input subsidy on land or 24 to 44 percent of the benefits from an output subsidy, depending on the values for the other parameters.

A more realistic view of the incidence of U.S. agricultural subsidy programs might be obtained by modeling program crops that receive the bulk of subsidy expenditure, as opposed to all of agriculture. Even if the total supply of land were fixed, the supply of land to the cropping industries would not be so. If we reinterpret the model above as representing the program crop sector of U.S. agriculture, rather than agriculture as a whole, the main implied difference would be to increase the elasticity of supply of land to the sector (say 0.2 rather than 0.1 or zero).[17] The other parameters may be about the same. Using these alternative parameters ($\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), landowners would receive 30 cents per dollar of output subsidy expenditure and 51 cents per dollar of input subsidy expenditure applied to crop land.[18]

This last analysis does not show the implications for the non-program crop producers who have to compete with the crop producers for the land. Figure A-1 shows the market for a fixed quantity of land that is to be allocated between two uses, cropping (C) and other non-cropping uses, such as forestry and pasture (N). The demand for land for cropping and the quantity of cropland are measured relative to the origin on the bottom left, and the demand for and quantity of land in other uses are measured relative to the origin on the bottom right. The initial demands are DC_0 for cropping and DN_0 for non-cropping uses of land, and the equilibrium allocation of land yields quantities of C_0 for cropping and N_0 non-cropping uses, with a price of

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[17] An elasticity of supply of land to crop production of 0.2 would indicate that a 50 percent increase in cropland rents in agriculture would induce a 10 percent increase in the quantity of land in crop production, coming from other uses such as grazing, the CRP, which holds 35 million acres compared with 442 million acres of cropland (in 2002), or non-agricultural use such as forestry.

[18] These parameters imply an elasticity of supply of program crops in aggregate of 0.45. If, alternatively, we assume an elasticity of supply of land of 0.3, and a cost share of land of 0.3, the implied elasticity of supply of program crops is 0.5.

$PC_0 = PN_0 = P_0$. If a uniform subsidy of τ per acre is applied to all uses of land, each demand will shift up by the amount of the subsidy—that is, to DC_1 and DN_1; the allocation will be unaffected, and the rental price will increase by the full amount of the subsidy $PC_1 = PN_1 = P_0 + \tau$. Alternatively, if the same per unit subsidy of τ per acre is applied only to land used in cropping, only the cropping demand will shift up by the amount of the subsidy, and the new equilibrium will be given by the intersection of DC_1 and DN_0 with a price of $PN_2 = PC_2 + \tau$. The allocation of land and the output mix will be affected (for instance, see Hardie, Gardner, and Parks 2006). In this analysis, the subsidy to cropland use has benefited all landowners regardless of how their land is used, but has advantaged crop producers and consumers and has disadvantaged producers and consumers of other products.[19]

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[19] Further complications arise if land is heterogeneous, or if the subsidy is restricted to particular specified acres of land, which will limit the potential for the incidence of the subsidy to be affected by changes in the allocation of land among uses.

Figure A-1. Allocation of Land Between Cropping and Other Uses
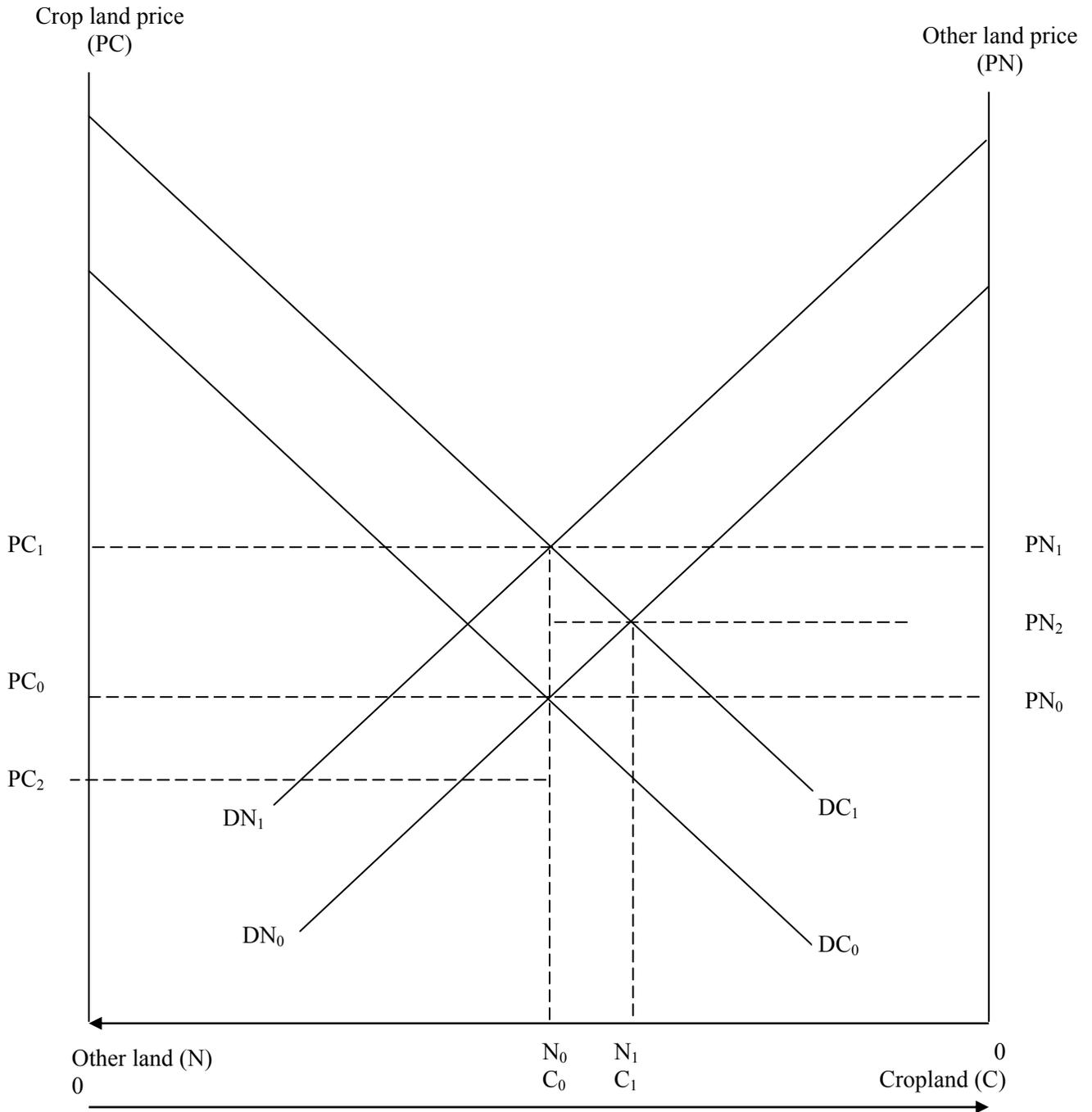*Source*: Author.

Table A-1. Implications of Key Parameters for Incidence of Farm Programs

Elasticity			Economic surplus change as a share of subsidy expenditure			
			Input subsidy		Output subsidy	
ε_1	σ	η	Consumers	Landowners	Consumers	Landowners
			Percent			
0.0	0.2	0.5	0	100	44	33
		1.0	0	100	29	43
		1.5	0	100	21	47
	0.1	0.5	0	100	35	48
		1.0	0	100	21	58
		1.5	0	100	15	62
0.1	0.2	0.5	24	71	52	24
		1.0	16	75	35	32
		1.5	12	77	27	37
	0.1	0.5	30	62	49	30
		1.0	20	68	32	39
		1.5	15	70	24	44
0.2	0.2	0.5	37	56	57	19
		1.0	26	60	40	26
		1.5	20	63	30	30
	0.1	0.5	43	45	55	21
		1.0	30	51	38	30
		1.5	23	54	29	34

Source: Prepared by the author using the model in this appendix

Notes: The parameters varying here are the elasticity of demand for U.S. agricultural output, η, the elasticity of substitution between land and non-land inputs, σ, and the relevant elasticity of supply of land, ε_1; other parameters being held constant are the elasticity of supply of non-land inputs, $\varepsilon_2 = 1.0$, and the share of land rent in total cost of production, $k_1 = 0.20$. The incidence shares for the input subsidy are computed using the following equations for suppliers of land and consumers (including domestic and foreign consumers), respectively:

Appendix B. Parameters of the Two-Factor Model of U.S. Agriculture

The model presented in appendix A allows for agricultural output to be produced under competitive conditions using land and an aggregate "other" input. The parameters of that model include the absolute value of the elasticity of demand for all agricultural output (η), the elasticity of substitution between land and other inputs in production of that output (σ), the elasticity of supply of land to agriculture (ε_1), the elasticity of supply of the other input (ε_2), and the share of land in the cost of production of the agricultural output k_1 (and by implication, the cost share of other inputs, $k_2 = 1 - k_1$). The main results in the text are based on the following values for those parameters: $\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.1$ or 0.2, $\varepsilon_2 = 1.0$, $k_1 = 0.20$ (and $k_2 = 0.80$).[20] This appendix provides arguments and evidence about the likely values of these parameters.

