Substitution Between Revenue Futures and Price Futures Contracts: A Note

DAVID A. HENNESSY

In recent years, commercial interest has been expressed in agricultural revenue insurance instruments. Participating parties may look to futures markets to offset assumed positions. In this note, conditions are identified such that revenue futures contracts are perfect substitutes for price futures contracts. If these conditions approximate reality, then it would seem questionable whether sufficient interest would exist to sustain markets in both futures contracts. © 2002 Wiley Periodicals, Inc. Jrl Fut Mark 22:387–391, 2002

INTRODUCTION

In recent years, perhaps the most significant innovation in U.S. agricultural output insurance markets has been the advent of revenue insurance products. Commencing in 1996, the U.S. Risk Management Agency, a

Journal paper No. J-19597 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project No. 3463, and supported by Hatch Act and State of Iowa funds. The author appreciates the comments of an anonymous referee, and also conversations with Chad Hart and Dermot Hayes.
For correspondence, David A. Hennessy, Department of Economics and Center for Agricultural and Rural Development, 578C Heady Hall, Iowa State University, Ames, Iowa 50011-1070; e-mail: hennessy@iastate.edu

Received June 2001; Accepted October 2001

■ *David A. Hennessy is a Professor in the Department of Economics and Center for Agricultural and Rural Development at Iowa State University in Ames, Iowa.*

The Journal of Futures Markets, Vol. 22, No. 4, 387–391 (2002)
 • DOI: 10.1002/fut. 10014

division of the USDA, has collaborated with private-sector insurance companies to develop a variety of revenue insurance products (USDA/RMA, 2001). By 2001, crops covered by established contracts or pilot program contracts included barley, canola, corn, cotton, rice, sorghum, soybeans, sunflowers, and wheat. By then, approximately half of all U.S. corn and soybean acres were covered through USDA-subsidized revenue insurance contracts. Interest has also emerged in livestock revenue insurance products (Hart, Babcock, & Hayes, 2001). As expanded upon by Hennessy, Babcock, and Hayes (1997) and also Mahul and Wright (2000), a reason proffered for the appropriateness of this insurance contract form is that it better targets the real risk concern that the agricultural producer is believed to have.

The popularity of these instruments has undoubted implications for the nature and strength of demands for agricultural futures and options contracts. In particular, revenue insurance and price futures contracts may be strong substitutes (Coble, Heifner, & Zuniga, 2000). If this is true, then the existence of subsidized revenue insurance contracts may reduce the demand for exchange traded agricultural price derivatives.

In response to this competition, and to better serve the needs of those that seek to hedge revenue insurance contract positions, market makers in futures contracts may wish to support trading in revenue futures contracts. The extent of substitutability between the demands for price futures contracts and revenue futures contracts will be a factor in determining the viability of a market for revenue futures contracts.

The intent of this note is to demonstrate that, when markets for revenue insurance contracts are not available, there exist circumstances under which price futures and revenue futures contracts can be perfect substitutes. It is hoped that this insight will help the applied analyst in establishing the key issues to look at when seeking to identify market niches and when gauging the likely extent of competition that will be countenanced upon launching a new product.

MODEL

A risk averse producer faces both price and quantity risk. She has at her disposal two futures contracts: an harvest maturity price contract with present contract price $\hat{p}$ and an harvest maturity revenue contract with present contract price $\hat{r}$. Planned production is given by q with increasing and strictly convex cost function $C(q)$. Quantity randomness is multiplicative so that we may write normalized revenue as $\tilde{R} = \tilde{P}\tilde{\varepsilon}$ where $\tilde{P}$

is the realized harvest-time price.[1] With z_r and z_p as the respective positions in the revenue and price futures contracts, harvest-time profit is

$$\pi = \tilde{P}\tilde{\varepsilon}q - C(q) + z_r(\hat{r} - \tilde{P}\tilde{\varepsilon}) + z_p(\hat{p} - \tilde{P}). \tag{1}$$

Notice that choices concerning a subsidized revenue insurance contract have not been made available to the producer.

For an increasing and concave utility-of-profit function $U[\pi]$ and expectation operator $E\{\cdot\}$, the first-order optimality conditions with respect to the choice instruments (q, z_r, z_p) are

$$\begin{aligned} E\{U_\pi[\pi] \times (\tilde{P}\tilde{\varepsilon} - C_q(q))\} &= 0, \\ E\{U_\pi[\pi] \times (\hat{r} - \tilde{P}\tilde{\varepsilon})\} &= 0, \\ E\{U_\pi[\pi] \times (\hat{p} - \tilde{P})\} &= 0, \end{aligned} \tag{2}$$

where subscripts denote derivatives. Label the solution vector as (q^*, z_r^*, z_p^*). From summing the first two conditions we have the usual separation result; optimal q solves $\hat{r} = C_q(q^*)$.[2] There remains a system of two choice variables to be solved for.

Market-level effects are important. A grower would, of course, hope that both her output and the price received are high. In reality, market feedback together with the strong spatial correlations in weather patterns imply that price and yield shocks are typically negatively correlated. Losq (1982) and also Sakong, Hayes, and Hallam (1993) accommodate this correlation through a stochastic micro-level price-quantity relation of the form $\tilde{\varepsilon} = Q(\tilde{P}; \tilde{\theta})$ where $\tilde{\theta}$ is random. We will specialize this correspondence. The polar case that we will consider is when each grower believes that the relationship between her production shock and the level of spot price is given by the hyperbolic form

$$\tilde{\varepsilon} = \beta_0 + \beta_1\tilde{P}^{-1}, \quad \beta_0 > 0, \beta_1 > 0, \tag{3}$$

so that production shock and the price level vary in an inverse manner, as one might typically expect.

