DECOUPLING FARM POLICIES: HOW DOES THIS AFFECT PRODUCTION?

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Abstract

This paper studies the extent to which decoupled income support measures in agriculture can have production implications both at the extensive and intensive margins. We develop a theoretical framework that analyzes production responses of agricultural producers to apparently decoupled payments, by explicitly considering risk attitudes and uncertainty. We use farm-level data collected in Kansas to estimate the model. Technology and risk preference parameters are jointly estimated. Results show that though lump sum payments are not fully decoupled in the presence of risk and uncertainty, their effects on agricultural production are likely to be of a very small magnitude.

JEL Classification: Q12, Q18

Introduction

Developed countries tend to provide income support to farmers. Recent years have seen significant agricultural reforms worldwide that have often involved a change in the way farm incomes are supported (Gardner, 1992; Hennessy, 1998; Rude, 2001). While, until recently, support was mainly provided through policies explicitly linked to production decisions (i.e., coupled policies), late policy changes have attempted to break this link through a process known as decoupling. Decoupling aims to support farm incomes, while reducing efficiency losses related to coupled policies such as price-support measures or deficiency payments (Chambers, 1995).

Not being an exception to this reform trend, U.S. overall farm policy underwent substantial alterations in 1996. These changes involved a decoupling of U.S. farm policy in that income-support payments were untied from production. With the passage of the Federal Agriculture Improvement and Reform (FAIR) Act, price-supports were reduced in favor of Production Flexibility Contract (PFC) payments,[1] not linked to the production of certain crops, actual production, or prices, and a deficiency payment program aiming at guaranteeing a minimum support price for program crops. Direct payments introduced by the FAIR Act were continued with the 2002 Farm Bill under the name of Fixed Direct Payments. However, the 2002 Bill involved an enlargement in the coupled element of support, as most crop loan rates were increased and counter-cyclical payments depending upon market prices institutionalized.

[1] To receive PFC payments, farmers who had participated in the wheat, feed grains, rice, and upland cotton programs in any of the years of the period 1991-95, had to enter a 7-year PFC program (1996-2002).

The literature that assesses production impacts of policy instruments has shown that, in the context of a deterministic world or under the assumption that agents are risk neutral, only those policies that distort relative market prices have an impact on producers' decisions. Also, an extensive literature shows that in a world with uncertainty, decoupled transfers, by means of altering total farm household wealth, can have an effect on economic agents' risk attitudes and thus on their production decisions (see, for some examples, Sandmo, 1971; Just and Zilberman, 1986; Bar-Shira, Just, and Zilberman, 1997; Hennessy, 1998; or Chavas, 2004). Under the assumption that farmers' are characterized by decreasing absolute risk aversion preferences, lump sum payments have the effect of reducing farmers' degree of risk aversion. Hennessy (1998) has shown that the willingness to assume more risk may result in an increase in production. These "second-order" effects are known as the wealth effects of policy. While a change in price supports is likely to exert a significant impact on production, it is less clear that producers will strongly react to decoupled government transfers. Second-order effects might be expected to be small relative to the effects of coupled policies. The existence of these effects and their magnitude are issues to essentially be sorted out by empirical analysis.

Our paper attempts to investigate the impact of U.S. agricultural policy decoupling mandated by the FAIR Act on agricultural production decisions taken both at the intensive and extensive margins. We develop a model that assesses the impacts of policy instruments by explicitly considering farmers' risk attitudes and uncertainty. A large body of literature exists on the impacts of risk preferences and uncertainties on economic agents' decisions (see, for example, Just and Zilberman, 1986; Chavas and Holt, 1990; Pope and Just, 1991; Leathers and Quiggin, 1991; or Just and Pope, 2002). Empirical studies on this topic have generally estimated technology and risk preference parameters separately, or alternatively, only risk preference parameters have been derived (see Pope, 1982; or Bar-Shira, Just, and Zilberman, 1997). Joint estimation, which is preferred as it involves gains in the efficiency of estimation, has been addressed by a small amount of studies. Most of them, however, have imposed restrictive assumptions on producers' risk preferences (see Love and Buccola, 1991). Only a few number of papers have performed joint estimation using flexible utility functions that do not impose any restriction on producers' risk attitudes (see Saha, Shumway, and Talpaz, 1994; or Isik and Khanna, 2003). In this analysis we follow Bar-Shira, Just, and Zilberman (1997) proposal to represent producers' risk attitudes without imposing any restriction on preferences. Risk and technology parameters are jointly estimated using farm-level data for a sample of Kansas farms observed from 1998 to 2001.

