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EVALUATING THE GAINS ASSOCIATED WITH BIOTECHNOLOGICAL IMPROVEMENT: THE CASE OF KIWIFRUIT IN NEW ZEALAND

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Significant productivity gains are achievable from the improvement of kiwifruit. Genetic engineering is perceived as a tool for product diversification associated with alterations in quality attributes and the seasonal growth of kiwifruit. Benefits from diversification to the industry are weighted against the net benefits of adoption to growers.

Key words: adoption scenarios; distribution of gains; growers' returns; kiwifruit; New Zealand; quality enhancement.

The gains from biotechnological improvement depend on both changes in production and changes in the marketplace. This paper focuses on these changes for kiwifruit, a seasonal perennial crop, within the industrial organization of the New Zealand kiwifruit industry. The potential productivity gains associated with product differentiation, subject to genetic engineering for quality change and growth enhancement, are evaluated. The focus is on evaluating the gains associated with diversifying the kiwifruit production mix rather than increasing the overall volume of production in the industry. Since estimates of the gains from quality improvement are done in advance, and future demand for "new" products and their overall market performance is uncertain, the estimated gains are represented as an average figure of perceived product performance.

When speaking of differentiated production of kiwifruit, we focus on the characteristics of the product - kiwifruit quality attributes (color, flavor, texture, and appeal), and the availability of the crop throughout the year. Due to the industrial organization of the kiwifruit industry in New Zealand (many growers and one exporter), this paper focuses on the distribution of premiums between those responsible for the input (growers) and those in charge of the output (exporters or marketers).

Timing Of Product Placement

The seasonal characteristics of kiwifruit and its distribution within and between the Southern and Northern Hemispheres make product placement strategies crucial for capturing greater returns in each market. The increased competition in both Hemispheres has also significantly reduced the advantage of exclusive windows of supply, which have historically provided the New Zealand kiwifruit industry with a monopoly position.

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Although the degree of overlapping of kiwifruit supplies has increased due to the greater number of competitors, and better storing conditions[1], an uninterrupted supply of kiwifruit could be profitable. Potential benefits of a year-round supply of New Zealand kiwifruit[2] stem from the strengthening of the distribution links, and the positioning of the product on the marketplace, as well as from greater consumer knowledge of the quality of kiwifruit associated with the ZESPRI brand. Constant market presence implies higher returns due to availability and reduced transaction costs, in contrast to seasonal supplies of kiwifruit.

The Scope Of Product Differentiation

New Zealand's product differentiation approaches are mainly associated with distinguishing the quality of New Zealand Hayward variety kiwifruit when compared with competitors' kiwifruit, rather than with diversification of the varieties used and types of quality kiwifruit produced. Therefore, further quality improvement of the same variety is not likely to provide the industry with a competing edge. Ideally, the mix of kiwifruit types within the ZESPRI brand needs to be further developed. Instead of a single New Zealand kiwifruit, there should be a range of different New Zealand kiwifruit, in order for customers to make their choice on the basis of product attributes rather than linking quality to product origin.

Product differentiation is important because of the loss of appeal of the original kiwifruit (demand-side factor), and the lack of diversification in the intrinsic characteristics of the fruit (supply-side factor). This implies that supply-side determinants are lagging behind rapidly changing consumer preferences, resulting in considerable losses in both consumer and producer surpluses. It also suggests that the scope of product differentiation should be determined by the rate of change in consumer preferences and the production capacity of the industry for new product development.

The lack of product-specific differentiation provides the incentives for diversification of kiwifruit varieties for specific quality attributes. With a change in the production mix[3] across different product types a greater profitability margin, in general, and greater marginal returns for each specific type of kiwifruit, should be expected. These gains should be achieved while providing the consumer with greater choice of fresh kiwifruit.

Simulation Analysis Of The Effects Of Product Differentiation On The Economics Of Growing Kiwifruit

The potential market performance of two new kiwifruit varieties is evaluated (Variety B with capacity for early maturation, and Variety C novelty kiwifruit with alterations to flavor and color) through a number of grower-specific and industry-wide adoption scenarios. The changes in the volume of each variety produced, including the old Variety A (i.e., the distribution of the product mix across the different varieties), are then linked to variety- and market-specific elasticity figures.   This analysis is undertaken in order to generate an approximate figure of the average market potential of the new kiwifruit varieties. The price premium generated is subsequently analyzed within a number of distribution scenarios in order to evaluate possible orchard-gate returns, and link these to adoption decisions. The simulation model is based on qualitative assumptions drawn from the past performance of the New Zealand kiwifruit industry.

