This is to certify that the
dissertation entitled

ESSAYS ON SPECIALTY COFFEE PROCUREMENT

presented by

M. LAURA DONNET

has been accepted towards fulfillment
of the requirements for the

Doctoral degree in Agricultural Economics

Dave Weatherson
Major Professor's Signature

8/14/07
Date

ESSAYS ON SPECIALTY COFFEE PROCUREMENT

By
M. Laura Donnet

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

2007

ABSTRACT

ESSAYS ON SPECIALTY COFFEE PROCUREMENT

By

M. Laura Donnet

Specialty coffees distinguish themselves by the quality of the coffee beans from what it is made. The demand for specialty coffees is growing consistent with the general trend in food upgrading (more quality less quantity). Specialty coffees are a differentiated product with complex and variable quality. This poses the challenge of coordinating the supply of premium quality beans with the consequent opportunity of capturing the specialty demand and increasing revenue of supply chain participants. This dissertation studies the coordination of procurement in the supply chain; in particular, product differentiation and valuation and the choice of procurement strategies in three separate papers.

The first paper analyzes the determinants of specialty coffee prices traded at e-auctions by estimating a hedonic price function on 541 coffees from the 'Cup of Excellence'. The analysis tests the hypothesis that specialty coffee prices are determined by both sensory and reputation attributes, as evidence from other specialty products suggests. Results show that specialty coffee prices are influenced by both sensory attributes, capture in the quality rating, and reputation attributes captured by quality rankings, country of origin, coffee variety and quantity available of a coffee lot.

The second paper analyses the economic impact of e-auctions under conditions of uncertainty by comparing the optimal strategies in a benchmark case solely based on relationships to a case in which auctions can be utilized, this paper analyzes the economic impact of auctions under conditions of demand uncertainty. Results indicate that auctions are especially beneficial for smaller roasters and in more uncertain environments. Moreover, auctions greatly aid in the discovery process of new sources of product.

The third paper proposes a 'differentiation measure' for calculating the degree of differentiation vis-à-vis quality ratings at the procurement level of the specialty coffee. The empirical analysis is based on cross-entropy analysis from information economics on 653 observations from the Cup of Excellence and 59 observations from the Q auction. The measure is a proposition to measuring value creation in supply chains.

The dissertation argues that specialty coffee roasters are achieving coordination of supply chains with scope for simultaneously increasing consumers' satisfaction and producers' income. This explicit, high level coordination of the complex coffee supply chain signify a profound change of the management role and the potential benefits to all participants.

ACKNOWLEDGEMENTS

I would like to thank Dr. Weatherspoon for his great job as my dissertation advisor. I appreciate the care and sense of humor that made working and learning most positive and enjoyable. Thanks for stimulating and supporting my ideas and for the training in writing, organizing, communicating and networking.

I am grateful to Allan Schmid for supporting my learning in the broadest sense during these five years and inspiring me to follow my own path. Thank you for fulfilling the major professor duties and making me meet all the program requirements. I am indebted to Dr. Hoehn for encouraging me to do the dissertation on the specialty coffee topic and providing important analyses on e-auctions which are at the core of this work. Also thanks for his help on improving my outlines and narratives.

My gratitude to Dr. Jeitschko for kindly committing to working with me to do research and writing it. I appreciate his confident teachings to develop the specialty procurement model and the paper; his contribution made this dissertation a certainty and favorably impacted my thinking.

I would also like to thank the special support from the following professors: Laura Cheney for an enjoyable and enlightening TA, Dr. Black for his teachings in information class and during RA, Dr. Crawford for his guidance on the program procedures and decisions, and Dr. Peterson for leading my learning on agribusiness and presenting our work at IAMA.

I am grateful to the Department of Agricultural Economics for the assistantship funding and the Graduate School for the Dissertation Completion Fellowship.

Special thanks to Pamela for her support and encouragement during this time and for checking regressions and paragraphs so many times. Tasting the specialty coffees would not have been so amusing without your presence. Specialty thanks to Lourdes for cheering up this dissertation and her motivations and discussions about coffee. Finally, I am grateful to my parents, brothers, Tere and Maria for their constant support and care.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

> "The nature of the international coffee market has changed dramatically over its five centuries of existence. So has control of that market, which moved in the sixteenth century from the producer to the exporter, and to national and international government institutions, and finally today to a few vertically integrated multinational firms. To simply speak of "the market" or "market forces" is to ignore the evolving nature of that market and the role of human agency in creating it. But the central fact continues to be that over 90 percent of all coffee is exported by relatively poor tropical countries and a similar percentage is imported by rich, temperate countries"
>
> (Clarence-Smith and Topik, 2003)

Background and Research Context

This dissertation is about one of the most exciting developments in the food industry in modern times. New ways of consuming coffee that focus on quality, differentiation and value-adding attributes have created a specialty coffee market segment that has grown dramatically since its formative years in the 1980s (Roseberry, 1996; Ponte, 2001). Specialty coffee is a growing market segment in an otherwise declining industry. The tremendous growth of this differentiated industry requires the full incorporation and improvement of producers in a highly demanding and coordinated supply chain. Coordination is crucial between coffee producers and roasters since "specialty coffee distinguishes itself first and foremost by the quality of the raw material" (Knox and Huffaker, 1997). The focus of this dissertation is on the procurement strategies that are unique to specialty coffee, in particular e-auctions and supply relationships.

The specialty food industry has placed coffee together with other differentiated food products including wines, beers, and cheeses, among others. One major difference with these food products, however, is that specialty coffee is the result of global supply chains in which consumers are largely located in the US, Europe and Japan and producers in

poor agriculturally-based developing countries. The consistent supply of premium quality coffee beans from its origin in coffee growing countries is crucial to sustaining the specialty coffee chains. Simultaneously, the impact on rural poverty in developing countries is not well understood. This represents a challenge to traditional producers who were used to selling to intermediaries in anonymous commodity supply chains. At the same time, this also represents a unique opportunity to show that the intrinsic quality and value of specialty coffees are created at the production level in the growing countries.

Specialty coffee entails the need for trade and procurement strategies different from the mainstream supply chains that deliver regular coffee[1]. Mainstream coffee supply chains are characterized by a large number of intermediaries and a system of market relations that give greater market power to the import side than to the export side resulting in a proportionally greater share of total export earnings accruing to importing companies (United Nations, 2003). In the commodity coffee, the grading of coffee beans is the basic measure of value. The mainstream coffee trade is organized around a grading hierarchy according to type (Arabica or Robusta), primary processing (wet or dry), country of origin, and grade (Ponte, 2001). However, beans that are relatively uniform in appearance would be graded into the same category, the problem is that the beans can vary significantly in the cup (Bates, 1997). In addition, most defects regarding appearance of the beans generally have little impact on cup quality (Barker, 2004). Because of the

---

[1] 'Mainstream' –supply chains and markets– is used in the global value chain literature to refer to the prevailing arrangements by which coffee is produced, traded and consume. 'Regular' coffee is the blended and homogeneous product appealing to a standardized taste of the mass consumer.

inability of buyers to assess quality, commodity traders offer prices that reflect the expected quality of the crop; the result is a weakening of the incentives to incur the costs of producing premium quality coffee by devoting above average resources to its production (Bates, 1997).