The Elasticity of Substitution Between Land and Other Inputs. Estimates of the elasticity of substitution between land and other inputs vary, but these numbers typically do not refer to substitution between land and all non-land inputs as an aggregate, for which the elasticity of substitution should be smaller. The assumed value of 0.1 is meant to reflect this fact. Although direct estimates of this elasticity of substitution are not available, an estimate can be deduced from estimates of the "own" elasticity of substitution for land, which does reflect the substitutability between land and all other inputs, obtained from studies using more disaggregated inputs.

Chalfant (1984) used a variety of functional forms to estimate cost functions for aggregate U.S. agriculture, and the associated systems of factor demands for four categories of inputs: capital, intermediate inputs, labor, and land. He estimated a matrix of elasticities of substitution, including the own-elasticity of substitution for land (σ_{LL}), for each of seven different flexible functional forms: (1) the Generalized Box-Cox, (2) the Generalized Leontief, (3) the Generalized Square-Root Quadratic, (4) the Fourier Flexible Form, (5) the Unrestricted Translog, (6) the unrestricted Generalized Square-Root Quadratic, and (7) the unrestricted Generalized Leontief. Across these alternative models, the own-elasticity of substitution for land (L) ranged from $\sigma_{LL} = -0.470$ to $\sigma_{LL} = -0.827$, with an average value of $\sigma_{LL} = -0.626$, all computed for 1967.

The output-constant elasticity of demand for land is equal to the own-elasticity of substitution multiplied by the cost share of land ($\eta_{LL} = k_L \sigma_{LL}$). Using the homogeneity condition, $\eta_{LO} + \eta_{LL} = 0$, where $\eta_{LO} = (1-k_L)\sigma_{LO}$ is the cross-price elasticity of demand for land with respect to the price of an aggregate of all other inputs (O), and σ_{LO} is the elasticity of substitution between land and other inputs in aggregate. Thus $k_L\sigma_{LL} + (1-k_L)\sigma_{LO} = 0$, and $\sigma_{LO} = -\sigma_{LL} k_L / (1-k_L)$. Using a cost share for land of 0.15 (as it was in the Chalfant data for 1967) implies $\sigma_{LO} = -\sigma_{LL}(0.15/0.85) = -\sigma_{LL}/5.7$. Thus Chalfant's estimates of σ_{LL} ranging from -0.470 to -0.827, imply values of σ_{LO} ranging from 0.08 to 0.15, with an average value of 0.11. A somewhat preferred model (the Generalized Box-Cox) had a value of $\sigma_{LL} = -0.503$, which implies $\sigma_{LO} = 0.09$. On the whole, this evidence would appear to support using a value of $\sigma = 0.1$ in the agricultural sector model.

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[20] Floyd (1965, p. 155) suggested values for these parameters of $\eta = 0.25$ to 0.50, $\sigma = 0.5$ to 1.5, $\varepsilon_1 = 0$, $\varepsilon_2 = 1.0$ to 3.0, $k_1 = 0.20$ (and $k_2 = 0.80$).

The Elasticity of Supply of Land. Direct estimates of the elasticity of supply of land to agriculture do not exist. A common assumption that that supply of land is fixed is extreme, given that the quantity of land in agricultural use does vary over time in response to changes in returns from agricultural and other uses of land. Even so the observed quantity of land in agricultural use does not change much from year to year. Some short-term responses (say, to leave land idle) are not readily observed. Other responses may involve complicated dynamics and speculative behavior. A switch from agricultural to nonagricultural use may be irreversible (or expensive to reverse) and thus may involve a longer-term decision compared with other allocation decisions made by farmers.

The supply of land to agriculture may respond asymmetrically to incentives. It may be much less elastic with respect to year-to-year fluctuations in returns, or small upward trends, than to large downward movements in returns from farming. Consequently, it may be difficult to judge how much the quantity of land in agricultural use might fall in response to a significant change in relative returns resulting from a significant, permanent policy shift against agriculture, based on past patterns of land use that have not reflected events of that sort.

An elasticity of supply of land to agriculture of 0.1 would indicate that a 50 percent decrease in land rents in agriculture would induce a 5 percent decrease in the quantity of land in agriculture. In 2002, the total amount of land in agriculture included 442 million acres of cropland and 587 million acres of grassland, pasture, and range. Forest use took 651 million acres. In addition, the Conservation Reserve Program holds 35 million acres. Lubowski and others (2006) provide detail on these and other data on agricultural land use.

The Elasticity of Supply of Other Inputs. The "other" non-land inputs include capital, purchased inputs, hired farm labor, and family labor and management. Some of these inputs would be expected to be highly elastically supplied to agriculture in the medium to long term. In the shorter run, specialized capital and managerial inputs may be even more limiting than land. I am not aware of any useful econometric estimates of the elasticities of supply of any of the inputs in this category to be used for the purpose at hand. In the analysis an elasticity of 1.0 is used, and this reflects a view that inputs other than managerial inputs and family labor are relatively elastically supplied, whereas family labor and managerial inputs are inelastically supplied.

Combining this value for the elasticity of supply of "other inputs" with an elasticity of supply of land of 0.2, a cost share of land of 0.2, and an elasticity of substitution of 0.1 between land and other inputs, the implied value for the elasticity of supply of farm output would be 0.45. This elasticity would be greater if a larger value was used for either (a) the elasticity of substitution, (b) the cost share for the more-elastically supplied "other" inputs, or (c) either of the factor supply elasticities.

The Elasticity of Demand for U.S. Agricultural Output. The elasticity of demand for aggregate agricultural output is a strange concept, but its magnitude is important. The strangeness comes from the fact that involves an unnatural-seeming aggregation across all agricultural outputs.[21] The importance of the magnitude stems from the fact that the

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[21] One concept of this elasticity of demand is that it measures what would happen to the aggregated

direction of the effect of changes in aggregate supply of agricultural products on the value of production, and thus the demand for land and other inputs (and the prices paid for them), depends on whether the demand for output is elastic or inelastic. Thus, for instance, whether farmers and landowners benefit or lose from technological change in agriculture turns on whether the aggregate demand is elastic, as do a number of other dimensions of policy questions. This fact notwithstanding, there is no clear consensus among agricultural economists over whether the aggregate demand is elastic or inelastic.[22]

The elasticity of aggregate demand for any agricultural commodity is a derived demand that reflects the characteristics of the demand for the final products it is used to produce. Since final consumer demand for food is generally inelastic, it appears to follow that the derived demand for food commodities will be even less elastic. Many economists appear to base an initial view on the issue on reasoning of this type. But such analysis ignores the fact that most food commodities are traded or tradable (if policies were not preventing trade), and the relevant demand facing domestic producers is therefore an excess demand that reflects the effects of the comparatively elastic demand for exports or supply of imports. In addition, many commodities are storable, and storage responses may amplify or mute the quantity implications of consumption responses to a price change, depending on whether the price change is perceived to be permanent or temporary. This aspect is set aside for now but must be remembered in conducting or interpreting empirical work.

Effects of International Trade. The elasticity of demand for a traded good can be computed as the share-weighted sum of the elasticities of domestic demand and export demand (for an exportable) and domestic demand and import supply (for an importable). That is, if the quantity of good i consumed domestically (D_i) is equal to the quantity produced domestically (Q_i) minus the quantity exported (X_i)—or $Q_i = D_i + X_i$—then:

(B-1) $\quad \eta_{ii}^T = \left(\frac{D_i}{Q_i}\right)\eta_{ii}^D + \left(\frac{X_i}{Q_i}\right)\eta_{ii}^X = k_{Di}\eta_{ii}^D + (1-k_{Di})\eta_{ii}^X,$

where η_{ij} denotes the elasticity of demand for good i with respect to the price of good j, and thus η_{ii} is the own-price elasticity; the superscripts refer total (T), domestic (D), and export (X) demand, and k_D denotes domestic consumption as a share of the total.

The demand for many individual commodities is highly elastic once we allow for the role of international trade, even though the domestic demand is highly inelastic (in many instances, effectively infinitely elastic) and even if the export share is fairly small. Table B-1 shows representative values from the literature (derived from the PeatSim model developed by Stout and Abler 2003) for domestic and export elasticities of demand for selected farm program commodities, along with recent figures on domestic

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quantity consumed (or value of consumption) if the prices of all U.S. agricultural outputs were to increase, together, by 1 percent—a strange experiment. Deaton and Muellbauer (1980) discuss Hicks aggregates that have this property of constant relative prices of component goods.

