So Many Articles and So Few Comparisons: Standardizing Results from U.S. Farm Policy Decoupling Literature

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Introduction

United States farmers benefit financially from a wide variety of government programs that aim to bolster and reduce the variability of farm household income. Depending on program design each program potentially affects production decisions about what to plant and the optimal mix of land and non-land inputs used. Program design in recent times has been strongly influenced by the desire to mitigate such effects. Policy makers pursue this so-called decoupling objective by applying program eligibility criteria meant to ensure that producers respond to market not policy signals. Each support program is distinguished by its unique list of eligibility criteria.

Our objective is to obtain numerical estimates of the production impacts of the main instruments of farm commodity support for subsequent use in assessing trade and welfare effects of past policy choices and in evaluating future policy options. We begin with a systematic review of past studies aimed at quantifying policy effects. In doing so, we rely heavily on the findings from past surveys by Abler and Blandford (2005) and Bhasker and Beghin (2009).

However, our approach differs substantially from these past surveys in one important respect. Neither of these surveys, nor the published studies reviewed in them, report results permitting 'apple to apple' comparison of findings. We compare results from past analyses using three coupling parameters: 1) the induced change in output (acreage, yield, production) per dollar of program payment, 2) the induced percent change in output per dollar of program payment and 3) the ratio of the induced change in output per dollar of program payment to the induced change in output for an equivalent increase in market revenue. While past studies rarely report estimates of these parameters directly, most provide sufficient detail to enable calculation of, at the least, one of them.

Each one of these three indicators serve its own purpose. The first enables comparisons of results across studies reporting results for the same crop and program but sometimes widely different regional coverage. The second standardizes comparisons across different studies each using different units of measure or crop aggregations. The third serves as a standard of comparison between payments made conditional on various eligibility criteria meant to limit production effects with market returns available to producers unfettered by such conditions. A fuller explanation of the approach is provided in a subsequent section.

These indicators allow researchers to use the literature results directly in a U.S. model to estimate the market effects of policies. However, the studies span different geographies, time periods and policies. Therefore, we develop measures of appropriateness for this use for the third indicator in the last section of this paper.

United States payment criteria and levels

U.S. agricultural policy has caused payments or other transfers to producers using a variety of programs historically. The characteristics of each program presumably relates to its production effect given the mechanisms through which payments can affect production, as listed above. This section lists recent programs and notes their characteristics and scale. The section only highlights some relevant facts about recent direct payments to crop or dairy producers. Other authors provide reviews of US agricultural policy over a longer time period (Zulauf and Orden, 2016) or with more detail (CRS, 2019; ERS, 2019a).

Crop payments criteria

Crop payments can be ranked according to their association with production decisions, with some judgments (Table 1). Production Flexibility Contract (PFC) payments or Agriculture Market Transition Act payments were created by the Farm Bill of 1996 (ERS, 2019b). The PFC and the following direct payments were based exclusively on historical criteria, namely base area and yields with fixed payment rates, irrespective of current production practices. There were certain exempt land uses, and the base area had to be kept in a condition that could allow for agricultural activity, rather than conversion to buildings or homes. Nevertheless, of all the U.S. crop programs the PFC and direct payments appear least tied to current production decisions and market events.

U.S. crop programs of the last several decades have often paid on the basis of historical base area and yields, but those besides PFC and direct payments have depended on market outcomes. Counter-Cyclical Payment (CCP), Price Loss Coverage (PLC), Agriculture Loss Coverage-County (ARC-CO), and Average Crop Revenue Election (ACRE) paid based on some market indicator, such as county revenue or national price, but the payment size depended on historical area. Apart from the excluded practices and occasional updates, base area and base yield are outside of the control of the producer and unaffected by the decision of which crop to plant, or whether to plant any crop at all. As such, these payments seem unrelated to decisions if assessed purely on the basis of whether or not the planting decision (among permitted land uses, including fallow) affects the payment rate.

Crop insurance subsidies and marketing loan gains from the Marketing Loan program are tied to directly to planting decisions. Crop insurance payments depend on national prices and farm and county yields. Marketing loan gains depend on current plantings and yield as well as local prices that are tied to national prices. A producer who opts to grow more of a crop can expect to be eligible for more potential marketing loan gains. Given these criteria alone, one might rank the marketing loan gains as most tied to supply decisions. To be clear, however, we define the coupling coefficient based on output effects, not whether the criteria for payment require output or relate to market conditions.

Table 1. Crop programs and their payment criteria

Correlation to production and markets	Program	Connections to production/markets
Less correlated or uncorrelated ↑	Direct and Production Flexibility Contract (PFC) payments	Based upon: • Historical plantings • Historical yields
	Counter-Cyclical Payment (CCP) and Price Loss Coverage (PLC)	Based upon: • Historical plantings • Historical yields • Current national prices
	Agriculture Loss Coverage-County (ARC-CO)	Based upon: • Historical plantings • Historical county yields • Current county yields • Current national prices
	Average Crop Revenue Election (ACRE)	Based upon: • Historical plantings • Historical farm and state yields • Current plantings • Current state yields • Current farm yields • Current national prices
	Crop insurance subsidies	Based upon: • Current plantings • Current national prices • Historical farm and county yield performance
	Market loss assistance payments	Based upon: • Current farm plantings • Current yields
↓ More or fully correlated	Marketing Loan Gains	Based upon: • Current farm plantings • Current farm yields • Current local price

As noted elsewhere, this ranking by criteria does not map directly to the coupling coefficient. For example, risk averse producers might respond to uncertainty and wealth effects.

These effects do not require a link to current planting decisions because a link to market outcomes can reduce uncertainty if it offsets price risk, and the related wealth effect depends on how much in total a decision maker has to wager. Regardless of their risk profile, producers might change their leisure-labor allocation, have easier access to capital, or revise their exit or entry strategies in the presence of even a payment that appears mostly unrelated to current production decisions so, again, the ranking given here is illustrative.

Updating is not used in this ranking even though periodic updating of the historical basis of payments is identified as a potential cause of output effects for an otherwise decoupled payment. Updating is not part of the programs listed above, but instead often takes place in the U.S. when a new agricultural policy package is implemented. Farm bills have allowed base updating, giving producers the opportunity to change the historical entitlement to reflect area allocation and yields since the period. The exact allowance has not suggested a one-for-one change going from the crop area planted or yield achieved in each year to the new base. Instead, the updating has been partial or required that data for some years be omitted and has always been optional. There was no provision in Farm Bills up to 2014 that reduced base or related payments even for those who had not planted any crops for some time. The 2018 Farm Bill did not take base away, but disallowed certain base area payments, including PLC and ARC, from 2019 to 2023 on any land planted grass or pasture, or left fallow, from 2009 through 2017.

