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6. Evaluating the Potential Productivity Gains Associated with Biotechnological Improvement: The Case of Kiwifruit in New Zealand

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Evaluating the Potential Productivity Gains Associated with Biotechnological Improvement: The Case of Kiwifruit in New Zealand

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Chapter 6

Evaluating the Potential Productivity Gains Associated with Biotechnological Improvement: The Case of Kiwifruit in New Zealand[1]

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Introduction

The economic evaluation of genetic engineering is dependant not only on the technical functions of biotechnological methods for quality or growth enhancement and their impact on cost-effective production, but also on the type of natural resource to which genetic engineering is applied. This paper focuses on the specific characteristics of 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 generation of a "new" (enhanced or altogether new) input and its utilization within a standardized production/distribution process require a long-term estimation of the cost-effectiveness of the project. There are risks associated with the introduction of a "new" input in different deployment environments, which could undermine any quality enhancing effort and increase the uncertainty margins in any economic analysis.

When speaking of differentiated production of kiwifruit, we focus on the intrinsic characteristics of quality improvement of the input. Within the broad notion of quality enhancement, specific quality traits could be aimed at, according to particular consumers' preferences, which implies the need for a more targeted (trait-specific) economic evaluation. We associate quality change with changes in the slope (rather than shifts) of the product-specific supply curve. In other words, 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.

Demand side factors are crucial for the generation of quality driven gains. While the characteristics of the "new" product are scientifically defined and acknowledged, the concern lies in the consumers' ability and willingness to identify them and value them more highly than the traditional product. Therefore, the shaping of the demand curve for the "new" product is dependent on the marketing strategies for product introduction and placement in specific niche markets, as well as on the willingness of consumers to purchase a product with altered quality attributes.

In general, the shape of both the supply and the demand curves of a "new" product in specific markets, their interaction, as well as the world market commodity price of the non-altered product, result in the formulation of pricing strategies. The price of the new product is also subject to the proportion of quality change, which *per se* is an attribute difficult to quantify. 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 an average figure of perceived product performance.

Finally, the allocation of quality premiums across the distribution chain is a difficult task, since each level of the production chain adds some value to the final performance of the product. 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).

Trends and Patterns of Production and Trade of New Zealand Kiwifruit

In order to understand the dynamics of the New Zealand kiwifruit industry a number of underlying factors need to be examined. The structure of the industry represents the framework within which assumptions are made. The production potential of the kiwifruit industry in New Zealand is evaluated on the basis of planted hectares of kiwifruit, yield, volumes and value (in terms of both free-on-board (fob) and growers receipts) of production and export across time. The marketing potential is emphasized by identifying the main markets for New Zealand kiwifruit, the timing of product placement and competition, as well as product differentiation strategies. The biological potential for selection and quality improvement purposes is also acknowledged.

Recent Regulatory Development of the New Zealand Kiwifruit Industry

"In its relatively short history, the New Zealand kiwifruit industry has tried a variety of marketing methods – unregulated competitive exporting [1970's], export licensing [1980's] and a single seller [1990's] to all markets except New Zealand and Australia – with each change bringing increased export regulation" (NZR, 1994; p. 2). Currently, the New Zealand kiwifruit industry is orchestrated by the New Zealand Kiwifruit Marketing Board (NZKMB), which was established in 1988 and is owned by domestic kiwifruit growers. The monopolistic structure (of a single-desk exporter) of the Board has been under significant pressure in recent years stimulating a number of changes in the operational structure of the industry.

Firstly, in 1997, the responsibilities of the Board became much more narrow (industry governance and onshore grower equity issues, inventory, quality and administration) due to the establishment of a separate entity - ZESPRI International - as a global marketing subsidiary, selling under the ZESPRI[3] New Zealand Kiwifruit brand.

The separation of responsibilities between growers (the Board) and exporters/marketers (ZESPRI) is expected to provide the incentives for more focused development strategies for adding value, e.g. the formulation of dynamic market and product-specific marketing strategies. Efficiency gains associated with within-industry specialization and function-specific accountability are also to be expected.

Secondly, collaborative marketing schemes (licensing agreements) have been formulated, allowing collaborative marketers (non-Board exporters) to source product directly from suppliers[4], and providing for a more deregulated on-shore structure by shifting the point of purchase from coolstore to domestic wharfs. The small scale of collaborative marketing activities could prove vital for entry into niche markets not targeted by the Board.

Although progressive changes have been undertaken, there are still a number of important shortcomings in the operational structure of the New Zealand kiwifruit industry[5]:

1. *Pooling of returns* - All financial proceeds from kiwifruit exporting (including the earnings of collaborative marketers) are allocated to the Board's common pool, which distributes them across growers, suggesting that growers returns are calculated on an average rather than marginal basis. "Because profits from the Board's marketing business are bundled together with the fruit price in the orchard gate return, the grower's per tray return contains profit from both the orchard and the marketing investments. … This is a misleading price signal because it implies the profitability of growing kiwifruit is higher than actual market returns[6] would suggest" (NZBR, 1994; p. 57). This distorted market information when transmitted to production decisions inevitably stimulates overproduction. Thus, under the current industry arrangements all growers are compelled to invest in both production and product marketing (rather than specializing in only kiwifruit production), which constrains profit maximizing behavior within the industry;

2. *Limited direct exporting arrangements* - Kiwifruit growers have a limited ability to export their products directly (only through collaborative marketing and to the Australian market), without the intervention or approval of the Board. Thus, since growers have little real control over their returns, commercial risk undertaken by the Board is fully bourn by the growers;

3. *Costs* - The direct and indirect costs of current regulatory arrangements are high. There are reduced incentives to seek innovation in terms of product development or marketing approaches to identify new export markets, to increase entry and competition in the industry, and to provide the base for both domestic and foreign investment and capital flow to export marketing of kiwifruit, thus, stimulating a profit minimizing behavior;

4. *Fruit quality* - Growers' returns are subject to the volume of kiwifruit they submit rather than the type (and therefore quality characteristics) of variety they grow. The objectives of the Board are focused on maximization of per unit output returns rather than profitability. One of the approaches adopted in this regard is the establishment of a single brand name, ZESPRI. This stimulates the tightening of quality standards for export kiwifruit and the targeting of specific markets. While the brand provides for the identification of quality New Zealand kiwifruit on the market, it also constrains lower quality kiwifruit from being allocated to export niche markets. The tighter standards and the lack of variety-specific focus on returns reduce the incentives for on-orchard adoption and innovation.

The overall result from the current industry framework, and particularly from the pooling system of returns, relevant to this paper could be summarized as a multi-level cross-subsidization effort. There is a weak ability to differentiate between 1) good and bad growers; 2) large and small crop; 3) well performing varieties of kiwifruit and poorly performing varieties; 4) sold versus lost product; 5) production risks versus marketing risks. This suggests a clear misallocation of resources, since the incentives for providing a better product are constrained by the inability to differentiate and value it due to returns averaging. Therefore, cross-subsidization, at any level, reduces the incentives for innovation, risk-taking, cost-effective production and product distribution.

In summary, the current developments within the New Zealand kiwifruit industry aim at the formulation of a more efficient structure for industry competitiveness, in general. However, this paper focuses on evaluating the industry competitiveness from the point of view of the potential of product differentiation, rather than the regulatory costs and benefits associated with restructuring.

Indicators of Production Potential

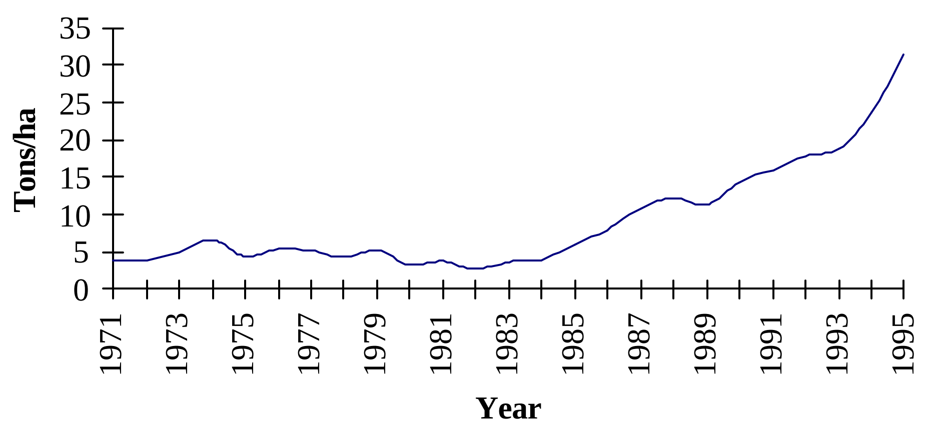
The industry's production potential is evaluated by considering the area allocated to kiwifruit production, the yield per planted hectare, the overall production of fresh kiwifruit (in tons or tray equivalent), and the volumes and value of exported fruit[7].

Planted Area with Kiwifruit. The commercial growing of kiwifruit in New Zealand began in 1937, when the first acre of kiwifruit vines was planted (unknown, 1979). The novelty of the fruit, the high opportunity costs of growing it, in addition to the lack of information regarding its market potential, meant that the planted area remained low, with only 190 bearing hectares[8] in 1968. During the next 10 years, the area allocated to kiwifruit exponentially increased to reach 2,230 hectares in 1978 (1,174% increase from 1968). In 1988 the area planted with kiwifruit reached its peak at 18,905 hectares (848% increase from 1978). More recently (after 1988) the area dedicated to kiwifruit growing has seen a steady decrease, to reach 10,430 hectares in 1997 (55% reduction compared to 1988). This is due to a number of factors:

1. declining returns from kiwifruit growing (due to greater competition and increased supply of kiwifruit in export markets), leading to considerable vine-pulling and a shift to more profitable use of the land for other horticultural crops or agricultural activities;
2. prevailing unfavorable climatic conditions and a decline in the volume and/or quality of product;
3. a more vigorous maximization of returns achieved by reducing costs and increasing yield per bearing hectare, rather than by increasing the amount of bearing hectares;

The industry average yield per hectare (tons/ha) has followed a steady upward trend, particularly in the mid-1980's. The rate of increase of yield per hectare after the mid-1980's corresponds to a declining area of planted kiwifruit and steady production volumes. It could also be associated with improved growing techniques, research and development for kiwifruit quality enhancement, existence of older kiwifruit vines producing greater yield per hectare, and the overall scale of production of the kiwifruit industry.

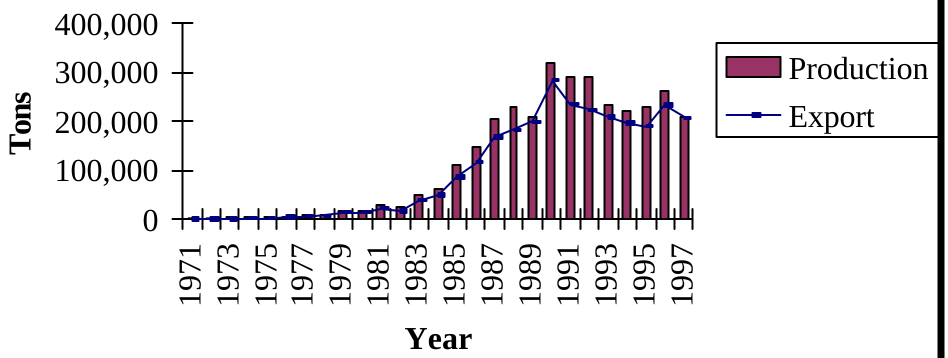
Figure 1 Kiwifruit Yield per Hectare (tons/ha)



Volumes of Kiwifruit Production and Export. During the 1940's, kiwifruit was sold as a new and exotic fruit only in the domestic market. It wasn't until 1953 when the fruit was offered to the overseas market. Total production of kiwifruit rose steadily throughout the 50's and 60's. In early 1980's the production of kiwifruit increased exponentially to reach around 30,000 tons. A 1,768% increase in production volumes was recorded between 1980 and 1990. From this year on, the production volumes have fluctuated, following a general downward trend.

It is evident that although total production has recently been declining, the proportion of volume of kiwifruit sold overseas has been increasing. In the early years of kiwifruit exporting (1950's), only 5-10% of the total production was destined overseas. By the end of 1960's, the proportion of exports rose to 20% of total production, reaching an average of 70% by the end of 1970's, 83% by the end of 1980's and 90% in the 1990's. In 1997, the proportion of production exported was 98%, suggesting an increasingly more efficient allocation of kiwifruit on the international market.