[22] The elasticity of demand for any individual product is less important for these big questions. We know more about some of these elasticities, but not much more.

and export shares, and the implied values for the overall elasticities of demand facing U.S. producers.[23]

Table B-1. Elasticities of Domestic, Export, and Total Demand, by Commodity

Program crop	2005 crop value (V)	Domestic consumption share (k_D)	Domestic	Perfect price transmission		Partial price transmission	
				Export	Total	Export	Total
	$ millions						
Corn	21,041	0.822	-0.063	-4.9	-0.92	-3.6	-0.69
Soybeans	16,928	0.660	-0.060	-3.0	-1.05	-2.6	-0.93
Upland cotton	5,204	0.291	-0.022	-3.6	-2.56	-2.7	-1.95
Wheat	7,140	0.526	-0.053	-12.5	-5.95	-11.2	-5.32
Total	*50,313*				*-1.85*		*-1.56*
Rice	1,789	0.532	-0.071	-47.3	-22.17	-33.9	-15.92
Total incl. rice	*52,102*				*-2.55*		*-2.05*

Source: Compiled by the author with assistance from Henrich Brunke and Antoine Champetier de Ribes using data from the USDA NASS Agricultural Statistics Database (http://www.nass.usda.gov/#top), and the PeatSim model code (Stout and Abler, 2003).

    Note: "Partial" price transmission allows for complete price transmission to all countries except Japan and China.

Aggregating Across Commodities. Suppose we wish to aggregate across commodities. Index number theory suggests some specific protocols for doing this (see, for example, Alston, Norton, and Pardey 1998). Setting those ideas aside for the moment, it seems intuitively reasonable to add up expenditures, where simply adding up quantities of different goods is less intuitively reasonable. That is, if we define $V_i = P_i Q_i$, then we can define the aggregate value of agricultural production as:[24]

$$(\text{B-2}) \quad V = \sum_{i=1}^{n} V_i = \sum_{i=1}^{n} P_i Q_i = \sum_{i=1}^{n} P_i (D_i + X_i).$$

    The elasticity of expenditure on good i with respect to the own price (E_{ii}) is simply equal to one plus the price elasticity of demand:

$$(\text{B-3}) \quad E_{ii}^{T} = 1 + \eta_{ii}^{T} = k_{Di}\left(1 + \eta_{ii}^{D}\right) + (1 - k_{Di})\left(1 + \eta_{ii}^{X}\right) = k_{Di} E_{ii}^{D} + (1 - k_{Di}) E_{ii}^{X}.$$

The overall elasticity of expenditure on agricultural commodities with respect to a uniform percentage price change (that is, $d\ln P_i = d\ln P_j$ for all i and j) can be computed as the share-weighted sum of the individual elasticities of expenditure with respect to price:

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[23] Henrich Brunke and Antoine Champetier de Ribes assisted with the data and computations reported in table B-1.

[24] A complicating factor is that many agricultural commodities are themselves intermediate products, and we must be careful to avoid various forms of double counting when adding up quantities and quantity responses to prices.

(B-4) $\quad E^T = \sum_{i=1}^{n} \left(\frac{V_i}{V}\right) E_{ii}^T = \sum_{i=1}^{n} \left(\frac{V_i}{V}\right)\left(k_{Di} E_{ii}^D + (1-k_{Di}) E_{ii}^X\right).$

Then we can convert from expenditure elasticities to price elasticities by subtracting one from both sides:

(B-5) $\quad \eta^T = E^T - 1 = \sum_{i=1}^{n} \left(\frac{V_i}{V}\right)\left(E_{ii}^T - 1\right) = \sum_{i=1}^{n} \left(\frac{V_i}{V}\right)\left(k_{Di} \eta_{ii}^D + (1-k_{Di}) \eta_{ii}^X\right) = \sum_{i=1}^{n} \left(\frac{V_i}{V}\right) \eta_{ii}^T.$

Thus the overall elasticity of demand for U.S. agricultural output could be computed as the value-share-weighted average of the individual commodity own-price elasticities of demand, each of which is itself a traded-share-weighted average of domestic and export demand elasticities.

Considering the group of goods in table B-1, assuming perfect price transmission, such that price differences among countries reflect multiplicative effects, the implied value for the overall elasticity of demand for this group of goods is equal to –1.85 if rice is excluded and –2.55 if rice is included. Alternatively, assuming that price differences among countries reflect additive effects, such that price transmission is imperfect, we can expect to find smaller elasticities of demand for U.S. exports and thus for U.S. output. The final two columns show the effects of reducing price transmission elasticities for China and Japan—two important importers of U.S. agricultural products that have significant import barriers—from perfect (1.0) to zero. All of the export and total demand elasticities for U.S. program crops are reduced as a result: the implied value for the overall elasticity of demand for this group of goods is now equal to –1.56 if rice is excluded and –2.05 if rice is included.

Cross-Price Effects. One significant problem with this procedure is it involves a type of fallacy of composition. Specifically, if we are conducting an experiment in which we change prices of multiple commodities together, the quantity changes for each good will include own- and cross-price responses. In other words, the computation in equation (B-5) will be correct only if all of the cross-price elasticities are zero. To consider this aspect, let us set aside the complications of international trade for a moment.

The domestic demand for the *i*th commodity can be written in general terms as a function of the prices of *m* goods and total expenditure on those goods, *Y*:

(B-6) $\quad D_i = d_i(P_1, P_2, \ldots P_n, \ldots P_m, Y).$

In logarithmic differential terms,

(B-7) $\quad d\ln D_i = \sum_{j=1}^{n} \eta_{ij}^D d\ln P_j.$

Now, once more, suppose that when the price of good *i* changes, prices of the other *n*-1 food commodities change in proportion: that is, $d\ln P_i = d\ln P_j$ for all *i* and *j* contained in *n*. Then we can express the elasticity of demand for good *i* as

(B-8) $\quad \eta_i^{\bar{D}} = \left. \frac{d\ln D_i}{d\ln P_i} \right|_{d\ln P_j = d\ln P_i} = \sum_{j=1}^{n} \eta_{ij}^D.$

Given that we would expect other agricultural commodities for the most part to be substitutes for good *i*, the cross-price elasticities would be predominantly positive numbers and the allowance for cross-price effects in equation (B-8) would be expected to result in a smaller (less-elastic) value for the aggregate domestic elasticity of demand for

agricultural products. Similar arguments may apply to export demands, as well, but probably to a lesser extent.

Direct Econometric Estimation[25]. An alternative to constructing an overall aggregate elasticity based on economic theory and estimates of individual elasticities is to estimate directly the relationship between the aggregate quantity of U.S. agricultural output and the price (or value) of that output. Andersen, Alston, and Pardey (2006) report a newly developed dataset comprising state-level indexes of prices and quantities of inputs and outputs for U.S. agriculture (excluding Hawaii and Alaska) for the years 1949 to 2002. These data are Fisher indexes, based on appropriate index number theory, and can be applied to estimate the elasticity of demand for aggregate agriculture at the level of the nation or for any of the 48 contiguous states. The same authors have also compiled an index of pasture and range conditions in each state from estimates provided by various National Agricultural Statistics Service (NASS) publications, which can be used to proxy weather effects in the analysis.

Consider the following model of supply and demand for agricultural output:

(B-10) $Q_t = s(E_{t-1}P_t, Z_t, T_t) + U_t$

(B-11) $P_t = d(Q_t, Y_t, T_t) + V_t$

In the first equation, current production, Q_t depends on expectations formed in the previous year of prices in year t, and the current values of weather conditions and technology, which are proxied respectively by the index of pasture and range condition, Z_t, and a time trend, T_t. In the second equation, the price for current production, P_t, is determined by total demand, which includes domestic and export components, and depends on aggregate U.S. income, Y_t, and a time trend variable included to represent the effects of other omitted variables such as demographic change and export market growth.[26] We also append a random error term to each equation.

If we use a naïve expectations model, with $E_{t-1}P_t = P_{t-1}$, this recursive system could be estimated as two separate equations, and the demand elasticity could be estimated by applying Ordinary Least Squares (OLS) to the second equation. Alternatively, if we are concerned about simultaneous equations bias, contemporaneous correlation, or endogeneity, we could use Two-Stage Least Squares (2SLS), Seeming Unrelated Regressions (SUR), or Three-Stage Least Squares (3SLS) methods to estimate the demand equation. The specification of the supply equation provides some useful choices for instruments for the 2SLS procedure. The ideal instruments are correlated with shocks in supply but uncorrelated with shocks in demand, allowing the estimation of a price effect that reflects movement along a demand curve.

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[25] The work reported in this part was conducted jointly with Matt Andersen.

[26] The income variable is U.S. Gross Domestic Product (GDP) in constant dollars, which is nominal GDP divided by the GDP implicit price deflator, base year 2000. It is not expressed in per capita terms in recognition of the fact that the total demand includes both U.S. domestic demand and export demand. The price variable is also in constant dollars, and is calculated as the index of the price of aggregate output divided by the GDP implicit price deflator, base year 2000. We considered regression specifications that included a U.S. population variable and/or an income per capita variable, but this resulted in a multicollinearity problem, given that the model included a time trend variable and real GDP that also has a strong trend, and so they were not included in the final estimation.