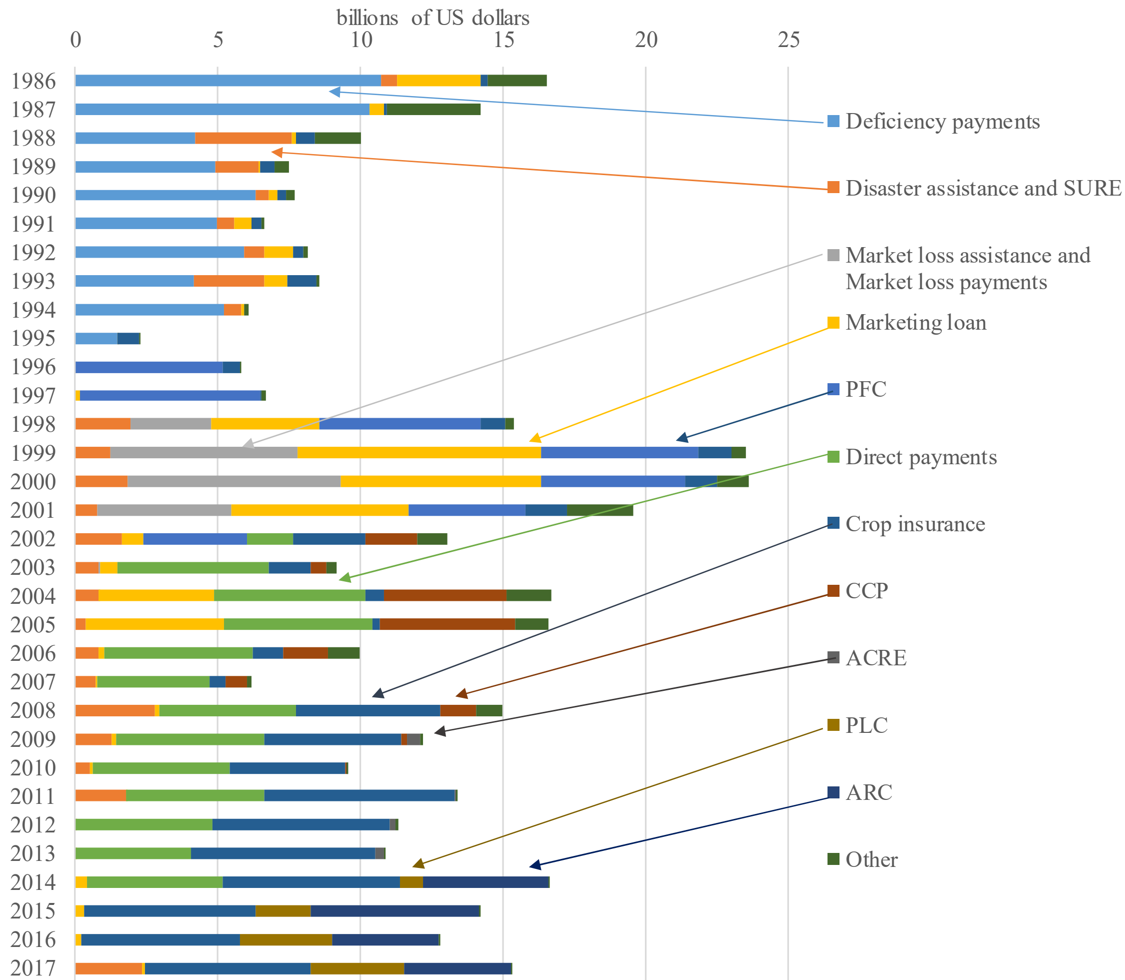
Scale of crop program payments

Budgetary expenditures indicate the scale of direct payments. These data are relevant to see which payments are largest at different points in time, but omit other forms of support. In particular, while this data source usefully summarizes budgetary data it also provides estimates of market price support – higher domestic prices caused by trade measures that create consumer-to-producer transfers – that is omitted in the representation given here (OECD, 2019). For U.S. dairy, market price support has been far more important source of transfers to producers than direct payments, at least since the mid-1980s. To see the scale of different payments, however, we use only the budgetary data here.

The data presented here corresponds approximately to the payments associated with crop production (Figure 1). There are two causes for discrepancies. First, the source database makes it somewhat difficult drawing a clear line between what crops are included and what are not, although we try to be consistent. Second, direct payments on base area need not relate to any actual crop production given that producers were permitted to engage in many other activities and receive the payments in the past.

Crop payments shifted from programs that were tied to output to payments tied to historical base in 1996, starting with the PFC program. Deficiency payments tied to output from base area dominated direct payments before that shift. At the same time that PFCs and subsequent direct payments became a common and predictable transfer, market loss assistance payments were introduced at times of low prices. More generally, the marketing loan program has continued throughout all the years shown, causing payments tied to output if key benchmark prices fall relative to the loan rate for a crop. PFC and direct payments were replaced by other programs that introduced payment variations based on market conditions, albeit still not sensitive to land use decisions, apart from some excluded uses, such as CCP's, and PLC and ARC that remain in place as of the 2018 Farm Bill.