Figure 2 Total Production and Export Volumes of Kiwifruit (tons)



The Value of Growing and Exporting Kiwifruit. The natural competitiveness of fresh kiwifruit in the early years of its production (due to the lack of competitors), the consumer acceptance of the new and exotic fruit in overseas markets, as well as the fast development of kiwifruit growing infrastructure were the determining factors of increasing export returns (both in terms of free-on-board value and growers returns) throughout the 1980's.

Between the late 1980's and mid-1990's other competitors entered the kiwifruit market, increasing year-round supply from both the Southern and Northern Hemispheres. In addition, trade restrictions in some overseas markets as well as transitional marketing strategies stagnated the flow of exports. The industry was no longer benefiting from its natural monopoly position, and export volumes were no longer the main tool for export competitiveness. Specific product attributes (quality, size, time of market positioning) and appropriate marketing strategies are becoming the major determinants of success for New Zealand kiwifruit in export markets.

In summary, the period between early 1980's and late 1990's has been characterized with a significant rise in total export value[9], attributed to a number of reasons, including more vigorous targeting of consumer segments within old markets, increased marketing efforts in new markets, and improved product quality to meet customer preferences. The magnitude of export values could also be associated with more favorable exchange rates for returns from overseas markets.

Returns to growers[10], on the other hand, have been fluctuating, following a somewhat downward trend for the 10 year period between 1980 and 1990, reflecting the overall changes in the structure of the industry domestically (the creation of the NZKMB in 1988) and internationally (the rise in the number of countries growing and exporting kiwifruit). However, there have been some recent improvements in gross returns to growers.

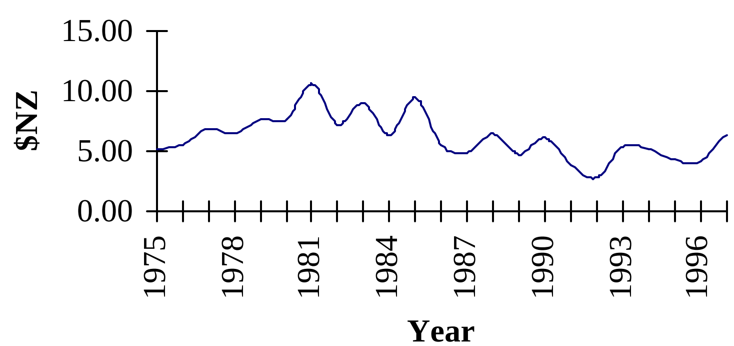
In order for existing growers to keep producing, an incentive scheme is required to meet growers' expectations for orchard-gate returns per tray. Such scheme could be based not only on factors such as the quantity and size of the kiwifruit submitted, but also on the type of product submitted. Product differentiation could be an important incentive for growers to match their expectations with consumer preferences in overseas markets.

Indicators of Market Potential

The scope and scale of the New Zealand kiwifruit industry is important when evaluating the changes in the product mix and distribution. The main overseas markets for kiwifruit (traditionally and recently), the timing of product placement on each overseas market and the nature of the product offered to overseas consumers are key determinants for making realistic assumptions of the impact of product change on overall market potential of the fruit.

Major Export Markets. Kiwifruit accounts for less than 1% of world fresh fruit consumption (NZ Yearbook, 1996). Global production of kiwifruit, on the other hand, is increasing significantly. Although New Zealand is a leading kiwifruit exporting country, and a producer that has consistently earned price premiums over its competitors, the large market share that it used to enjoy in the early 80's (70%) has dramatically shrunk to represent only 27% in 1996 (NZ Yearbook, 1996), which exceeds Chile's 10% share, but is below Italy's 30% share (Brookes *et al*., 1994).

Figure 3 Return to Growers per Tray Submitted ($NZ)



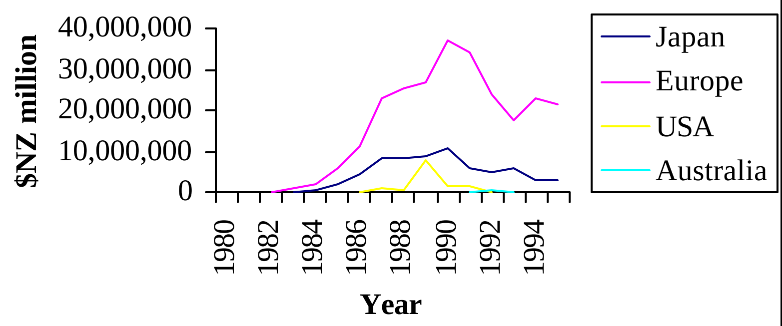
Furthermore, for the period 1991-1996, kiwifruit exports from two of New Zealand's major competitors (Italy and Chile) grew at annual rates of 14% and 13%, respectively. In comparison, New Zealand had a negative annual growth rate of 3% during the same period of time. This may be due to the scale of the exporting potential of New Zealand (being a large exporter), in conjunction with the goal of maintaining high prices for New Zealand kiwifruit[11]. When the overall export production is examined, New Zealand does not appear to have significant market power. However, market power could be argued to exist in particular markets at particular points of time when seasonal production is examined.

New Zealand kiwifruit exports have historically concentrated on European markets, with an average of 56% of the total exports[12] (in the 1980's and 1990's) flowing there. The second major importing region of New Zealand kiwifruit is Asia, with an average of 29% of total exports. The rest is distributed to the USA and other single markets in Latin America, the Middle East and the Pacific area (including Australia).

> *Asian market* - The single biggest importer of New Zealand kiwifruit has been and still is Japan, importing an average of 27% of the total volume of kiwifruit sold overseas. Within the Asian export region, however, countries like Taiwan, Hong Kong and the Republic of Korea have significantly increased their demand for New Zealand kiwifruit between 1985 and 1995 (4,358%, 1,176% and 145,600% respectively). During 1996 and 1997, the rate of growth of exports to Japan was negative (-14%), which was almost fully offset by the growth rate achieved in other East Asian countries (13%).
>
> *European market* - Strong European importers of New Zealand kiwifruit are Belgium, Germany, France, Italy, Denmark and Sweden.
>
> *US market* - The volume of New Zealand kiwifruit exports to the United States followed a very unsteady upward trend during the 1980's, with an overall increase in volume over a ten year period of 3,500%, peaking in 1990 with 34,885 tons of kiwifruit. However, this trend has been reversed with a significant exponential decrease in the volumes imported between 1990 and 1995 (6,935% decrease) reaching a low of 503 tons in 1995. This is attributed to an anti-dumping order placed on New Zealand exports in 1990[13], which, on the other hand, provided a perfect opportunity for Chilean kiwifruit.

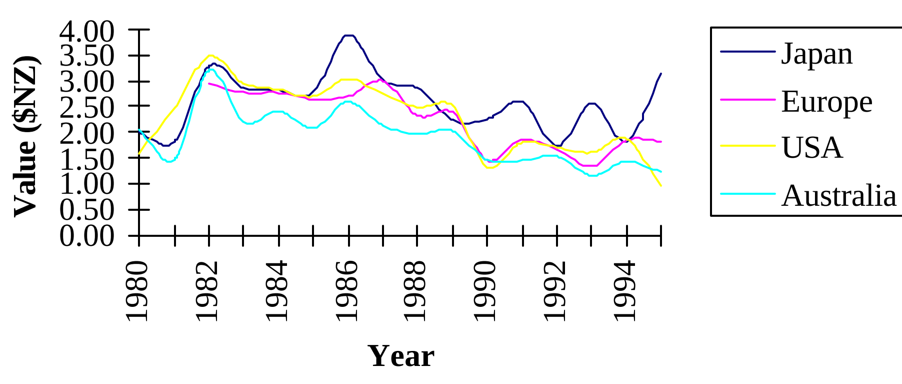
Total export revenue in the two major export markets (Europe and Japan) significantly increased between 1980 and 1990, peaked in 1990, and since then followed a downward trend. Although the trends in both countries are similar (with marginal changes being much more significant in Europe than in Japan), there is a marked difference in the magnitudes of export revenue generation.

Figure 4 Total Export Revenue ($NZ million) by Major Market



The magnitude of the value captured as part of the total revenue generated from each market is important for evaluating the potential of new product introduction, and the expectations for premium generation within each of the major markets. While export revenue from the European market is much higher than that of Japan, export value is predominantly higher in Japan than any other of the three markets. This observation suggests that the high total export revenue from Europe is sustained by increasing export volumes, rather than prices. In Japan the opposite is true - although export volumes of kiwifruit to the Japanese market have been reduced since 1990, more stable (even though declining) revenue figures have been sustained by capturing a higher price for the product.

Figure 5 Export Value ($NZ) per Kilogram in Major Markets



Kiwifruit New Zealand (1998) reports that, in the 1997 season, the growth in price achieved in the European market was 6.8%, while volumes increased by 5.3%. In the Japanese market, New Zealand kiwifruit continued to outperform other imported kiwifruit. In this market, volume figures were reduced by 11.5%, while prices were 9.8%

higher, in addition to a slowly declining fresh fruit demand. The higher price sensitivity in Europe would constrain expectations for higher product premiums, while in Japan, consumers exhibit more inelastic behavior towards quality New Zealand kiwifruit. Thus, there is a clear potential in the Japanese market to influence the product price mainly by the quality supplied.

In summary, while the export value figures are indicative of the market-specific potential of kiwifruit, they are constrained by a major shortcoming. They represent the average value acquired in each market and are not indicative of the type of producer (small or large, technologically advanced or traditionally oriented) or the type of product sold. These are important considerations when evaluating kiwifruit production and associated returns.

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 number of competitors 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.

New Zealand's supply season runs from the first week of May through the end of December[14], with the majority of fruit being exported between June and December, and peak exports in September (Brookes *et al*., 1994). New Zealand kiwifruit exports widely overlap with Chilean[15] kiwifruit. Chile is the other major Southern Hemisphere producer, with very similar growing regimes to the ones in New Zealand and with the capacity to produce greater volumes of quality kiwifruit at lower on-orchard costs[16]. The increased availability of Chilean kiwifruit in Europe and USA (the two major Chilean export markets, with Mercosur being the third) causes demand for New Zealand kiwifruit to be more price sensitive, reducing the margins for quality premiums in these markets.

Table 1 A Scheme of Time of Product Placement (Monthly) and Degree of Overlapping by Major Exporting Country

COUNTRY/MONTH	J	F	M	A	M	J	J	A	S	O	N	D
NEW ZEALAND	■				■	■	■	■	■	■	■	■
CHILE		■	■	■	■	■	■	■	■			
ITALY	■	■	■	■	■					■	■	■
CALIFORNIA(US)	■	■	■	■	■					■	■	■
FRANCE	■	■	■	■	■					■	■	■
GREECE	■	■	■							■	■	■
JAPAN	■	■	■	■	■	■					■	■

Note: The dark rectangles represent the periods of kiwifruit exporting for each of the exporting countries to all exporting markets.

Source: Brookes, R. et al. (1994)

In the European market, the effective New Zealand window has been reduced to approximately 4 weeks, due to competition from Chilean, Italian and Greek kiwifruit. The exclusive selling window for New Zealand kiwifruit in the Japanese market is of approximately 13 weeks, which is expected to shrink significantly as the Chilean supply period extends. In the US market, the exclusive window is approximately 2 weeks. Intense price competition occurs around the shoulders of each window, especially towards the end of each country's supply period when kiwifruit with rapidly diminishing life expectancy must be sold. "Thus, with contracting exclusive selling windows, competition will intensify and the challenge for the New Zealand industry is to differentiate its products and merchandizing more successfully, in order to avoid intense price-based competition" (Brookes *et al*., 1994; p. 26).

In Table 1, overlapping is represented in monthly terms, rather than within or across specific markets. This suggests that, although major exporters of kiwifruit conduct their activities at the same period of time within a year, the overall result of their efforts would depend on the targeting of specific markets in search for higher returns. This goes hand in hand with the allocation of marketing strategies that link the specific product qualities with the customer expectations in particular niche-markets. Furthermore, there is no indication of the quality or the main varieties of kiwifruit that overlap. Thus, even within a framework of significant overlapping, marginal returns could be derived from a specific variety or product quality.

Although the degree of overlapping has been increased due to the greater number of competitors and better storing conditions[17], uninterrupted supply of kiwifruit could be profitable. Potential benefits of year-round supply of New Zealand kiwifruit[18] 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. Higher prices could also be achieved depending on the degree of market and product-specific overlapping, as well as the nature of consumer demand.