In contrast to the mainstream industry, the assessment of the quality attributes in the cup, acidity, body and flavor, is of foremost importance in the specialty industry. Specialty coffee buyers evaluate quality in the cup, transmit quality information to producers and remunerate them according to quality. This is a breakthrough in the transaction of green coffee beans and the basic idea of procurement strategies in specialty coffee. There are two specific systems or procurement strategies unique to specialty coffee: relationships and e-auctions. Both relationship and e-auction coffees– "strive to achieve a market-based system that allows the transmission of quality information to the source, and therefore a payment in relation to quality. They are market-based systems, as opposed to certification systems, such as the organic and fair trade, because quality "stands on its own" and is assessed directly by the buyer who remunerates according to this evaluation (Ponte 2002).

Research Goals, Gap and Relevance

The goal of this dissertation is to examine the procurement approaches that are distinctive to specialty coffee supply chains and their valuations, incentive and strategic properties and implications. These procurement approaches are relationships and e-auctions and their characteristic is that they transmit quality information and remunerate according to it. In this sense, these procurement approaches represent a breakthrough in coffee trading and represent a relevant alternative to traditional procurement. This is important because

failure to distinguish and remunerate high value and differentiation at the specialty coffee production level constrains the capacity of coffee producers to make the necessary investments to maintain and enhance quality. Consequently there is a risk of the supply chain collapsing due to an ever declining quality. In addition, innovations at the producer level are improbable since risk taking is not rewarded. Without continual reinvestment, coffee producers miss the growth opportunity from the value creation in differentiated supply chains. All of these imply that in the medium to long run there is a decline in producers' income and increasing rural poverty.

Previous research has addressed the opportunity to increase coffee producers' income from the differentiation in specialty coffee from the political economy perspective of value chain analysis[2]. Kaplinsky and Fitter (2004) argue that coffee producers' prices and income is increased from the systematic application of knowledge at all stages of the supply chain to create value and competitive advantage. Lewin et al (2004) discuss possible ways in which some coffee producers can take advantage of specialty markets to increase their income. They point to the difficulties of small producers to access specialty markets and maintaining and improving quality according to the changing characteristics of specialty coffee markets. Fitter and Kaplinsky (2001) outline the fact that the capacity to meet increasingly complex demands from consumers and buyers in coffee does not necessarily mean that the returns to differentiation accrue to poor producers.

---

[2] Global value chain analysis is a framework that highlights the relative value of the activities required to bring a product or service from conception through the different phases of production, delivery to final customers and final disposal after use, to analyze underlying factors that affect governance, employment generation and growth capacity, etc..

Oberhänsli (2001) argues that the possibility of producers capturing price differentials will depend on consumers recognizing valuable characteristics produced at the green coffee production level. Also, Kaplinsky and Fitter (2004) detail the importance of erecting barriers to entry at the production level to sustain competitive advantage in the highly competitive environment of specialty coffee production. These political economy studies discuss the macro context and governance of supply chains and firms operating in them but do not go into detail of how to interpret increased information flows, how coffee producers create value or what other strategic decisions they can make to sustain value and income. Studies at the micro and case study level, Bacon (2005) discusses the impact of premium prices paid to organic and fair-trade certified cooperatives on coffee producers' livelihoods. The author also discusses the perceived benefits by producers on this alternative trade networks in relation to the reduction of production costs, diversification of marketing channels, learning processes and relationship networks.

Methodology

This dissertation examines the developments in specialty coffee from the active point of view of supply chain participants to create value for the industry through differentiation (paper 1), procurement management (paper 2) and the making and use of quality evaluation procedures (paper 3). Our primary analysis is at the roasters' level because they are the captains of the specialty coffee supply chains; they link the dynamic consumers' market with the technologically, informationally, managerially and geographically challenged coffee producers. The supply chain depicted in Figure 1 shows the economic stages and as well as the players that deliver the coffee product to the final

consumers. The focus of this dissertation is on the transaction between coffee producers and roasters in the supply chains that deliver a specialty coffee product.

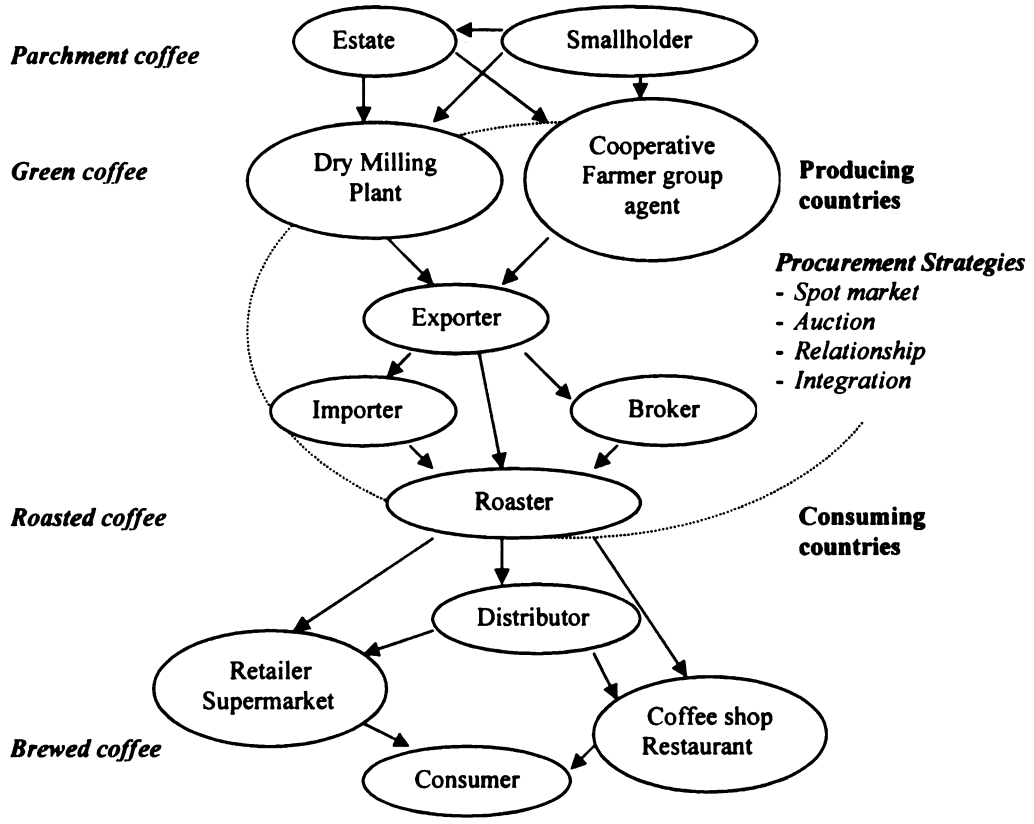

Figure 1: The Coffee Supply Chain. Source: Adapted from (Ponte, 2001)

The background information for the dissertation comes from industry literature, communication with industry participants and academic literature. The industry literature includes trade journals and magazines, publications of the Specialty Coffee Association of America (SCAA) and publications and websites of specialty coffee roasters. Most of the industry contacts that provided information on the specialty coffee chains were the Cup of Excellence and the Q auctions which were contacted at the SCAA Annual Meeting in Charlotte, North Carolina, 2006. Informally talking with industry participants

has been of foremost importance to learning about the most important facts, making sense of the information and developing a more rounded idea of the industry. Specific information obtained through this source is appropriately cited throughout the dissertation. The academic literature used mainly pertains to the field of global value chains (Ponte, Daviron, Gereffi, Lewis and others).