Figure 1. U.S. crop payments over time

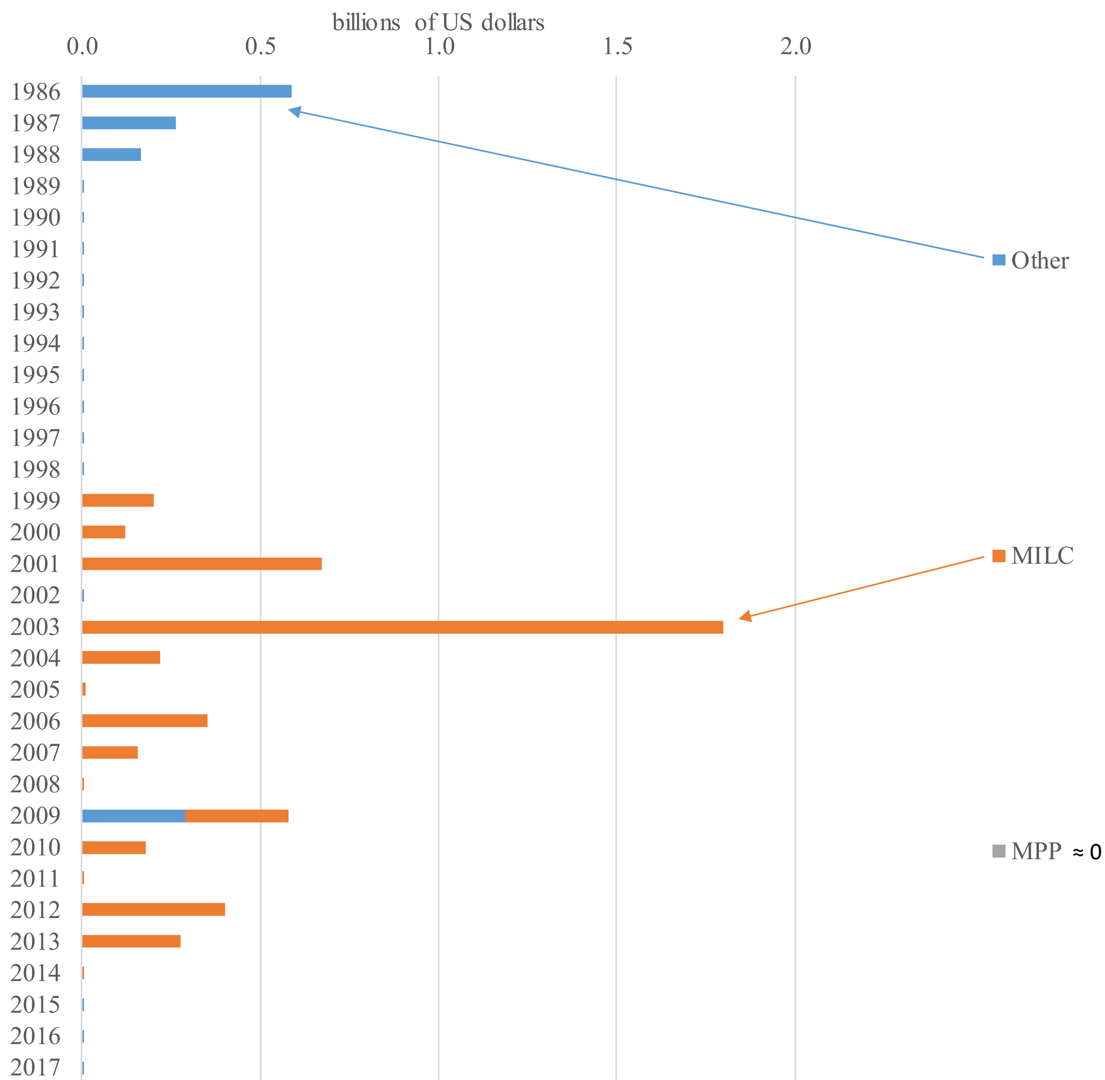


Source: calculated from OECD (2019) payment data, excluding market price support and input subsidies other than those based on land.

Dairy payments

Dairy payments are smaller than crop payments and take a much smaller role in support as compared to trade measures that increase internal prices relative to world prices (OECD, 2019). We also do not assess the role of Federal Milk Marketing Orders that play roles in the regional allocation and pricing of milk. Policies in the 1980s, such as those under a dairy herd termination program, are no longer relevant.

Figure 2. U.S. dairy payments through time



Source: calculated from OECD (2019) payment data, excluding market price support and input subsidies.

There have been payments to dairy producers in recent years (Figure 2). The Milk Income Loss Contract (MILC) program paid producers per unit of output, up to a set limit, if a specified regional fluid milk price fell below a legislated benchmark (Schnepf, 2014). The Margin Protection Program (MPP) replaced the MILC program. As defined in the 2014 Farm Bill, the MPP makes payments to participating dairy farmers if the margin between milk and feed prices, evaluated using national average prices and fixed feed input weights, falls below a threshold. The gap is assessed on a two-month time frame. Producers would pay a small fixed amount to enroll at the lowest level of participation, only receiving payment if the margin fell below $4 per hundredweight, and were given the option to pay more to be eligible for payments if the margin were to fall below a higher trigger margin. These payments are based on a dairy farm's historical production up to a fixed limit, but the historical base of a farm is increased by the proportional increase in national milk production for each year that the farm participates. The MPP was replaced by the Dairy Margin Coverage that is similar but with certain provisions changed in the 2018 Farm Bill (FSA, 2018), but we do not yet have any data relating to how this program is working given these changes. Moreover, source data suggest little or no MPP payments from its inception in 2014 through 2017 (OECD, 2019).

Program payments potential production effects

Government programs providing support to farmers may comprise multiple instruments, and the mix changes from one farm act to another. In this analysis we seek to measure decoupling parameters for each instrument separately in order to, ultimately, assess the total effect of a given program through aggregation of the effects of its individual components. Production effects of program payments may come via one or more of multiple channels:

- Payments tied directly to an activity, such as production of the output or use of certain inputs, presumably affect effective producer prices.
- Restrictions placed on the types of activities a farmer can engage in order to retain payment eligibility may discourage production of excluded activities.

- Payments inversely correlated with market returns can reduce risk and have production impacts to the extent that producers are risk averse.
- Regardless of the particular instrument employed, financial support to farmers increases producer wealth that can affect their willingness to take risks, depending on the whether they are risk averse and the nature of their risk aversion.
- Even if producers are risk neutral, expectations of a future updating of the area or yield upon which payments are based may lead them to maintain or increase current production. More generally, if producers believe payments will be made according to certain criteria in the future, then they might take actions to meet those criteria.
- Payments that increase income can lead to changes in the household allocation of labor and increase the amount of time producers allocate to leisure, and if a normal good, leading to less labor allocated to agriculture.
- Payments that reduce the need of producers to access capital markets can overcome imperfections in these markets. More generally, a predictably steady stream of income from a payment might reduce need for and cost of capital.
- The existence of payments could affect entry and exit decisions, causing some farmers who might otherwise exit the industry to remain.

Some past studies focus narrowly on one or some small sub-set of these channels. Others estimate response parameters that, explicitly or implicitly, may embody large numbers of them. Accordingly, calculation of coupling parameters needs to distinguish which of the avenue(s) of policy effects are studied.

