Returns to Scale and Size in Agricultural Economics: Reply

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We appreciate the opportunity that Färe's comment provides to further discuss the topic of returns to scale and size. His summary of literature on ray homothetic functions is useful for establishing further linkages between returns to scale and size and associated economic theory. This literature and his comment reiterate several points made in our paper. First, the careless use of size and scale concepts, which we discuss in agricultural economics, is also a problem in the mining economics literature (Boyd). His summary further demonstrates the relevance of returns to scale in applied production economics and the influence of technology characteristics on long-run cost. We are pleased that the importance of this subject is emphasized by Färe's comment.

Färe's summary does introduce a potential ambiguity. He states that ray homothetic and ray homogenous functions fail to satisfy free disposability and quasi-concavity of inputs. In particular, the latter property limits his contention that "this property makes them suitable for the study of returns to scale." However, Färe, Jansson, and Lovell (p. 625) state "Although neither of these two strong properties is imposed globally by the ray-homothetic function, either may be satisfied locally. . . ." Thus, ray-homothetic functions may have applications where environmental constraints preclude standard regularity conditions holding globally.

Färe correctly points out an additional limiting condition on ray production technologies. He states that "the class of functions that satisfies (3) consists of the ray-homothetic production functions alone." We agree that the general statement concerning expansion paths for (3) is misleading. A linear expansion path is characteristic of a technology if and only if the input structure of the technology is homothetic. However, equation (3) is a basic equation corresponding to the class of ray production functions including homogenous, homothetic, ray homogenous, and ray homothetic functions. Appropriate modifications of this general form result in these four particular specifications and provide a link between our propositions 1 and 2 and previous research. Proposition 1 establishes a relation between elasticity of size and scale for a homothetic production technology. We noted that this proposition does not hold for ray homogenous or ray homothetic technologies (p. 131).

Färe's comment did not address proposition 2, which is the main contribution of our article. Proposition 2 establishes elasticity of size as the envelope of the elasticity of scale, or the long-run average cost curve as the envelope of scale average cost curves. For a homothetic technology, the scale average cost curve corresponding to the expansion path is the long-run average cost curve. Otherwise the long-run average cost curve is the envelope of scale average cost curves. Subsequently, Revier independently derived these results. Investigating additional implications associated with proposition 2 appears more fruitful than further attention to the taxonomy of production and cost functions.

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References

Boyd, G. "Factor Intensity and Site Geology as Determinants of Returns to Scale in Coal Mining." *Rev. Econ. and Statist.* 69(1987):18–23.

Färe, R., L. Jansson, and C. A. K. Lovell. "Modeling Scale Economies with Ray-Homothetic Production Function." *Rev. Econ. and Statist.* 67(1985):624–29.

McClelland, J. W., M. C. Wetzstein, and W. N. Musser. "Returns to Size and Scale in Agricultural Economics." *West. J. Agr. Econ.* 11(1986):129–33.

Revier, C. F. "The Elasticity of Scale, the Shape of Average Costs, and the Envelope Theorem." *Amer. Econ. Rev.* 77(1987):486–88.