We performed tests for heteroskedasticity and serial correlation, as well as diagnostic tests for common specification errors, including endogeneity and omitted variables, before settling on a preferred model and a set of estimates. Additionally, we tested for unit-roots and found that the price and quantity variables are both non-stationary in levels and logarithms, but stationary after first differencing.[27] This helped to guide the choice of functional form, as we decided to avoid the possibility of spurious regression results by specifying our system of equations in logarithmic-differences.[28] After first-differencing variables in logarithms we have the following system for estimation:

(B-12) $\quad q_t = \alpha_S + \beta_{S1} p_{t-1} + \beta_{S2} z_t + u_t$

(B-13) $\quad p_t = \alpha_D + \beta_{D1} q_t + \beta_{D2} y_t + v_t$

Lower-case italics are used to indicate that the variables are expressed as logarithmic-differences. The trend term has been dropped but the constant has been retained in the regressions, which is consistent with including a linear trend in the model that has the variables in levels. After plotting the data, we included an indicator variable in the price-dependent demand equation for the year 1973 to control for a large shock in the price series. The indicator variable is significant in the regressions, and generally results in an increase in the R^2 and a reduction in the coefficient on the income variable (by one-third) and its statistical significance, compared with the results obtained from the same model without the indicator variable.

We estimated our system of equations (B-12) and (B-13) using the four estimation methods previously mentioned (that is, OLS, 2SLS, SUR, and 3SLS), and ultimately decided on a preferred method based on selection criteria that included a series of hypothesis and diagnostic tests. The growth regressions include 53 annual observations of the variables over the period 1950 to 2002. The parameter estimates and the associated test statistics for the growth regressions are summarized in table B-2, which lists results for the different methods, including the coefficient estimates and the implied elasticities. Table B-3 summarizes the results from the various diagnostic tests performed—including a statement of the null hypothesis, the test statistic, and the *p*-value in support of the null hypothesis.

Table B-2. Regression Models of Demand for Aggregate U.S. Agricultural Output in Price-Dependent, Growth-Rate Form

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[27] We performed a Dickey-Fuller unit root test on each series to establish stationarity.

[28] We also estimated a full set of results in first-difference of levels, which produced similar results to the growth regressions in terms of estimated coefficients and diagnostic testing.

Price dependent growth regressions

Estimator	Q	GDP	D(1973)	Constant	R^2	F	χ^2	P
			Parameter estimates		**Goodness-of-fit**			
OLS	-0.545***	0.604*	0.322***	-0.036**	0.46	14.13		-1
	(-3.13)	(1.69)	(5.35)	(-2.49)		*0.00*		
2SLS	-0.306	0.423	0.325***	-0.036**		10.56		-3
	(-1.05)	(1.09)	(5.31)	(-2.36)		*0.00*		
SUR	-0.440***	0.501	0.324***	-0.036**			41.42	-2
	(-2.59)	(1.39)	(5.60)	(-2.53)			*0.00*	
3SLS	-0.306	0.520	0.321***	-0.039***			36.27	-3
	(-1.09)	(1.43)	(5.57)	(-2.71)			*0.00*	

Data Source: Andersen, Alston, and Pardey (2006). Data represent the years 1950 to 2002, N=53.

T-statistics and Z-statistics in parentheses, p-values in italics

Dependent variable is the real price of aggregate output, Q = Index of the quantity of output,

GDP = Real Gross Domestic Product, D(1973) is an indicator variable for the year 1973

***denotes estimates are statistically significantly different from zero at the 1 percent level of significance.

** denotes estimates are statistically significantly different from zero at the 5 percent level of significance.

* denotes estimates are statistically significantly different from zero at the 10 percent level of significance.

Table B-3. Results from Diagnostic Tests of Price-Dependent Models of Demand for
U.S. Agricultural Output, in Growth-Rate Form

Diagnostic Tests

Estimator	Test	Method	Null Hypothesis	Test-Statis
OLS	Heteroskedasticity	Breusch-Pagan	Constant variance	$\chi2$ (1) = 0.9
OLS	Serial correlation	Durbin-Watson	na	d (4,53) = 1.
OLS	Omitted variables	Ramsey RESET	No omitted variables	F (3,46) = 1
2SLS, 3SLS	Endogeneity	Hausman	Difference not systematic	
			2SLS	$\chi2$ (3) = 1.5
			3SLS	$\chi2$ (3) = 1.1
SUR	Independence	Breusch-Pagan	Independent error terms	$\chi2$ (1) = 0.3

Source: Author.

48

First, we estimated the price-dependent demand equation (B-12) using OLS, and ran some diagnostic tests, including: (a) a Breusch-Pagan test for heteroskedasticity, which supports acceptance of the hypothesis that the residuals have constant variance; (b) a Durbin-Watson test for positive first-order serial correlation, with an estimated d-statistic above the upper critical limit, which supports the hypothesis of no positive first-order serial correlation in the residuals; and (c) a Ramsey RESET test for omitted variables using powers of the fitted values, which supports the hypothesis of no omitted variables. Furthermore, the residuals from the OLS regression were retained, and a χ^2 test of normality that combines a skewness test and a kurtosis test into a single test statistic indicated that we cannot reject the hypothesis that the residuals are normally distributed.

The OLS estimates were then compared with 2SLS and 3SLS estimates. We included all the exogenous variables as instruments in the 2SLS and 3SLS estimation procedures, including P_{t-1}, Z_t, T_t, and Y_t. Hausman's specification test indicated no systematic difference between the estimated coefficients in the models, which implies OLS is a consistent and efficient estimator. Additionally, we estimated the system defined by equations (B-12) and (B-13) using SUR, calculated a correlation matrix of the residuals, and performed a Breusch-Pagan test for independence, which indicated that the residuals are statistically independent. Hence the estimates obtained using OLS are preferable to those obtained using SUR. Referring to table B-2, the OLS produced the only set of estimates in which all the variables in the regression are statistically significant at the 10 percent level or greater. Our preferred model for estimating the demand for U.S. agricultural output in price-dependent form, then, is a single equation OLS model specified in logarithmic-differences. The model passed a host of diagnostic tests.

The elasticity of demand with respect to price for aggregate output in U.S. agriculture is estimated as −1.83. The estimate is statistically significantly different from zero at the 1 percent level of significance. This estimate is obtained as the inverse of the price flexibility, which is estimated directly; hence if the flexibility is underestimated, the elasticity will be overestimated. The 95 percent confidence interval on the estimated price flexibility ranges from −0.896 to −0.195, which implies an elasticity of demand in the range of −1.12 to −5.13. The estimated elasticity of demand, −1.83, implies that a 1.83 percent increase in quantity supplied would result in a 1 percent decrease in the price of aggregate output—a less-than-proportionate decrease in price that implies an increase in the value of production of about 0.83 percent. It is mostly a coincidence, but nonetheless interesting, that this is essentially the same value as the constructed estimate of the elasticity of demand for program crops excluding rice, under an assumption of perfect price transmission, −1.85.

An estimate of the elasticity of demand with respect to national income (*GDP*) is obtained by dividing the flexibility of price with respect to income by the flexibility of price with respect to quantity: $d \ln Q / d \ln GDP = (d \ln P / d \ln GDP) \div (d \ln P / d \ln Q)$; hence if the price flexibility with respect to quantity is underestimated, the income elasticity will be overestimated. The results imply that the elasticity of demand with respect to national income is 1.11. This result may be surprising to economists familiar

with Engel's law, who might expect to find that the demand for agricultural products, in a wealthy country like the United States, is inelastic with respect to income. However, growth in *GDP* reflects both growth in per capita income (*GDP/H*), the concept of income to which Engel's law applies and for which the relevant income elasticity may be quite small (perhaps in the range of 0.1 to 0.2) in the United States, and growth in population (*H*), for which the elasticity of demand may be 1.0.[29] The estimated elasticity of demand for agricultural output with respect to *GDP* of 1.11 is significantly different from zero at the 10 percent level of significance (but not at the 5 percent level), but is not statistically significantly different from 1.0, nor from values close to but less than 1.0, such as would be expected.