This dissertation uses theory and methods germane to economics and management. The first paper is conceptually framed in the determinants of price in specialty food products. The method is hedonic price analysis applied to a data set of 541 specialty coffees from the Cup of Excellence. The second paper uses organizational economics to frame the choice of procurement strategies based on supply relationships and e-auctions. The theoretical modeling relies on a newsvendor approach adapted to the profit maximization function of specialty coffee roasters. The third paper relates to the strategic management concepts of differentiation and economic concept of quality evaluation to proposes a 'differentiation measure' for calculating the degree of differentiation vis-à-vis quality ratings at the procurement level of the specialty coffee. The empirical analysis is based on cross-entropy analysis from information economics. The data contains 653 observations from the Cup of Excellence and 59 observations from the Q auction.

Contributions of this Dissertation

This dissertation offers an analysis of specialty coffee procurement from the point of view of economics and management. In this sense it offers an additional point of view to previous analysis for example in the fields of sociology and anthropology (see for example, Roseberry, 1996; Mathieu, 1999; Samper, 2003) and political economy (see for example Kaplinsky and Fitter, 2004; Daviron and Ponte, 2005). The dissertation provides

conceptual and analytical frameworks and evidence to understand specialty coffee in the context of specialty food products, procurement strategies and value adding in the supply chain.

The novelty of the topic in the economics and management disciplines has the advantage that one can utilize tools developed in other areas and products to our case. This is the case of the hedonic analysis that we apply to specialty coffee for the first time in paper 1. The contribution of the hedonic study of specialty coffee prices is that it provides evidence to support that the price of specialty coffees is not only related to the product material quality (sensory attributes) but also to the product symbolic quality (reputation attributes). The study complements the analyses of other specialty food products, especially wine. The idea of marginal prices of attributes is important for supply chain participants to make better decisions regarding marketing possibilities and resource allocation.

The contribution of this dissertation is however not limited to applying developed tools to new products and data set. A unique contribution of this dissertation is the 'original adaptation' of a modeling and an econometric approach in papers 2 and 3 respectively. The first is an adaptation of the classical newsvendor approach to the analysis of procurement strategies in specialty coffee. The original contribution is that it proposes a theoretical model of evaluation of the trade-offs and complementarities among procurement strategies in specialty coffee. Another interesting feature of the study is that it covers a common ground for strategic and management operations with the broader economic organizational forms. The outlook is that similar and additional problems can

be addressed in an analogous way. An application is that the theoretical model can be put to work empirically with firm data and provide direct assistance to management.

The originality of the 'differentiation measure' is the adaptation of an approach from the field of information economics and income inequality to measures product differentiation for which there are no previous measurements as such. The differentiation measure provides an addition to the field of price analysis, e.g. different from the hedonic analysis. The measure is a proposition to measuring value creation in supply chains. It could be further applied for other food products and provide for comparative analysis between different marketing channels within an industry and between industries.

Organization of the Dissertation

The dissertation consists of an introduction, three independent papers and a conclusion. The introduction provides the motivation, questions, the methodology and contributions of this research. The central body includes the three papers that are intended to stand alone individually. Research extensions and conclusions offer a final thought on this work. The appendix contains background material on: A. the coffee supply chain, B. the emergence, and C. The definition of specialty coffee. Appendix D shows detailed derivation of the specialty coffee procurement model.

PRICE DETERMINANTS IN TOP QUALITY E-AUCTIONED SPECIALTY COFFEES

Introduction

The specialty coffee industry experienced an explosive growth in the 1990s driven by the roasters and retailers' investments in product innovation and market segmentation, hence increasing value added in the coffee supply chain (Ponte, 2001; Lee, 2006). The US specialty coffee market has grown from $1 billion in 1990 to $11 billion in 2006, according to the Specialty Coffee Association of America (SCAA), the National Coffee Association (NCA) and Mintel group industry reports (Hillside Agricultural Program, 2002; California Libraries Association Conference, 2005; Lee, 2006). The only operational definition for specialty coffee is, those "made from exceptional beans grown only in ideal coffee-producing climates; they tend to feature distinctive flavors, which are shaped by the unique characteristics of the soil that produces them" (SCAA, 2007)[3]. Traditionally, expert tasters, usually the buyers and/or roastmasters of coffee firms, define the quality that determines whether a coffee fits into the specialty category or not.[4] As an industry, there is an attempt to encode information about these subjective gustation experiences into 'certified' quality systems (Ponte and Gibbon, 2005), such as the coffee

---

[3] This definition emphasizes that specialty coffee stands for an outstanding cup quality and does not include classifications which refer to 'immaterial' or 'credence' attributes such as organic, fair-trade, and bird-friendly. This definition for specialty coffee is the one being increasingly accepted in the industry.

[4] "Like an excellent chef or wine maker, such people typically apprentice for many years with more experienced tasters, gradually developing a taste memory and sense of the range of qualities that can be expected by tasting hundreds of samples from each major origin country over many crop cycles, at many degrees of roast, singly and in combination with other coffees" (Knox, 2006).

standards by the SCAA, the Cup of Excellence cupping form, and the quality rating in the Coffee Review. The prices paid according to this quality information by specialty coffee buyers to growers are the crucial element of supply chain coordination in these market-based supply chains (Ponte, 2002).

Coffee is a product that lends itself to differentiation. There is a wide diversity of flavors and aromas that emerge from different coffee growing soils and climates, tree varieties, and cultivation and processing methods, all of which impact quality. The natural variation of coffee places it in a widening spectrum of differentiated food products which include wines, beers, and cheeses among others (Roseberry, 1996). Measuring quality of specialty food products is complex as they need to be 'looked and felt' (de Figueiredo, 2000). Complexity arises from the variability of the sensory experience from person to person (quality is subjective) and from product to product (specialty products are different from one another). The practice to assess coffee quality in the specialty industry is the cupping. Analogous to wine tasting, cupping is the sensing of aromas, flavors and body through olfaction, gustation and mouthfeel, respectively (Lingle, 2001). The specialty coffee industry has operationalized quality assessment through the convention of a cupping form that rates coffees with 100 point scale.

Price discovery is even more complex given that quality is subjectively determined. Prices of specialty food products depend on both sensory as well as reputation attributes (de Figueiredo, 2000). Complexity in appraising sensory quality characterizes a situation of imperfect information in which reputations provide extra information to supply chain participants to ascertain the value of the product (Nelson, 1970; Kreps and Wilson, 1982; Shapiro, 1983; de Figueiredo, 2000; Carriquiry and Babcock, 2004). Reputation quality is

the recognition awarded to the names of specific farms, origins and conditions and methods of production known to consistently produce coffee with desirable attributes (Samper, 2003). Similar to the concept of terroir in wine production, high quality coffees can be produced only in certain places. There are origins that have proven their ability to grow great coffees due to altitude, latitude, soil and other conditions while other origins have not demonstrated such ability (Holly, 2005). For example, Colombian (as well as Guatemalan, Costa Rican, and Kenyan) coffees earned longstanding reputations for producing high quality coffee (Samper, 2003).[5] Moreover, similar to grapes, the genetic strain of the coffee plant and its unique adaptation to the environment profoundly influence the character of the coffee cup (Arvidson, 2003; Davids, 2004). Specialty coffees are usually obtained from several varieties of *Coffea arabica*: the traditional cultivars of Typica and Bourbon, the more recent Catuai variety and the heirloom Pacamara are outstanding producers of specialty coffees[6,7]. Growing methods also impact quality, fertilization, harvest and processing practices affect the characteristics in the coffee beans (Samper, 2003). Therefore, origin and the individual conditions of altitude, soils and climate, the variety of the coffee plant and the cultivation methods constitute potential reputation attributes. This paper examines the market values of specialty coffee attributes, especially those associated with the sensory evaluations of

---

[5] The international classification system has remunerated this reputation by separating Colombian Mild Arabicas are distinguished from Other Mild Arabicas.

