Supermarket market-channel participation and technology decisions of horticultural producers in Brazil

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Resumo: *Este artigo analisa as relações entre a escolha dos canais de distribuição dos produtores (enfatizando distribuição por meio de supermercados versus outros canais), o uso da tecnologia e as características dos produtores como capital humano e tamanho da propriedade. Foram identificados três resultados principais. O primeiro revela que produtores de tomate e alface que distribuem por meio de supermercados apresentaram maior capital humano que aqueles que não utilizam esse canal. O segundo resultado indica que enquanto o tamanho da propriedade foi importante para produtores de alface decidirem distribuir por meio de supermercados, essa variável não foi importante para produtores de tomate. O terceiro resultado sugere que o uso da tecnologia foi significativamente mais intenso em capital entre os produtores de alface que vendem seus produtos para os supermercados, no entanto, isso não foi observado para produtores de tomate. Esses resultados são importantes para pesquisadores e formuladores de políticas interessados em tecnologia, pesquisa e extensão visando a ações que permitam aos produtores se adaptarem às necessidades atuais do mercado. Essas necessidades envolvem atributos de produtos e das transações, que por sua vez, implicam em investimentos em tecnologia e capital humano. Esses fatores têm pressionado países como o Brasil onde o mercado de produtos hortícolas tem mudado rapidamente em função do rápido crescimento dos supermercados.*

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Palavras-chaves: *canal de distribuição, produção, supermercados, horticultura.*

Classificação JEL: *L2 - Objetivos, 0rganização e comportamento da empresa*

Abstract: This paper examined the relationships between growers' choice of market channel (emphasizing the supermarket market-channel versus others), technology use, and grower characteristics such as human capital and farm size. Three key findings emerged. First, both tomato and lettuce growers selling to the supermarket market-channel had more human capital than those not participating. Second, while farm size was important in whether lettuce growers sell to supermarkets, it was not important for tomato growers. Third, technology use was significantly more capital-intensive among lettuce growers selling to the supermarket channels, however, that was generally not the case for tomato growers. These results are important to agribusiness researchers and policymakers interested in technology design and research and extension to enable producers to adapt to the needs of changing agrifood markets, with new requirements of attributes of products and transactions, which in turn have implications for technology adoption and human capital investment among growers. This is particularly pressing in places like Brazil where the market for horticultural products is changing quickly, conditioned by the rapid rise of supermarkets.

Key words: market channel, produce, supermarkets, horticulture

JEL Classification: L2 - Firm Objectives, Organization, and Behavior

1. Introduction

Supermarkets[1] in Brazil, as in other developing countries, have seen a rapid growth in consumer demand for qualitative attributes such as food quality, safety, variety, healthfulness, and convenience. At the same time, supermarkets compete on cost with traditional retailers and

[1] We use "supermarkets" for simplicity to mean large-format stores, including supermarkets, hypermarkets, discount stores and so on, and distinguish only where necessary.

with other supermarkets. Chains thus tend to have a dual merchandising strategy for fresh produce (fruits and vegetables), focusing on low prices for poorer consumers and quality for richer consumers, and have transformed their procurement systems to be able to deliver these produce attributes to consumers. Thus new market channels are emerging – with a particular channel defined by a combination of type of buyer, attribute requirements, and contractual relations with their suppliers. The investments and practices required of suppliers differ over the channels, as do the returns and risks. This is because supermarkets tend to set private standards that differ from public standards, or from the requirements of informal markets without explicit standards. For example, see Berdegue et al. (2004) for the case of Central America.

The supermarket sector has grown quickly from a tiny niche in 1990 to a major and often dominant share of food retail in Latin America in general (Reardon and Berdegue 2002), and in Brazil in particular (Farina, 2002). Yet there has as yet been little treatment in the literature of the domestic market channels to supermarkets in developing countries, in particular how private standards and other product and transaction requirements of local supermarkets are transmitted to, and affect local growers. The few studies that address this issue do so focusing on how developed country retailers affect developing country farmers, such as US and European quality standards for horticulture producers in Central America (Thrupp, 1995), or UK supermarket chains standards on Kenyan and Zimbabwean horticultural producers (Dolan and Humphrey, 2000, McCulloch and Ota, 2002, Jaffee, 2003, and Henson, Boselie and Weatherspoon, 2004), or EUREPGAP European retailers collective standards on developing country producers, such as voor den Dag (2003) for the case of French beans in Kenya. More generally, research on how changes in market structure (such as consolidation of the processing or retail sectors) affects technology adoption by growers, is in incipient stages, with recent contributions such as that of Heiman, McWilliams, and Zilberman (2000), examining effects of input agribusiness marketing strategies on growers' technology adoption in the U.S.