If New Zealand was to provide year-round supply of kiwifruit (i.e. supply kiwifruit during the months of February, March and April) the plausible outcomes could be interpreted as below[19]:

a) European market - the New Zealand kiwifruit is likely to vigorously compete with mainly Italian kiwifruit, but also with some Greek and French kiwifruit at the beginning of the period and some Chilean kiwifruit at the end;
b) Japanese market - competition during this period would be mainly from domestic and some Californian production;
c) US market – competition would be mainly from domestic and some Chilean kiwifruit.

This suggests that an early targeting of the three major markets may not prove to be beneficial in terms of premium price generation, due to a more likely price-sensitive competition between New Zealand and locally produced kiwifruit. While on the market place the product can generate some premiums associated with time of placement, the magnitude of these gains would be associated with the continuity of supply and the reduction in transaction costs. The margin of the gains associated with year-long flow of a single type of kiwifruit need to be carefully evaluated against gains from product differentiation.

Product Differentiation. The kiwifruit category has matured in the developed markets as a minor type of fresh fruit with low consumption levels. In becoming commonplace, the kiwifruit's image is undergoing a change and its future depends on how this seemingly irreversible change is handled (OECD, 1990). New Zealand's product differentiation approaches are mainly associated with distinguishing the quality of New Zealand Hayward variety kiwifruit (sold under a ZESPRI brand) when compared with competitors' kiwifruit, rather than with diversification of the varieties used and types of quality kiwifruit produced. Ideally, the mix of kiwifruit types within the ZESPRI brand needs to be further developed.

"Many within the New Zealand [kiwifruit] industry have adopted the belief that there is only one kiwifruit product category. … The industry has a high level of paralysis caused by commitment to the Hayward variety" (Brookes *et al*., 1994; p. 48). "The [kiwifruit] industry is based not just on one type of fruit, but on a single variety of that fruit – the Hayward variety. Competitors in the world market take different approaches to grading for size and quality, or packing, presentation, branding and promotion. All those differences are minor alongside the over-riding similarity between all kiwifruit of the Hayward variety, wherever they are grown. In the absence of more important differences, price becomes the customer's main means of choosing between competing products. The lowest price will tend to get the business" (Douglas and Burgess, 1992, p. 37). Therefore, further quality improvement of the same variety is not likely to provide the industry with a competing edge.

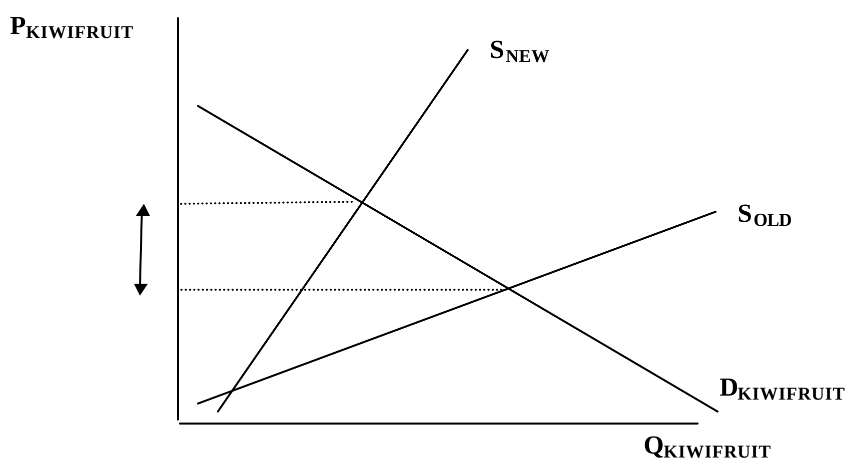
Quality improvement efforts should focus on diversifying product attributes *per se* (i.e. color, flavor, texture, furriness) in order to provide greater choice of kiwifruit[20] to the consumer and an edge of product-specific competition to the producer. Instead of a single New Zealand kiwifruit, there 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 origin. A greater variety would also reduce threats from price-sensitive competition between major kiwifruit exporters, as well as it has the potential "to create barriers to [market] entry which are difficult for competitors to overcome, or to create a business relationship with distributors and subsequent participants in the distribution chain such that they are unwilling to change from New Zealand to other suppliers" DTR (1991, p. 11).

"The market is talking new varieties as a basis for specialized, premium, value-added niche marketing. Where innovation is concerned, the first-mover gets the main advantage" (Douglas and Burgess, 1992, p. 39). "There is no longer a clear logic to competing on a single product basis. Stores require a range of sizes and prices in order to achieve both their positioning and their sales volume/value objectives. The increasing segmentation of retailer offerings on the basis of size/price combinations or packages clearly indicates that multiple kiwifruit sub-categories could be established at retail" (Brookes, *et al*., 1994; p. 34). Segmentation could also be associated with different product qualities for expanding the choice of kiwifruit at retail.

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 across different product types a greater profitability margin in general and greater marginal returns for each specific type of kiwifruit should be expected, while providing the consumer with greater choice of fresh kiwifruit. The magnitude of the gains would depend on a number of factors, such as the specific quality characteristics of the new products, the strength of marketing efforts, consumer knowledge and acceptance of new product attributes, the costs associated with producing and growing new kiwifruit varieties, and the overall structure of the kiwifruit industry.

The rationale of product differentiation focuses on changes in the mix of production (quality enhancement) rather than increases in the volume produced (yield enhancement). Thus, quality diversification is associated with changes of the slope, rather than a shift, of the supply curve, suggesting that product differentiation has the potential to influence prices, allowing for premium margins. This idea could be represented graphically. The underlying assumptions are:

1) the demand curve ($D_{KIWIFRUIT}$) represents demand for original kiwifruit - it is assumed to be elastic due to increased availability of similar quality substitutes on the international market;
2) the supply curve for a traditional kiwifruit (S_{OLD}) is also more elastic, due to the increased competition and, hence, volume of kiwifruit produced and exported;
3) the supply curve for a new type of kiwifruit is expected to be more inelastic (in the short-run), due to the novelty nature of the product and/or the time of product entry in the market. How quickly the supply curve of the new variety is likely to revert to the supply curve of the old variety depends on the nature of the product, among other factors.



The difference between the prices obtained for the old and the new product could be interpreted in two ways: 1) the premium foregone by supplying a greater quantity of the old product; 2) the premium captured by selling a "new" product and rationalizing on the amount supplied. The differentiation of production across product types is expected to provide for greater marginal returns due to market-specific quality and quantity allocation.

The length of the success of an original variety depends on the ability and speed of competitors for matching established quality standards. When this is achieved, the introduction of a new product is required for future profitability. The life cycle of a new product would vary according to the type of quality change, its consumer acceptance, and the existence (or development) of other similar products in the market place.

Biological Potential

The most widely grown kiwifruit variety in New Zealand is the Hayward variety, which is characterized with superior size and flavor with improved storage qualities. It is also widely used for the development of new commercial varieties. Other varieties[21] are also grown according to the climatic conditions of orchards or to the growers' particular choice.

Propagation Approaches. During the late 1970's and early 1980's some of the areas of the R&D focus in the New Zealand kiwifruit industry were the establishment of spray residue tolerances, methods of obtaining early maturity, weed control, new varieties (breeding and variety improvement) and crop management techniques to avoid swings between high and low yields. There were increasing efforts in the area of breeding and variety improvement of kiwifruit. "In general, the aim of such approaches [was] to seek variation in characters by re-mixing genes in seedling populations of *Actinidia chinensis* by mixing genes of two species to transfer the characteristics of one to the other, or by using either natural or induced mutations. All methods involve[d] substantial field evaluation and the selection programs [were] long term" (NZKA, 1982, p. 22).

Conventional propagation methods for kiwifruit production include the use of seedlings, cuttings, root-cuttings, or budding. Mature vines can be further reworked to change them into more desirable fruiting or pollinator varieties by using grafting techniques (older varieties can be top-worked to more desirable varieties). Although conventional breeding techniques to variety improvement are considered appropriate for achieving a number of breeding objectives (e.g. yield, maturation time, dsease resistance, fruit quality, flesh color, taste, skin characteristics) (White *et al.*, 1985), they tend to be very time and effort-consuming, and the outcomes are uncertain due to the dioecious[22] nature of the plant. There is not a reliable method of distinguishing between male and female plants until the vines produce flowers, which may be 2-3 years after grafting (or even 4-7 years for seedlings). Moreover, seedlings are variable and not suitable for commercial fruit production, while rooted cuttings tend to grow a little slower than vines on seedling rootstocks, and a good variety, such as the Hayward variety, may take longer to establish (Sale, 1985). These weaknesses (among others) suggest that there is significant further potential for innovation within the kiwifruit bank of genetic material (Douglas and Burgess, 1992).

"Within New Zealand, perhaps the best known attempt at varietal innovation [in late 1980's] is the Wilkins variety, significantly longer and more cylindrical in shape than the Hayward kiwifruit" (Douglas and Burgess, 1992, p. 38). More recently, the ZESPRI Gold variety was developed and sold, with distinctive shape, appeal, flavor and color. There is little information on the market performance of these "new" varieties: "Initial consumer reaction to the variety indicates an excellent future for another New Zealand first" (KNZ Annual Report, 1998; p. 13).

In a 1990 report, OECD attributes the role of genetic research as a tool to generate early growing varieties for targeting an early starting of a season ahead of competitors, as well as to increase consumption by stimulating production of seedless as well as hairless varieties. In the most recent literature, there is increasing emphasis on the growing environment of the fruit[23] rather than on variety diversification, with no mention of any involvement of genetic engineering. However, genetic engineering efforts could prove promising in a number of areas:

- *Prevention of non-pathogenic and pathogenic conditions***:** The production of fasciated (fan-shaped and flat) fruit is an example of genetic failure in some vines. It should thus be possible to provide genetically for the low incidence of poor quality fruit (Dine, 1986). There is also an increasing need for controlling the presence of the Leaf Roller caterpillar[24]. This could be achieved by the generation of insect resistant vines.
- *Provision of specific quality* – flavor, texture of fruit, durability.
- *Stimulating growth potential and control of ripeness* – develop a kiwifruit variety with different maturing times according to sugar content levels.

The fruit size is also important in differentiating between kiwifruit categories. However, the use of genetic engineering is not likely to be targeted to providing size control. This could be successfully achieved by either cloning vines with desired size, or implementing size-targeted pruning and thinning management techniques.

In general, the development of kiwifruit as a crop is necessary. The identification and utilization of genetic information for establishing specific quality attributes is essential for the commercial production of diversified kiwifruit. "There is … dramatic scope for adding value through innovative modern scientific breeding and selection programs" (Douglas and Burgess, 1992, p. 38). "New Zealand must invest in research on variety improvement to maintain the present leadership in [kiwifruit production]" (NZKA, 1982; p. 22).

Orchard Management Approaches. Good vine and orchard management (irrigation, fertilizer use, pruning and thinning regimes) is essential for sustaining high kiwifruit yields. The yield of export grade fruit and fruit size can be directly manipulated by pruning and thinning practices. In general, heavy pruning and thinning reduce the proportion of small fruit and increase the proportion of fruit in the larger sizes.

More pruning per row gives lower total fruit yield, but the size the fruit is bigger. Fruit is larger on vines that have also been heavily thinned. The lower total volume yields are offset by higher net income, due to the greater price per unit volume sold. Less (or no) pruning gives higher total fruit yield, associated with a significant increase in the percentage of small sized and undersized fruit, which reduces the mean fruit weight per vine[25], thus reducing net income ($/ha), due to the lower amount of product sold and the lower prices captured. Export yield is maximized in a sense that fruit numbers per vine increase. There is a turning point to this increasing capacity and this is when vines reach overloading, i.e. there is a maximum load at which export yield per vine begins to decline due to overcropping (this results in a large proportion of undersized fruit[26]) (Dine, 1986; MAF, 1986). Control of overcropping is also important in order to prevent a vine from producing light crop in the following year (Sale and Lyford, 1990).

The choice of pruning and thinning regimes is subject to both determining the optimum fruit numbers per plant for maximum yield of export grade fruit, and identifying market signals in relation to preferred sizes. The trade-off is between growing more small fruit or less bigger fruit. It could be argued that the greater volume of smaller fruit would maximize revenue by increasing the quantity, while, the more scarce bigger fruit is likely to capture higher premium and maximize revenue by capturing higher price per fruit.

Finally, pollination plays a very important role in providing quality kiwifruit. Because kiwifruit vines produce a small number of flowers, pollination is vital for a good yield. Without good pollination, fruit will be below the required exportable size.