[6] Presentation at the SCAA 17th Annual Conference and Exhibition, panel 'Exploring Distinctive Characteristics and Virtues of Coffee Varietals: the Bourbon and Pacamara case.'

[7] Holly (2005) Specialty Coffee Definition.

specialty coffee buyers and production reputations of coffees traded in top quality e-auctions. Although the volume traded at e-auctions is still very small, the coordination based on the remuneration of quality attributes is of great importance for developing the top quality segment of the industry. Moreover, the value associated with distinguishing among coffee groups becomes important for the whole industry as it continues to move from a commodity to a differentiated beverage.

We hypothesize that specialty coffee prices are influenced by both sensory and reputation attributes since specialty coffee is a highly differentiated specialty food product. We expect quality ratings from the sensory evaluation of coffees in the cupping competitions to have a significant impact on prices, particularly, since the specialty coffee market is in the early stage of its life cycle, in which the taste experts at the cupping competitions have a crucial role in defining sensory quality. Despite the exhaustive procedure for measuring quality developed by the specialty industry, our conjecture is that prices are not a function of this measure alone but that preferences supported by reputations are likely to be observed in their bidding behavior. This observation was made by Boccaletti (1999) for food products with designation of origin, where he argued that for reputations to work as a quality signal, buyers should have developed skills in inferring the –sensory– attributes associated with these reputations. Moreover, since specialty coffee buyers are interested in passing quality information on to the consumer, they are likely to value the communication capacity of reputations for use in their marketing strategies.

Understanding what determines the price of specialty coffees is crucial to developing a sustainable supply base for the specialty coffee industry and to pass the benefits of growth on to the growers. On the one hand, what buyers pay for the beans informs

growers about the consumers' quality preferences so they can direct production practices towards obtaining the desired attributes. On the other hand, the transmission of price to consumers informs them about the resources involved in producing the attributes they desire. Contrary to the mainstream coffee markets, in which roasters disclose as little information on quality as possible to growers and consumers, the original configuration of the specialty coffee industry was based on transparency, where consumers and roasters engaged in a mutual definition and redefinition of quality and remuneration accordingly (Ponte and Gibbon, 2005; Daviron and Ponte, 2005). Thus, specialty supply chains (Lewin et al., 2004) are seen as a possible way to increase the income of some coffee growers. The possibility of growers capturing the price differentials depends on consumers recognizing the link between desired traits and their underlying determinants at the production level (Institute of Development Studies, 2001).

The paper proceeds with a review of the literature on hedonic price models and their application to specialty foods such as wines. Next, we describe the specialty coffee e-auctions. Then we present our empirical specialty coffee hedonic price model, followed by the presentation and discussion of the results. In the final section we recap what has been learned and address limitations and further research.

Hedonic Approach and Applications to Specialty Food Products

An approach to studying the relationship between prices and quality attributes is the hedonic analysis of prices. The analysis consists of modeling the price of individual products as a function of various attributes that can be encountered in them in order to estimate the implicit or marginal prices of such attributes. If the estimated implicit price is not significantly different from zero, then the attribute is not valued by consumers.

Possibly, the earliest reference to this approach is Waugh (1928). Waugh analyzed individual prices of asparagus, tomatoes and cucumbers using their physical attributes such as color, size of stalks, shapes, maturity, uniformity, and similar factors in order to determine consumers' marginal valuations of these attributes. The quality attributes analyzed by Waugh were all sensory. He viewed this type of analysis as of great practical value for growers to adjust production to the market demand.

Later, the approach advanced from developments in demand theory for quality attributes and the statistical methods applied to the hedonic regression. In 1966, Lancaster presented a theory of consumer utility based on preferences with respect to characteristics rather than with respect to goods. This approach allowed goods to be viewed as a bundle of characteristics desired by consumers. In 1974, Rosen presented a model of product differentiation based on the hedonic prices of attributes empirically estimated as the relationship between the observed prices of products and the specific amounts of individual attributes associated with them. Hedonic price functions relate to both the underlying supply costs and the underlying demand preferences for individual attributes and hence they do not identify the structure of either (ibid.). Hence, a significant and large implicit price may not reflect consumers' high valuation of an attribute, but rather a high cost incurred in producing that attribute. However, if the supplied quantity was exogenously determined, the regression of price on quantity may be used to estimate the demand elasticity (Schultz, 1938).

Great advances have been made in the application of hedonic price functions to specialty products such as en the case of wine. Hedonic price analysis has been extensively applied to determine the attributes that significantly influence prices in wine. In an early study,

Oczkowski (1994) argued that it is important to understand implicit prices of attributes because of their marketing implications, they help: producers to evaluate the implementation of practices leading to attaining a particular attribute; and consumers to evaluate their wine purchases relative to average values of attributes made available through wine guides or newspapers (ibid.). The author further illustrates with an Australian wine example, he found that quality rating, cellaring potential, grape variety, region, vintage, and producer size determined price.

In subsequent papers, authors generally distinguished among sensory, chemical, objective, and climatic attributes. Sensory attributes were subjectively assessed measures like 'aromatic intensity', 'aromatic complexity' and 'finish'; chemical attributes were technical measures, such as sugar and acid levels; objective attributes were those that appeared on the bottle label and easily recognizable by the consumer, including grape variety, origin, vintage year, rankings, and climatic attributes; and climatic were those which measure the effects of weather on the grapes used in wine production (Oczkowski, 2001). Most studies indicated that objective attributes, which consumers can identify far easier than sensory attributes, were the most influential. The general finding was that sensory attributes influence the quality assessments of experts but because they were less evident to consumers, had little to no influence on price (Troncoso and Aguirre, 2006).

Combris et al. (1997) found that Bordeaux wine prices were largely determined by the variables appearing on the bottle label, including color, vintage, and appellation of origin, but not by sensory variables. The authors provided an explanation in terms of imperfect information; consumers can more easily assess objective attributes compared to sensory attributes, hence their purchasing decision was influenced by the former. Lecocq and

Visser (2003) also found for Bordeaux and Burgundy wines that the objective attributes appearing on the bottle label, ranking, vintage and appellation, were largely responsible for determining wine prices while sensory attributes had a small influence.

Some studies found quality ranking to have the most influence in determining price. Landon and Smith (1997) highlighted the important role the wine classification system (cru, grand cru, and premier cru) played in Bordeaux wines. Combris et al. (2000) also found that the most influential attributes for Burgundy prices were the ranking of grand cru, premier cru, communale and regionale, and the vintage (year of bottling).