Quantitative assessment of findings in the relevant literature

Based on microeconomic theory, we consider three key supply equations for a crop or an aggregate of crops. Each of the following equations is the optimizing value given prices, payments, and other factors. From theory, we expect that optimal area relates to market returns and payments on the basis of a unit of area and that optimal yield and supply depend on the price or payment per unit of output, so two sets of values for independent variables are required. These are as follows (Table 2).

Table 2. Variable definitions.

Variable definition	Expressed per unit of area	Expressed per unit of output
Market returns	R	P
Subsidy	H	G
Other factors	Z	Z

Given these variables, we can define our supply equations as follows.

Area: A(R, H, Z).

Yield: Y(P, G, Z).

Supply: S(P, G, Z) and can also be expressed as the product of area and yield.

As noted above, our goal is to compare the findings about the effect of support on supply in two ways.

First, compare the first derivatives of the effect of each form of support on the supply variable among studies. For example, if studying the effect of a specific payment, Hi, on area among studies j=1, … J, then our data would consist of a listing of all the first derivative effects of a one unit change in the payment per unit of area on the area planted, or

$$\left\{\left(\widehat{\frac{\partial A}{\partial H_\iota}}\right)_{j=1}, \left(\widehat{\frac{\partial A}{\partial H_\iota}}\right)_{j=2}, \dots, \left(\widehat{\frac{\partial A}{\partial H_\iota}}\right)_{j=J}\right\}.$$

For yield, this is changed to reflect the fact that the units of decision-making are different so the independent variables are different. Assuming that we have K studies that generate yield observations, this listing would be

$$\left\{\left(\widehat{\frac{\partial Y}{\partial G_\iota}}\right)_{k=1}, \left(\widehat{\frac{\partial Y}{\partial G_\iota}}\right)_{k=2}, \dots, \left(\widehat{\frac{\partial Y}{\partial G_\iota}}\right)_{k=K}\right\}.$$

Second, compare the relative impacts of the payment to a like change in returns from the market as estimated in each study. If we have L studies that generate comparable ratios for area and M studies that allow such comparisons for yields, then we have these two sets of comparisons:

$$\left\{\left(\widehat{\frac{\partial A}{\partial H_\iota}}\Big/\widehat{\frac{\partial A}{\partial R}}\right)_{l=1}, \left(\widehat{\frac{\partial A}{\partial H_\iota}}\Big/\widehat{\frac{\partial A}{\partial R}}\right)_{l=2}, \dots, \left(\widehat{\frac{\partial A}{\partial H_\iota}\Big/\frac{\partial A}{\partial R}}\right)_{l=L}\right\}; \text{ and}$$

$$\left\{\left(\widehat{\frac{\partial Y}{\partial G_\iota}\Big/\frac{\partial Y}{\partial P}}\right)_{m=1}, \left(\widehat{\frac{\partial Y}{\partial G_\iota}\Big/\frac{\partial Y}{\partial P}}\right)_{m=2}, \dots, \left(\widehat{\frac{\partial Y}{\partial G_\iota}\Big/\frac{\partial Y}{\partial P}}\right)_{m=M}\right\}.$$

In practice, we expect J > L > K > M. While our ideal is comparing relative effects that correspond with a decoupling coefficient directly, many studies do not go that far.

Other study data

We can relate these calculated indicators of supply impacts to other variables that characterize the study and the specific quantitative results. As regards the study, variables include the following:

a. What method is used (estimation, simulation, other)?
b. Was it published and peer-reviewed?
c. When was it published and to what period of time do the data relate?
d. If available, what is the effect of market returns or price on the supply variable studied (area, yield)?

Some studies can produce multiple observations. A study might provide a distinct quantitative estimate of the supply effect of each of several program payments, not just one. Some studies might apply a method to different crops or different regions, each of which results in a different estimate. The database includes each result to which the authors grant credence. We omit intermediate results, such as strawman results that authors present to highlight how their preferred model adds scientific knowledge.

For studies with multiple observations, each observation is characterized by the following information:

a. What is the impact per unit of payment on the supply variable (area, yield)?
b. To what program(s) do the results relate?
c. Which potential effects of a decoupled payment are studied (price, risk, capital, labor, etc.)?
d. What is the ratio of payment effect to market effect?

e. Do results relate to all of the U.S., a single state, a region comprising multiple states, or another country

Selected findings from previous analyses of effects of program payments

The following sections contain results obtained in analysis of studies representing some of the mechanisms by which government payments to farmers may induce production responses. We chose these examples to illustrate our approach. The list is incomplete both in terms of the number of studies in each category of policy effects and in terms of coverage of all categories. Ongoing work aims at filling these gaps.

Risk and wealth effects

Serra et al. (2005) analyze the production impacts of PFC payments. They develop a theoretical model that explicitly accounts for producers' risk attitudes and uncertainty. They apply that model to identify the potential output responses to seemingly decoupled payments which arise due to induced effects on producer wealth and associated reductions in risk and uncertainty. Farmers in the model have two income sources: market revenues and the PFC payments treated as lump sum government transfers.

The empirical variant of the model is specified as a two factor Cobb-Douglas production function and its associated first order conditions. To estimate the model they use a panel data-set comprising farm level data collected in Kansas, covering the years 1998-2001. Output is measured by a quantity index of wheat, corn, grain sorghum and soybeans - the principal crops in the state. The two factors are chemical inputs and fertilizer. This means that, in essence, this is a model of potential impacts at the intensive margin, i.e., of yield effects.

Table 3 below summarizes their findings based on the method we have adopted for current purposes.

Table 3. Estimated effects of payments from Serra et al., 2005

Effect of payments	
Averages of key data	
Output (quantity index of wheat, corn, grain sorghum and soybeans) [i]	104316
Price (Paasche index of expected prices for above crops) [i]	$0.92
PFC Payments (constant 1998 $) [i]	$11,412
Output elasticities	
Price [ii]	2.137
Payment [ii]	0.0064
Induced production impacts	
Quantity increase in output due to +1% payment [iii]	7
Percent increase in output due to payment	0.006%
Quantity increase in output due to +1% market revenue [iii]	2229
Extra output per dollar increase in market revenue	0.20
Coupling Parameters	
(1) Change in output per payment dollar	*0.001*
(2) Percent increase in output per payment dollar	0.00006%
(3) Ratio of payment effect to market revenue effect	*0.003*

i. Serra, et al. (2005) Table 1, p.19
ii. Serra, et al. (2005) Table 3, p.21
iii. Product of payment elasticity & output
iv. Product of price elasticity & output

Other studies addressing risk and wealth effects of government payments on production include Hennessy (1998); OECD (2001); Chambers and Voica (2016). Analysis to estimates of coupling parameters implied by results of these studies is underway.