A Model of the Kiwifruit Production Potential

Changes in the nature of the output are associated with alterations of the set of inputs that add value to it. Technological *know-how* makes such alterations a necessary step forward in the process of product development. The success of different kiwifruit products depends on their biological potential and quality characteristics, as well as on their ability to generate demand and capture price premiums in international markets. The schematic model presented below aims at establishing the relationships between factors in the chain of production and exporting of kiwifruit. Qualitative assumptions are drawn from the model and further integrated into a simulation analysis.

Theoretical Evaluation of the Industry Relationships

The model represents the horizontal (industry-wide) dynamics of the production of kiwifruit, as well as it provides some insight into the vertical (sector-specific) determinants of successful production. Although the Board is owned by the growers and it also influences marketing decisions, in the model, growers, the Board and ZESPRI are represented as three separate entities in order to allow for a greater transparency of their specific functions and responsibilities.

The model also separates dynamic from static factors. Factors that are associated only with the volume of production and export are considered constant in the model. This is done in order to differentiate between factors affected by quality (and quantity) change – variables - from those subject to quantity change - constants. By doing so, the idea is to identify the dynamic areas associated with quality modifications and evaluate marginal relationships within them.

The choice of crop management regime by the growers is considered as a "constant", as no rational grower would prefer a bad management regime for their crop. Growing conditions are assumed to be similar across growers. High pruning and thinning regimes are also assumed to be undertaken by each grower in order to provide for an industry crop size distribution of bigger kiwifruit[27] (i.e. sizes 30 and 33), rather than small or undersized crop with very little export potential (i.e. sizes 42 and 46). These assumptions reduce the variation of fruit size. By keeping the size and the growing conditions constant, premium prices captured in the market would be mainly associated with the quality of kiwifruit.

Costs associated with the on-shore dynamics and the off-shore distribution are also assumed static. It is the volume of production, rather than the quality of the product that determines their variation. Any cost-minimization efforts within the industry will increase general profitability. The purpose of the analysis, however, is to evaluate the magnitude of the gains associated with quality change, rather than the benefits of rationalizing on- and off-shore industry costs. This suggests that the magnitude of the returns to growers is predominantly due to the characteristics of the kiwifruit sold and its market-specific price, rather than the cost-reducing capacity of the industry.

The assumption about the static nature of market- and product-specific marketing strategies is linked to the difficulty for quantitative estimation of their effects on the magnitude of price premiums in the major export markets. The static nature could also be explained by the marketing of one brand – ZESPRI New Zealand kiwifruit. Since all varieties (or kiwifruit types) are marketed under the ZESPRI brand, successful (or unsuccessful) strategies would be expected to affect all varieties equally. It may be possible to separate between marketing efforts and variety performance, by distributing product-specific price premiums between those who produce the variety (the growers) and those who sell the product (the marketers).

The factors associated with changes in quality are considered dynamic and represent the substance of the analytical model. The growers choose the variety type (and the specific adoption scenario[28]) according to the environment of their orchard and the expected returns from each variety. The assumption is that there are two new types of varieties (B and C) and the original variety, widely produced and exported by other competitors (A). The range of quality change in each of the new varieties is associated with the performance of a particular characteristic of the plant, as presented in Table 2.

RELATIONSHIP MODEL

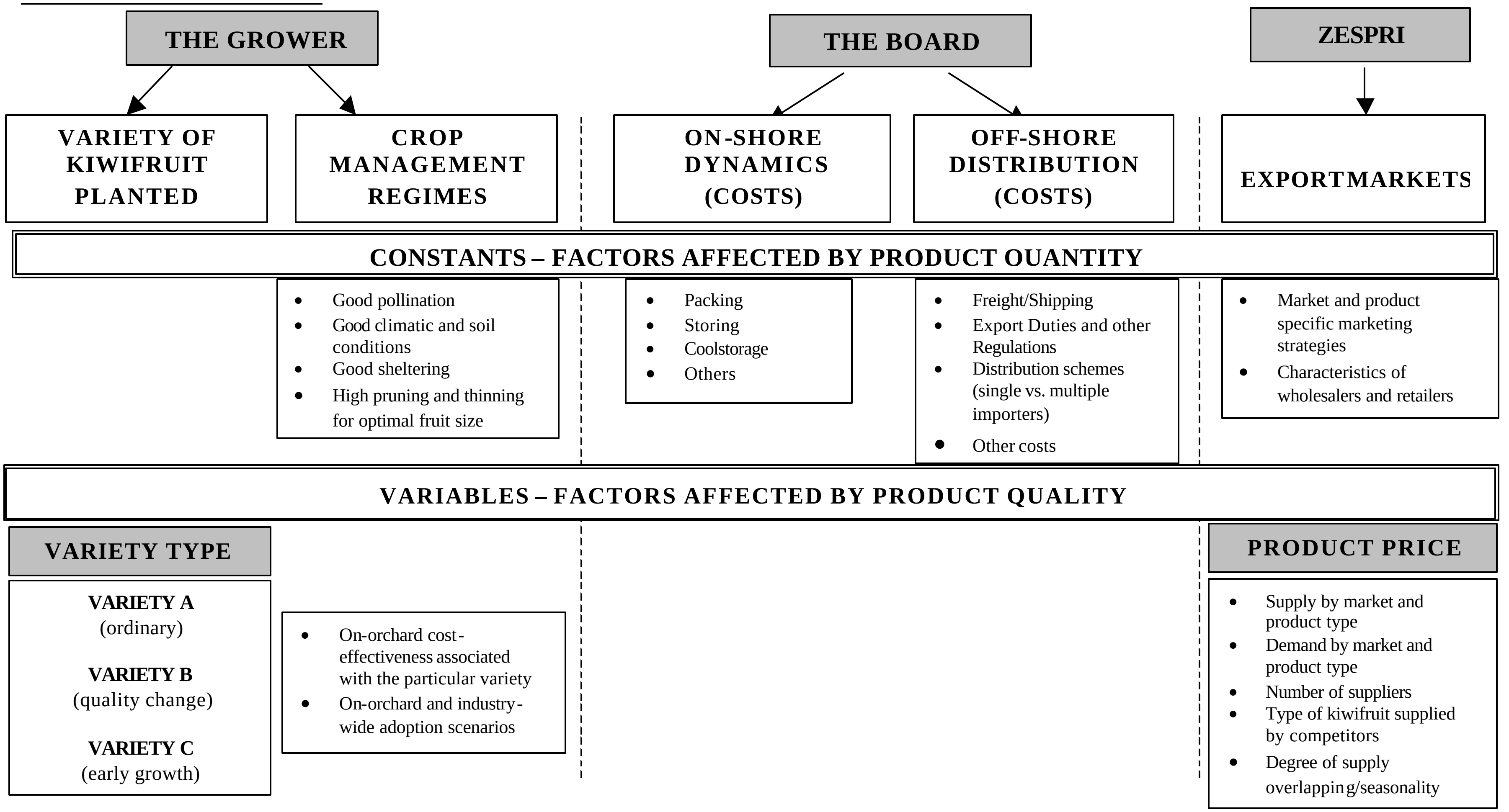


Table 2 Specific Quality Characteristics of Selected Variety Types

VARIETY TYPE	TYPE OF PRODUCT QUALITY
VARIETY A	Original kiwifruit characteristics
VARIETY B	Kiwifruit capacity for early growth
VARIETY C	Novelty kiwifruit: alterations in color, flavor, general appeal

Since each variety is associated with a different set of quality characteristics, the generated products will be associated with a different set of returns, according to the features of market-specific consumer demand. The aim is to identify the returns associated with different quality, and compare those to the returns captured by the original variety A.

In theory, the cost-effectiveness of each variety is important for maximizing returns on an on-orchard level. In practice, however, growers' costs represent a small proportion (10 to 12%[29]) of the total cost structure of the industry and a more cost-effective on-orchard production process would have small impact on industry return figures (considering that returns are allocated on an average basis and costs are associated with marginal changes of production). Thus, it could be assumed that although on-orchard cost figures could vary across different varieties, their variation would be small.

The Scope of Product Differentiation

There is a considerable potential for product development in the industry that has not yet been explored. This is partly due to the long-term natural profitability that New Zealand has enjoyed from growing one type of good quality kiwifruit, and more recently due to the lack of incentives for product diversification within a monopolistic structure of production. The initial exotic nature of the kiwifruit is no longer the driving force for kiwifruit sales. Competition is mainly based on the size of the product supplied and the country of origin of the product, with increasingly narrowing differences in quality. Also, *per capita* consumption in the major kiwifruit markets is improving very slowly.

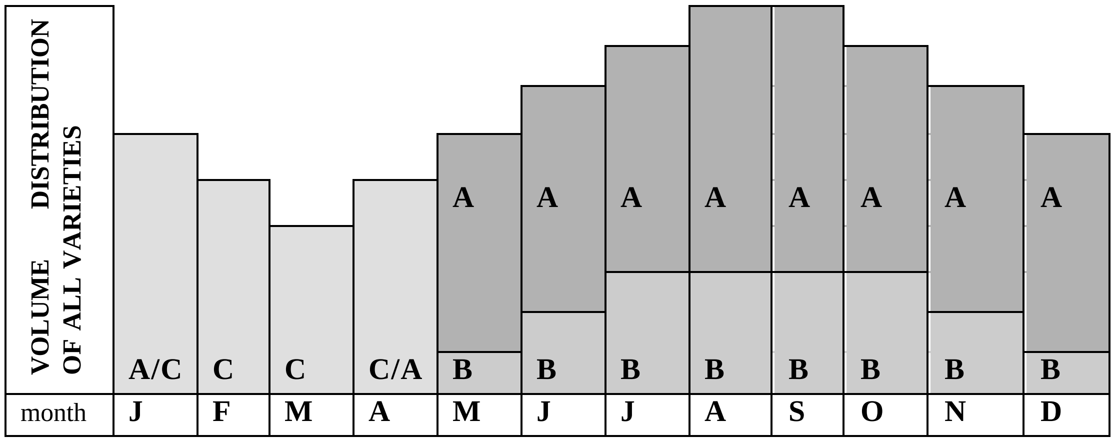
In general, product differentiation is subject to general trends in both supply and demand of fresh fruit and two major shortcomings could be identified in the case of kiwifruit: the loss of appeal of the original kiwifruit (demand-side factor) and the lack of diversification in the intrinsic characteristics 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. This is represented in the Table 3 below:

Table 3 Qualitative Interpretation of the Potential for Product Differentiation

<table>
<tr><th>THE PROBLEM</th><th>THE NEED</th><th>THE SOLUTION</th></tr>
<tr><td>Existence of only one general type of kiwifruit sold (green flesh, furry skin, specific flavor).</td><td rowspan="2">Diversification of choice of kiwifruit to consumers and securing market control (share) for producers.</td><td rowspan="2">VARIETY B
a new product (stimulation of change in color, flavor, shape and furriness of kiwifruit)</td></tr>
<tr><td>Reduced levels of appeal.</td></tr>
<tr><td>Fragmented (seasonal) export structure of kiwifruit.</td><td>Year-long supply of New Zealand kiwifruit for the reduction of transaction costs associated with product entry and placement in key export markets and for the continuity of product-specific consumer confidence.</td><td rowspan="2">VARIETY C
an early growing variety (stimulation of sugar contents in kiwifruit, allowing it to ripen earlier)</td></tr>
<tr><td>Early entry of other Southern Hemisphere (Chilean) kiwifruit in key export markets.</td><td>Early product entry in key export markets to secure market share.</td></tr>
</table>

Other fruit industries offer a wide range of products (e.g. different types of apples, rather than a single, very good quality, green apple) to maintain the appeal of their main product, e.g. “apple”, while offering a range of product characteristics to consumers (red apple, sweet apple, sour apple, etc.). This is not the case in the kiwifruit industry. While breeding efforts emphasize selection for quality kiwifruit, they converge to the same general quality features. The role of genetic engineering may be attributed to the provision of faster and more controlled changes of the attributes of kiwifruit for matching rapidly altering consumer demands for specific product quality and product availability. The success would be partly attributed to the potential of genetic improvement and partly to the ability to predict consumer behavior in the future.