Both the elasticity of demand with respect to price and the elasticity of demand with respect to GDP, implied by the model, are generally consistent with our expectations. However, the point estimate of 1.11 for the income elasticity is greater than 1.0, whereas we would expect it to be less than 1.0. The point estimate for the price elasticity of −1.83 is plausible, though at the high end of the range of plausible values, but the estimated value is certainly not statistically significantly different from a value of, say, −1.50 which is closer to prior expectations. We cannot rule out the possibility of some remaining specification error in the model, such as an errors-in-variables problem, that is biasing the coefficient estimates downward (and the elasticity estimates up), and a larger estimate of the price flexibility would be consistent with both a smaller price elasticity, say −1.50 and an income elasticity less than 1.0, in the range of prior expectations.[30] All of the evidence from these estimations supports the view that the demand for U.S. agricultural output is elastic with respect to price.[31]

Further support for the view that demand is elastic is drawn from scatter plots of the annual growth rates of prices (figure B-2) and annual growth rates of the value of production (figure B-3) against the growth rates of the quantity of U.S. agricultural output. These graphs indicate that demand is elastic: the relationship is negative between price and quantity but positive between revenue and quantity. This general pattern in the data is consistent with the results from the regression analysis, which controls for the effects of income growth and the outlier of 1973. As noted above, specification error could have contributed to an underestimate of the price flexibility (and a corresponding overestimate of the elasticity). Further, any elasticity estimated in this fashion is likely to be reflecting short- to medium-run demand response. In the longer-run, demand for U.S. agricultural output is likely to be more elastic, reflecting the greater elasticity of foreign supply response and thus the greater elasticity of foreign excess demand for U.S. exports,

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[29] In algebraic terms, income growth may be partitioned as $d \ln GDP = d \ln (GDP/H) + d \ln (H)$, and thus the measured elasticity of demand with respect to GDP, could be expected to be a weighted average of the two elasticities—less than 1.0 but perhaps not by much—reflecting effects of growth over the period of analysis in both per capita income, $d \ln (GDP/H) = 2.18$ percent per year and population $d \ln (H) = 1.24$ percent per year.

[30] If significant measurement error exists in the independent variables in a linear regression model, then a common result is attenuation to the null, or a tendency for the coefficient estimates to approach zero as the measurement error increases. If this problem is substantial it can only be alleviated with the availability of better data sources and data construction methods.

[31] The alternative estimators (from the 2SLS, SUR, or 3SLS models) all implied larger values for both the price and income elasticities of demand, but the OLS estimates are preferred.

as we allow for greater time to adjust with dynamic supply response to price. On the other hand, short-run demand responses may reflect storage responses, if price changes are perceived to be temporary. Short-run demand is more elastic than long-run demand with respect to temporary price changes, but less elastic with respect to permanent price changes.

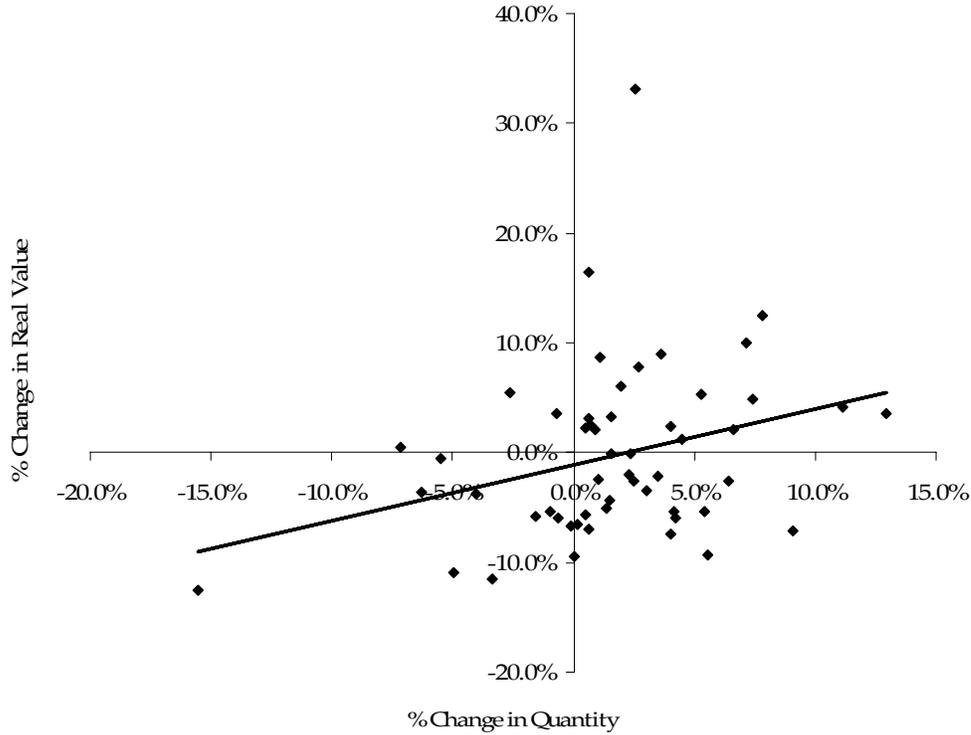**Figure B-1.** Growth in Output and the Growth in Real Price, 1950-2002 (percent)
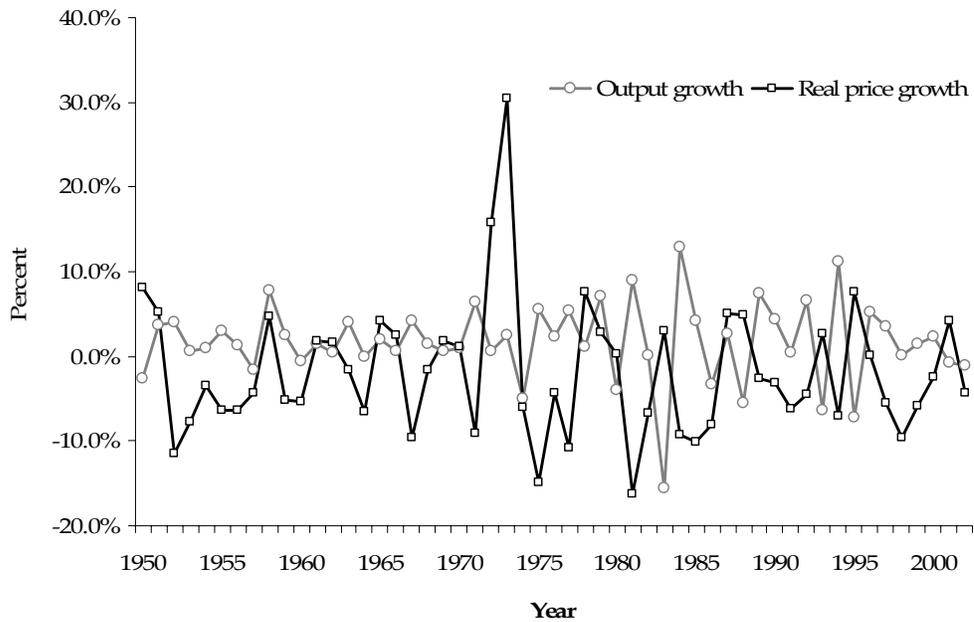
Source: Author.

Figure B-2. Growth in Real Price and Output (regression line included)
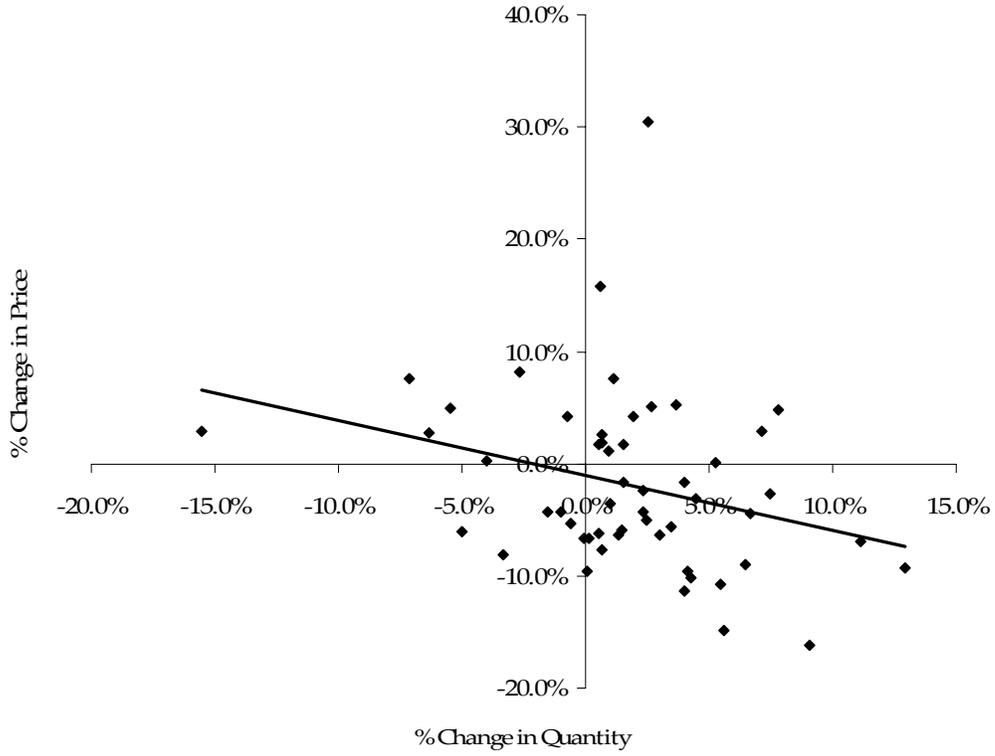
Source: Author.