This paper aims at contributing to filling that gap in the literature, with a study based on field research in Brazil. After presenting a taxonomy of market channels, based on distinct sets of requirements imposed by

buyers on suppliers, and thus marketing choices of suppliers, we address two research questions. (1) What determines the supplier's choice among those marketing channels? (2) What are the technology implications of the market channel choice – that is, what is the relation between market channel choice and technology use? The importance of these questions for agribusiness and rural development is that the analysis reveals requirements and challenges facing small/medium producers in accessing dynamic markets through modern retailers – and thus informs policy, agricultural research, and development programs in Brazil and elsewhere. The research questions are addressed by analyzing data on tomato and lettuce producers in the area supplying São Paulo. The data come form a survey of 55 tomato and lettuce growers conducted from April-July 2002.

2. Conceptual Framework

Retailer demand for food safety and quality attributes in produce and corresponding efforts by producers to supply produce with these attributes lead to the emergence of dual supply channels. The first is for what we can call "conventional attributes" and the other for produce with "new attributes" (such as higher cosmetic quality and lower pesticide and bacterial residuals relative to conventional). In this paper we ascribe demand for the new attributes only to the supermarket market-channel.

Production of the new attributes (such as higher cosmetic quality and lower pesticide residues than "conventional") requires of the grower production technology, commercial practices, and investments, which, in principle, differ from those required to produce conventional attributes. For example, to produce the "new attributes" required by the supermarket market-channel, the grower may have to follow an input use regime; specific production practices that require worker training, such as in pruning and handling and packing that allow for specific organoleptic or cosmetic quality attributes in the produce; certification of water quality which in turn requires investments in and maintenance of the wells and irrigation infrastructure; adoption of good agricultural practices (GAPs) which imply additional expenditures relative to conventional such as in reporting; and post-harvest practices and investments such as in transport and packing crates. These can be thought of as the vector of technological

choices implied by the attribute vector derived from the private standards for quality and safety of the supermarket chain (Reardon et al. 2001).

Producing to meet these "new" attribute requirements presents new risks and costs to suppliers—the costs of making the necessary investments to comply with the new product standards, and the risks of failing to meet these standards or opportunistic hold-up on the part of the buyer. Buyers who seek the "new attributes" must provide growers with either a price premium or some other boost to revenues or lower risk or both, relative to returns and risk of conventional market channels, to compensate them the additional risks and costs incurred in the decision to supply them. Using the example here of the supermarket-channel, the supermarket specifies the requirements of the product and the transaction (including the specification of quality and safety attributes of the produce) and thus, implicitly, the costs to be incurred above those for the conventional market. The supermarkets then either offer a price premium relative to "conventional" or they offset the higher production costs with cost savings elsewhere (such as transaction costs saved in marketing to few buyers who purchase a large share of the suppliers' total output, and also commit to purchase the product from the supplier thus reducing the market risk of this channel.

The specification of prices and services and other transaction terms between all buyers and sellers constitutes a contract. We use the term "contract" here in the broad sense used by Hueth et al. (1999), where a contract is a relationship or agreement, written contract or not, in which there is some penalty implicit or explicit, tangible or intangible (such as in loss of reputation) in non-compliance. Such contracts are common in the produce industry (the world over) and applicable in the present case for the "new attributes" market segment.

The profit-maximization, risk-minimization choices of a supplier to supply produce with "new attributes" to the supermarket market-channel, instead of to the conventional market channel, can be characterized here as a set of recursive choices. (In practice the choices might be recursive or simultaneous.) The first choice of the grower is the choice of supplying for (and thus producing for the vector of required product and transaction attributes of) a given market channel. This is simplified here as a choice between the supermarket market-channel, versus the con-

ventional market-channel (to traditional wholesalers). This choice can be modeled in the same way as a technology adoption choice (Sadoulet and de Janvry, 1995) if modeled as a function of a vector of output prices (P) (including produce j with new attributes and produce k with conventional attributes, and other products), vector of input prices (w), vector of risks (σ) (including risk in the supermarket-channel versus the conventional channel), a vector of quasi-fixed capital other than that specific to the channel (K) (including human, organization, and physical capital, as well as land, which can be own or rented), and other shifters (Z):