Though several empirical studies have assessed the effects of decoupling, most of these analyses have assumed risk neutrality (see, for example, Moro and Sckokai, 1999; or Guyomard, Baudry and Carpentier, 1996). Hence, our paper contributes to the literature on decoupling by providing an empirical application that explicitly considers producers' risk attitudes and uncertainty and by jointly estimating technology and utility parameters.

Our paper is organized as follows. In the next section we present a theoretical model of production under uncertainty and assess non-risk neutral farmers' responses to decoupled government payments. In the empirical application section we specify a parametric representation of our model and offer details on the estimation techniques applied. Specifics on the data used and the definition of the model variables are also presented. We then offer estimation results derived from the analysis of farm-level data obtained from a sample of Kansas farms. Concluding remarks are offered in the last section.

Conceptual Framework

In this section we develop a conceptual model that investigates the influence of decoupling on farm production decisions. We compare production responses to changes in decoupled payments with production effects of price variations. Farmers in our model have two income sources: market revenues and lump sum government transfers. Agricultural policy in developed countries usually involves the use of price-support measures (such as U.S. deficiency payments). Given the fact that we do not have experimental data that allows to compare two situations, one with only coupled and the other with exclusively decoupled support, we compare production effects of lump sum payments with the effects of prices, representing the latter a coupled element of support. A decoupled payment is defined as an income-support payment that is exogenously fixed and does not depend on actual production or prices. We assume that new producers without production histories are not entitled to the payments. Likewise, new land entering the sector is not eligible for the payments.

Suppose a single-output firm produces output y using a technology that can be represented by $y = f(x)$, where x is the quantity utilized of a variable input. It is assumed that farmers take their decisions with the aim of maximizing the expected utility of their wealth. A farm's total wealth is represented by $W = \omega + pf\left(x\right) - wx + G$, where ω stands for a farm's initial wealth. The market output price is represented by p and assumed to be a random variable[2] with mean $\bar{p}$ and variance σ^2. The variable input price is represented by w and G stands for decoupled government payments. Producers' optimization problem can be represented by:

$$\max_x E\left[u(W)\right] = \max_x E\left[u(\omega+\pi)\right] = \max_x E\left[u\left(\omega + pf\left(x\right) - wx + G\right)\right] \tag{1}$$

where π represents the profit derived from the farm business. The first-order condition of the expected utility maximization problem is:

$$\frac{\partial E\left[u(W)\right]}{\partial x} = E\left[u_W\left(pf_x - w\right)\right] = 0 \tag{2}$$

where subscripts denote derivatives. We follow Newbery and Stiglitz (1979) and expand u_W around expected wealth, $\bar{W} = \omega + \bar{p}f\left(x\right) - wx + G$. This yields $u_W = \bar{u}_W + \bar{u}_{WW}\, y\left(p - \bar{p}\right)$, where $\bar{u}_W$ and $\bar{u}_{WW}$ are the first and second-order derivatives

[2] We choose output price as the stochastic variable, because our focus is on policy decoupling processes. Policy decoupling usually involves a reduction in price-support measures, which may in turn alter price volatility. Output risk will only affect production decisions if variable inputs have an impact on output variability. To capture the influence of inputs on output risk we used Just and Pope (1978) functional specification. However, results not compatible with economic theory were derived. These results may be an indicator that either inputs do not have a strong impact on output risk, or that farmers do not consider this issue in their decisions. Hence, we settled with a specification that accounts for price uncertainty and assumes output to be deterministic.