Figure B-3. Growth in Real Value and Output (regression line included)

Source: Author.

Note: Real value is the nominal value of output divided by the GDP-IPD. The growth rate is calculated as the logarithmic-difference of real value.

Weighing these arguments and the evidence from our estimations, it is reasonable to conclude that the demand for U.S. agricultural output is elastic in the short to intermediate run, and even more so in the long run. A value of −1.5 seems reasonable to use for policy analysis. It will yield different qualitative results than would an elasticity of −1.0 or smaller (that is, less elastic), and it is important to have this feature; but is a little smaller (and in some senses therefore more conservative and less debatable) than our point estimate of −1.83.

Appendix C.

Capitalization of Farm Program Payments into Land Values

We wish to compare the effects on capitalized land values of three alternative forms of subsidy, an output subsidy (OS), a decoupled payment (DS), or an input subsidy (IS). For the purposes of that comparison, we can consider a policy scenario in which the expenditure by the government is the same with each of the three elements: $OS \times Y_1 = DS = IS = S$ dollars per acre per year. In the current year, t, the capitalized present value per acre of the stream of benefits from owning land (PV_t), is equal to:

$$(\text{C-1}) \qquad PV_t = \sum_{n=0}^{\infty} B_{t+n}(1+r)^{-n}$$

where B_{t+n} is the benefit per acre from owning land in the future year $t+n$, and r is the rate of discount to transform future income into present value. For simplicity, let us assume that income from the market in the absence of policy will be R_0 per acre per year in perpetuity. Then, in the absence of policy, equation (C-1) simplifies to

$$(\text{C-1a}) \qquad PV_t^M = \sum_{n=0}^{\infty} R_0(1+r)^{-n} = \frac{R_0}{r},$$

where the superscript M denotes that this is the value of the land from market income. Alternatively, with the input subsidy policy in place, the flow of benefits is equal to $R_0 + S$ dollars per acre per year.

If it is known that, like income from the market, the subsidy will continue in perpetuity, and it is therefore discounted at the same rate as income from the market, then the price of land in the presence of the input subsidy is:[32]

$$(\text{C-1b}) \qquad PV_t^{IS} = \sum_{n=0}^{\infty} (R_0 + S)(1+r)^{-n} = \frac{R_0 + S}{r} = PV_t^M + \frac{S}{r}.$$

If, instead of an input subsidy, the policy is to provide a decoupled transfer as a direct payment to landowners based on their past history of ownership of land, equal to S dollars per acre per year, the incidence is identical to that of the input subsidy. But this transfer will be capitalized into the land only if continued ownership of the land is a necessary condition for continuing to receive the subsidy. If the land can be sold separately from the title to the stream of direct payments, then the land price will be unaffected by the introduction of direct payments.

$$(\text{C-1c}) \qquad PV_t^{DP} = \begin{cases} PV_t^M & \text{if DP fully decoupled from land ownership} \\ PV_t^{IS} & \text{if DP fully coupled to land ownership} \end{cases}$$

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[32] The capitalization model has been applied econometrically to farmland markets with mixed success, especially as a representation of shorter-run responses. The fundamental problem is how to conceive and represent asset owners' unobservable expectations about income accruing to the asset over the indefinite future, including rental income and capital gains. Other problems arise because markets may be thin, available data on transactions are incomplete, and expert opinions are often used instead of data on actual transactions. Even so, the capitalization model provides a reasonable representation of the long-run relationship between expected rental income and the asset value of land.

Last, in the case of an output subsidy, assuming once more that, like income from the market, the subsidy will continue in perpetuity and is therefore discounted at the same rate as income from the market:

$$(\text{C-1d}) \qquad PV_t^{OS} = \sum_{n=0}^{\infty} (R_0 + s_L S)(1+r)^{-n} = \frac{R_0 + s_L S}{r} = PV_t^M + s_L\left(\frac{S}{r}\right).$$

These equations show that, with these three types of subsidies, holding the amount of the subsidy expenditure constant, and assuming that in each case it is known with certainty that the subsidy will continue in perpetuity, the subsidy payment may be either (a) fully capitalized into the price of land at the same rate as income from the market (in the case of a subsidy on land with a fixed supply of land or in the case of a decoupled direct payment that requires the recipient to continue to own land); (b) not capitalized into land at all (in the case of a decoupled direct payment that does not require the recipient to continue to own land); or (c) partially capitalized into land. This could happen in the case of an output subsidy, as shown in equation (C-1d), where the incidence is only partially on land because of variable factor proportions or downward sloping demand for the product. It could also happen in more realistic representations of the input subsidy on land, allowing for some elasticity in the supply of land, or if direct payments are not fully decoupled, as is suggested by much of the literature.

Further complications arise if the different types of income are effectively discounted at different rates, reflecting different expectations about the odds that the different sources of income will continue into the future. For instance, suppose the input subsidy payment is expected to decline geometrically at a rate d per year (see, for example, Gardner 1987). Then, the equation for the present value becomes

$$(\text{C-2a}) \qquad PV_t^{IS} = \sum_{n=0}^{\infty} \left[R_0 + S(1-d)^n \right](1+r)^{-n} = \frac{R_0}{r} + \frac{S}{r+d} = PV_t^M + \frac{S}{r+d}.$$

Alternatively, suppose that the subsidy program is subject to risk of being discontinued. Then, following the approach of Alston (1992) used to adjust the price of output quotas for policy risk (see, also, Barichello 1996; Barichello, Cranfield, and Meilke 2006), an equation for the present value of land allowing for an input subsidy that is subject to such policy risk is:

$$(\text{C-2b}) \qquad PV_t^{IS} = \frac{R_0}{r} + \frac{S}{r+p+\rho(p)} = PV_t^M + \frac{S}{r+p+\rho(p)},$$

where p is the annual probability that the stream of subsidy payments will be discontinued, permanently, in any future year, and $\rho(p)$ is a risk premium associated with the given probability. If different forms of payment have different odds of being discontinued, then capitalization rates will differ even if the incidence is identical. This last step introduces the point that income from the farm program payments may be uncertain; so is income from the market. Land and other assets are valued ex ante, based on expectations about the future values of streams of income and rates of discount and so on. This should be kept in mind when comparing rates of apparent capitalization of current—perhaps ex post—amounts of subsidy and market income into land values that were based on ex ante expectations of the same variables.

Application of models like the one in equations (C-1a) and (C-1b) to pricing of agricultural quotas has indicated that quota owners discount flows of quota rents as though they expect them to decline rapidly (that is a real depreciation rate in equation (C-

1a) of $d = 10\text{-}20$ percent) or that there is a significant risk of elimination of the program without compensation (that is, a significant annual probability of quota elimination in equation (C-1b) such that the risk, p plus the risk premium $\rho(p)$ is 10-20 percent or more).[33] If similar relationships held in the capitalization of other types of farm program payments into land values, the rates of capitalization may be much lower than we would expect and we might falsely infer a low rate of incidence of farm program payments on land. Lermer and Stanbury (1985) suggested that the overdiscounting of quota rents was equivalent to a partial loss of the stream of future benefits that should be added to the deadweight loss from the transfer. If such an approach is reasonable and applied to the capitalization of farm program benefits into farmland, the implications for social waste from the programs could be quite substantial.

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[33] Such heavy discounting of quota rents ex ante does not appear to be supported by the typical ex post evidence. First, streams of quota rents typically have not depreciated rapidly (see, for example., Barichello 1996, Barichello, Cranfield, and Meilke 2006). Second, substantial compensation has been paid to quota owners when quota programs have been eliminated (see, for example Alston 1999; Alston and Sumner 2006), suggesting that it would have been unduly pessimistic to presume that termination of the program would result in substantial losses to quota owners.

Appendix D.

Econometric Evidence on Decoupled Subsidies and Land Market Impacts

Tables D-1 and D-3 summarize the results from the empirical literature on the effects of U.S. agricultural subsidies, in each instance showing the main features of the study and findings about decoupling (table D-1) and the effect of subsidies on land rents or land prices or both (table D-2). The two sets of findings are related but nonetheless separate and will be treated separately here, beginning with the results on decoupling.