The purpose of Variety C is associated with closing the gap between the time of exit and re-entry of Variety A. While Variety C has the same quality attributes as Variety A, it makes the supply of this particular quality kiwifruit uninterrupted (even though the two Varieties have their separate entry and exit periods[30]). Thus, Variety C fully substitutes for Variety A due to early market entry. Variety B, on the other hand, is a completely new type of kiwifruit, supplied at the same time as Variety A (in significantly smaller proportions). Complete market substitution between Varieties A and B is unlikely, due to the different nature of the products, their targeting to different markets (or market segments) and the price difference between them. The distribution of the three types of products on a yearly basis is presented below:



Variety-specific marginal gains should be expected: for Variety A they are associated with the reduction in volume supplied and consumer identification of the product, for Variety B – with the 'new' product characteristics supplied, and for Variety C – with the time of supply. In the long run, the old variety could be either fully or partially replaced depending on the performance and acceptance of characteristics of the new varieties. "The old variety will continue to serve a particular market segment; some loss from the segment to the new product might be expected, but new market opportunities will be exploited by the new variety. Where this occurs, the loss to the old variety will be minimized. The net gain to the kiwifruit market will be positive as new market opportunities are explored" (Sheppard and Scrimgeour, 1996, p. 7).

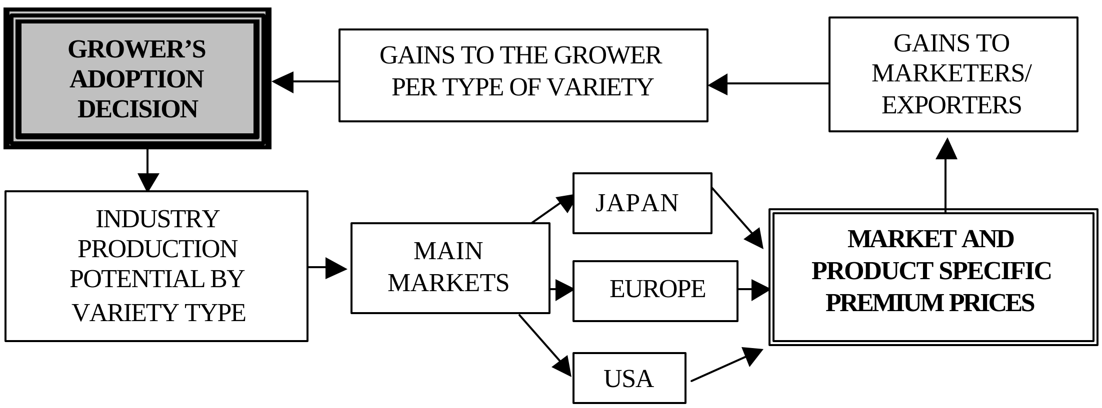
A Simulation Analysis of the Effects of Product Differentiation on the Economics of Growing Kiwifruit

Growing a new variety is associated with a new set of costs, returns, and development periods, as well as with incentives for adoption offered to growers. The potential market performance of two new kiwifruit varieties is evaluated (Variety B and Variety C) 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 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.

Due to the nature of the analysis, which focuses on evaluating future potential rather than relying on experimental data from new kiwifruit varieties, the simulation model is based on qualitative assumptions drawn from the past performance of the New Zealand kiwifruit industry. The lack of disaggregated industry data on seasonal price and quantity variations, in general, and in terms of different kiwifruit varieties in different markets also favors a more qualitative approach.

The Rationale of the Simulation Analysis

The simulation analysis begins with on-orchard adoption decisions and their impact on the industry-wide volume produced of each variety. The volume produced and the quality characteristics of each variety would then play an important role for capturing different premium prices in the three main markets (Japan, Europe and USA), subject to market-specific demand and supply interactions. The magnitude of the market- and product-specific premium prices and the proportion of net (from marketing expenses) gain allocated to the grower are the main determinants for the profitability of growing each variety. Thus, although it is in the industry's interests to diversify production, this can be achieved only if product-specific quality is valued by consumers highly enough to guarantee the required returns for variety adoption by the producers (i.e. growers), assuming an industry-wide cost-minimizing effort. These relationships are summarized in the scheme below:



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

1) *On-Orchard* - scenario-specific net present value (NPV) analysis for determining required growers' returns for adoption;
2) *Industry* – scenario-specific (product-specific) distribution of volume produced and exported;
3) *Market* – simulation of market- and product-specific premiums associated with qualitative assumptions;
4) *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.

Each of the above approaches relies on assumptions substantiated by some existing production information. The available raw data is highly aggregated, hindering attempts for more focused analysis. The other limitation is associated with regulatory-type shortcomings, such as the averaging of industry returns and therefore the lack of information on product-specific marginal returns in a particular market. Moreover, information on monthly changes in volume supplied and prices captured for each market, as well as associated elasticities of demand and supply, is qualitative in nature, i.e. it is based on results from market studies rather than on econometric analysis of key market relationships.

This analysis does not represent an exhaustive attempt to evaluate the potential profit maximizing effort of the kiwifruit industry as a whole. It is designed to establish and simulate the main industry relationships associated with product diversification (i.e. change in the production mix, assuming no change in total volume exported) in a way that changes in one aspect of the model could impact the overall result.

Assumptions about On-Orchard Production Potential

The production potential of the three varieties is assumed to be similar in terms of obtainable yield per hectare. A set of underlying assumptions is made about the growth potential of Variety A in order to provide for a base of analysis.

A typical grower produces 100 tons (or 27,000 trays[31]) of kiwifruit per season, on a planted area of 5 hectares. In other words, a typical grower's yield is about 20 tons (or 5,400 trays) per hectare of mature crop[32]. The maturity of the yearly crop is dependent on the sugar content of the fruit.

Table 4 A Yield Profile for Variety A (trays/hectare)

Year	*Yield in trays/ha*	*Yield Growth (%)*
1	0	
2	134	
3	268	100%
4	1,340	400%
5	2,238	67%
6	2,685	20%
7	3,813	42%
8	4,500	18%
9	5,400	20%
10	5,400	0%

Source: The original yield numbers and respective growth proportions were extracted from Sale (1985; p. 67). The numbers in the table are modified in proportion with the original numbers, while based on the underlying assumptions.

It usually takes 3 to 4 years for a kiwifruit vine to start bearing worthwhile crop, and about 8 to 9 years for the vine to reach full bearing capacity (Sale and Lyford, 1990). Under good growing conditions, the plant can thrive for at least 40-50 years. Once full production has been achieved, yields will fluctuate according to seasonal conditions[33] (Sale, 1985).

Assuming that the vines have reached full capacity (year 9), and all kiwifruit produced is submitted and exported capturing an average orchard-gate return of NZ$3.75[34] per tray, the typical grower's gross income[35] per hectare could be expected to be on average $ 20,250[36]. On-orchard expenditure is assumed to represent 80% of revenue[37], or $16,200 per hectare (20% profit[38]). Thus, net income per hectare would on average be of about $4,050. This suggests that if the profit is spread across yield, the net return per tray sold would be expected to be around $0.75.

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 present value of the stream of future returns is an important indicator of the likelihood of adoption. The grower could forego adoption and continue growing the old variety (A), in which case the net present value (NPV) would be $172,400 ($34,480 per hectare) at a return of $3.75[39], assuming production of 27,000 trays, a period of time of 20 years of mature crop, a discount rate of 10% and production costs representing 80% of total on-orchard revenue from kiwifruit growing.

However, if adoption of a new varieties is contemplated, 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 (lump sum) 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. This relationship is represented as follows:

(1) ***NPV (Variety A) + 1,000 NPV (Variety B or C)***

By using the yield potential data for Variety A different scenario performances could be designed. Table 5 summarizes the return figures (with or without the continuous growing of Variety A) necessary for the above relationship to be justified, i.e. the required return (given the adoption scenarios) in order for the NPV of a new variety to exceed the risk adjusted NPV of the old variety.

Table 5 NPV Returns (per tray) Associated with Adoption Proportions of New Variety (B or C) with or without the Continuous Growing of Old Variety A

Adoption Percentage	Adoption of New Variety and no growing of Old Variety	Adoption of New Variety and continuous growing of Old Variety	
	Return for New Variety	***Return for New Variety***	***Return for Old Variety***
100%	$6.92	$6.92	$0
80%	$10.70	$8.58	$3.75
50%	$17.05	$8.62	$3.75
20%	$42.50	$8.80	$3.75

If the grower decides to fully (100%) adopt a new variety the required return per tray in order for adoption to take place is $6.92. Full adoption of a new variety is associated with either the pulling of the vines of the old variety or the grafting of the new varieties onto old variety vines. Therefore no continuous growing of Variety A would be possible. However, if no full adoption is contemplated, the grower faces two choices:

1. Adopt (i.e. allocate land to) a proportion of the new variety (e.g. 80%) while ceasing to grow the old variety, in which case the required return would have to be $10.70;
2. Adopt (i.e. allocate land to) a proportion of the new variety (e.g. 80%) and continue growing the remaining 20% with the old variety, in which case the required return for the new variety would be $8.58 (incorporating the impact of 20 years of mature production of a proportion of the old variety, and associated per tray return of $3.75, rather than its full elimination).

The choice of the adoption proportion has an impact on the volume produced of both the old and the new variety, and thus, on the market returns associated with each variety.

The adoption decision is subject to the number of growers in the kiwifruit industry willing to adopt each of the new varieties, as well as the potential performance of each variety in specific markets. In other words, the premium price captured for each variety in the market place and the distribution of gains between the marketer and the grower would determine the magnitude of the potential orchard-gate return and therefore, the most likely adoption scenario.

Assumptions about Industry Production Potential

The main constraint to the industry production potential is associated with diversification within current production volumes (i.e. change 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. Industry adoption is represented as the proportion of growers adopting, assuming that each grower produces the same amount of trays on an area of 5 hectares. All production is submitted and sold in overseas markets. In order to simplify the analysis, we assume that 50% of all growers will not adopt (i.e. they will continue growing Variety A), and industry-wide adoption would represent the remaining 50%, with an even split of 25% between Variety B and Variety C. This implies an assumption of a simultaneous and even adoption of two different varieties, genetically engineered to suit specific consumer demands[40].

Adding the industry-wide adoption constraints to the on-orchard adoption decisions provides us with an indication of the proportion of each variety within the production mix. This is represented in Table 6.

Table 6 The Proportions of Each Variety within the Production Mix Subject to On-Orchard Adoption Decisions and Industry Adoption Constraints

Industry Production Mix (%)	**50%**	**25%**	**25%**	**Total Industry Production**
ON-ORCHARD ADOPTION (%)	**VARIETY A**	**VARIETY B**	**VARIETY C**	**All Varieties**
	Adoption without on-orchard continuous growing of Variety A			
100%	*50%*	*25%*	*25%*	***100%***
80%	50%	20%	20%	90%
50%	50%	12.5%	12.5%	75%
20%	50%	5%	5%	60%
	Adoption with on-orchard continuous growing of Variety A			
100%	*50%*	*25%*	*25%*	***100%***
80%	*60%*	*20%*	*20%*	***100%***
50%	*75%*	*12.5%*	*12.5%*	***100%***
20%	*90%*	*5%*	*5%*	***100%***

The adoption of new varieties without the continuous production of Variety A would imply loss of production (except when a full adoption of each variety is considered), rather than a change in the mix of production, since the total volume of kiwifruit produced in the industry is reduced due to the low on-orchard adoption of the new varieties. For example, if 80% adoption is contemplated by growers who wish not to continue growing Variety A, the industry-wide adoption proportion would be 20% (rather than the full 25%), suggesting that there will be a remaining 5% of the land no longer allocated to growing Variety A. If this is the adoption decision involving the two new varieties, total industry production will drop by 10%. Therefore, the adoption scenarios associated with no continuous growing of Variety A do not satisfy the constraints of the model and will not be considered for analysis.

On the other hand, if 80% adoption is contemplated by growers who whish to continue growing some of the old Variety A, the industry-wide adoption proportion would still be 20% (rather than the full 25%). The difference in this case is that the remaining 5% of the land would continue to be allocated to growing Variety A. If this is the adoption decision involving the two new varieties, total industry production will remain being 100%, while the mix of production would be diversified by adopting two new varieties and growing 60% (the 50% of industry-wide adoption plus the remaining 10% associated with adopting the new varieties while continuing to grow some of the old Variety A.

The adoption proportions represented in Table 6 could vary, resulting in different production mixes – e.g. 25% of growers could decide to adopt on their orchards 80% of Variety B and the other 25% of growers could adopt 50% of Variety C, leaving Variety A with a 67.5% proportion of total production. This suggests that a number of adoption scenarios that comply with the on-orchard and industry adoption constraints (i.e. no change of total production, rather change in the mix of production) exist, but only the ones presented in Table 6 are used in the simulation analysis.