Expectations about future decoupled

Hendricks and Sumner (2014) report results of an analysis of the potential effects on current crop production of expected base updating in future US crop programs. The idea is that current crop production may be affected if farmers believe that plantings in this and subsequent years will become the base from which future subsidies are calculated.

The authors note that prior studies of the effect of expectations about policy changes usually focused on a single commodity, neglecting cross-commodity effects. However, as the authors emphasize, the potential payoff from base updating affects planting decisions for the full range of crops covered by U.S. crop programs, some of which may be either complements or substitutes in production. Their analysis addresses this issue by considering planting decisions for corn and soybeans by farmers in three Corn Belt states: Iowa, Illinois and Indiana.

The model they develop considers the case of a representative farm that maximizes expected returns from producing the two program crops including the discounted stream of expected government payments. The farmer is seen as choosing the acreage to plant to each crop, where current acreage affects the stream of future government payments through expected base updating. Crop yields are exogenous in the model.

Their analysis comprises evaluation of three policy scenarios for each of two future farm bills: (a) base acres and base yields are updated for both crops; (b) base acres and base yields are not updated but the programs continue; or (c) direct and counter-cyclical payments are ended for both crops. Farmers are assumed to assign a probability that base is updated and a probability that the programs are ended.

The solution to the farmer’s optimization problem leads to an expression representing the expected present value of marginal government payments from base updating. That expression can be evaluated empirically using data on payments, prices, plantings and yields for corn and soybeans. To calculate the acreage response the result is first expressed as a percentage of market revenue. This percentage is then used to estimate acreage response by applying own and cross-price elasticities of acreage response. Estimated elasticities are taken from analysis of crop acreage response reported in Hendricks, Smith and Sumner (2014).

Table 4 reports our findings. The setup Hendricks and Sumner adopted assumes that if farmers expected base updating with certainty, every dollar of the expected present value of a future base acreage update would count the same as an increase in expected market returns. Thus, setting aside certain potential complications associated with risk aversion, the only difference between responses due to expected payments and those due to equivalent increase in market revenues derive from the expected probability of an update. In our parlance then, the final coupling parameter that we calculate, the ratio of payment to market effects, is nothing more than the expected probability of an update. For the calculations reported in Table 4 we chose the mid-point of the probability range, 0.5.

Table 4. Estimated effects of expected extra corn and soybean base updating on acreages, Hendricks and Sumner, 2014

Effect of corn and soybean payments on corn acreage			
Key data	Corn	Soy	Total
Acreage [i]	10.5	8.1	18.6
Yield [i]	168.0	48.0	na
Price [i]	$4.01	$8.84	na
Payments [ii]	$348.57	$270.30	$618.87
Acreage elasticities	Own	Cross	
Price [iii]	0.400	-0.300	na
Payment [iv]	0.200	-0.150	na
Induced change in <u>corn</u> acreage due to expected payments	Corn	Soy	Total
Level change [v]	1.09	-1.00	0.08
Percent change	10.3%	-9.6%	0.79%
Level change for an equivalent increase in market revenue [vi]	2.17	-2.01	0.17
Per dollar increase in market revenue	0.00623	-0.00742	0.00062
Coupling Parameters			
(1) Change in output per payment dollar	*0.00312*	*-0.00371*	*0.00013*
(2) Percent increase in output per payment dollar	0.00030	-0.00035	0.00001
(3) Ratio of payment effect to market revenue effect	*0.500*	*0.500*	*0.500*
Induced change in <u>soybean</u> acreage due to expected payments	Corn	Soybean	
Level change [v]	-0.96	0.92	-0.03
Percent change	-11.9%	11.5%	-3.22%
Level change for an equivalent increase in market revenue [vi]	-1.92	1.85	-0.07
Per dollar increase in market revenue	-0.0055	0.0068	9.4156
Coupling Parameters			
(1) Change in output per payment dollar	*-0.0027*	*0.0034*	*-0.00006*
(2) Percent increase in output per payment dollar	-0.03414%	0.04242%	-0.0005%
(3) Ratio of payment effect to market revenue effect	*0.500*	*0.500*	*0.500*

i. Average area for Iowa, Illinois, Indiana 2006-2010, mil. acres; average yield for these states over the same period, bushels per acre; and national average prices in 2006-2010, dollars per bushel.

ii. Present value of extra future base payments per acre, evaluated using numerator of Eq. 17 of Hendriks and Sumner (2014)

iii. Hendricks, Smith and Sumner (2014)

iv. Product of price elasticity and average expected probability of base updating (= 0.5)

v. Product of payment elasticities & acreage

vi. Product of price elasticities & acreage

Bhasker and Beghin (2010) develop a model to examine and quantify the role of base updating in a farmer's decision-making process on current acreage decisions of a representative

825-acre corn farm in Iowa. They employ their model to study the effects on corn plantings for 2002-2006 of an expected base update in 2007. The model is conceptually similar to that adopted by Hendricks et al. (2014). Farmer's planting decisions are linked to expected government payments in the future through the possibility of a base update in the 2007 Farm Bill.

The empirical analysis results in estimates of acreage response for five initial corn price states and five expected probability of update states (see their Table 3, p. 855).

At low prices, when CCPs are positive, any opportunity to update base would increase both the DPs and the CCPs. But at higher prices, ($2.375 to $3.375) the link between optimal acreage planted in 2002-2006 and is due only to expected direct payments. Here, we utilize only the results obtained for the five higher initial price states ($2.375 to $3.375 in increments of $0.50) to focus exclusively on direct payment effects. For presentational purposes here, we use averages across initial price states and the mid-point of the probabilities that they explore (0.50).