Table D-1. Estimated Effects of Decoupled Program Payments on Farmer Behavior

Authors	Year	Data	Dependent variables	Effects of d
Hennessy	1998	Operating cost data from a 1996 survey of Iowa corn farmers, and estimated nitrogen-input-conditioned yield distributions for several regions in Iowa.	Representative farmer utility is a function of yield.	Production increas payments increase fixed number of a
Young and Westcott	2000	Wealth elasticity estimates from previous literature.	Not applicable.	If farmer wealth i Production Flexib payments could g 180,000 to 570,00
Goodwin and Mishra	2005	1,609 farm-level observations from the USDA-National Agricultural Statistics Service Agricultural Resource Management Surveys (NASS) for 2002 and 2003; all farms located in the Corn Belt.[a]	Corn, wheat, and soybean acreage.	No significant eff
Key, Lubowski, and Roberts	2005	Three panels of farm-level data constructed from five round of the U.S. Agricultural Census (1987, 1992, 1997, and 2002), each with over 300,000 observations.	Growth in program crops, in farm size, and in sales from year 1 to year 2 of each panel.	Program participa 38.0, 15.8, and 22 crop acres, total a respectively.[b]
Goodwin and Mishra	2006	4,121 farm-level observations from the NASS surveys for 1998 to 2001; all farms located in the Corn Belt.	Corn, wheat, and soybean acreage.	Direct payments p acres and soybean
Hardie, Gardner, and Parks	2006	Data for 3,066 U.S. counties from the NASS survey, U.S. Natural Resource Inventory survey, and other sources. Cross-sectional data from 1987, 1992, and 1997 are pooled together.	Share of county land in cropland, pasture, range, and forest.	In 1997, direct pay of cropland in a g 0.018 at the margi

Source: Compiled by the author with assistance from Conner Mullally.
a. Corn Belt states include Illinois, Indiana, Iowa, Kentucky, Minnesota, Missouri, Nebraska, Ohio, and South Dakota.
b,c. Payments were designed to be more decoupled in 1997 under the FAIR Act.

Table D-2. Estimated Effects of Farm Program Payments on Land Rents and Prices

Authors	Year	Data	Are the effects of subsidies allowed to vary by program?
Goodwin and Ortalo-Magné	1992	Regional data for wheat growing regions in the United States, France, and Canada, spanning 1979 to 1989.	No
Weersink, Clark, Turvey, and Sarker	1999	Time series spanning 1947 to 1993 in Ontario, Canada.	No
Goodwin, Mishra, and Ortalo-Magné	2003	13,606 observations of U.S. farms from the USDA-National Agricultural Statistics Service Agricultural Resource Management (NASS) survey, spanning 1998 to 2001.	Yes
Lence and Mishra	2003	Repeated cross section of 465 Iowa farms surveyed in 1996 and 2000.	Yes
Roberts, Kirwan, and Hopkins	2003	61,532 observations of U.S. farms from the 1992 Agricultural Census, and 61,873 observations from the 1997 Agricultural Census.	No
Gardner	2003	Repeated cross-section of 90 rural U.S. counties spanning 1950 to 1992, and the 2000 Agricultural Census.	No
Goodwin, Mishra, and Ortalo-Magné	2003	11,207 observations of U.S. farms from NASS survey, spanning 1998 to 2000.	Yes
Kirwan	2005	57,793 observations of U.S. farms from the 1992 and 1997 Agricultural Censuses.	No
Shaik, Helmers, and Atwood	2005	State-level data for the United States, 1940 to 2002.	No

Source: Compiled by the author with assistance from Conner Mullally.

Evidence on Farmer Responses to Decoupled Payments. The studies listed in table D-1 represent a variety of approaches to the problem of estimating the impact of decoupled payments on farmer decision-making. Hennessy (1998) simulates the behavior of a representative, risk-averse farmer, comparing outcomes under a subsidy paid for a fixed number of bushels (the decoupled scenario) with those of a subsidy on every unit of output. In the presence of risk aversion and uncertainty, decoupled payments may have repercussions for production decisions because of their wealth and insurance effects. Hennessy's results suggest that the insurance effects of decoupled payments on production can be quite large. However, Hennessy's representative farmer grows a single crop using a single input; expanding the choice set for each of these decision variables would provide the farmer with means to diversify risk that might substitute for the price insurance benefits of the subsidy.

Drawing on work by Chavas and Holt (1990) on the elasticity of production with respect to wealth for U.S. farmers, Young and Westcott (2000) estimate production

impacts of Production Flexibility Contract payments (PFCs). PFCs were introduced in the 1996 Farm Bill (the FAIR Act), and were designed to be more decoupled than previous farm support instruments. This was accomplished by making payments a function of a fixed number of "base" acres (the number of program acres sown in 1995) and disconnecting the subsidy rate from commodity prices. Westcott and Young find that PFCs could lead to average annual acreage increases of 180,000 to 570,000 acres, assuming farm operator income grows by the full amount of the payment. Given that over 317 million acres were sown to program crops in 2005, the results of Westcott and Young suggest that PFCs have a negligible impact on crop acreage.

Several studies use cross-sectional data from the USDA to identify the impacts of program payments on farm-level outcomes. Goodwin and Mishra (2005, 2006) examine the effects of per acre program payments on corn, wheat, and soybean acreage in the Corn Belt. They are able to disaggregate payments by source, making it possible to estimate the behavioral impacts of coupled versus decoupled programs, and attempt to control for unobserved differences between program and non-program farms by conditioning on base acreage from an earlier time period. Their results indicate that if decoupled payments do influence farmer behavior, the effect is very small in magnitude.

Key, Lubowski, and Roberts (2005) control for additional heterogeneity through the use of panel data from the U.S. Agricultural Census. While they are not able to disaggregate the effects of individual support programs, Key, Lubowski, and Roberts find relatively large positive effects of program participation in 1997 on growth in program crop acreage, total farm size, and farm revenue. Since payments under the 1996 Farm Bill were relatively more decoupled than in other years, these results suggest that decoupled payments do indeed influence farmer behavior. The soundness of these results hinges on whether the unobserved differences between program and non-program farms are time invariant. That relative trends between program and non-program farms should be stable over time is not obvious.

Hardie, Gardner, and Parks (2006) take an approach somewhat different from those of the above studies, and estimate the effect of payments per acre on the share of land in cropland, range, pasture, and forest at the county level; instrumental variables estimation is used to eliminate bias caused by reverse causality. If payments are truly decoupled, then all land uses should be unaffected by payments, not just farmland. Support payments are not disaggregated by source, but program participation is separately identified for various years and the effects are allowed to vary by region. The results indicate that payments in 1997 had a positive and significant impact on the share of cropland at the county level for all regions, with the largest marginal effects occurring in the South.

The general conclusion from the relevant empirical literature appears to be that decoupled program payments have statistically significant effects on farmer behavior. The magnitude of these effects varies from study to study, however, and econometric issues remain. The crux of the problem is that non-program farms will not likely serve as a valid comparison group in any investigation of program impacts, and it is unclear to what extent analysts are able to control for unobserved heterogeneity. Fixed-effects models are certainly an improvement on ordinary cross-sectional regressions, but their conclusions are only valid to the extent that differences between program and non-program farms are time invariant; it is not clear that this will be the case. Although the

evidence generally indicates that decoupled payments do have some effects on farmer behavior, the evidence is mixed on the size of the effects. O'Donoghue and Whitaker (2006) and Serra and others (2006) provide further results suggesting that direct payments have significant effects on production.

Effects of Program Payments on Land Rents and Land Prices. The attempts made by analysts to estimate the impact of program payments on land rents and land prices can be broken down into two broad categories. In the first approach, the present value of land is modeled as a function of government payments and other explanatory variables. These estimated models are the empirical counterparts to appendix equations (C-1a) through (C-2b). Examples of this approach include Goodwin and Ortalo-Magné (1992), Weersink, Clark, Turvey, and Sarkar (1999), and Shaik, Helmers, and Atwood (2005). While estimated elasticities of land prices with respect to program payments are often small (see the estimated marginal effects in table D-2), the total share of land value determined by support payments can be quite large. For example, Shaik, Helmers, and Atwood estimate the share of land values generated by program payments between 1940 and 2002 at 30 percent, although this share has fallen from a peak of 40 percent in the 1960s and 1970s to between 15 and 20 percent in recent years. Weersink, Clark, Turvey, and Sarkar find that program payments and farm revenues are discounted at different rates, with the latter being discounted more steeply. Goodwin and Ortalo-Magné estimate that a 50 percent reduction in producer support for wheat growers would lead to a $60–$120 land price decrease in France, and a $50–$60 decrease in the United States and Canada.

The second approach uses farm-level variation in government payments and farm revenues to explain variation in land rents, controlling for observable covariates and fixed effects when panel data are available. These studies face the same hurdles as the nonexperimental, cross-sectional estimates from studies of decoupled payments outlined above: unobserved heterogeneity, errors in variables, and other potential sources of bias.

Gardner (2003) and Goodwin, Mishra, and Ortalo-Magné (2003a, 2003b) use pooled cross-sections to estimate program impacts. Gardner finds that an additional dollar per acre in program payments would have increased the average growth rate in U.S. land values from 1950 to 1992 by 0.017 percent. Goodwin and his coauthors estimate marginal impacts of per acre subsidies on land values that range from $2.59 and $7.78, depending on the source of the program payment. If we assume a discount rate of 5 percent (10 percent), their results suggest that landowners capture between $0.13 and $0.39 ($0.26 and $0.78) of the marginal subsidy dollar in the form of higher land rents, and that this incidence varies by program.