(1) Participation in supermarket market-channel = f(P, w, σ, K, Z)

The second choice of the grower is the choice of technology. Technology is embodied in variable input use and capital investment decisions, contingent on choice of marketing channel and thus the vector of product and transaction attributes required to participate in that channel and the vector of net returns and risks. The technology choices here are embodied-technology choices that are hypothesized to differentiate growers producing and delivering to the buyer produce with "new attributes" by their use of production and post-harvest equipment such as packing and cleaning equipment, cooling chambers, refrigerated trucks, and communications equipment (internet, fax, mobile phones). The embodied-technology choice equations are again adoption equations similar to (1); in implementation, some of the prices may be 0 because of non-variation:

(2) Use of embodied-technology j = f(P, w, 6, K, Z)

3. Context (Market Channel Characteristics and Categories)

In this section we identify the relevant categories for the left-hand side of the adoption equations 1 and 2 presented in the previous section, that is, the channel and technology choices. To do so, we analyze the salient characteristics of the Sao Paulo region's tomato and lettuce markets.

Tomato market channels and marketing chain

Tomatoes are produced in the peri-urban area of São Paulo by farmers who are largely specialized in tomato production, in some cases

producing tomato in rotation with grains. Growers can sell to wholesalers based in the traditional wholesale market, wholesalers based in the growing regions, or to several types of intermediaries who purchase tomatoes to re-sell to wholesalers. The traditional tomato marketing chain, still used outside the supermarket procurement channel, moves tomatoes from the farms to packing houses where they are classified and packed into wooden crates, then to the traditional wholesale market. These wholesalers sell the bulk (on average 48%) of their merchandise to small retailers and fresh processors who visit the traditional wholesale market to inspect the product and negotiate transactions.

The Supermarket Channel moves tomato from growers to wholesalers that have packing houses in the growing regions and for whom supermarkets are their primary buyers, responsible for 68% of their sales. Given supermarkets' stringent quality requirements, the intermediaries who supply them have technologically sophisticated classifying plants (that, for example, have optical scanners to differentiate tomatoes by color, and pack in plastic or cardboard boxes that supermarkets prefer).

Growers can thus choose among three marketing channels: 1) the Traditional Wholesale Channel, 2) the Supermarket Channel, and 3) and the Intermediary Channel which in turn sells to either the Traditional Wholesale or Supermarket Channel. The contracts characteristically used for each type of channel are discussed below.

Intermediary channel with Fixed-price contract. Growers marketing tomatoes to the Intermediary Channel sell their produce at the farmgate to intermediaries who purchase on behalf of wholesalers and classifiers. Purchase arrangements are made at harvest time, and include transport of the tomatoes. Prices are discounted slightly to account for the value of the services provided. These contracts do not offer forward planning of sales, but once a sales agreement is made (at harvest usually) then payment is immediately made. The most significant entry barrier is that the Intermediaries seek to purchase tomato in large volumes, which favors growers who are specialized in tomato production (rather than those who produce a number of vegetable crops). (Unfortunately, the nature of data collection did not allow for determination of to what extent tomato purchased by these intermediaries enters the Traditional vs. Supermarket channels).

Supermarket Channel with Financing contracts. Financing contracts involve the provision by the buyer of working capital to support production on a specific area of land. In exchange, the grower commits to sell his output from that land to the buyer at harvest. A fixed deduction per box produced is agreed upon in advance and subtracted upon payment following harvest. These contracts are offered by classifiers and wholesalers (in combination with the consignment contract), though the focus here is on financing contracts offered by classifiers. Entry into these contracts requires one-on-one negotiation between the classifier and a proven capacity to produce. They are used increasingly as classifiers increase in number and seek to ensure that they will have adequate throughput to keep their plants working at efficient levels of throughput. The contracts are advantageous in that the grower is assured of a buyer for his harvest. They involve some risk in that the payment is deducted from the final payment (which is made at going market prices) at a fixed price per box. Thus, depending on actual output and market prices, the value of the final payment is difficult to predict (i.e. it will amount to a large payment if the harvest is very large and prices low, but a small payment if the harvest is small and prices are high).