Table 5. Estimated effects of expected extra corn base updating on acreages, Bhasker and Beghin, 2010

Key data	Corn
Direct payment rate [i]	$0.28
Base acreage under current policy regime [i]	825
Program yield under current policy regime (bu/acre) [i]	134.97
Program payments per acre [ii]	$37.79
Market price ($/bu) [iii]	$1.97
Yield (bu/acre) [iii]	142.3
Acreage price elasticity [iv]	0.412
Induced change in acreage due to expected payments	Corn
Percent change [v]	2.37%
Level change (acres) [vi]	20
Level change for an equivalent increase in market revenue (acres) [vii]	46
Level change per dollar increase in market revenue [viii]	1.21
Coupling Parameters	
(1) Change in output per payment dollar	*0.52*
(2) Percent increase in output per payment dollar	0.12%
(3) Ratio of payment effect to market revenue effect	*0.427*

i. Table 2, p. 853, Bhaskar and Beghin (2010)

ii. Product of direct payment rate and program yield

iii. USDA data as reported by FAPRI-MU.

iv. Footnote 7, p. 853, taken from Lin et al., (2000)

v. Table 3, p. 855, average across price states $2.375 to $3.375 at probability state 0.5. For those price states direct payments constitute the sole source of expected benefits from base updating.

vi. Product of percent change, immediately above, and base acreage at zero probability of update (825 acres)

vii. Product of three terms: percent change in market revenue/acre (payment per acre divided by product of price times yield) equal to 13.5%; 0.412 price elasticity as stated on the table; and base acreage at zero probability of update of 825 acres.

vii. Ratio of level change due to equivalent increase in market revenue and payment per acre

Entry/exit decisions and program payments

Chau and de Gorter (2005) develop a model of the U.S. wheat sector calibrated on data for 1998 to compare the potential production impacts of combined PFC and MLA payments and loan deficiency payments (LDP's). In their model LDP's are assumed to affect production in the same way as a fully coupled output price subsidy, while PFC/MLA payments have an impact on production only when the possibility of farm exit is included.

The authors assume that by increasing a farmer's ability to cover fixed costs the PFC/MLA payments encourage producers who might otherwise exit farming to remain in production. Their theoretical model illustrates the potential that the exit deterrence effect could lead to production distortions from ostensibly decoupled payments even greater than those of coupled payments.

The paper reports estimates of the wheat production impacts obtained in evaluation of three policy scenarios: 1) eliminate only LDP's, 2) eliminate only PFC payments and 3) eliminate both LDP's and PFC. These policy scenarios are evaluated for two cases. The first case assumes that the number of farms remains unchanged, i.e., no farms cease production in consequence of program removal. The second case assumes those farms not earning sufficient returns to cover fixed costs after elimination of program payments cease production. The latter is the author's preferred case and the one coupling coefficients are estimated here.

To evaluate the preferred case, a new base level of production had to be estimated. This required first a simulation of what wheat production in 1998 would have been had those farms not covering fixed costs in 1998, even with program payments, ceased production. With this starting point, the study estimated that elimination of LDP payments alone would have resulted in a 7.7% decline relative to the new base. Elimination of PFC payments alone in this case would have resulted in a 3.4% reduction relative to the baseline.

Table **6** contains our estimates of coupling coefficients.

In their review of decoupling studies, Abler and Blandford (2004) note that Chau and de Gorter do not consider the possibility that land and machinery owned by exiting farmers could be rented or sold to other farmers, which would diminish the impact of the payments on production. In a similar vein, Kropp and Whittaker (2011) point out that while absent the payment an unprofitable farm may exit the market, agricultural production on the land belonging to the farm does not necessarily cease. Land might be sold or leased to more efficient agricultural producers, leaving aggregate agricultural production unchanged or even increased with the removal of subsidies. A more appropriate question is whether agricultural decoupled subsidies cause land (not farms) to remain in production.

Table 6. Estimated effects of PFC payments on US wheat production due to farm exit, Chau and de Gorter, 2005

Key Data		
US Wheat Production 1998 (mil. Bu) [i]		2229.11
	Government payments:	
	LDP [ii.]	$4111
	PFC [ii.]	$10083
Simulated output (mil. Bu) with: [i.]		
	Elimination of LDP	2058.42
	Elimination of PFC	2152.65
Reduction in simulated output (mil. Bu) with:		
	Elimination of LDP	-170.69
	Elimination of PFC	-76.46
Percent reduction in simulated output (mil. Bu) with:		
	Elimination of LDP	-7.66%
	Elimination of PFC	-3.43%
Change in output per dollar change in market revenue [iii.]		0.04
Coupling Parameters		
	(1) Change in output per payment dollar	*0.008*
	(2) Percent increase in output per payment dollar	0.0003%
	(3) Ratio of payment effect to market revenue effect	*0.18*

i. Status quo with exits from Table 1 of Chau and de Gorter (2005). This is an author-created estimate wherein farms not meeting fixed costs in 1998 were eliminated from the sample. This transformation was done to ensure a 'like to like' comparison of base and simulated results.

ii. Table 2, Chau and de Gorter (2001) based on the understanding that the working paper results correspond to the summary in the AJAE article.

iii. Based on the authors assumption that the effect of a change in LDP payments would be the same as an equivalent change in market revenue.

iv. Table 5B, LDP only case, of Chau and de Gorter (2005).

Analyses that incorporate (implicitly) multiple avenues of payment effects

Goodwin and Mishra (2006) use data for individual farms in the U.S. Corn Belt to estimate acreage equations for corn, soybeans and wheat in order to measure the land allocation effects of PFC and MLA payments. The dataset created for their regression analysis comprises farm-level observations for more than 4,000 commercial farms for 1998-2001. (Commercial farms are those with annual sales of USD 250,000 or more.)

As stated earlier for direct estimation of supply variable effects more generally, the authors emphasize that the exact mechanism by which PFC payments affect acreage response—wealth effects, changes in risk preferences, capital constraints, or changes related to the anticipation of future benefits—is not identified by the analysis.

Their acreage equations incorporate corn, soybean and wheat prices per bushel, PFC and MLA payments per acre and variables that attempt to capture the indirect effects of PFC payments on area response through farmers' aversion to risk and capital constraints. The data are drawn primarily from the U.S. Department of Agriculture's (USDA) Agricultural Resource Management Survey (ARMS).

Complications arise in attempting to calculate coupling coefficients for individual crops using coefficients from their regression analysis. This is due to the fact that in their analysis both the PFC and MLA payments are averages per acre, per farm and not allocated to individual crops. It is possible however to estimate coupling coefficients for total crop acres (corn, soybeans and wheat combined).

The coupling estimates obtained are based on comparisons of the total acreage effects of a one-dollar increase in payments (first for PFC and then for MLA) to a one-dollar increase in all of the three crop prices. Comparisons are then standardized on a per-dollar of support basis.

