eastern Wyoming irrigated crop farm could increase gross margin by 7 percent and reduce the coefficient of variation from 0.63 to 0.42. Woolery and Adams indicated that diversified land use, combined with livestock, could increase net income and reduce relative income variability for South Dakota and Wyoming farms. Other studies have reached mixed results as to the risk-return tradeoff (see Persaud and Mapp; Sonka and Patrick). Despite any benefits that may accrue to enterprise diversification, the opportunities are often limited by resources, climatic conditions, market outlets, and other factors (Sonka and Patrick).

Geographical diversification (farming at several noncontiguous locations) may also mitigate risks in crop production by reducing the chances that local weather events (such as hail storms) will have a disastrous effect on income. Nartea and Barry examined this form of diversification using Illinois corn and soybean data, and found that risk was not reduced significantly until land parcels were separated by at least 30 miles. They accounted for the costs associated with farming across widely dispersed plots (for example, moving equipment and people and monitoring crop conditions), and concluded that widely dispersed tracts typically create unfavorable risk-return tradeoffs for producers. When widely dispersed parcels are observed, it is likely because of farmers' desire to expand their operations, and their difficulty in finding additional tracts of farmland that are close to their farming bases. Those most likely to gain from geographic dispersion of parcels are institutional investors with large acreages who do not have to transport equipment and who use tenants to farm their holdings.

Vertical Integration

Vertical integration is one of several strategies that fall within the umbrella of "vertical coordination." Vertical coordination includes all of the ways that output from one stage of production and distribution is transferred to another stage. Farming has traditionally operated in an open production system, where a commodity is purchased from a producer at a market price determined at the time of purchase. The use of open production has declined, however, and vertical coordination has increased as consumers have become increasingly sophisticated and improvements in technology have allowed greater product differentiation (Martinez and Reed; Allen). A vertically integrated firm, which retains ownership control of a commodity across two or more levels of activity, represents one type of vertical coordination (Mighell and Jones).[7]

There are many examples of vertical integration in farming. Farmers who raise corn and hay as feed for their dairy operations are vertically integrated across both crop and livestock production. Similarly, cattle producers who combine raising a cow-calf herd, backgrounding the animals to medium weights, and feeding cattle to slaughter weights

Opportunities for diversification can be limited by resources, climatic conditions, market outlets, and other factors.

[7]Other types of vertical coordination reflect differing degrees to which a firm at one stage of production exerts control over the quality or quantity of output at other stages (Martinez and Reed). When production contracts are used, for example, the contractor (or integrator) typically retains control over the commodity and most inputs, and the farmer usually receives an incentive-based fee for production services. In this case, the producer retains little control over production decisions. When marketing contracts are used, in contrast, a firm commits to purchasing a commodity from a producer at a price formula established in advance of the purchase, and the producer retains a large degree of decision-making control. Both production and marketing contracts are discussed in subsequent sections in this report.

Vertical integration is much more common in certain livestock and specialty crop industries than in field crops.

are vertically integrated. As these examples illustrate, vertical integration can encompass changing the form of the product (corn into livestock), or combining stages in the production process under ownership by one entity (as in the cattle example).

From the farmer's perspective, the decision to integrate vertically depends on many complex factors, including the change in profits associated with vertical integration, the risks associated with the quantity and quality of the supply of inputs (or outputs) before and after integration, and other factors. In particular, the relationship between vertical integration and risk involves an evaluation of the expected returns and the variance and covariance of the farmer's return on investment for the current activity and the integration alternative (Logan). If the correlation is positive and large across activities, the gains in risk efficiency from vertical integration may be relatively low. In contrast, a negative correlation across activities implies that integrating vertically may well reduce risk for the farmer by internalizing processes within the operation.

In practice, vertical integration in agriculture often involves ownership of both farm production and processing activities, particularly in certain parts of the livestock sector (table 4). Vertical integration is fairly common in the turkey industry, for example, where about 30 percent of production takes place on farms that perform multiple functions. On the largest operations, the enterprise mix may include a feed mill, a hatchery, a grow-out operation, a slaughter facility, and a packing plant. In such cases, integration moves both backward into inputs (feed manufacturing) and forward into the finished, consumer-ready product. Similarly, egg producers with large operations may own their own feed mill, hatchery, laying operation, and freezing/drying plant for the processing of egg products (Manchester).

Vertical integration is also common in certain specialty crops, particularly for fresh vegetable and potato operations (table 4). In these industries, vertical integration often encompasses not only production of the crop, but also sorting, assembling, and packaging products for retail sales. Large, vertically integrated vegetable growers, for example, often both pack and sell their own vegetables, displaying their private brand names on packages, and at times

Table 4—Extent of farm production coordinated by vertical integration

Commodity	1970	1990
	Percent	
Livestock:		
Broilers	7	8
Turkeys	12	28
Hogs	1	6
Sheep and lambs	12	28
Field crops:		
Food grains	1	1
Feed grains	1	1
Specialty crops:		
Processed vegetables	10	9
Fresh vegetables	30	40
Potatoes	25	40
Citrus	9	8
Other fruits and nuts	20	25
Total farm output	5	8

Source: Martinez, Steve W., and Al Reed, *From Farmers to Consumers*: *Vertical Coordination in the Food Industry,* AIB-720, U.S. Dept. Agr., Econ. Res. Serv., June 1996.

investing in research targeted at developing new varieties. Incentives prompting an operation to adopt this type of vertically integrated strategy include the need for extensive quality control (through control of cultural practices and planting dates) and the desire for brand-name identification of products, signaling known-quality produce to buyers (Powers).