Traditional Wholesale Channel with Consignment contracts. A consignment contract involves the grower sending his product to an intermediary who then sells it and gives the proceeds to the grower, minus a marketing commission (of approximately 17%) and various other costs such as taxes, transport and other explicit fees. These contracts are considered undesirable by growers, as they are used as a means for intermediaries to shift price risk to growers, and also because the growers cannot verify the sales price that the intermediary receives and are thus vulnerable to opportunistic behavior on the part of the intermediary. There are very low barriers to entry with these contracts, and many wholesalers will finance the operating costs of the crop. This market channel is also one of the most accessible to the smallest growers who, due to their tendency to have diversified crop portfolios, tend to have small volumes of tomatoes to sell, lessening other buyers' interest in them.

Lettuce market channels and marketing chain

Lettuce is produced in the green belt surrounding metropolitan Sao Paulo by small growers who typically produce a fairly large mix of products. Growers can sell to a diversity of different buyers including to intermediaries who buy at the farm gate, small supermarkets, large supermarket chains, the wholesale market, to processors, and direct to consumers. Most growers operate individually, but there is also limited participation in marketing cooperatives. The high perishability of lettuce, lack of a cold chain, and the non-existence of automated classifying infrastructure make direct sales between growers and retailers much more common than in the tomato market. Likewise, the traditional wholesale market plays a relatively minor role, with only 8% of São Paulo's lettuce production passing through the main wholesale market in 1999 (a decline from 55% in 1990).

Growers can choose among three market channels, the first two of which are characteristic of traditional channels. These are 1) the Traditional Intermediary Channel which moves the product from the production area to intermediaries who sell in turn to a variety of small retailers and to a lesser extent at the traditional wholesale market; 2) The Traditional Small Retailer Channel which moves lettuce directly from the grower to retailers (without participation of intermediaries) who come direct to the farm gate; and 3) the Supermarket Channel, in which lettuce is purchased by Supermarkets directly from growers, grower associations or firms that perform value-added services on lettuce that they purchase from growers.

Though both involve direct sales between growers and retailers, the Supermarket Channel has important organizational differences from the Traditional Small Retailers Channel. Principle among these are that the growers are responsible for providing a number of services with the lettuce (such as delivery to individual retail outlets of the large chains) as well as for meeting stringent product and process standards such as certification of water quality. The Supermarket Channel is "captained" by the large retail supermarket and hypermarket chains which set the standards in terms of product requirements and account for the most movement of produce, however it also in-

cludes the small and medium-sized supermarkets, particularly those oriented to higher income clienteles and who seek to provide many higher-quality attributes.

Lettuce contracts do not show the wide diversity that are characteristics of tomato contracts, with neither the consignment nor the financing contracts in evidence. Instead, a variety of Fixed Price contracts exist. The Supermarket Channel contract is a Fixed Price Contract with High Service Requirements. The Intermediary and Small Retailer Channels both rely on Fixed Price Contracts with Low Service Requirements, but differ in terms of negotiation and pricing methods. The characteristics of these contracts are summarized below.

Supermarket Channel with Fixed price contracts and high service requirements. Supermarket Channel buyers are very demanding of their suppliers in terms of the provision of both physical services and services to guarantee the quality and safety of their products. Physical services sought include product packaging, transport of the product, and delivery among individual stores. Quality and safety assurance services include water quality certification, HACCP, and Good Agricultural and Manufacturing Practices. It is interesting to note that only the largest chains require these quality and safety services (as opposed to all the firms that seek but do not explicitly require the services). However, the fact that a producer qualifies on these fronts to sell to the large chains is an important point in gaining access to the smaller high-end supermarkets that generally do not require them explicitly. These are fixed price contracts; however, unlike the Low Service Fixed Price contracts, the supplier has some degree of bargaining power, and often provides the retailer with a price table on which negotiation is based. These contracts have high entry barriers, particularly investments in advanced post-harvest practices, investments to meet certification requirements, transport and communications.