Other studies in this category i.e., analyses that estimate production responses to payments but do not distinguish among the various mechanisms, include Key and Roberts (2008), Weber and Key (2012) and O'Donoghue and Whittaker (2010). Analysis is underway to obtain coupling coefficients from these studies.

Table 7. Estimated effects of PFC and MLA payments on Corn Belt crop acreage, Goodwin and Mishra (2006)

	Corn	Soybeans	Wheat	Aggregate
Averages of key data [i.]				
Yield (bu/acre) [ii.]	150	43	56	
Area (acres)	373	386	41	800.08
Price ($/bu)	$2.47	$5.62	$3.28	
PFC payments per acre (average per sampled farm)				$13.74
Debt to asset ratio				0.1907
Change in acreage per dollar change in payments/acre [iii.]				
PFC (total effect per payment dollar) iv.	0.99	0.73	0.28	2.00
Percent change in acreage/$PFC	0.27%	0.19%	0.67%	0.25%
MLA	5.81	0.83	-0.62	6.02
Percent change in acreage/$MLA	1.6%	0.2%	-1.5%	0.75%
Change in acreage per dollar change in price per bushel [iii.]	Corn	Soybeans	Wheat	
Corn	24.42	-93.91	-2.51	
Soybean	-3.91	101.67	-32.13	
Wheat	6.20	-1.41	44.88	
Total crop area [v]	26.72	6.35	10.24	43.30
Acreage impacts for equivalent change in market revenue:				
Estimated impact of 1$ increase in price/bu on receipts per acre [v].	$149.97	$43.00	$56.13	$93.54
Estimated impact of $1/bu increase on market receipts/acre [vi.]				0.46
Coupling Parameters PFC				
(1) Change in output per payment dollar	*2.00*			
(2) Percent increase in output per payment dollar	0.25%			
(3) Ratio of payment effect to market revenue effect	*4.325*			
Coupling Parameters MLA				
(1) Change in output per payment dollar	*6.02*			
(2) Percent increase in output per payment dollar	0.75%			
(3) Ratio of payment effect to market revenue effect	*13.01*			

i. Goodwin and Mishra (2006), Table 1, p. 78 (excepting yields)
ii. USDA via FAPRI state model, corn belt averages for 2001-2004
iii. Goodwin and Mishra (2006), Table 2, p.79, plus values calculated based on those coefficients.
iv. Sum of coefficients for direct and cross effects plus those for debt to asset ratios and insurance as share of total expenses
v. Aggregate is an acreage weighted average of increased corn, soybean and wheat revenues.
vi. Ratio of increase in acreage per $1/bu increase in crop prices to estimated impact of that $1 increase

Appropriateness tests for use in U.S. models

The question this research intends to answer is whether the coupling parameters derived from the literature are suitable for use in a U.S. level model with multiple crops. The units of study vary widely in the literature- from farm level to national, for a variety of crops and different time periods. For these reasons, we do not expect every result to be equally suitable to use in a national model with multiple commodities. However, the appropriateness of parameters from the study can be measured.

In order to estimate U.S. area equations, we first construct a dataset from multiple sources. Planted area is from the National Agricultural Statistics Service of the U.S. Department of Agriculture (USDA). Variable costs by commodity are published by the Economic Research Service (ERS) of the USDA. Expected government payments per acre are calculated from the FAPRI-MU deterministic crop production model which breaks out area for 15 states. The state numbers are aggregated to a national total via a weighted average. Crop insurance net indemnities (indemnities minus producer paid premiums), marketing loan benefits, ACRE and MLA payments are weighted by planted acres whereas direct payments, ARC, CCP and PLC payments are weighted by base acres. PLC and CCP payments are given the same parameter since the programs have the same structure. Expected market revenues per state are the product of the state trend yield and the planting-time futures price of the harvest contract adjusted for basis. The revenues are weighted to a national average by planted acres. The data spans the years 1996 to 2018. Data prior to 1996 lacks relevance for the analysis as programs that no longer exist placed many restrictions on plantings.

The coupling factors convert the government payments to a market equivalent basis. Consequently, expected market net returns plus the sum of the products of the coupling parameters and corresponding expected payments gives a new expected net returns that has all terms normalized to the market net return equivalent. Note that actual variable costs are used in the calculation as those are mostly known at the time of planting. Expected net returns are calculated for U.S. corn, soybeans and wheat. For estimation purposes, the net returns are adjusted for inflation using a GDP deflator with a base year of 2013. We regress U.S. corn, soybean and wheat area against the real expected net returns of the three.

Given the limited number of observations, several constraints are imposed on the linear system. First, the cross effects of returns on acreage are non-positive. In other words, the derivate of corn area with respect to the soybean return is less than or equal to zero, and so on. Second, area planted to a crop cannot decrease if all returns increase by an equal amount. This is equivalent to the sum of the derivatives of corn area with respect to corn, soybeans and wheat returns being non-negative. Note that along with the first assumption this forces planted area with respect to own returns to be non-negative. Finally, it is assumed that the cross effects are symmetric. A dollar increase in corn returns will lower soybean acreage by the same amount that an increase in a dollar of soybean returns would lower corn acreage. This helps ensure consistency of effects. For example, it prevents the case where a dollar increase in corn returns might reduce soybean and wheat acreage more than it increased corn acreage, thereby reducing total acreage even though returns increase. It also reduces the number of parameters to be estimated.

Ordinary Least Squares (OLS) was chosen for the estimator, as Seemingly Unrelated Regression is equivalent to the former when all of the equations in the system have the same independent variables. The OLS estimation with inequality constraints was performed by recasting the problem as a quadratic programming equation and solving with the quadprog package in R. Standard errors were determined by bootstrapping the estimators with 1,000 iterations. A baseline case was initially estimated using the coupling parameters currently in the FAPRI-MU model. They are in Table 8. Table 9 displays the results from the regression and verifies the incorporation of the constraints. Care should be taken when comparing the standard errors with the parameter estimates as the returns coefficients cannot change signs due to restrictions which complicates hypothesis tests checking for significant differences from zero.