of the utility function evaluated at the expected wealth ($\bar{W}$). Substituting the Taylor series expansion into (2) and rearranging terms yields:

$$f_x\left(\bar{p}+\frac{\bar{u}_{WW}}{\bar{u}_W}y\sigma^2\right)=w \tag{3}$$

The Arrow-Pratt coefficient of absolute risk aversion is $R=-\frac{\bar{u}_{WW}}{\bar{u}_W}$. Following Bar-Shira, Just, and Zilberman (1997), we assume that R is a function of a farm's expected wealth[3] and can be represented by $R=-\frac{\bar{u}_{WW}}{\bar{u}_W}=\eta\bar{W}^{\beta}$. This specification does not impose any restriction on risk behavior. It accommodates risk aversion ($\eta>0$), risk-neutral ($\eta=0$), or risk-seeking attitudes ($\eta<0$). Further, it does not restrict the sign of the wealth elasticity of absolute risk aversion (β), thus allowing for decreasing absolute risk aversion (DARA) preferences ($\beta<0$), constant absolute risk aversion (CARA) attitudes ($\beta=0$), or increasing absolute risk aversion (IARA) behavior ($\beta>0$). The wealth elasticity of relative risk aversion ($\beta+1$) is not restricted either. A value of $0>\beta>-1$ is equivalent to increasing relative risk aversion (IRRA), $\beta<-1$ corresponds to decreasing relative risk aversion (DRRA), and $\beta=-1$ represents constant relative risk aversion (CRRA).

[3] Our measure of risk aversion based on expected wealth is only an approximation to farmers' actual risk preferences. This measure does not change with different realizations of the random variable because it is measured at the expected price, but varies with the level of a farmer's wealth.

The first order condition in (3) shows that the expected utility maximization requires the marginal product of an input f_x valued at the certainty equivalent (CE) of price $CE = \bar{p} - \eta \bar{W}^{\beta} y\sigma^2 > 0$ be equal to the variable input unit price w.

As noted above, farmers in our model have lump sum payments and market revenue as income sources. We choose market prices to represent a form of coupled income support, and compare their effects with production responses originated by decoupled payments. We assume throughout the comparative statics analysis that farmers are decreasingly absolute risk averse ($\eta > 0$ and $\beta < 0$) and that the marginal productivity of the variable input is positive ($f_x > 0$). The effects of lump sum payments on the level of agricultural production can be determined through the following elasticity (ε_{y_G}):

$$\varepsilon_{y\_G} = -\frac{\varepsilon_{CE\_G} CE}{A} \frac{xf_x}{y} > 0 \tag{4}$$

where $A < 0$ is the second order condition of the optimization problem multiplied by $\frac{x}{f_x}$. Expression $\varepsilon_{CE\_G} = -\frac{R_G y\sigma^2 G}{CE} > 0$ represents the CE elasticity with respect to decoupled government transfers, and $R_G = \eta\beta\bar{W}^{\beta-1} < 0$ is the risk aversion effect of G and shows the risk preference adjustment to a change in decoupled transfers. In accord with what has been shown by previous literature (see Hennessy, 1998), expression (4) suggests that an increase in decoupled government transfers increases DARA farmers' willingness to assume more risk, which in turn stimulates production

($\varepsilon_{y\_G} > 0$). Output prices' impact on y can be computed through the following elasticity (ε_{y_p}):

$$\varepsilon_{y\_p} = -\frac{\varepsilon_{CE\_p} CE}{A} \frac{x f_x}{y} > 0 \tag{5}$$

where $\varepsilon_{CE\_p} = \frac{\left(\bar{p} - R_p \bar{p} y \sigma^2\right)}{CE} > 0$ represents the CE sensitivity to a change in output prices, and $R_p = \eta \beta \overline{W}^{\beta-1} y < 0$ measures the impacts of a price change on farmers' risk preferences. Expression ε_{CE_p} shows that an output price variation generates two changes that can impact on the level of output. The first effect, the marginal income effect ($\bar{p} > 0$) represents the marginal income obtained from an increase in output prices. The second effect is the risk aversion effect ($R_p \bar{p} y \sigma^2 < 0$) and measures the impact derived from farmers being less risk averse as a result of an increase in output prices. Expression (5) is positive, which shows that an increase in output prices will also stimulate production.