Intermediary Channel with Fixed price contract and low service requirements. These contracts involve the provision of less service by the supplier. In many cases, the product is collected at the farm gate on a regular basis. Ongoing long-term relationships between buyer and seller predominate. Given the highly variable quality of lettuce and the lack of enforceable grades and standards, personal relationships and negotia-

tion are important. The above characterization is also true for the *Small Retailer Channel with Fixed price contract and low service requirements.*

4. Empirical Model, Hypotheses, Methods and Data

Data

The data used come from a survey of retailers, intermediaries and farmers from April to July 2002. Fifty-five farmers (32 lettuce growers and 23 tomato growers) in the peri-urban region of Sao Paulo were interviewed. The sample was chosen as a "judgement sample" (www.statpac.com/surveys/sampling.htm); the main producing areas of lettuce and tomato (for the Sao Paulo market) were identified, and extension agents as key informants were used to identify the sample of growers, maximizing representation of characteristics. Data was collected on farming activities and resources, and trends in these over the past five years. Additionally, a survey of 15 tomato intermediaries was conducted, nine located in the traditional wholesale market in Sao Paulo and six (with their own processing facilities) in the peri-urban area.

Market Channel Choice

Using the market channel categories identified in section 3 as a starting point, an empirical analysis was made of growers' participation in market channels and the specific composition of these market channels. We used cluster analysis of the market outlets that growers reported using. Partitional cluster analysis techniques using the k-means algorithm and within group average measures to minimize the squared Euclidean distances of all points between clusters were used to differentiate the market channels to which growers belong. The mean points of the clusters generalize the market-channel choices of the growers, with the growers' selection of the channel determined by the grower's characteristics (in particular, the K vector in equation 1, because the P and w vectors do not vary in the cross section analysis over the limited geographical scope of the peri-urban area.

The growers' characteristics variables used in the cluster analysis, representing determinants of market channel choice, are outlined be-

low. Note that in general, given the incentive to produce for the supermarket channel (price premium and lower risk through contract), the main determinants are the capacities to meet the supermarket requirements which are communicated directly or via a wholesaler buying for the supermarket. These requirements include, as noted in section 3, consistent delivery of high quality produce which implies having equipment and skills. The specific correlates and our hypotheses of their relation to the supermarket channel choice are as follows.

First, we hypothesize that larger the farm, the greater the probability that the grower will be in the supermarket channel cluster. It is commonly assumed, for example by policymakers designing agricultural diversification programs, that fruit and vegetable production displays no economies of size or scale – and thus mere labor intensity (which it is assumed that small growers can supply in abundance) is sufficient to be competitive in fruit and vegetable production for urban markets. But, as signaled by Cook (2004), fruit and vegetable production systems that consistently produce quality and sufficient volumes for supermarkets are technology-, capital-, non-labor input-, information system- and infrastructure (packaging, pre-cooling, cold chain management)-intensive, and meeting these requirements involves economies of size. Moreover, evidence from elsewhere (such as Berdegue et al. 2004) suggests that supermarkets and specialized/dedicated wholesalers have a predilection, all else equal, to source from medium/large farmers in order to reduce the number of suppliers and thus transaction costs.

Second, other assets that we hypothesize to be important in participating in the supermarket market-channel include human capital (reflected by own-education, use of skilled labor, and specialization in horticulture in farming operations), reliance on off-farm sources of income to serve as risk management mechanisms to balance the initial risk of selling to a non-traditional market and also to provide finance for operations, and access to finance for working and investment capital

Specialization in agriculture is measured by the share of individual growers' family budgets from agriculture; the share of their agricultural income from vegetables, and the number of different vegetables produced. Specialization in the production of "high-value" products includes specialty produce such as organic, hydroponic, pre-pack-

aged, greenhouse-grown and pre-processed produce. The employment of skilled labor is proxied using the share of total employees who are permanent on the farm, either as hired or family labor. Have access to financing for operational and investment expenses is reflected by growers' use of different sources of operational and investment capital, including banks, special government programs such as PRONAF and FINAME, input suppliers, business associates and family and friends. The level of education in agricultural pursuits is indicated by growers' completion of specialized educational programs in agriculture, either at the university (such as an agronomy degree) or technical schools.

Third, the use of modern production practices, such as regular employment of soil analysis, is expected to be correlated with participation in supermarket market-channels. Growers' market-oriented management practices are indicated by the extent to which they purchase key inputs from the market, specifically whether they have a greenhouse to produce their own seedlings or rely on the market for these.

Note that the use of cluster analysis allows us not to assume strict causality, but rather general relationships, and hence obviates the need to have only exogenous variables among the above correlates.

Technology Choice

Technology use was analyzed in two manners. First, cluster analysis was used to separate growers into high and low technology groups. Here within-group averages were minimized using Jaccard measures, drawing on growers' dichotomous responses regarding their use of specific post-harvest, transportation, communications and value-added (for lettuce only) technologies (Tan et al.). The resulting clusters were then matched with growers' participation in different market channels using cross-tabs with chi-square tests for statistical significance.