While the above examples relate to individual operations, farmers may join together in a cooperative organization that is vertically integrated across functions.[8] Examples of farmer-owned, vertically integrated cooperatives include Ocean Spray, which is owned by about 950 cranberry and citrus growers in the United States and Canada and markets fresh products and bottled juices (Shee). Other vertically integrated cooperatives include Land O'Lakes (owned by dairy growers) and Sunkist (owned largely by California citrus growers).

There are also examples of grain farmers who have cooperatively integrated into processing and other functions. Wheat growers in the Fairmount, North Dakota, area jointly invested in the construction of Dakota Valley Mills in late 1997, a farmer-owned mill supplied with wheat from local producers (Sosland Publishing Company, Sept. 1997). Similarly, a Kansas-based farmer cooperative, Twenty-first Century Grain Processing, secured an option in early 1997 to buy a New Mexico flour mill. Producer members who participate in this venture deliver wheat under a marketing agreement to different points in Kansas and Oklahoma for transport to the New Mexico milling site (Sosland Publishing Company, Feb. 1997; Fee).

[8]For more information on cooperatives, see Frederick. Although the discussion here focuses on farmer cooperatives that also engage in processing, many other types of cooperatives exist.

The Dakota Growers Pasta Company, which is run by producers in a three-State area in the upper Midwest and includes a mill and pasta plant, is similar in concept to the Twenty-first Century venture just discussed. Each Dakota Growers farmer buys a share of the company and enters into a contract for delivery of a pre-determined quality and quantity of wheat by a certain date each year (Martinez and Reed). If the average open-market price for a given period exceeds the contract price, a farmer's payment is increased above the initial contract amount. Conversely, if the average market price is less than the contract price, the firm makes up the difference. Premiums are paid for wheat of exceptional quality, and growers can purchase wheat from company-held stocks in severe yield-loss years. By operating in such a manner, the Dakota Growers Pasta Company is not only vertically integrated into milling and pasta production, but also relies on marketing contracts (see later discussion) among its farmer-members.

As noted earlier, the incentives for vertical integration can arise either from producers or from buyers further down the marketing chain who realize an opportunity to enhance their potential profits or reduce their risk. A farmer (or group of farmers) may vertically integrate "downstream" (forward in the marketing channel), for example, to assure a market for their commodity and to capture a greater share of the value that is associated with the production process. By doing so, they may enhance their profits by lowering transactions costs and by using management and other resources more efficiently. Risk can also be reduced by guaranteeing a market outlet and by avoiding the uncertainties of selling and purchasing intermediate commodities in imperfect markets. Conversely, a

The incentives for vertical integration can arise either from producers or from buyers further down the marketing chain who realize an opportunity to enhance their potential profits or reduce their risk.

processor may vertically integrate "upstream" (backwards in the marketing channel) to exercise greater control over the quality and timing of deliveries and the quality of inputs used in the production process. Again, reduced risk and/or greater profits may result.

The risk-reducing benefits associated with vertical integration depend to a great extent on the nature of the industry. Typically, the benefits associated with integration increase as production and marketing interrelationships become more complex and when breakdowns in marketplace competition are most likely (such as opportunistic behavior by contracting parties). For perfectly competitive industries, all firms are subject to price fluctuations caused by supply and demand shifts—whether or not they are vertically integrated—and integration cannot provide protection from such risks. In such industries, the benefits to integration may be small. When imperfect markets exist, in contrast, firms can benefit by some combination of improved information access, internalized transactions costs, and efficiencies in market exchange (Perry, 1989). As a result, firms tend to integrate when the costs incurred in using the market price mechanism exceed the costs of organizing those activities within the management control of a single operation (Scherer).

The benefits associated with integration typically increase as production and marketing relationships become more complex and when breakdowns in marketplace competition are most likely.

While vertical integration can lead to reduced risks and/or enhanced profits for some firms or growers, others may find such a strategy unattractive. Depending on the size of the firm and the extent of the proposed integration, the benefits associated with specialization and scale economies can be greatly reduced or lost, particularly in perfectly competitive markets. For growers in such markets who choose to vertically integrate, the gain may be primarily through enterprise (or business) diversification (Perry, 1989). In addition, the size and scope of the operation can have a major impact on integration choice.

Empirical applications have examined the linkage between vertical integration and farm-level risk. One such study, focusing on cattle production in the Texas rolling plains, illustrates the importance of size of firm and income growth on integration choice (Whitson, Barry, and Lacewell). This study, responding to concerns about price uncertainty and the changing structure of the livestock industry, evaluated the risk-return effects of selling fed calves or holding them through subsequent stages in the production process. It included a weaned calf stage, a stocker phase (grazing on wheat pasture), a custom feeding phase (bypassing the stocker phase and custom feeding), and other options.

The authors found that, at low-income levels, the preferred sequence involved production of weaned calves with subsequent placement in a feedlot, a result consistent with negative covariances. As growth in ranch income increased, however, a wheat pasture activity was included in the vertical sequence to increase income and meet increased cash flow requirements over a 5-year horizon. The manager's willingness to accept risk and constraints to his or her ability to borrow were critical in determining the final integration choice.

Production Contracts

Production contracts typically give the contractor (the buyer of the commodity) considerable control over the production process (Perry, 1997). These contracts usually specify in detail the production inputs supplied by the contractor, the quality and quantity of a particular commodity that is to be