Some studies concentrate on the impact of wine experts' reviews on the prices paid by consumers. Wine reviewers rate wines using a 100 point scale and describe their gustatory experiences which they make available to consumers in wine guides and magazines as well as in non-specialized publications. Schamel and Anderson (2003) found that the magazine for premium wines from Australia and New Zealand, "James Halliday", was highly significant on determining wine prices. Ali et al., (2005) analyzed the impact of the renowned wine critic Robert Parker on Bordeaux *primeur* wine prices, i.e. the prices determined by the winery owners when the wines are still very young. The authors compared Bordeaux wines which prices have been established with and without knowing the Parker grade. They found that, on average, the impact of the expert valuation was 2.80 euros per bottle of wine. Specialty coffee buyers, unlike consumers, are themselves coffee experts who use their skill to offer coffees with a unique taste (Knox, 2006). Thus, the quality rating in hedonic wine studies measures the impact of experts' opinion on prices whereas in this coffee study, the quality rating is the variable that measures the coffee sensory quality.

Combris et al. (2000) provide two types of arguments to explain why quality grading by experts was not an irrefutable measure of quality. The first view was that tastes converge to a consistent quality measure as long as there were a sufficiently large number of juries, in which case, the grading would also be an 'objective' quality indicator. Quality measures that do not reach an irrefutable measure of quality do so because they do not have enough graders. In contrary, the second view states that tastes were irreducible, so grades represent a compromise between different opinions which are not representative of the actual subsets of preferences and hence their weakness. However, this does not mean that there was a conflict between the two sets of variables, sensory (those describing the taste experience) and objective (those appearing on the bottle). Objective attributes boost prices by highlighting some of the effects of sensory variables (Combris et al., 2000). Lecocq and Visser (2003) argued that the debate on how much weight should be placed on the importance of sensory versus reputation results in a 'puzzle' for pricing specialty food products.

With respect to the origin, Landon and Smith (1997) also highlighted the influence of the origin, which they considered a collective reputation variable. The authors argued that consumers form their predictions of the quality of an individual firm by using information on the quality of similar firms. Troncoso and Aguirre (2006) found that valley of origin was the most important price determinants of Chilean wines in the US market, along with grape variety. From those results, they stated that the most important management decision in wine production was the choice of alternative vineyard locations and varieties at the moment of planting.

In this paper, we draw on the previous wine studies to identify and construct explanatory variables for coffee prices. From the wine studies we have the concept that specialty coffee prices may be influenced by attributes analogous to wine experts' quality ratings and rankings, regions, and wine varieties. We also draw on the wine hedonic studies to interpret the implicit prices of attributes and infer implications on the supply chain participants. Although the cases of wine and specialty coffee are analogous in many ways, there are some differences that need to be taken into account. The most important difference is that while wine studies use retail price data and information on attributes from wine reviews and consumers' guides, the data set for this paper is from a competition-auction at the processing (roasting) level in the supply chain. We perform our analysis at the processing level because roasters are leading the definition of quality and the education about specialty coffee attributes. As specialty roasters preserve the identity of the grower in their marketing strategies and consumers become more educated about the origin characteristics, we can expect to be able to analyze the preferences for attributes at the consumers' level.

E-Auctions of Specialty Coffee

E-auctions are a quality competition-auction process in which the highest quality coffees are selected at a national level and then sold through internet auctions (Ponte, 2002). In this paper we analyze data from the Cup of Excellence specialty coffee competition and auction. The CofE ran the first specialty coffee auction in 1999 as part of the Gourmet Project (funded by the International Coffee Organization, the International Trade Centre and the UN Common Fund for Commodities) and continues to be organized by the Alliance for Coffee Excellence (ACE). Since then, trade has been increasing at the CofE

and the prices formed at the auctions have significantly influenced the structure of the specialty coffee market (United Nations, 2003). As the appreciation of and remuneration for quality increases, not only at e-auctions but also in private trade and supply relationships, the relevance of this type of auctions as a price discovery and reference system for the specialty coffee market becomes more important.[8]

The CofE schedule is organized to following the coffee harvest in the participating countries (Figure 2). This corresponds to once a year in the case of Bolivia, Brazil, El Salvador, Honduras and Nicaragua, and twice a year in the case of Colombia. Coffee growers submit samples of their coffee lots that are prepared and codified for participating in the cupping competition. The competition consists of three stages: a pre-screening stage to pre-select the best of all entries and two cupping stages where national and international jurors successively evaluate the pre-selected coffees using the CofE cupping form. The categories included on the form are: absence of defects, cleanness of cup, sweetness, acidity, mouthfeel, flavor, aftertaste and balance (Howell, 2005). The assessment on each of the categories is added to yield a final score or quality rating. The juries' individual assessments are averaged to give one final quality rating for each

[8] Auctions have the role of providing a way for market participants to obtain approximately the market value for the items being traded (Ashenfelter, 1989).

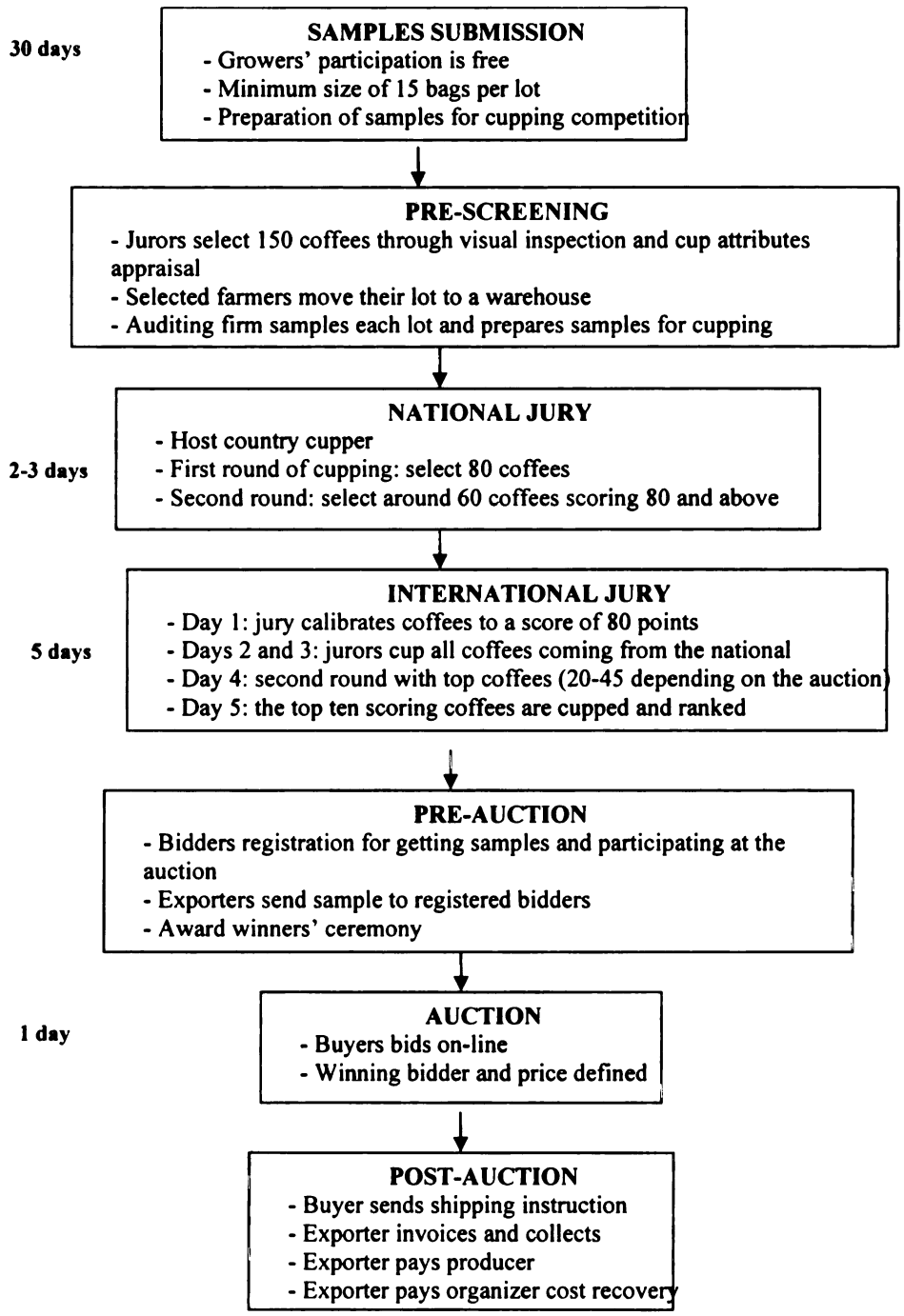

Figure 2: CofE Auction Schedule. Source: own elaboration.