Second, indices were created based on growers' possession of specific equipment (the same equipment analyzed in the cluster analysis). Growers' possession of different equipment was then analyzed with respect to their market channel participation using comparison of means with analysis of variance to determine the statistical significance of the results.

The technology variable is modeled as dichotomous, reflecting that a

grower either has a package of needed equipment and other components that are necessary for producing the requirements of the supermarket channel, or does not. The choice is thus between traditional and "advanced" technology, where "advanced" equipment and infrastructure includes transportation, post-harvest communications, and value-added technologies. Specific equipment included open, closed and refrigerated trucks for transportation and delivery of produce; plastic crates, vegetable washers, and cold storage rooms for post-harvest technologies; computer and internet access for communications, and greenhouses and preprocessing infrastructure for value-added technology. Again, the choice of correlates focused on grower characteristics (the same set as used in the market channel choice cluster analysis) because of the lack of variation in prices in this cross section over a limited geographic area.

5. Results and Discussion

Cluster analysis results of market channel choice

Tomatoes. Cluster analysis of tomato growers' marketing decisions (summarized in Table 1) revealed consistent patterns of participation in the three market channels – the Modern Classifier channel (the most direct to the supermarket), the Intermediary Channel, and the Traditional Wholesale Channel. Around 75% of the growers sold to the Intermediary Channel, only 5% sold to the Modern Classifier Channel, and the rest (20%) sold to the Traditional Wholesale Market Channel.

Table 1. Cluster analysis results for market channel participation and composition for tomato growers

Variable	Supermarket Channel	Intermediary	Traditional Wholesale	
Participation in cluster	5%	75%	20%	
Division of Sales by Buyer Type	Mean Share of sales to market outlets			P-value
To intermediaries	7%	100%	5%	.000
To wholesale market	3%	0%	91%	.000
To classifiers	27%	0%	2%	.039
To retail buyers	64%	0%	2%	.000

Table 2 reports results on the tomato grower characteristic correlates of market channel choice. As hypothesized, participants in the Supermarket Channel are more likely to use more skilled labor (controlling for land), and have higher levels of specialized education (Technical School), as compared to those participating in the other channels. It is interesting that farm size did not have a significant effect – whereas physical capital and skills to produce quality and consistency do matter. Furthermore, the use of greenhouses for production of seedlings was higher for growers in the Supermarket Market-Channel than for others. Given the importance of quality in producing for the Supermarket Market-Channel, it is possible then that one of the ways that growers ensure high quality is by vertical integration of some of the key activities that determine the quality of the product—such as the production of seedlings.

Lettuce. Cluster analysis of lettuce growers' marketing choices (summarized in Table 3) also showed consistent patterns of participation in three market channels. Twenty-five percent of the growers sold to the Supermarket Channel, which was comprised of large supermarket and hypermarket chains and small and medium-sized supermarkets. Another 25% of the growers

Table 2. Characteristics of tomato growers participating in different market channels

Variable	Supermarket Channel	Interme-diary	Traditional Wholesale	P-Value
% Family budget from agriculture	77%	73%	89%	.567
% Agriculture revenue from vegetables	97%	73%	72%	.291
Number of different vegetables produced	1	2	2	.592
Hectares vegetables cultivated	54	19	22	.162
Share of permanent laborers among total	66	11	10	.002
Age	40	50	37	.496
Technical education in agriculture (chi-sq)	67%	7%	0%	.015
Outside sources for operational capital (chi-sq)	100%	100%	80%	.168
Days of credit for input purchases	120	99	119	.423
Outside sources for investment capital	33%	57%	80%	.412
Has greenhouse for seedling production	33%	0%	0%	.036

sold to a Small Retail Channel, comprised primarily of small non-supermarket retailers such as street fair vendors and discount green grocers. The remaining 50% sold to an Intermediary Channel. P-values show that each market channel has statistically different levels of sales to different types of buyers except for sales to the wholesale market and processors and consumers.