The underlying approaches to conducting the simulation analysis focus on a number of relationships:

- ***On-Orchard*** - scenario-specific net present value (NPV) analysis for determining required growers' returns for adoption;

- ***Industry*** – scenario-specific (product-specific) distribution of volume produced and exported;
- ***Market*** – simulation of market- and product-specific premiums associated with qualitative assumptions;
- ***Distribution of gains from product diversification*** – simulation of the distribution of gains between the exporters/marketers and the growers, and the impacts for future production.

On-Orchard Adoption Strategies

Growing a new variety involves decisions regarding not only the type of variety to be grown, but also the allocation of land across different varieties. The grower's decision whether to grow a new variety (B or C) is mainly influenced by the magnitude of expected returns associated with growing a new variety. The grower would only adopt if the NPV of growing a new variety is greater or equal to the NPV of no adoption, including a risk allowance to account for uncertainties. Thus, adoption is associated with the amount of risk a grower is willing to undertake, the type of variety to be adopted, and the potential gains associated with growing this variety. The present value of the stream of future returns is an important indicator of the likelihood of adoption.

Industry Production Potential

This research focuses on diversification within current production volumes (i.e., changes in the product mix) rather than the increase in the total volume of kiwifruit produced and exported. Therefore, if a new variety is adopted, the production of some (or all) of the old variety will be foregone.

Market Potential

In order to evaluate the market potential of the new types of kiwifruit, assumptions are made about the specific market characteristics and the return expectations in each market. The performance of each variety (or product) type is dependent on the intrinsic characteristics (i.e., quality attributes) of the product; the time of product placement on the market; the number and strength of competitors at each market; the market-specific (seasonal) elasticity of demand; and the volume of each product supplied to the main export centers. While Variety B's premium generation is linked to its novelty characteristics and consumer preferences for a new and different product, Variety C's performance is associated with premiums dependent on time of placement in each market, rather than a change in the product's attributes. Japan, Europe[4], and the United States (U.S.) are the chosen markets for simulating premium prices. Each market is composed of segments with different consumer preferences and, thus, willingness to pay different prices for different product features.

The goal of the simulation analysis is to establish credible and economically sound relationships between variety type and market-specific premium prices. However, due to the availability of highly aggregated data our approach relies on known information and model assumptions associated with industry adoption scenarios. For example, available information includes the total volume of kiwifruit exported in 1997 which was 56.7 million trays, and its distribution across the main markets which was 27% in Japan, 56% in Europe, 9% in the U.S., and 8% in the rest of the world. By establishing variety and market specific volume allocations of kiwifruit, we are able to generate a set of disaggregated data useful for simulating market relationships. Table 1 summarizes one production scenario across markets and product types[5].

Table 1. Distribution of Total Exports by Variety Type and Export Markets.

Total Market Distributions			Market and Variety Specific Distributions					
Market	**%**	**Volume**	**%**	**Variety A (50%)**	**%**	**Variety B (25%)**	**%**	**Variety C (25%)**
Japan	27	15,309,000	27	7,654,3,500	30	4,252,500	24	3,402,000
Europe	56	31,752,000	56	15,876,000	56	7,938,000	56	7,938,000
USA	9	5,103,000	9	2,551,500	13	1,842,750	5	708,750
ROW	8	4,536,000	8	2,268,000	1	141,750	15	2,126,250
Total	100	56,700,000	100	28,350,000	100	14,175,000	100	14,175,000

Table 1 assumes an industry adoption rate of 50% for variety A, a 25% adoption rate for variety B, and 25% adoption rate for variety C. In the above scenario, variety A follows the same distribution pattern as the aggregate level. However, variety B and C are distributed differently across markets at the disaggregated level. For example, 30% of variety B is exported to Japan compared to 27% for the aggregate of all varieties. Only Europe imports the same disaggregated percentage across all varieties.