coffee. The coffees are ranked according to the quality rating and the final winners are awarded the Cup of Excellence. Immediately following the competition, all information

is gathered on the coffees and growers and is made available to the potential buyers (Table 1). In addition, samples of the coffee lots are shipped to potential buyers for them to cup personally. During the auction, the lot numbers are displayed on the auction website. The bidding is ascending and bids are shown to all participants. Buyers can see their bids on the screen or can check later via e-mail how their bids compare with those of other bidders (United Nations, 2003). After the winning bid is determined, the auction manager facilitates the arrangements for payment and delivery.

Table 1: Example of Coffee and Grower Information Available to Potential Bidders of the CofE

Coffee Characteristics		Property Characteristics	
Variety:	Typica	Farm:	Agricabv BV Calama Marka
Processing System:	Pulped, naturally fermented, mechanically washed, sun drying	Farmer:	Juan de Dios Blanco
Lot Size:	16 bags	Rank:	1
International Jury Score:	93.52	City:	Calama
		Region:	Calama
		Country:	Bolivia
		Farm Size:	11.00 Hectares
		Coffee growing area:	4.50 Hectares
		Altitude:	1200 masl
Jury Descriptions:	Orange honeysuckle fragrance, lemony tang, chocolate orange, improved as it cooled, deep dark chocolate, sweet floral and cherry blossom, complex, rich and delicate at the same time, sweet citric, very clean, great balance, caramel, butterscotch flavor	Certification:	None

Source: 2005 Bolivia Cup of Excellence® Winning Farms - Auction December 1, 2005

The CofE provides a unique data source on –sensory– quality rewarding coffee trade. The information on specialty coffee prices would not exist without these public specialty coffee auctions. The majority of specialty coffee roasters market coffees of the highest quality by procuring beans from the Cup of Excellence and offer CofE coffees in their

assortment. The CofE is where leading specialty coffee firms discover new qualities and new values of specialty coffees thus increasing product and price differentiation. Differentiation is possible because the quality information is disclosed to many prospective buyers who show their valuations thus increasing transparency not only for other buyers but also for growers and consumers. The price discovery at these auctions can be a benchmark for private transactions outside the auction system, which is the case of coffees traded within direct supply relationships[9].

The annual trade volume at the CofE is very small relative to the volume traded in the commodity and other supply chains including Starbucks and the organic and fair-trade certifications (Table 2). However, comparing the CofE to any of these supply chains is misleading since they are essentially different products, which can be readily seen from the price differences with respect to the other supply chains. The coffees traded at the CofE are representative of the 'truly' specialty coffee market in the sense of the SCAA definition and the results apply to the highest quality segments of specialty. As the broader coffee market moves towards differentiation and appreciation of individual attributes, we deduce that our study has relevance for future research on price coordination in the coffee supply chain.

---

[9] Direct relationships are another trade system based on coffee quality in which roasters build long-term relations with growers, directly transmitting quality and price information; many relationships are formed following the auction between participant roasters and growers.

Table 2: Comparison of Coffee Supply Chains: Volume and Prices of Dry Coffee Beans in 2005

Supply chain	Coffee	Volume (bags)	Price ($/lb)
Commodity coffee[1]	Brazilian and Other Naturals Group	27 million	1.0229
	Colombian Mild Arabicas Group	11 million	1.1573
	Other Mild Arabicas Group	20 million	1.1486
Certifications	Fair trade	2.2 million[2]	1.26[3]
	Rain Forest Alliance	0.71 million[2]	no minimum
	Utz Kapeh	1.5 million[2]	no minimum
	Organic	1.5 million	no minimum
Starbucks	CAFE Practices	581,818[4]	1.28[5]
Internet auctions	Q auction	9,083[6]	1.42[6]
	Cup of Excellence	4,060[6]	4.128[6]

[1]Monthly averages of ICO Indicator prices for Other Mild Arabicas Group.
[2]Ganes-Chase, Judith. Presentation at the SCAA 17th Annual Conference and Exhibition, panel "State of the Industry Report: Global Supply and Demand Outlook".
[3]Fair Trade minimum price. Fair trade website. Coffee. http://www.fairtrade.net/coffee.html
[4]Starbucks 2005 annual report.
[5]Starbucks press release.
[6]Average 2005 auctions: Q (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua) and Cup of Excellence (Bolivia, Brazil, Colombia, El Salvador, Honduras, Nicaragua)

Specialty Coffee Hedonic Model

Following the hedonic approach, we propose that the price paid by buyers is a function of the information that is available to them when submitting their bids. Thus, the price of the *i*-th specialty coffee is a function of the value the buyer attaches to its attributes Z_{ij} (j=1,...,m), i.e. both sensory and reputation attributes according to our hypothesis. Thus, the hedonic regression for specialty coffee has the following form:

$f(P_i) = \beta_0 + \Sigma_j f(Z_{ij})\,\beta_{ij} + \Sigma_j f(Z_{iw})\,\beta_{iw} + \varepsilon_i$

where $i=1,\ldots,n$ are the observed specialty coffees, P_i is the price of the i-th coffee, Z_j are the j-th variables representing sensory attributes and Z_w are the w-th variables representing reputation attributes and ε_i is an independently distributed error term with mean 0 and variance σ^2. The functional form will be tested not imposed, hence $f(P_i)$ is either the identity function $f(P_i) \equiv P_i$ or the natural logarithm function $f(P_i) \equiv \ln P_i$. Similarly, $f(Z_{ij})$ and $f(Z_{iw})$ are the identity function, the logarithm function or a dummy variable which takes on the value 1 if the characteristic j is present for the i-th observation or 0 otherwise. We use a Box-Cox test for guidance to determine which variables need to be transformed for appropriateness of the functional form. We test for joint significance of dummy variables and then estimate the hedonic regression using ordinary least squares (OLS) robust estimation. The estimated β_j are the implicit prices for the attributes.

Data

Our data set includes 541 observations from 21 CofE e-auctions. The purchase prices for specialty coffee range from \$1.20 to \$49.75 with an average of approximately \$4 per pound. The sensory and reputation explanatory variables are the information on the coffee lots and the production characteristics available to potential bidders from the CofE website which includes one sensory variable, 1) the quality rating in a 100 point scale; the following reputation variables: 2) quality ranking, a dummy variable indicating if the coffee came in the first, second, third, fourth or lower than forth place in the competition; 3) country of origin, a dummy variable indicating whether the coffee is from Bolivia,

Brazil, Colombia, El Salvador, Honduras or Nicaragua; 4) coffee tree variety, a dummy variable indicating Bourbon, Catuai, Caturra, Pacamara, Typica or Other variety; 5) available quantity of coffee, the size of the coffee lot in bags; and two macro variables: 6) competition year, a dummy variable indicating 2003, 2004, 2005 and 2006; and 7) the price of commodity coffee, the monthly averages of the International Coffee Organization (ICO) for the corresponding auction month and coffee groups[10]. All of these variables are exogenous and available to buyers prior to the auction bidding.