Simulation Analysis of the 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 framework of analysis. 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. Distribution and marketing issues are not considered in the simulation analysis, since they are assumed not to vary according to Variety type.

Japan, Europe[41] and USA 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 lack of coherent preference order in each market suggests that premium prices are feasible, given that the consumer is aware of the 'new' characteristics of the product. A common characteristic within the three markets is that kiwifruit is considered to be an established, but minor fruit, with significantly increasing competition within kiwifruit suppliers and between kiwifruit and other established fresh produce[42].

Due to the lack of seasonal volume and price information on kiwifruit in each of the main markets, information on specific demand and supply elasticities is based on facts extracted from the literature. We use this information for the formulation of a generalized, and qualitative in nature, distribution of product and market-specific elasticties.

> *Europe* - New Zealand kiwifruit wholesale prices have consistently been reported above competitors' (on an average annual basis). Supplying fruit ex-stock in Europe is essential, and it is a strong source of competitive advantage. Price sensitive market behavior is partly explained by price convergence in the European market, due to increasing quality of competitors' kiwifruit. There exists a strong tradition of fresh fruit consumption, which is steadily growing by 2.5%-3.0% p.a. Kiwifruit is regarded as a mainstream fruit with expected continuous availability. The special image and the narrow range of valued attributes are the major reasons for kiwifruit consumption per capita being low. The major substitutes for kiwifruit are apples, bananas, grapes, oranges and peaches.

Japan –Static demand and levels of appeal (associated with slowing growth of kiwifruit consumption[43]) are characteristic of the Japanese market. There is no clear sign of price convergence, suggesting wide price margins between competitors. Kiwifruit demand is less price sensitive in Japan than in other importing countries. There is evidence to suggest that a 1% increase in price results in a consumption decline of 0.5%. Conversely, a 1% increase in supply depresses prices by 3%. This would explain why prices in Japan are higher than in other markets and, although distribution costs are also higher, this market contributes greater average net revenue than other markets. Due to the inelastic demand, increases in aggregate supply of kiwifruit are likely to reduce the net achievable benefits in this market[44]. In Japan, most fruit are purchased primarily because of flavor, one exception is kiwifruit, which are purchased more for nutrition (Vitamin C) and health reasons. Price is not an important consideration in fruit selection. The concept of 'right fruit for the season' and availability of appropriate quality is more important. Thus, product differentiation associated with quality change (rather than volume increase) and a continuous product supply would prove beneficial in the Japanese market. The major fresh fruit substitutes for kiwifruit are mandarins, strawberries, nashi pears and apples.

USA –New Zealand kiwifruit faces considerable pressures from the very large range other fruit and regulatory constraints for access to the US market. The market for fresh fruit is expected to grow only between 3%-4.5% p.a. Consumers' fresh fruit choice criteria have more to do with taste, appearance and freshness than with health, price and nutrition. The year-round supply availability has gained kiwifruit a status of a mainstream fruit, despite its low per capita consumption. Bananas, apples, oranges and grapes are major fresh fruit substitutes, although kiwifruit is generally positioned in a category of "exotic" or "tropical" fruits.

Efforts for Data Disaggregation. 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 highly aggregated available data our approach relies on both known information, e.g. total volume exported in 1997 (56,700,000 trays) and its distribution across the main markets (27% destined to Japan, 56% - Europe, 9% - USA and 8% - rest of the world), and model assumptions associated with industry adoption scenarios. 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 7 summarizes the initial effort of data disagregation across markets and product types[45].

The total export volume per market type and the market and variety-specific distributions are held constant, while the quantity of each variety (subject to industry adoption scenarios) allocated to each market is variable. The distribution of export volumes is subject to no-excess supply per type of variety and market, in addition to qualitative model assumptions about expected variety performance.

Table 7. Distribution of Total Exports by Variety Type and Export Markets Assuming Industry Adoption of 50% Variety A, 25% Variety B and 25% Variety C

Total Market Distributions			Market and Variety Specific Distributions					
Market	**Distr**	*Volume*	**Distr**	**Variety A 50% (VA)**	**Distr**	**Variety B 25% (VB)**	**Distr**	**Variety C 25% (VC)**
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

The combination of distribution proportions of the three varieties to Japan, for example, has to be such that the sum of the volumes exported of each variety equals the total volume exported to Japan (15,309,000). This combination also has to comply with variety specific production. For example, if 30% of Variety B is allocated to Japan, the allocation to the other markets has to be such that the total volume of this variety is equal to the specific adoption figure (with 25% industry adoption of this variety this figure is 14,175,000).

The market and variety-specific distributions are not selected on a random basis. The starting point for variety specific distribution proportions is associated with keeping the distributions for Variety A the same as the total market distributions (i.e. these associated with the total distribution of A if adoption was not considered). On the other hand, the novelty nature of Variety B is expected to capture high returns in the Japanese market, which implies that more of Variety B (compared to Variety C) would be allocated to this market. Variety C is likely to compete with other kiwifruit due to its time of entry into the Japanese market. The distribution of the two new Varieties on the European market is assumed to be the same due to concerns associated with genetically developed fruit and strong competition with kiwifruit from other countries. The assumptions for the US market are similar to the ones for the Japanese market, with Variety B outperforming Variety C. The small percentage allocation of Variety B to the rest of the world (ROW) is due to the fact that Variety B is intended for major export markets. The early entering product C is likely to consolidate the position of New Zealand kiwifruit in the rest of the export markets, hence the greater distribution.

Evaluation of Potential Market Prices. After the initial disaggregation, the analysis focuses on the simulation of approximate market and product-specific prices. Price premiums are associated with changes in the available quantity of each variety[46] in each market, as well as with assumed market and product specific average seasonal elasticities. Elasticity assumptions are based on qualitative market information for Variety A and other market factors that influence slope determinants. Elasticity figures vary according to type of variety and market place, but they are unchanged across scenarios. Price premiums are then applied to known average market-specific prices for Variety A.

Table 8 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% VB				
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 P (% increase)	$18.47 (119%)	$7.98 (33%)	$8.39 (51%)	$7.22 (44%)	**$10.52 (68%)**
	SCENARIO 2: 60% VA, 20% VB, 20% VB				
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 P (% 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% VB				
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 P (% increase)	$19.07 (126%)	$8.06 (34%)	$8.62 (55%)	$7.23 (45%)	**$10.75 (72%)**
	SCENARIO 4: 90% VA, 5% VB, 5% VB				
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 P (% increase)	$19.49 (131%)	$8.12 (35%)	$8.75 (57%)	$7.22 (44%)	**$10.90 (74%)**

The results, summarized in Table 8, are not only market and product-specific, but they are also subject to the different industry adoption scenarios. In the case of no adoption (i.e. current situation) the marginal gains for Variety A in each market are not transparent. Country-specific prices are bundled together to represent the overall (average) market potential of New Zealand kiwifruit (Variety A), which is $6.25[47]. The prices are intended to be average seasonal prices rather than entry or exit market prices. The results may be interpreted by considering price changes of a specific variety when sold to a particular market and under a specific industry adoption scenario:

- *Variety A after Adoption:*
  When there is adoption, the price that Variety A can generate is mainly associated with its reduced export volumes and established market position. The average scenario-specific gains for Variety A are \$2.46, \$1.97, \$1.23, and \$0.51, respectively, which suggests that the lower the adoption proportion of the other two varieties (i.e. the greater the percentage of on-going production of Variety A), the lower the associated gains for Variety A. In other words, growers who decide not to adopt are likely to benefit more, in general, if more adoption of the new varieties is stimulated within the industry. This brings about the issue of adoption incentives, risk-sharing and distribution of gains within the industry.

- *Variety B after Adoption:*
  The premium prices for Variety B are associated with the novel quality of the product and the relatively small initial volumes produced and exported of the variety. Although Variety B is likely to compete with established kiwifruit and other fresh fruits, the natural monopoly that the variety enjoys in the market is likely to stimulate a highly inelastic demand. On average, the world average price of Variety B is likely to be between 130% and 168% higher (depending on the adoption scenario) than the average world price obtained before adoption, and 65%-148% higher than Variety A's average price after adoption. In general, Japanese consumers are expected to pay the highest price for Variety B, followed by US and European consumers. However, the margin of the price premiums varies across the three markets (e.g. under scenario 1 the premium is 110%, 40% and 44% respectively).

- *Variety C after Adoption:*
  The premium price for Variety C is associated with the time of product placement, rather than change in the intrinsic quality of the product, and the relatively small initial volumes produced and exported of the variety. Across all markets and under the four adoption scenarios, Variety C is associated with lower returns (marginally and on average) in comparison with Variety B and in some markets with Variety A. This is due to a significant degree of overlapping with domestic kiwifruit production in the main export markets. Variety C's average price is likely to be between 36% and 47% higher (depending on the adoption scenario) than the average world price obtained for Variety A before adoption, and up to 36% higher than Variety A's average price after adoption. In general, Japanese consumers are expected to pay the highest price for Variety C (due to their appreciation of availability of kiwifruit), followed by US and European consumers. The small marginal differences between prices for Variety A and Variety C (after adoption) could be due to the fact that Variety C is a full substitute for Variety A (at a time when Variety A is not supplied) and therefore, the price of market entry and exit of both varieties is similar (rather than fluctuating), due to year-long availability.

However, competing with a product on the grounds of year-long availability may not prove to be beneficial in terms of capturing price premiums. The benefits from Variety C are to be found in the reduction of industry transaction costs due to a year-round availability of New Zealand kiwifruit. However, while Variety C provides for cost-rationalization within the industry, our concern is its competitiveness on the market place and quality associated gains. In other words, Variety C could be logistically good for the industry in general, but it does not seem to capture the desired returns for justifying on-orchard adoption.

In general, compared to the case of no adoption, the average (all varieties) market-specific prices are higher (see the percentages presented in the brackets). The average market, product and scenario-specific prices (i.e. the world average) are also higher than under the no adoption scenario. The marginal differences in prices between scenarios are mainly due to the effect of quantity change, 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. The implications of this to adoption decisions could be interpreted both in marginal and average terms when orchard-gate returns are considered.

Distribution of Gains from Product Diversification

The disaggregation of volume/price, market and scenario specific information leads to the next stage of simulation, which focuses on assumptions about the distribution of the gains between those who grow each variety and those who export and market the varieties. "Marketers and growers who can supply what the market requires have the basis of a mutually advantageous relationship. … However, while grower profitability must be sufficient to ensure market requirements are met, this does not mean growers can successfully demand prices higher than the market is prepared to pay" (NZBR, 1994; p. 55).

The dynamics of efficient product and market specific allocation of returns are summarized by Sheppard and Scrimgeour (1996): "Where [the] varieties are being sold in higher priced markets, then these prices would be reflected directly to growers and this would encourage additional production of the new varieties. As the returns for the new varieties started to decline through the introduction of them to other lower returning markets, then these lower returns would be reflected in the prices paid to growers for the proportion of their fruit which was supplied to such markets. This would encourage rational and efficient resource allocation decisions" (p. 10).

A number of distribution scenarios of the gains from product differentiation could be designed, according to the specific characteristics of the industry. Arguably, the greatest proportion of returns should be allocated to the party exhibiting the greatest amount of risk in terms of foregone returns due to the adoption of a specific variety and future uncertainty about the market performance of the product. Four scenarios are considered – returns of 70%, 60%, 50%, 40% of the simulated market prices in Table 8.

The distribution of returns is represented from the point of view of the growers, since they make the on-orchard adoption decision according to the magnitude of the return. Return figures are kept disaggregated (i.e. market, product and scenario specific) in order to compare marginal with average information and the implications for adoption. They are also net from costs associated with distribution and marketing efforts and are considered as orchard-gate returns (i.e. they are not net from on-orchard production costs).

The results are interpreted in both average and marginal terms and are closely linked to on-orchard specific return figures presented in Table 5. In other words, under a 25% industry adoption of both Variety B and C (i.e. the two varieties are fully adopted on an on-orchard level) the returns to Variety B or C have to be equal or greater than $6.92[48] (the NPV return figure). Since 50% of total production remains Variety A, the required return for continuing to grow this variety is $3.75. Having this in mind, the findings from Table 9 can be interpreted as follows:

1. Considering the ***average*** industry return - In theory, growers should choose the allocation of resources that maximizes their returns and profitability (i.e. what variety to grow and in which market to export). In practice, however, due to cross-subsidization between types of varieties grown and the averaging of the returns from all key markets, a grower is provided with an average return figure as an indication of the value of kiwifruit sold. This average return, if considered in Table 9, would suggest that under 70%, 60% and 50% return, the grower is likely to adopt Variety B and keep producing Variety A, while Variety C is unlikely to be adopted; under a 40% return, adoption of either new variety is not worthwhile and production of Variety A is questionable. Therefore, Variety C would not be grown, while production decisions involving Variety B would be subject to high potential returns.