Lence and Mishra (2003), Roberts, Kirwan, and Hopkins (2003), and Kirwan (2005) are able to use the panel nature of their data sets to control for additional heterogeneity. These studies focus on land rents, and find positive marginal impacts of support payments per acre that range from $0.25 to $0.86 in additional rent per acre; Lence and Mishra actually find negative marginal impacts in one instance, which should raise concerns with respect to misspecification or data problems.

Roberts, Kirwan, and Hopkins, and Kirwan address the additional issue of expectation error through a clever instrumentation strategy. They point out that production decisions are based upon expectations of future farm revenues and support payments. These expectations will not be completely accurate, thus creating a

measurement error problem for the analyst if observed realizations of these variables are used in estimation. As a result of expectation errors, estimated coefficients will be biased. To address this both Roberts, Kirwan, and Hopkins, and Kirwan exploit the fact that program payments made in 1997, after the 1996 FAIR Act was introduced, were known more than a year in advance, making it highly unlikely that farmers would have made any expectation errors with respect to support payments. Furthermore, 1997 payments will be highly correlated with earlier program payments, given that the former were a deterministic function of previous program acreage, but 1997 payments should not be correlated with any expectation errors made with respect to support in 1992. Recognizing this, the authors predict 1992 payments using 1997 payments. Their estimates indicate that landowners capture between $0.25 and $0.41 of the marginal per acre subsidy dollar, on average.

In sum, the literature on the incidence of farm subsidies on land values indicates that while landowners certainly benefit from support programs, they do not appear to capture the full value of subsidies, at least in the short to medium run. This finding is not surprising in relation to subsidies generally. However, much of the econometric work relates to forms of subsidies that would be expected to have most—if not all of their final incidence on land—and those studies generally have found a surprisingly small share of subsidy benefits going to land owners. The work by Roberts, Kirwan, and Hopkins and by Kirwan are good examples.[34]

The authors have made exhaustive attempts to identify and address potential sources of econometric bias, but their estimates of the multiplier for decoupled subsidies are still well less than half what theory would predict.[35] One possible interpretation is that the authors are estimating an intermediate-run effect, which is smaller than the long-run effect, because of fixity associated with contracts or because of roles played by expectations or other dynamics. An implication may be that the so-called decoupled subsidies are much less decoupled than is commonly thought: that is, either the subsidies are fully reflected in land rents or they are being transmitted to other non-land inputs or consumers with consequences for production and consumption. Alternatively, the estimates may be biased because, notwithstanding the comprehensive efforts of the authors, they have not fully resolved the econometric issues that they identified. Perhaps

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[34] In their model, Roberts, Kirwan, and Hopkins divide land rent into two components: a component, π, represented by a measure of variable profit, (revenues net of variable costs), and a component, g associated with direct payments. This use of π as a proxy for market-based income to land is problematic in general—since it treats land as the residual claimant for agricultural income, which is inappropriate in general but perhaps especially so in a model designed to test whether it is so. The use of π as a proxy for market-based income to land may result in a biased estimate of the coefficient on g in the regression.

[35] A direct analogy can be drawn between this finding and the more general findings about the elasticity of supply response to output prices. Synthetic models based on theory and assumptions about parameters yield much larger elasticities of supply response than econometric models do. A reasonable interpretation is that the synthetically estimated elasticities are too high and that the econometrically estimated ones are too low to represent long-run responses; though they might well represent intermediate-run or short-run responses. See, for instance, Cassels (1933). In the context of supply response, there is not such thing as "the" elasticity; it depends on the length of run. Similarly, perhaps we should not think of "the" multiplier effect of farm programs on land rents, and we should identify the relevant length of run for particular estimates.

the only way to obtain different types of answers is to use different types of data, such as farm-specific time series, or more data of the same type.

Appendix E.

Deadweight Losses from Subsidies

Since the effects of complete elimination of U.S. farm programs on quantities and prices of farm commodities would be mostly modest, the associated deadweight losses from distortions in resource use and consumption would also be modest. The deadweight loss from the programs (or the net national benefit from eliminating them) could be computed if the full details of the model structure were available: for instance, using the type of approach discussed by Martin and Alston (1994) as an application of the trade expenditure function with distortions. In the absence of those details, we can draw rough inferences from the multi-market simulation results using measures that apply to partial equilibrium models of subsidies.

The deadweight loss from an output subsidy at an ad valorem rate of τ_Q, in a closed economy, is approximately equal to:

$$\text{(E-1a)} \qquad DWL_S = \tfrac{1}{2}\tau_Q PQ d\ln Q = \tfrac{1}{2}\tau_Q^2 PQ\left(\frac{\varepsilon\eta}{\varepsilon+\eta}\right),$$

where $d\ln Q$ is the proportional change in quantity associated with the subsidy. Given total subsidy expenditure approximately equal to $\tau_Q PQ$, the deadweight loss as a share of the total transfer from taxpayers is approximately equal to:

$$\text{(E-1b)} \qquad \frac{DWL_S}{\tau_Q PQ} = \tfrac{1}{2}d\ln Q = \tfrac{1}{2}\tau_Q\left(\frac{\varepsilon\eta}{\varepsilon+\eta}\right).$$

That is, of the amount taken from taxpayers to be transferred to producers and consumers, the percentage wasted is approximately equal to half the percentage distortion in production and consumption. Thus for subsidies that cause modest distortions in production and consumption, very little of the transfer from taxpayers is wasted through Harberger triangles of distortions in production and consumption. Even with highly distortionary subsidies that cause increases in production of more than 20 percent, only 10 percent of the government funds are wasted through distortions in production and consumption of the subsidized commodity.

This analysis has counted only the Harberger triangles, neglecting some other sources of deadweight loss, including the costs of compliance and enforcement, and the marginal deadweight cost of taxation to finance transfers (or the marginal social opportunity cost of government funds), as discussed by Gardner (1983) and Alston and Hurd (1990), for instance. The latter may be the most important. For instance, suppose a dollar of government spending in farm programs has a social opportunity cost of $1+\delta$ dollars (as implied if δ is the marginal excess burden of general taxation as measured by Fullerton 1991; Ballard and Fullerton 1992). Taking this additional cost into account, the deadweight cost of an output subsidy expressed per unit of transfer from taxpayers is now approximately equal to:

$$\text{(E-1c)} \qquad \frac{DWL_S}{\tau_Q PQ} = \tfrac{1}{2}d\ln Q + \delta = \tfrac{1}{2}\tau_Q\left(\frac{\varepsilon\eta}{\varepsilon+\eta}\right) + \delta.$$

Suppose δ is in the range of 0.2: that is, the opportunity cost is $1.20 per dollar of government spending. Then in the case of subsidies that cause only modest distortions in production and consumption, the main sources of deadweight loss are associated with the taxes used to raise the government revenue rather than with the consequences of the use of the funds to subsidize farm output. Only when the subsidies cause distortions in the range of those for U.S. sugar production, more than 30 percent, are the deadweight losses associated with Harberger triangles of comparable magnitudes to those associated with the excess burden of general taxation. In every other case the Harberger triangles would be much smaller.

These approximations to deadweight loss are for the case of a closed economy. In the case of an export good, some of the consumer benefits accrue to foreigners, and these foreign benefits

amount to a deadweight loss from the domestic standpoint. This additional deadweight loss is approximately equal to the proportional change in production times the value of production, multiplied by the fraction exported, k_e, and divided by the overall demand elasticity. Thus counterparts to equations (E-1a) and (E-1b) may be derived for an export good as:

$$(E\text{-}2a) \qquad DWL_S = \left(\tfrac{1}{2}\tau_Q + \frac{k_e}{\eta} \right) PQd \ln Q = \left(\tfrac{1}{2}\tau_Q + \frac{k_e}{\eta} \right) PQ\tau_Q \left(\frac{\varepsilon\eta}{\varepsilon+\eta} \right),$$

$$(E\text{-}2b) \qquad \frac{DWL_S}{\tau_Q PQ} = \left(\tfrac{1}{2} + \frac{k_e}{\tau_Q\eta} \right) d \ln Q = \left(\tfrac{1}{2} + \frac{k_e}{\tau_Q\eta} \right) \tau_Q \left(\frac{\varepsilon\eta}{\varepsilon+\eta} \right).$$

In the case of U.S corn, for instance, with an export share of $k_e = 0.18$ in 2005, a subsidy rate of $\tau_Q = 0.33$, and an overall demand elasticity of $\eta = 1$ (see table 4 and appendix B), the term $k_e/(\eta\tau_Q) = 0.55$, so allowing for the export market means the estimate of deadweight loss is roughly doubled from that given by equations (E-1a) and (E-1b); similarly for wheat. In these cases the rate of deadweight loss per dollar of subsidy expenditure is roughly equal to the proportional change in output. In the case of cotton, the deadweight loss as a share of subsidy expenditure allowing for exports (in equation (E-2b) is roughly three times its counterpart in (E-1b), about 1.5 times the proportional change in output from the subsidy.