Table 3 shows the summary statistics of the variables in the specialty coffee hedonic model. The quality rating ranges from 80 to 96 with an average of 86.70. The reputation variables include the quality ranking, the country of origin, and the tree variety. Since buyers get to cup the coffee first hand from the samples submitted by the auction and are taste experts, we take the quality rating given by the competition panel of juries as a proxy for the buyer's individual assessment of the coffee sensory quality. The quality ranking is constructed by ranking the coffees from first to last according to their quality rating and it captures the relative placing of a coffee within the competition. Thus, the ranking captures the impact of the assessment of the panel of experts on the coffees. Country of origin and variety serve to characterize the market status of coffees in terms of a relative differentiation within the specialty coffee sector much in the same way as in the wine industry, e.g. Bordeaux versus Burgundy or Merlot versus Cabernet. The size of the coffee lot is the number of bags that are sold together, indicating the total availability of a particular coffee. Year indicates to which harvest the coffee belongs. Commodity

---

[10] Brazilian Natural Arabicas for Brazil, Colombian Mild Arabicas for Colombia, and Other Mild Arabicas for Bolivia, El Salvador, Honduras and Nicaragua.

prices provide a benchmark from which to obtain a specialty premium relative to commodity coffee.

Table 3: Descriptive Statistics CofE E-Auctions: N=541

Variable		Mean/ Frequency	Std. Dev.	Min	Max
Dependent Variable					
Price	$/lb	3.97	3.15	1.2	49.8
Sensory Variable					
Quality Rating	score	86.70	2.80	80.3	95.9
Reputation Variables					
Quality Rankings					
	First	0.04	0.18	0	1
	Second	0.04	0.18	0	1
	Third	0.04	0.18	0	1
	Fourth	0.04	0.18	0	1
	Lower	0.86	0.35	0	1
Countries					
	Bolivia	0.06	0.24	0	1
	Brazil	0.19	0.40	0	1
	Colombia	0.15	0.36	0	1
	El Salvador	0.20	0.40	0	1
	Honduras	0.17	0.38	0	1
	Nicaragua	0.23	0.42	0	1
Varieties					
	Bourbon	0.25	0.43	0	1
	Catuai	0.19	0.39	0	1
	Caturra	0.38	0.49	0	1
	Typica	0.08	0.27	0	1
	Pacamara	0.06	0.23	0	1
Quantity	Bags	21.25	10.98	9.0	122
Macro Variables					
Commodity Price	$/lb	0.94	0.24	0.6	1.4
Harvest Years					
	2003	0.21	0.40	0	1
	2004	0.23	0.42	0	1
	2005	0.37	0.48	0	1
	2006	0.19	0.39	0	1

Functional Form

Since the results of the hedonic approach often depend critically on the functional form, we follow Rodríguez (2002). We first use the Box-Cox procedure to give guidance on

which functional form describes the hedonic relationship between price and the continuous explanatory variables more appropriately. Then, we estimate the functional forms suggested by the Box-Cox results with ordinary least squares (OLS). Lastly, we select the most appropriate functional form according to the performance of the estimation. From the Box-Cox test results we reject the linear form and find no evidence to reject the log-linear and log-log specifications (Table 4). Since both functional forms yield very similar estimates. We are selecting among the acceptable functional forms. We follow Halvorson and Pollakowski's recommendation[11] and choose the log-linear form for quality rating and the log-log form for quantity and commodity price for more meaningful interpretation of their units.

Table 4: Box-Cox Test of Functional Form for the Specialty Coffee Hedonic Price Model

Box-Cox test[1]	**Functional form**	
Variables to apply functional form	**Identity**[2]	**Log**[3]
	707.83	1.08
Left Hand Side Only	(0.000)	(0.298)
Both Left and Right Hand Side (same coefficient)		
	707.52	1.15
Quality rating	(0.000)	(0.284)
	703.31	0.98
Commodity price	(0.000)	(0.322)
	735.41	1.85
Lot size	(0.000)	(0.174)
	731.03	1.79
Commodity price and lot size	(0.000)	(0.181)

[1] X^2 test statistic of the lambda coefficient in the functions $f(P)=P^{\lambda}$ and $f(Z)=Z^{\lambda}$
p-values in parentheses, N=541
[2] Ho: lambda = 1, or no transformation
[3] Ho: lambda = 0, or log transformation

[11] To resort to theoretical grounds if possible or to convenience in dealing with the problem at hand.

Explanatory variables

We follow a Chow procedure to test the joint significance of the groups of explanatory variables: quality rankings, harvest years, countries of origin, and varieties. From the test results we find that all groups are jointly significant at the 1% level of statistical significance (Table 5). Thus, we are able to confirm that the proposed model specification, containing the groups of variables quality rankings, countries of origin, coffee tree varieties, and harvest year is appropriate. The reference variables for the categorical variables are: lower than Fourth, Brazil, Bourbon, and 2003 for ranking, country of origin, tree variety and harvest year respectively.

Table 5: Chow Test of Differences between Linear Specialty Coffee Hedonic Price Models

Group of variables tested	R-squared	Chow test[1]
Unrestricted model	0.66	
Restricted models		
	0.59	26.76
Quality rankings		(0.000)
	0.63	15.29
Years		(0.000)
	0.60	18.35
Countries		(0.000)
	0.65	3.06
Varieties		(0.001)

[1]F test statistic

p-values in parentheses

N=541

Interpretation of Results

Table 6 shows the robust OLS estimation results of the specialty coffee hedonic price model and the implicit price of the significant variables[12]. The sensory variable quality rating; the reputation variables: First, Second and Third quality ranking, El Salvador, Honduras and Nicaragua origins and quantity, and the macro variables commodity price and year 2005 are significant at the 1% level. The reputation variables Fourth ranking, Colombia origin and Pacamara variety are significant at the 10% level.

The quality rating is highly significant indicating the importance of experts' evaluation in determining coffee prices. This is not surprising given the structure of the e-auction; the bidding is largely based on the previous evaluation in the cupping competition. In addition, the jury members are usually buyers and thus the willingness to pay expressed at the auction coincides with the preferences expressed in the quality rating. The price premium for a one point increase in the 100-point quality rating scale is 7.7%; i.e., a 5 point increase in the quality rating translates into almost 40% increase in the price. Given that quality ratings in the CofE supply chain range from 80 and 95, this represents a fairly high price differentiation range with respect to sensory quality. Whether this 7.7% impact per percentage point provides a great incentive for the producers to adopt quality

[12] In the log-linear function, the coefficient of continuous variables, multiplied by 100, can be correctly interpreted as the percentage variation of the dependent variable in relation to a unitary change in the variable in question. Correspondingly, the percentage impact of the dummy variables can be calculated as: exp (βj - 0.5 s.e. βj) -1, multiplied by 100, being s.e. the standard error of the coefficient βj. We use the F test to test for joint significance of dummy variables' groups.