Our comparative statics analysis allows to derive expressions (4) and (5) that capture the effects of coupled and decoupled instruments on the level of production. A comparison of these two expressions, however, does not allow to draw a clear conclusion on their relative magnitudes. This is an issue that needs to be empirically determined. It is however expected that prices will have a stronger impact on production relative to decoupled payments: while lump sum transfers only impact on producers' behavior through a risk aversion effect, prices influence production by means of the marginal income and the risk aversion effects.

The potential of decoupled government transfers to influence farmers' production decisions is not restricted to the intensive margin. These payments are also likely to have an effect on the extensive margin. A risk-averse producer will probably only stay in the sector if the expected utility of the farm business' profit is non-negative $E[u(\pi)] \geq 0$. If the utility function is approximated through a second-order Taylor series expansion, this involves that $\bar{\pi} - \frac{1}{2} R y^2 \sigma_p \geq 0$, where $\bar{\pi}$ is the expected profit (see Chavas 2004, p. 48-50). The extensive margin sensitivity to government payments is determined in a simulation exercise. The non-negative expected utility constraint is checked for different levels of subsidies and the number of farms that are likely to stop production under each of these levels is determined. A reduction in subsidies will reduce a farm's profit, but will also increase a farmer's degree of risk aversion. Both changes are likely to trigger the contraction of the extensive margin.

This section shows that, though the sign of the effects of decoupling can, to a certain extent, be predicted by theory, their magnitude needs to be sorted out by empirical analysis. We devote the next two sections to study the impacts of decoupling on production decisions taken by a sample of Kansas farms.

Empirical Application

In order to be able to econometrically estimate our model, we provide a parametric representation. Generalizing the model outlined in the previous section, we define y as a function of two inputs $y = f(x_1, x_2)$. The technology structure is approximated through a Cobb-Douglas[4] production function $y = \lambda x_1^{\mu} x_2^{\gamma}$. Following expression (3) a system of first-order conditions can be determined:

$$\begin{cases} \lambda \mu x_1^{\mu-1} x_2^{\gamma} \left(\bar{p} - \eta \bar{W}^{\beta} y \sigma^2 \right) = w_1 \\ \lambda \gamma x_1^{\mu} x_2^{\gamma-1} \left(\bar{p} - \eta \bar{W}^{\beta} y \sigma^2 \right) = w_2 \end{cases} \tag{6}$$

The system of first-order conditions (6) is jointly estimated with the production function by full information maximum likelihood, yielding consistent technology and risk preference parameters. The elasticities of output with respect to coupled and decoupled policies are constructed based on the generalization of expressions (4) and (5) to a two-input model[5] and computed at the sample means.

The dataset

Our empirical analysis focuses on the influence of government payments on production decisions taken by a sample of Kansas farmers. Farm-level data are taken from farm account records from the Kansas Farm Management Association database for the period 1998-2001.[6] Thus, our period of analysis corresponds to a time during which the FAIR Act was effective. FAIR Act payments correspond to our definition of fixed payments per farm. Though the analysis is based on individual farm data, aggregate data are needed to define several important variables not registered in the Kansas dataset. These aggregates are taken from the National Agricultural Statistics

[4] Other functional forms such as quadratic or translog were also tried, but yielded inferior results.

[5] Details of this generalization are available from the authors upon request.

[6] Retrospective data for these farms are used to define several lagged variables used in the analysis. To be able to do so, a complete panel is built out of our sample.

Service (NASS), the United States Department of Agriculture (USDA), and the BRIDGE database. NASS provided country-level price indices and state-level output prices and quantities. USDA facilitated state-level marketing assistance loan rates (LR) and PFC payment rates. From the BRIDGE database we extracted information on agricultural commodity futures prices.