Table 3. Cluster analysis results for market channel participation and composition for lettuce growers

Variable	Supermarket Channel	Traditional Market Channel		
		Intermediary	Small Retailer	
Number in cluster	25%	50%	25%	
Division of Sales by Buyer Type	Mean value			P-value
Share of sales to large chains	34%	2%	0%	.000
Share of sales to small and medium supermarkets	32%	1%	0%	.000
Share of sales to intermediaries	6%	71%	4%	.000
Share of sales to non-supermarket retailers	3%	18%	96%	.000
Share of sales to wholesale market	15%	2%	0%	.177
Share of sales to processors or consumers	10%	6%	0%	.485

Table 4 reports results on the lettuce grower characteristic correlates of market channel choice. It shows a consistent pattern of results in which the relatively more attractive market channels are used by growers who are more specialized in agriculture, produce a broader array of products, have larger farms, and for whom the production of high-value "specialty" produce constitutes a larger portion of the revenue of those who produce it. These growers also rely very heavily on skilled laborers (86% of their total compared to only 8% for the other groups), are younger, and have highly specialized training in agriculture as evidenced by 43% of the Supermarket Channel growers having university educations in agriculture compared to none of the other growers. Interestingly, while Supermarket Channel growers are not the most reliant on outside sources of capital for operational expenses (though only half of the growers selling to Small Retailer Traditional Channel rely on outside capital for their operational expenses), those Supermarket Market-

Channel growers who do borrow for operational expenses are extended credit for approximately twice as long as the other growers.

Table 4. Characteristics of lettuce growers participating in different market channels

Variable	Supermarket Channel	Traditional Market Channel		P-Value
		Interme-diary	Small Retailer	
% Family budget from agriculture	96%	98%	90%	.230
% Agricultural revenue from vegetables	100%	99%	93%	.090
Number of different vegetables produced	18	7	7	.002
Hectares vegetables cultivated	33	7	10	.018
Produces "specialty" produce (chi-sq)	13%	13%	0%	.576
"Specialty" produce share of produce sales (for those who produce)	32%	7%	0%	.057
Share of permanent laborers among total	86%	8%	8%	.001
Age	36	39	57	.036
University education in agriculture (chi-sq)	43%	0%	0%	.003
Outside sources for operational capital (chi-sq)	88%	92%	50%	.054
Days of credit for input purchases	62	29	33	.127
Outside sources for investment capital	75%	56%	50%	.558
Conducts soil analysis	88%	92%	63%	.212
Has greenhouse for seedling production	63%	71%	88%	.543

Why does farm size matter for lettuce growers but not for tomato growers? We surmise that the reason is based on the structure of the marketing channel. All tomatoes pass through mechanized classification plants. However, there is no mechanized classification of lettuce, and a large proportion of it moves directly from producers to retailers. Thus, the classifiers play two roles in the tomato markets that they do not play in lettuce markets. First, they aggregate the production of numerous tomato growers in order to meet demand. Second, they perform most of the operations that qualify tomatoes for the Supermarket Market-Channels. That is, though it is crucial for tomato coming into the plant to be of high quality, the value-added operations on the tomato such as sorting, packaging and transport, take place at the plant. Thus, there is no inherent scale advantage for tomato

growers to sell to the Supermarket Market-Channel buyers. In fact, given the increasing number of classifiers in the area and competition for adequate volumes of throughput to meet demand and keep plants running at efficient capacity levels, it is likely that the classifier-intermediaries do not currently seek to purchase tomato from large-scale growers exclusively. In contrast to this situation for tomato, the proportion of sales of lettuce direct from the grower to the retail buyer means that the services and attributes that make lettuce qualify for the Supermarket Market-Channel frequently take place at the farm level. Furthermore, Supermarket Market-Channel buyers tend to require a minimum variety of produce (such as different varieties of lettuce or value-added features) as well as a minimum volume, which creates a bias towards larger growers.

Results of technology use analysis

As shown in Tables 5 and 6, there were no statistically significant differences between tomato growers in the different market channels in terms of their technology use, in terms of embodied-technology reflected in the equipment use shown. The explanation for this lack of statistically significant difference in technology use also lies in the structure of the marketing chain. Again, it is key that a grower producing for the Supermarket Market-Channel be able to produce a high quality tomato, but given the importance of classifiers in the activities that qualify the tomato for the Supermarket Market-Channel, it does not turn out to be crucial for the grower to possess these technologies.