Table 8. Planted acres regressed on returns for the baseline

	Area planted (1,000 acres)		
	Corn	Soybeans	Wheat
Intercept	86,215.5	71,620.6	59,850.9
	(2181.8)	(2315.1)	(2177.7)
Corn real net returns	55.3	-22.0	0.0
	(15.4)	(12.8)	(0.0)
Soybean real net returns	-22.0	41.5	-10.4
	(12.8)	(21.9)	(22.7)
Wheat real net returns	0.0	-10.4	10.4
	(0.0)	(22.7)	(24.1)

Standard errors in parentheses

The constrained OLS was used to construct appropriateness measures of the coupling parameters through five-fold cross validation. Mean Squared Error (MSE) was calculated for each out of sample fold to determine the predictive ability of different coupling parameters. This method also provides a test has less risk of overfitting relative to a single regression result of the full data. With limited post-1995 data, it would be difficult to estimate actual parameters for every coefficient on every payment and market returns – and additional complications are suggested by the various estimation techniques used in past studies. This method allows the use of previous studies with adjustments for appropriateness for our purposes. The average MSE for each of the tested scenarios was divided by the baseline average MSE to construct a ratio. Values less than one indicate that it predicted better than the baseline values and above one are worse.

It is important to note that MSE ratios are not a verification of the original results but are instead testing the ability of the parameters to scale to our use. Table 9 contains the parameters and results for a limited number of the studies. Many of the studies only consider a subset of crops in a particular part of the U.S. Our appropriateness measure seeks to determine if we can use those results in a national level model for multiple commodities.

Table 9 starts with the baseline case that uses current FAPRI-MU coupling parameters. If a study's findings for a particular program are able to be converted into coupling parameters, those results replace the baseline numbers where appropriate. If a study investigates programs separately, each parameter is tested for appropriateness separately. The ratio of MSE's on the left column has a range from .87 to 1.18. Note that these numbers are inversely related to appropriateness. In nearly every case, higher coupling factors resulted in less appropriateness. The lowest MSE ratio of .87 was obtained from Weber and Key (2008) based upon a coupling parameter of -5.098 on many of the programs.

Table 9. Decoupling parameters and appropriateness results

Study	Notes	Crops examined in study	Geographic scope of study	Marketing loan benefits	Crop insurance net indemnities	Direct payments	ACRE	ARC	CCP or PLC	Market loss assistance	Average MSE relative to baseline
Baseline				1	0.75	0.05	0.2	0.25	0.25	0.05	1.00
Goodwin and Mishra 2006		Corn, soybeans and wheat	Corn Belt	1	0.75	4.166	0.2	0.25	0.25	0.05	1.07
Goodwin and Mishra 2006		Corn, soybeans and wheat	Corn Belt	1	0.75	0.05	0.2	0.25	0.25	12.531	1.18
Bhaskar and Beghin 2010		Corn	Iowa	1	0.75	0.000006	0.2	0.25	0.25	0.05	1.00
Anton and Le Mouel 2004	Average of the three crops examined used	Corn, wheat and sorghum	Assumed U.S.	1	0.75	0.05	0.2	0.25	0.147	0.05	1.00
Anton and Le Mouel 2004	Average of the three crops examined used	Corn, wheat and sorghum	Assumed U.S.	0.916	0.75	0.05	0.2	0.25	0.25	0.05	1.00
Weber and Key 2008		All program crops	U.S.	-5.098	0.75	-5.098	0.2	0.25	-5.098	-5.098	0.87
Chau and de Gorter 2005		Wheat	U.S.	1	0.75	0.183	0.2	0.25	0.25	0.05	1.01
Hendricks and Sumner 2014	25% probability that base will be updated	Corn and soybeans	Iowa, Illinois and Indiana	1	0.75	0.25	0.2	0.25	0.25	0.05	1.01
Hendricks and Sumner 2014	50% probability that base will be updated	Corn and soybeans	Iowa, Illinois and Indiana	1	0.75	0.5	0.2	0.25	0.5	0.05	1.02
Hendricks and Sumner 2014	75% probability that base will be updated	Corn and soybeans	Iowa, Illinois and Indiana	1	0.75	0.75	0.2	0.25	0.75	0.05	1.04
Hendricks and Sumner 2014	100% probability that base will be updated	Corn and soybeans	Iowa, Illinois and Indiana	1	0.75	1	0.2	0.25	1	0.05	1.05

Gray shading indicates a parameter different from the baseline

Discussion

The decoupling literature is vast; much of it focused on analysis of various provisions of multilateral trade agreements and not specifically concerned with quantifying policy effects. U.S. crop support shifted to direct payments mostly unrelated to land use or market conditions in 1996. Subsequent changes have tied payment levels to market indicators, allowing the occasional updating of the basis for receiving payment. For more than twenty years, this array of policies, have invited applied economists to subject decoupling to greater theoretical and empirical examination.

This body of literature remains in disarray for the simple reason that the results tend to be non-comparable among studies and possibly unrelated to key policy decisions. It is not easy to build on or extend results from previous analyses because of the wide diversity in the way empirical findings are reported. For example, elasticities of supply variable response with respect to a payment tend to be extremely sensitive to the payment level and change, with results that may look big and take on statistical significance but may be of little economic significance. Other effects are presented in ways that obscure the fact that the implied impact of the payments exceeds the effect of a like amount of returns from the market.

Many studies might lose broad relevance because they focus on a subset of producers; lessons drawn from survey data, regional data, and representative farm simulations might have no relevance for aggregating to measure response at the national level. Studies often focus only on a subset of the potential mechanisms through which a decoupled payment can affect output. Taken together, this renders the decoupling literature far less valuable to policy makers than it could be.

Our objective is to synthesize findings from prior analyses to improve the representation of policy in empirical models. The goal is to better quantify the impact of program payments relative to the effects of market returns and prices on national supply. In pursuit the aforementioned objective, this paper develops and deploys mechanisms that aim to (a) standardize supply-inducing effects of payments reported in the literature, (b) associate standardized results with their characteristics, and (c) measure the appropriateness of each result to be used for modeling national supply. The project is in its early phases, the method we have adopted is preliminary and refinement continues. We anticipate revisions and corrections even for the examples presented here. Nevertheless, the results show promise. The analysis presented comprises proof of concept establishing that most studies examined so far can be set on a standardized basis despite the original authors' wide variety of estimation or simulation methods, datasets used, and widely different expressions of final results. The analysis also demonstrates that the proposed indicator for the appropriateness of findings for broader uses of assessing national supplies is feasible. Additional work will improve on what is presented here and expand the review to include more studies. Planned additional work includes the incorporation of qualitative elements and at least some quantitative meta-analysis.

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