Using these sources, the variables required to estimate the model are defined. Summary statistics for the variables of interest are presented in table 1. Two variable inputs are considered; x_1 includes chemical inputs and x_2 includes fertilizers. Because input prices are not registered in the Kansas database, country-level input price indices are taken from NASS. Implicit quantity indices for variable inputs are derived through the ratio of input use in currency units to the corresponding price index.

Following the theoretical model, a single output category is considered as a quantity index that includes production of wheat, corn, grain sorghum and soybeans-the predominant crops in Kansas. An aggregate output price index is defined as a Paasche index that represents farmers' expected prices. To build the expected price index, unit prices for the crops considered are defined as expected prices in the following way: $\bar{p} = \max\left[E(Cp), LR\right]$, where $E(Cp)$, the expected cash price, is computed as the futures price adjusted by the basis.[7] The basis is calculated as the five preceding years' average of the difference between the cash price and the futures price. The cash price is the state-level output price. The futures price is defined as the daily average price during the planting season for the harvest month contract. LR

[7] When the futures price is unavailable, the lagged cash price is taken as the proxy for the expected price. This only happens for sorghum futures price.

represents the state-level assistance loan rate. State-level production is employed to derive the aggregate expected Paasche index.

Kansas database does not register PFC government payments. Instead, a single measure including all government payments received by each farm is available. To derive an estimate of farm-level PFC payments, the acreage of the program crops (base acreage) and the base yield for each crop are approximated using farm-level data. The approximation uses the 1986-88 average acreage and yield for each program crop and farm. PFC payments per crop are derived by multiplying 0.85 by the base acreage, yield and the PFC payment rate. PFC payments per crop are then added to get total direct payments per farm.[8] A farm's initial wealth is defined as the farm's net worth.

Results

Our article studies the effects of decoupling on farmers' production decisions both at the intensive and extensive margins. Results of the joint estimation of technology and risk preference parameters are presented in table 2. Parameter estimates for the production function are all statisitically significant and suggest that production of the farms in our sample is characterized by decreasing returns to scale. At the data means, $f_{x_i} > 0$ and $f_{x_i x_i} < 0$, which involves that an increase in input "*i*" use will increase output at a decreasing rate.

[8] This estimate is compared to actual government payments received by each farm. If estimated PFC payments exceed actual payments, the first measure is replaced by the second. This happens to 7% of our observations.

The elasticity of the measure of absolute risk aversion (β) takes the value of -0.39. This measure is statistically different from zero as well as from -1, which involves that farmers are decreasingly absolute and increasingly relative risk averse. Our results are compatible with the findings of Bar-Shira, Just, and Zilberman (1997) who report a wealth elasticity of the coefficient of absolute risk aversion equal to -0.31, or Binswanger (1991) who derived a value of -0.32 for the same measure.

Price and payment elasticities of agricultural output are computed at the data means and results are offered in table 3. For information purposes, elasticities of input consumption are also presented. All elasticities are statistically significant and have the expected sign. As expected, $\varepsilon_{y\_p} > \varepsilon_{y\_G}$, i.e., coupled instruments have a much stronger impact on production than decoupled public transfers. The decoupled payment elasticity of output, $\varepsilon_{y\_G} = 0.006$, shows that indeed very large changes in these payments are required to generate perceptible effects. These results are compatible with Hennessy's (1998) findings that under DARA preferences, an increase in decoupled payments will have a minor effect on variable input use. An exercise is conducted to determine the impacts of decoupling on agricultural production. A reduction in output price supports is simulated. It is assumed that this reduction is fully transmitted to market prices. Lump sum payments are increased to exactly compensate the effects of the decline in prices on farms' income. At the data means, results show that the average production per farm will be reduced from $y = 104,315.98$ to $y' = 93,434.42$, $y' = 82,552.87$, $y' = 60,789.75$ if prices are reduced by 5, 10, and 20% respectively. From these results we can conclude that a decoupling process that involves a reduction in price supports compensated by an increase in lump-sum payments is likely to have the effect of reducing agricultural output.