2. Considering ***marginal*** returns – The average return figure distorts adoption decisions and implies a lack of incentives for innovation and product diversification. Marginal (market-specific) information clearly indicates that different marginal returns are obtainable by each variety. Under a 70% return scenario, the three varieties are likely to be grown only if exported to the Japanese market, and Varieties A and B are likely to be grown only if exported to the European and US markets; under 60% return growing of the three Varieties is likely only if production is allocated to Japan; and no adoption is likely if production is exported to Europe and the USA; under 50% and 40% return only Variety B will be adopted and Variety A grown if exported to Japan. In other words, in the case of Variety A under a 50% return scenario and Variety B under 50% and 60% return scenarios, although average information suggests the adoption of B and continuous growing of A, marginal information indicates that if this is done and the products are exported to the European and the US markets, the growers would incur a loss (e.g. $5.87 is less than the required $6.25 for Variety B) instead of a promised average gain.

Table 9 Returns to Grower Net from Marketing Expenditure Assuming Industry Adoption of 25% of Variety B and/or C

PERCENT RETURN	TYPE OF VARIETY	MAIN EXPORT MARKETS			
		JAPAN	EUROPE	USA	AVERAGE[49]
70%	A	**$9.64**	**$4.91**	**$5.18**	**$6.10**
	B	**$20.17**	**$6.85**	**$7.43**	**$10.06**
	C	**$8.99**	$5.00	$5.02	$5.93
60%	A	**$8.26**	**$4.21**	**$4.44**	**$5.23**
	B	**$17.29**	$5.87	$6.37	**$8.62**
	C	**$7.71**	$4.28	$4.30	$5.09
50%	A	**$6.89**	$3.51	$3.70	**$4.35**
	B	**$14.41**	$4.89	$5.31	**$7.18**
	C	$6.42	$3.57	$3.59	$4.24
40%	A	**$5.51**	$2.81	$2.96	$3.48
	B	**$11.53**	$3.91	$4.25	$5.75
	C	$5.14	$2.86	$2.87	$3.39

Note: The returns in bold satisfy the NPV constraint for a required return for adoption. For Variety A the required return has to be equal or greater than $3.75, while for Varieties B and C the return should be equal or greater than $6.25.

A number of broader implications arise from Table 9:

- The average return figure is not a good indicator for adoption decisions (it could overestimate returns and stimulate adoption);
- Adoption decisions are subject to specific market characteristics;
- Adoption is maximized under a 70% return scenario, with partial maximization under 60%;
- Variety C's adoption is not likely (except in two cases), while Variety B could enjoy a greater adoption potential;
- Marketers/exporters shouldn't expect a return of more than 50% of the market price for Variety C, because of the nature of this variety (the implications of year-long supply on cost-effectiveness of distribution, as well as the marketing of Variety C free rides on existent awareness of quality associated with Variety A);
- Marketers/exporters could expect a return of more than 50% of the market price for Variety B considering the novelty of this Variety and the required marketing efforts for introducing it and positioning it in each market.

The above simulation approach, when applied to the remaining price premium information associated with the industry-wide adoption scenarios, generates the following results:

- *Returns to Grower Net from Marketing Expenditure Assuming Industry Adoption of 20% of Variety B and/or C* - Only under 70% return scenario with exports to Japan are the two new varieties likely to be adopted. This is the only case when Variety C is likely to be adopted. Variety B is likely to be adopted under 70% return if exported to all markets, and under the other three return categories only if exported to Japan.

- *Returns to Grower Net from Marketing Expenditure Assuming Industry Adoption of 12.5% and 5% of Variety B and/or C* – The results are the same as in the previous adoption scenario. The difference is in the magnitude of the return figures, where the lower the proportion of industry-wide adoption of the new varieties, the greater the associated returns.

Comparing the four adoption scenarios and the likelihood of adoption within each, the results indicate that the most likely adoption scenario is the full adoption of both Variety B and Variety C on-orchard (which corresponds to 50% adoption within the industry) with expected growers' returns representing 60%-70% of the achieved market price. Although lower adoption proportions of either variety are associated with higher returns for the new varieties (and lower returns for Variety A), the industry-wide implications would not be able to substantiate such maximization of returns, since they are subject to reducing the scale of industry-wide adoption, and therefore the limited ability to influence market behavior. This suggests that if market-specific marginal performance was taken as the base for on-orchard decision making, risk-averse growers would either themselves adopt some proportion of a new variety or would stimulate greater adoption within the industry.

In the case of Variety B, the gains are associated with the novelty of the product, while Variety C's performance is linked to cost-minimization efforts within the industry associated with year-long operation. Since in our model adoption is conditional on market and product specific price premiums, no industry-wide cost-minimizing potential is transparent. This suggests that if judging by the variety's market potential, Variety C is not likely to be adopted, although the variety may be beneficial to the industry and valued by the consumer. In other words, Variety C's adoption would be dependant on its industry cost-minimizing potential rather than market premium potential.

While the focus of the simulation analysis follows the current industry criteria for decision-making, i.e. return maximization rather than profit maximization approach, it distances itself from the established norm by providing for a more disaggregated interpretation of the results. Thus, in summary, depending on the type of variety grown, the adoption scenario undertaken and the export market chosen, growers can enjoy significant gains associated with differentiating between new and old varieties and by focusing on the nature of kiwifruit.

Distribution of Research and Development Costs for Product Diversification

In theory, 'sunk' costs are past costs and decisions should be made on the basis of future costs and benefits, since the spill-over effect of new variety adoption is to be acknowledged by future growers (who would benefit from the investment of current growers). This suggests that production decisions should be made on the basis of future expectations. However, under the current industry arrangements, the costs from developing and adopting a new variety are not "sunk" costs *per se*, since they are deducted from a pooled system of returns. This implies that all growers have to allocate some proportion of their orchard-gate return for the improvement of a variety they may or may not choose to grow.

The results of this analysis indicate that if future investment in R&D for product differentiation is contemplated the importance of a scheme for risk-sharing and cost allocation within the industry is crucial for adoption to take place. Since all growers are likely to benefit from product diversification (returns are higher for all three varieties as compared to the growing of only one variety), although not all growers will be willing to adopt, the gains to growers who do not adopt are associated with somebody else taking the risk. This suggests that an R&D levy collected from all growers (rather than only the growers who decide to adopt) is necessary. The levy could be designed as a royalty scheme for capturing the value added within the industry. In order for cross-subsidization to be avoided any level of the production process, and for adoption-decisions to be made according to potential product and market-specific returns, the new varieties should be marketed separately. This suggests that greater marginal returns associated with an adopted variety should accrue to growers who adopt it and marketers who market it.

In summary, the costs of development of the new variety should be spread across all growers. However, the dynamics of such distribution of costs should be associated with marginal differences between growers (whether they adopt, the variety adopted, and the specific marginal returns). This could be achieved by designing scenario specific framework of user charges (e.g. royalties) for capturing returns to the R&D investment. In order for the costs of genetic engineering to be efficiently spread vertically (across the parties benefiting from the investment) and horizontally (across time) property rights need to be in place. In a monopoly-type (collective ownership) framework, such divisibility of gains is difficult. However, it is beyond the purposes of this paper to suggest an efficient ownership arrangement and a royalty distribution scheme within the New Zealand kiwifruit industry.

Conclusions

This paper is an attempt to evaluate potential future developments in the New Zealand kiwifruit industry, associated with the use of genetic engineering for the provision of product quality and diversity. Current industry arrangements constrain incentives for innovating on-orchard by failing to allocate variety-specific valuation within the generalized system of pooled returns and tight industry quality standards.

However, in face of increasing competition in the volume and quality of kiwifruit produced in other countries, the New Zealand kiwifruit industry needs to diverge from its established path and focus on product differentiation for matching specific consumer demands, in order to maintain its leadership in the production of premium kiwifruit.

The need for product differentiation is the focus of this analysis. Product differentiation is the product of genetic engineering for specific quality traits. The success of the type of differentiation is, on the other hand, subject to the potential market performance of the new product and the magnitude of returns that accrue to the grower. In other words, identifying product differentiation as a strategic focus of the industry's future development is a single step in the analytical process. The substance of the analysis is associated with evaluating what type of product will substantiate the industry strategic plan. The results indicate that the product able to capture high premium prices and provide for a reasonable return to the grower will be the product which substantiates product differentiation efforts. This suggests that the industry strategic plan can not be divorced from the magnitude of the gains allocated to the grower, considering that the growers make the ultimate decision of whether adoption (product diversification) is worthwhile and they are the driving factor for product development.

Discussion of the Results

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. A number of positive outcomes as well as shortcomings could be identified from the analysis. They are discussed below and provide the framework for formulating future, and more detailed, research opportunities into some of the identified relationships within the industry.

Positive Outcomes. The structure of the simulation analysis (i.e. the underlying industry/markets relationships) and the results derived from it provide for an insight into the potential gains from product differentiation in the kiwifruit industry. A number of key positive outcomes are briefly summarized:

- Approaches for facing increased competition in the volume and quality of kiwifruit are identified – the use of genetic engineering for developing new kiwifruit products (improve the appeal of the fruit, meet consumer demands, beat competitors and be a technological leader in the industry, establish new niche markets, minimize losses associated with export overlapping);

- A more disaggregated approach to conducting business in the kiwifruit industry is identified, where product-specific market returns are the base for on-orchard production decisions (even within a monopolistic structure of the industry there are gains associated with product diversification, but whether they are captured depends on how efficiently they are distributed across to growers in order to serve as incentive mechanisms for adoption);

- The need for product differentiation is linked to the need for marketing kiwifruit varieties as separate products in order to target the intrinsic characteristics of each product to specific consumer demands (the need to reduce the lags of supply side changes, and provide for a more transparent link between these and demand side factors globally, and in specific markets);

- The gains from product differentiation are associated with the market potential of the specific variety of kiwifruit, suggesting that not all product differentiation can be justified by potential price premiums (and associated returns) and therefore it may not be desirable (from a grower's point of view);

- Growers' adoption decisions and industry goals could coincide depending on the nature of the variety grown and the market potential of the product. If they don't coincide, cross-subsidization within the industry between the adopted variety (i.e. the variety which potential market returns are equal of greater than the required return by the grower) and the variety which the industry favors (i.e. the variety which potential market returns are less than the required return by the grower, but it can provide for cost-minimization within the industry) is possible, which will erode the marginal gains associated with each of the new varieties;

- The marginal gains of different types of kiwifruit when sold in different markets, rather than the maximized average gross returns, are identified, impacting on the grower's involvement with the market performance of their product, which would also provide the right signals and incentives for the grower to engage in the growing of a specific variety.

Shortcomings. An extensive list of shortcomings of the structure and the results of the simulation analysis could be drawn and could serve as an indicator for strengthening future research approaches. Some of the main limitation of the analysis are briefly summarized:

- The main shortcoming of the analysis is associated with the aggregate nature of the limited raw data – lack of seasonal information on volumes and prices of different New Zealand kiwifruit varieties (their monthly distribution and demand relationships) in different overseas markets, as well as seasonal information from other countries producing and exporting kiwifruit. The simulation analysis is based on a hypothetical example of volume distributions across varieties and markets. The relationship between annual volume changes and annual price changes needs to be analyzed carefully before establishing the season's pricing policy. In general, pricing decisions could benefit from more formal collection and analysis of prices of other fresh fruit.

- "One of the most difficult areas for biotechnology is market figures. Many of the potential products are completely new and it is therefore not possible to estimate future sales by extrapolating from the price and sales volume of existing products" (Moses and Cape, 1991; p. 121). The task becomes more difficult when the price and returns from an already existing variety are determined on an average basis, thus ignoring marginal costs and benefits from producing the variety and providing for cross-subsidization between growers and varieties. This leads to limitations associated with current industry regulatory arrangements - bundled returns and the assessment of the industry production efficiency based on maximization of returns per tray sold, rather than growers' profitability;

- Another feature which would improve the above simulation analysis is the formulation of econometrically sound supply and demand elasticities. Elasticity figures in the analysis are based on qualitative assumptions of demand behavior in the main export markets. They are assumed to be an average indicator for the whole season, and do not include assumptions about cross- and income-elasticity for supporting the price elasticity qualitative assumptions. This calls for a formal econometric analysis of elasticity figures for assessing the potential of each variety in each market. Monthly changes in the volume and prices of the different kiwifruit products suggest that an average season price should be subject to non-linear demand behavior.