Table 2 shows a range of prices across markets and variation for food production scenarios. In general, compared to the case of no adoption, the average market-specific prices are higher (see the percentages presented in the brackets). For example, the average price for all three varieties is 33% higher in European markets than with no adoption of biotechnology. The average market, product and scenario-specific prices (i.e., the world average) are also higher than under the no adoption scenario. For example, in the case of scenario 2 the average price is 70% higher across all varieties than under the case of no adoption. The marginal differences in prices between scenarios are mainly due to the effect of quantity changes, suggesting that the lower the proportion of adoption of the new varieties, the higher the prices they are likely to capture in each market and, thus, the higher the overall world average market prices.

Conclusions

This paper evaluates potential future developments in the New Zealand kiwifruit industry, associated with the use of genetic engineering for the provision of product quality and diversity. The results of the simulation analysis are intended to be an indication of the potential, as well as limitations, of the type of product differentiation chosen to maximize industry returns.

The model and the simulation analysis provide a framework for future detailed analysis of the economics of utilizing genetic engineering for quality enhancement and product diversification within the kiwifruit industry. This analysis could be further augmented by the provision of specific raw data on variety and market specific production, distribution, and prices. It should also be supported by conducting a formal econometric analysis for identifying numerical coefficients to substantiate the relationships between dependent and explanatory variables presented (in a qualitative fashion) in the simulation analysis. A quantitative link between product quality attributes and specific consumer preferences would thus substantiate adoption decisions.

Table 2. Approximation To Market And Variety Specific Prices Per Tray.

Variety Type	Japan	Europe	USA	Row	World Average
			NO ADOPTION: 100% VA		
A	$8.45	$6.00	$5.56	$5.00	**$6.25**
			SCENARIO 1: 50% VA, 25% VB, 25% VC		
A	$13.77	$7.02	$7.39	$6.65	$8.71
B	$28.81	$9.78	$10.62	$8.25	$14.37
C	$12.84	$7.14	$7.17	$6.75	$8.48
Average Price (% increase)	$18.47 (119%)	$7.98 (33%)	$8.39 (51%)	$7.22 (44%)	**$10.52 (68%)**
			SCENARIO 2: 60% VA, 20% VB, 20% VC		
A	$12.68	$6.78	$7.06	$6.35	$8.22
B	$30.34	$10.02	$11.23	$8.25	$14.96
C	$13.10	$7.20	$7.23	$7.10	$8.66
Average Price (% increase)	$18.71 (121%)	$8.00 (33%)	$8.51 (53%)	$7.23 (45%)	**$10.61 (70%)**
			SCENARIO 3: 75% VA, 12.5% VB, 12.5% VC		
A	$11.07	$6.48	$6.51	$5.85	$7.48
B	$32.70	$10.38	$12.07	$8.30	$15.86
C	$13.44	$7.32	$7.28	$7.55	$8.90
Average Price (% increase)	$19.07 (126%)	$8.06 (34%)	$8.62 (55%)	$7.23 (45%)	**$10.75 (72%)**
			SCENARIO 4: 90% VA, 5% VB, 5% VC		
A	$9.55	$6.18	$5.95	$5.35	$6.76
B	$35.07	$10.74	$12.95	$8.30	$16.77
C	$13.86	$7.44	$7.34	$8.00	$9.16
Average Price (% increase)	$19.49 (131%)	$8.12 (35%)	$8.75 (57%)	$7.22 (44%)	**$10.90 (74%)**

Endnotes

[1]"Kiwifruit will keep in most cases for up to 6 months [even though it is technically feasible to extend the storage period to 9 months] and its physiological make-up is such that cold storage will not affect its quality providing certain precautions are taken" (OECD, 1990, p.6).

[2]Year-long provision of kiwifruit could be achieved by two means: 1) investment in research and development for the improvement of the growth potential of specific kiwifruit varieties, and 2) the formulation of licensing agreements with Northern Hemisphere kiwifruit producers.

[3]The rationale of product differentiation focuses on changes in the mix of production (quality enhancement) rather than increases in the volume produced (yield enhancement).

[4]The European market is a set of different countries with different consumer segments and preferences. Hence, even though countries like Germany have historically paid high prices for New Zealand kiwifruit, the effects of a strong skeptical approach to genetically engineered food could reduce the premium in this market (as the product will appeal to only some market segments) and affect the overall price premium achievable in Europe.

[5]Table 1 summarizes the idea for disaggregation when applied to an industry adoption of 25% of variety B and C. This idea is subsequently used for identifying volume changes associated with the other adoption scenarios (i.e., 20%, 12.5% and 5% of variety B and C). These volume changes are incorporated into the market specific simulation of potential premium prices.

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