The results of the analysis of the effects of decoupled payments on the extensive margin are presented in figure 1. Recall that this analysis involves the consideration of the non-negative expected utility constraint. We check inequality $\bar{\pi} - \frac{1}{2} R y^2 \sigma_p \geq 0$ for different levels of decoupled transfers. Results show that if PFC payments were cut by half, 2.2% of the risk-averse farmers would probably abandon production (see figure 1). The elimination of PFC payments would likely trigger the abandonment of almost 6% of the farms. Thus, once more, results show very small impacts of decoupled transfers on farmers' production decisions.

Concluding remarks

This paper studies the extent to which U.S. agricultural policy decoupling mandated by the FAIR Act could have had an impact on agricultural production decisions both at the intensive and extensive margins. We develop a theoretical model of production under uncertainty and assess non-risk neutral farmers' responses to decoupled government payments. Farmers' risk preferences are represented as a function of expected wealth that does not impose any restriction on producers' risk attitudes. Risk preference and technology parameters are jointly estimated.

Although several empirical studies have assessed the impacts of decoupling, most of these analyses have assumed risk neutrality. Hence, our paper contributes to the literature on decoupling by providing an empirical application that explicitly accounts for producers' risk attitudes and uncertainty.

Though the theoretical framework allows to predict the sign of the effects of decoupling, it does not allow to anticipate their magnitude. We hypothesize that the impacts of lump sum payments on production are likely to be small relative to the effects of coupled policies. Farm-level data for a sample of Kansas farms are used to estimate the model.

Results show that farmers in our sample are decreasingly absolute and increasingly relative risk averse. Though decoupled government transfers are found to motivate an increase in input use and thus in agricultural output, elasticity values are very small, requiring substantial changes in payments to generate perceptible effects on production. Conversely, the effects of coupled policies such as price-supports are found to be substantially higher. Hence, a decoupling process consisting of a reduction in price supports in favor of decoupled government transfers is very likely to involve a reduction in both input use and output.

The impact of lump sum payments on the extensive margin is not found to be very relevant either. Our results show that an elimination of PFC payments could trigger the abandonment of only about 6% of the farms in our sample, while a reduction in the order of 50% of these payments could involve 2% of the risk averse farmers abandoning production. Hence, though PFC payments are not fully decoupled in the presence of risk and uncertainty, their effects on agricultural production seem to be of a very small magnitude.

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Table 1. Summary statistics for the variables of interest

Variable	Mean (Standard deviation) n= 2,384
y (output)	104,315.98
	(120,636.51)
$\bar{p}$ (expected price)	0.92
	(0.06)
x_1 (chemical input)	14,209.34
	(17,177.62)
w_1 (chemical input price)	0.99
	(0.01)
x_2 (fertilizer)	18,809.25
	(20,829.04)
w_2 (fertilizer price)	1.01
	(0.06)
G (PFC payments)	11,412.08
	(9,337.62)
ω (initial wealth)	656,214.29
	(577,944.67)

Note: all monetary values are expressed in constant 1998 currency units

Table 2. Parameter estimates and summary statistics for the production function

Parameter	Coefficient estimate (Standard error)
λ	6.13**
	(0.06)
μ	0.44**
	(0.01)
γ	0.54**
	(0.01)
η	0.30**
	(0.07)
β	-0.39**
	(0.02)
$H_0 : \lambda = \mu = \gamma = \eta = \beta = 0$	6.25E8**

Note: An asterisk (*) denotes statistical significance at the $\alpha = 0.1$ level

Two asterisks (**) denote statistical significance at the $\alpha = 0.05$ level

Table 3. Elasticity estimates at the data means

	Elasticity value
$\varepsilon_{x_1\_G}$	0.0064**
	(0.0003)
$\varepsilon_{x_2\_G}$	0.0064**
	(0.0003)
$\varepsilon_{x_1\_p}$	2.2899**
	(0.0431)
$\varepsilon_{x_2\_p}$	2.2899**
	(0.0431)
ε_{y_p}	2.1367**
	(0.0438)
ε_{y_G}	0.0060**
	(0.0003)

Figure 1. Reduction (in %) in economically viable farms if PFC payments are reduced