- The model relationships and the simulation results are focused on the short-run rather than the long run dynamics of both production decision-making and market performance. For example, the production potential (summarized under four adoption scenarios) is based on the assumption that industry-wide production is kept at the same level while spreading the mix between three types of products. This suggests that in the short run, per unit cost reductions are unlikely. Starting from this assumption, product prices are simulated. In the long run, however, the volume produced of each variety would vary, thus reducing per unit cost, rationalizing production and consequently affecting long term prices;

- The analysis is static in nature. The theoretical model is made up of a number of important relationships, which are kept constant for the purposes of the simulation analysis. Only variations in quality and their effects on prices are simulated. However, sustainable high premium prices are dependent not only on the quality of the product supplied, but also on the cost-effectiveness of the entire industry. "Top quality will generally receive top prices. But achieving this quality is not costless – it is more expensive to produce and to market. Furthermore, it does not follow that higher prices resulting from higher quality always maximize profits. New Zealand's apparent record of obtaining prices at the top end of the market has not stopped the industry experiencing severe profitability problems" (NZBR, 1994; p. 35). Therefore, the effects to the overall industry performance of many of the elements kept constant in the model and in the simulation analysis should be analyzed.

- Another necessary approach to price formulation is the adjustment of prices over time to exchange rate changes. Devaluation of the New Zealand dollar would stimulate rising gross income per tray to the grower. The magnitude of the return, associated with specific market premium and exchange rate adjustment, would be important for future production decisions;

- The model also parts away from uncertainties associated with deployment and commercial growing of genetically engineered varieties, as well as with selling the products. Consumer perceptions about the attributes of the new products will determine their magnitude of success. Even though the economic analysis suggests that there are significant benefits from product differentiation, these benefits are strictly subject to the set of preferences consumers exhibit within each market, as well as their ability to value a new product, and therefore their willingness to accept it as a worthwhile alternative. The model abstracts from possible consumer threats to genetically engineered products in order to demonstrate the pure economic gains from product diversification;

- Other areas of interest would be to evaluate: 1) how much of the price premium is due to the ZESPRI brand (which differentiates New Zealand kiwifruit from other countries' kiwifruit) and how much is associated with implicit quality change (which differentiates one type of kiwifruit from any other type of kiwifruit, from New Zealand or not); 2) evaluate what alternative would maximize gains from year long supply of kiwifruit – genetically engineer a variety for stimulating early growth within a season, formulate franchising agreements with offshore producers (from the Northern Hemisphere) or further improve the potential of coolstorage;

Industry Implications

The importance of genetic engineering in the kiwifruit industry is paramount for securing and expanding market share. Identifying genetic traits with economic significance and their implementation in the production of specific new varieties would provide a leading approach to linking supply-side potential to faster growing and evolving demand-side changes. Key issues for management will be developing strategic plans to deal with increased world production of kiwifruit, more flexible methods of product pricing and targeting to established and new markets, product diversification and quality improvement, period and length of selling.

The success of the New Zealand kiwifruit industry, in the longer run, is based on the degree and type of product differentiation undertaken and the expansion of the quality (rather than quantity) supplied to consumers in different markets. On the on-orchard level the effects of product differentiation will be pronounced in increased specialization in product-specific production and the growth in the provision of a range of quality attributes. This will stimulate a revision of the industry's tight quality standards to differentiate between products and value them accordingly.

Future Research Opportunities

The potential research opportunities that stem from this analysis could be approached in a number of ways. Firstly, changes in the regulatory structure of the industry could be evaluated as potential providers for value capture in the industry. Issues such as divisibility of responsibilities within the industry and the divisibility between returns associated with different products sold to specific markets should be addressed in detail in order to evaluate the effects of returns averaging and maximization efforts on production behavior and industry-wide efficiency, and compare these to the industry's marginal potential and actual profitability.

Secondly, the potential of genetic engineering for adding value to the industry has to be evaluated from the initial stages of investment, focusing on the cost of production of the improved plant material, its nursery deployment and subsequent distribution across growers willing to adopt a new variety. An important feature for the success of a new variety is the establishment of property rights regimes for their appropriate management and valuation. This issue is crucial for securing gains associated with new technological developments. This paper discusses the distribution of gains from the new varieties between growers and marketers in an industry where both players are interdependent, rather than independent, and the value of the new varieties is calculated as an integral part of growers returns (i.e. costs of development are considered to be sunk costs), rather than a royalty value associated with the cost of product development. In the future, however, increasing growers' independence in the choice of variety and exporting markets would make licensing agreements an integral part of the industry dynamics. The allocation, value distribution and time span of royalty schemes would be an exciting topic for future research.

Finally, the model and the simulation analysis provide the framework for future detailed analysis into 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. Adoption decisions would thus be substantiated by a quantitative link between product quality attributes and specific consumer preferences.

Endnotes

[1]Paper prepared for the ICABR conference on “The Shape of the Coming Agricultural Biotechnology Transformation: Strategic Investment and Policy Approaches from an Economic Perspective”. University of Rome “Tor Vergata”, June 17-18-19, 1999.

[2]Dr Frank Scrimgeour is Associate Dean Research, University of Waikato Management School. Svetlana Bohorova, Research Assistant, University of Waikato management School.

[3]The name ZESPRI does not refer to a new variety of kiwifruit. It is a brand name representing a guaranteed quality sign for all New Zealand grown kiwifruit.

[4]An approval from the Board is required for collaborative marketing activities. Collaborative marketers are also required to work (rather than compete) with ZESPRI International, as its agents.

[5]Most of the information in the following section was obtained from an Internet document: www.treasury.govt.nz/pubs/rtp/ProducerBoard/toc_prod.htm.

[6]“On the assumption that the KMB makes a profit, the size of the distortion depends on the size of the profits relative to the actual fruit return” (NZBR, 1994; p. 58).

[7]The data used for the figures has been gathered from different sources, all of which are included in the bibliography section.

[8]Hectare figures are presented in cumulative planting totals.

[9]The value of exports refers to the value of tons of kiwifruit exported, rather than trays exported.

[10]Returns to growers are calculated in NZ$ fob of sold product, which is a gross return figure, not adjusted to operational costs.

[11]This information was extracted from:
www.treasury.gov.nz/pubs/rtp/ProducerBoard/toc_prod.htm.

[12]This percentage is based on the volume of exports in tons, rather than their fob value.

[13]“The anti-dumping order was placed on New Zealand kiwifruit exports in 1990 following a slow selling season during which a shipment of kiwifruit was diverted from Japan and sent to the USA. Subsequent low prices raised objections from growers who alleged dumping. Minimal sales have been made since this time…”. (Internet document: www.zespri.com).).

[14]During this period, New Zealand kiwifruit enjoys a market share of 70% (KNZ Annual Report, 1998).

[15]Another similarity between the New Zealand and Chilean kiwifruit industries is that both face very small domestic demand and focus mainly on exporting their domestically produced fruit.

[16]"The Chilean fruit industry is now moving from expansion to a period of consolidation involving product refinement, higher value product development and a search for new products and different markets" (NZBR, 1994; p. 88)

[17]"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).

[18]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.

[19]The information regarding the length of the overlapping period for kiwifruit from different exporting countries to major export markets was obtained from Brookes et al., 1994. The outcomes are suggested by the authors.

[20]The idea is based on the apple industry where different varieties of apples exist and are associated with differences in color, flavor and texture, rather than with a country-specific quality identity.

[21]The other New Zealand named female kiwifruit varieties are Abbott, Allison, Bruno, Gracie, and Monty. The male varieties used are called Matua (the most common in commercial orchards) and Tomuri. (Internet document: www.crfg.org/pubs/ff/kiwifruit.htm)

[22]Kiwifruit has separate male and female plants, producing male and female flowers on different plants. The presence of male vines, which flower but do not fruit, is essential for pollination and crop production.

[23]All ZESPRI New Zealand kiwifruit is grown under a Kiwigreen program – an orchard management system based on monitoring rather than spraying, keeping the use of control agents to an absolute minimum (Internet document: www.zespri.com).

[24]The presence of leaf rollers on the crop is not only detrimental to the quality of kiwifruit, but it is also a quarantine hazard for export fruit.

[25]1g drop in fruit size is worth about $1,000/ha (Dine, 1986)

[26]"The highest fruit densities clearly represent overcropping, with some 25% of fruit below export size. If size 46 is added in … the figure is over 50%" (NZKA, 1982; p. 22)

[27]Export quality kiwifruit is graded by size and weight.

[28]A number of adoption scenarios are discussed and analyzed in the simulation model - Section 4 in this paper.

[29]Orchard costs in New Zealand, reported by OECD (1990), are found to represent 12% of the fob price per tray.

[30]The entry of Variety A coincides with the exit of Variety C and vice versa.

[31]The assumption is that, on average, 1 ton corresponds to 270 trays of kiwifruit.

[32]"Yields of 25 tones/ha are commonly obtained from well-maintained orchards of Hayward and yields of 50 tones/ha or more have occasionally been recorded" (Sale and Lyford, 1990). "The average New Zealand orchard yields 4,500 trays per hectare, with a majority of them yielding in the 3,300-5,900 trays range. The best orchadists achieve up to 10,000 trays per hectare in the most favorable locations, but location plays a critical role in achieving those high yields" (Douglas and Burgess, 1992, p. 40).

[33]However, climatic fluctuations are assumed to be constant across growers, therefore, yield is likely to fluctuate due to other factors, such as expected price of kiwifruit on the international market, area planted, variety type, etc.

[34]This assumption is based on a gross return to the grower which represents 60% of the reported by the Board average price for the Hayward variety of $6.25 for the 1998 season (Kiwi Flier, 1998).

[35]The growers obtain all their income from selling kiwifruit, i.e. no other income is derived from on-orchard activities other than kiwifruit.

[36]The average orchard-gate return per hectare during the period between 1993-1997 reported by the Kiwifruit Board in their 1998 Annual Report is around $16,000.

[37]Sheppard and Scrimgeour (1996) represent costs as 90% of growers' revenue; MAF's 1984 Kiwifruit Monitoring report represents orchard expenses as 65%-81% from kiwifruit orchard income (for the 1983/84 season), and in Agricultural Statistics (1993) reported net profit per total sales and other income for 1991-93 is between 0.5%-10%.

[38]20% profit may be a rather optimistic assumption, given the recorded on-orchard deficits in the last five years. However, it is difficult to use industry based data due to an industry approach of return rather than profit maximization.

[39] All prices are intended in New Zealand dollars.

[40] The idea behind this assumption is to isolate on-orchard differences in volumes produced and focus on the market potential of each of the two varieties. In other words, the differences in the magnitude of the gains associated with each variety would be due to the intrinsic characteristics of the product and the market-specific demand and supply interactions, rather than the initial volumes produced.

[41] The European market is a set of different countries with different consumer segments and preferences. Thus, 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.

[42] The information for this section was extracted from Brookes *et al.* (1994) kiwifruit market analysis.

[43] "Overall consumption of fresh fruit has been declining for several years at around 1.8% per year, associated with price increases averaging over 7% per year" (Brookes *et al.*, 1994; p. 75).

[44] "Volume demand is mature. Prices of kiwifruit at wholesale have moved steadily downwards since 1986, as supplies have increased. Domestic Japanese production has led the pressure on prices since 1989" (Brookes *et al.*, 1994; p. 76).

[45] Table 7 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), which are incorporated into the market specific simulation of potential premium prices.

[46] Since no experimental information exists for the two new varieties, and the assumptions of the model are based on changes in the product mix, the volumes of the new varieties are simulated as changes from previously known volumes of Variety A.

[47] This figure could be compared to an actual average price figure for the 1997 season (published in the 1998 Annual Report of Kiwifruit New Zealand) of $9.58 per tray sold, while the 1998 Season forecast (in Kiwi Flier, 1998) provides a total fruit price figure of $5.74.

[48] For 20% industry-wide adoption of either variety the required return is $8.58, for 12.5% - $8.62 and for 5% - $8.80.

[49] The calculation of the average return figure includes the market and variety-specific returns from the rest of the world (ROW).

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