Table 5. High and low technology holdings and market channel choice among tomato growers

Variable	Supermarket Channel	Traditional Wholesale	Intermediary
High Technology	100%	80%	79%
Low Technology	0%	20%	21%
Pearson Chi-square test for significance	.678		

Table 6. Specific technology holdings and market channel choice among lettuce growers

Variable (0/1 index, where 0 equals no possession/ access and 1 equals possession)	Supermarket Channel	Traditional Market		P-Value
		Interme-diary	Small Retailer	
Possession of post-harvest equipment	1	.45	.45	.028
Possession of advanced delivery equipment	.55	.08	.06	.000
Access to communications equipment	.75	.58	.21	.028
Possession of value-added equipment	.19	.03	.07	.112

By contrast, Table 7 shows that there are sharp differences in technology use among lettuce growers, over the market channels. Among lettuce growers, 100% of those selling to the Supermarket Channel are in the "high technology group", compared to 69% of the Intermediary Channel growers, and only 38% of the Small Retailer Channel growers. This pattern is as one would expect given the production and post-harvest requirements of the different channels.

Table 7. High and low technology holdings and market channel choice among lettuce growers

Variable	Supermarket Channel	Traditional Market Channel	
		Intermediary	Small Retailer
High Technology	100%	69%	38%
Low Technology	0%	31%	62%
Pearson Chi-square	.026		

Table 8 shows that Supermarket Channel lettuce growers scored ranked significantly higher than any of the Traditional market channel growers in the possession of post-harvest equipment, advanced delivery equipment, access to communications equipment, and value-added equipment. Interestingly, with the exception of access to communications equipment (for which Intermediary Channel growers rated almost three times as high as Small Retail Channel growers), there was little difference, on average, in the different Traditional Market Channel growers' ratings on indices for equipment possession in these categories.

Table 8. Specific technology holdings and market channel choice among lettuce growers

Variable (0/1 index, where 0 equals no possession/ access and 1 equals possession)	Supermarket Channel	Traditional Market		P-Value
		Interme-diary	Small Retailer	
Possession of post-harvest equipment	1	.45	.45	.028
Possession of advanced delivery equipment	.55	.08	.06	.000
Access to communications equipment	.75	.58	.21	.028
Possession of value-added equipment	.19	.03	.07	.112

There are two important implications of these results for tomato growers. First, they point to the key role that intermediaries play in the tomato market channels in facilitating the access of heterogeneous growers to the Supermarket Market-Channel. Second, they point to the importance of the human capital dimension in determining the access of growers to the Supermarket Market-Channel—while there are clear differences in the characteristics of tomato growers producing for the different market channels, these differences are not easily attributable to differences in their technology holdings or size. Instead it is crucial that the tomato growers who participate in the Supermarket Market-Channel be able to produce quality, but the results indicate that the ability to produce quality is more a function of their having skilled labor and specialized educations (i.e. the human capital dimension) than their using specific equipment portfolios. For lettuce growers, however, the situation is very different—like tomato, the human capital element is crucial. Unlike tomato growers, however, lettuce growers need to have access to specific advanced technologies and be of sufficient size to participate effectively in the Supermarket Market-Channel.

6. Conclusions

This paper examined the relationships between growers' choice of market channel (emphasizing the supermarket market-channel versus others), technology use, and grower characteristics such as human capital and farm size. Three key findings emerged. First, both tomato and lettuce growers selling to the supermarket market-channel had more human

capital than those not participating. Second, while farm size was important in whether lettuce growers sell to supermarkets, it was not important for tomato growers. While the latter was expected due to hypothesized economies of size, the latter was surprising until one notes that the role of specialized/dedicated wholesalers is far more important in intermediating tomato growers (as opposed to lettuce growers) access to supermarket channels. The wholesalers thus classify, grade and bulk from many smaller growers and deliver to supermarkets, while in the lettuce channel larger, well-equipped growers deliver that service and sell directly to supermarkets. Third, technology use was significantly more capital-intensive among lettuce growers selling to the supermarket channels, as hypothesized given the product and transaction attributes demanded by the supermarkets. However, that was not the case for tomato growers, except to note the greater importance of greenhouses for quality-seedling production. Again, the explanation lies in the intermediation point noted above.

These results are important to agribusiness researchers and policymakers interested in technology design and research and extension to enable producers to adapt to the needs of changing agrifood markets, with new requirements of attributes of products and transactions, which in turn have implications for technology adoption and human capital investment among growers. This is particularly pressing in places like Brazil where the market for horticultural products is changing fast, conditioned by the rapid rise of supermarkets.

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