[1]Multiplicative and separable production risk is a common assumption (see, e.g., Moschini & Lapan, 1995). Chambers and Quiggin (2000), however, demonstrate the inflexibilities inherent in classes of stochastic technologies that are more general than the case of multiplicative, separable production risk.

[2]Actually, circumstances exist under which a second separation formula can be extracted from the first-order conditions. The analysis to follow will clarify.

Notice that (3) is nonstochastic in the sense that the value of the multiplicative yield shock is determined once the value of $\tilde{P}$ has been determined. In contrast with Losq (1982), Sakong et al. (1993), Moschini and Lapan (1995), Mahul and Wright (2000), and Coble et al. (2000), there are no idiosyncratic production shocks. The intent of this assumption is to establish production shocks at sub-aggregate levels as one of the key sources of departure from the environment where price and revenue futures contracts are perfect substitutes.

Substituting in (3) and evaluating at $q = q^*$, equation (1) may be re-written as

$$\pi = (q^* - z_r)(\tilde{P}\beta_0 + \beta_1) - C(q^*) + z_r\hat{r} + z_p(\hat{p} - \tilde{P}). \tag{4}$$

The analysis of system (2) will be furthered through an arbitrage argument. Two cases warrant consideration.

Case I: $\hat{r} \neq \hat{p}\beta_0 + \beta_1$. Upon setting $z_p^* = q^*\beta_0 - z_r^*\beta_0$, equation (4) becomes

$$\pi = (q^* - z_r^*)(\beta_1 + \beta_0\hat{p}) - C(q^*) + z_r^*\hat{r}. \tag{5}$$

This is non-stochastic with derivative $d\pi/dz_r^* = \hat{r} - \beta_1 - \beta_0\hat{p}$, so that infinite profits can be achieved if z_r^* is set to be arbitrarily large (small) whenever $\hat{r} > (<) \beta_1 + \beta_0\hat{p}$. Thus, positions z_r^* and $z_p^* = q^*\beta_0 - z_r^*\beta_0$ provide a risk-free portfolio with the potential for infinite profits. Market equilibrium will require that price relation $\hat{r} = \hat{p}\beta_0 + \beta_1$ holds between the perfectly substitutable risk management contracts.

Case II: $\hat{r} = \hat{p}\beta_0 + \beta_1$. Upon setting $z_p^* = q^*\beta_0 - z_r^*\beta_0$, equation (4) becomes

$$\pi = q^*\beta_1 - C(q^*) + q^*\beta_0\hat{p}, \tag{6}$$

and it is readily seen that $\hat{r} = \hat{p}\beta_0 + \beta_1 = C_q(q^*)$ determines the optimal level of planned production.

DISCUSSION

Some comments are warranted concerning the decision environment that has been made available to the grower in our model. Suppose, as is the case in the United States in 2002, that the producer can also choose over levels of revenue insurance or crop insurance where the indemnity is based on actual yields. This changes the problem in two senses. Most obviously, there are more ways in which revenue risk can be reduced. Second, moral hazard becomes an issue and this might cause the separation result, $\hat{r} = \hat{p}\beta_0 + \beta_1 = C_q(q^*)$, to fail. Concerning the first issue, and in our common risk production environment, if the moral hazard problem could be solved then revenue insurance or crop insurance are unlikely to be attractive alternatives unless these insurance contracts are subsidized. This is because an actuarially fair insurance contract generally does not eliminate risk whereas an actuarially fair revenue futures contract can do so. Concerning moral hazard, it is unlikely to be a severe problem when idiosyncratic yield risks are small. For then it would be easy to identify and punish a grower that engages in morally hazardous behavior.

This brings us back to the purpose of this note. Whether or not revenue or crop insurance alternatives are available, there exist conditions under which a revenue futures contract would not serve a market that is significantly differentiated from that served by a price futures contract. Of course, in reality the markets will be differentiated for a variety of reasons including local disparities in prices and yields, non-multiplicative yield shocks, and also a departure from the price-quantity relation given in (3) above. It is, in part, the extent of such deviations that would determine the viability of a market in revenue futures contracts.

BIBLIOGRAPHY

Chambers, R. G., & Quiggin, J. (2000). Uncertainty, production, choice, and agency: The state-contingent approach. Cambridge, UK: Cambridge University Press.

Coble, K. H., Heifner, R .G., & Zuniga, M. (2000). Implications of crop yield and revenue insurance for producer hedging. Journal of Agricultural and Applied Economics, 25(2), 432–452.

Hart, C. E., Babcock, B. A., & Hayes, D. J. (2001). Livestock revenue insurance. Journal of Futures Markets, 21(6), 553–580.

Hennessy, D. A., Babcock, B. A., & Hayes, D. J. (1997). Budgetary and producer welfare effects of revenue insurance. American Journal of Agricultural Economics, 79(3), 1024–1034.

Losq, E. (1982). Hedging with price and output uncertainty. Economics Letters, 10(1–2), 65–70.

Mahul, O., & Wright, B. D. (2000, July–August). Designing optimal crop revenue insurance. Paper presented at the annual meetings of the American Agricultural Economics Association, Tampa FL.

Moschini, G.-C., & Lapan, H. E. (1995). The hedging role of options and futures under joint price, basis, and production risk. International Economic Review, 36(4), 1025–1049.

Sakong, Y., Hayes, D. J., & Hallam, A. (1993). Hedging production risk with options. American Journal of Agricultural Economics, 75(2), 408–415.

U.S. Department of Agriculture, Risk Management Agency. (2001). http://www.rma.usda.gov/policies/, visited September 26.