Table 6: Specialty Coffee Hedonic Model Estimates and Implicit Prices of Attributes. Dependent Variable: log (Price)

			Coefficient	S.E.	Significance	Implicit price (%)
Sensory	Quality rating (%)		0.077	(0009)	***	7.7
Reputation	Quality rankings[1]					
		First	0.877	(0.104)	***	153.2
		Second	0.318	(0.104)	***	44.8
		Third	0.312	(0.078)	***	42.0
		Fourth	0.139	(0.076)	*	19.4
	Country of origin[2]					
		Bolivia	-0.148	(0.096)		
		Colombia	-0.145	(0.079)	*	-10.0
		El Salvador	-0.191	(0.055)	***	-15.1
		Honduras	-0.448	(0.056)	***	-34.3
		Nicaragua	-0.262	(0.063)	***	-20.6
	Tree variety[3]					
		Catuai	-0.056	-0.054		
		Caturra	0.049	-0.069		
		Typica	-0.002	-0.075		
		Pacamara	0.158	(0.095)	*	22.8
		Other	0.002			
	Log Quantity (%)		-0.375	(0.039)	***	-0.375
Macro	Year[4]					
		2004	-0.084	(0.066)		
		2005	-0.326	(0.107)	***	-23.9
		2006	-0.046	(0.093)		
	Log Commodity price (%)		0.589	(0.153)	***	0.589
	Constant		-3.982	(0.741)	***	
		Observations	541			
		R-squared	0.67			

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

1 Dummy variables indicating if ranking 1, 2, 3 or 4, respectively. Base group is rank between 5 and 43.

2 Dummy variable indicating country of coffee origin. Base group is Brazil.

3 Dummy variable indicating coffee tree variety. Base group is Bourbon.

4 Dummy variable indicating auction year. Base group is 2003.

improvement practices depends on the production effort involved in each particular case, i.e. the individual grower's cost function.

The quality rankings are the variables that have the greatest impact on specialty coffee prices. The price premium for winning the first prize in the cupping competition is 153 %

relative to the places lower than fourth. The second, third and fourth places also have a highly significant impact of 45%, 42% and 20% respectively. These implicit prices indicate that competition winning coffees are highly valuable for specialty buyers. Winning a competition is a quality signal that can be easily conveyed to consumers. Indeed, CofE roasters are using the CofE winners' logo on their coffees and educating consumers about cupping competitions and outstanding coffees. This is an extra value in addition to the value that the coffee already has from a high quality rating. This indicates that specialty coffee rankings have an important marketing value throughout the supply chain and that roasters are eager to purchase and capitalize on the quality competitions in general and on the first, second, third and even forth places in particular. Moreover, note that these premiums are above and beyond the premium paid for just being qualified as a specialty coffee versus commodity coffee, indicating that the differentiation within specialty coffees is likely to be meaningful for consumers similar to what rankings are in wines –grand cru, premier cru and cru. The market's emphasis on relative performance in which relatively small or no differences between absolute quality result in substantial differences in incomes for the first place winners allows this market to be characterized as a 'winner-take-all' market (Rosen, 1981; Frank and Cook, 1995).

When examining the country coefficients, Bolivian specialty coffees attain the same price as the Brazilian coffees. Columbian, El Salvadorian, Nicaraguan and Honduran specialty coffees, however, receive prices that are 10%, 15%, 20%, and 35% lower, respectively. Similar to the rating and ranking, this result suggests that country of origin provides valuable information to buyers that they might have an interest in transmitting to

consumers so they can also value the information on origin in general and certain origins in particular.

Buyers also pay attention to the information about the variety of the coffee plant. Pacamara has a positive implicit price of 24% with respect to the reference variety Bourbon, indicating the preference of buyers for this type of tree. Similar to the other reputation variables, the name Pacamara conveys an image of high quality that buyers are willing to market to the final consumer. Catuai, Caturra, Typica and Other (varieties with smaller representation) present no significant differences with respect to Bourbon, indicating that these varieties are equally valuable as specialty coffees.

The reputation variable, quantity availability, is negatively associated with price. A one percent decrease in quantity increases price by 0.38 percent. This indicates that specialty coffee buyers place a higher value on coffees that are available in smaller quantities, i.e. the specialty industry values exclusivity. We suggest that the marketing venue of this attribute is on 'limited editions' of a coffee product. From the point of view of the coffee grower, the coefficient of -0.38 represents the elasticity of demand facing the growers, which indicates a price reduction less than proportional for each additional unit of quantity available, i.e. growers can increase revenue by increasing quantity in the specialty coffee market.

When examining the year variable, specialty coffee prices in 2004 and 2006 do not present differences with respect to 2003. However, prices in 2005 were 24% significantly lower on average. We consider year to be a macro variable that captures broader supply and demand factors influencing coffee prices. Similarly, the commodity price estimate indicates that the specialty coffee premium is influenced by the commodity price level

during the auction month. For every one percent increase in the commodity price there is a 0.58% increase in the specialty price. For specialty coffee producers, this means that they are subject to the price fluctuations of the supply and demand factors in the broader coffee market. The coefficient of 0.58 specifically indicates that while producers can expect higher prices when the commodity price goes up, they can also expect that the premiums, i.e. the difference between the two markets, is proportionally smaller when the commodity price is higher.

Conclusion

Our hedonic analysis of the CofE data indicates that prices are determined by both a sensory attribute, the quality rating determined by experts, and several reputation attributes, which include the first places in the cupping competition winners, country of origin, and incipiently tree variety. These results can be interpreted as representative of the highest quality segments of specialty coffee and indicative of the trends in coffee differentiation in broader coffee markets. In addition, the macro level variables controlling for the commodity price and the competition-auction year were significant. From the results we offer four main conclusions: 1) implicit prices for sensory and reputation attributes can be distinguished in explicit prices of specialty coffees, 2) reputation attributes constitute quality signals, 3) quality rankings have the dominant impact on price, and 4) implicit prices of attributes at the producers level make coffee growers visible to consumers and vice versa. An elaboration on these four key findings is give below.

First, the hedonic equation of specialty coffees traded at the CofE e-auctions shows that both sensory and reputation attributes determine the overall price of specialty coffees, as

expected for specialty food products. Moreover, the combination of attributes is such that high sensory quality plus high reputation quality results in extraordinarily high coffee values. A combination of all outstanding attributes results in super-premium prices, as exemplified by the Brazilian and Colombian winners in 2005.

Second, reputation attributes convey information on quality that although related on the sensory quality it is distinguishable from it. While the quality rating refers to the quality of aroma, flavor and body, the quality ranking recognizes the consensus process to achieve it and of the value of the quality certification thereby attained. The reputation of the origin gives information that enhances the sensory experience by giving meaning and a foundation to build on the concept that the coffee has been grown where conditions and practices are best for growing coffee. This idea that there are unique combinations of conditions that might be difficult to reproduce is what lies behind the marketing concept of 'limited edition'. The implication for supply chain coordination is that reputations can be used as identifiable quality signals by buyers in their marketing strategies to consumers.

Third, of all attributes quality ranking is the single most important factor in fostering economic impact. At these relatively early stages of development of the specialty coffee industry, these premia provide a super-incentive for stressing quality thus creating value for the industry. To further support this statement, there is evidence that buyers at specialty coffee auctions are trying to push the industry towards further differentiation and greater value. This level of premia generates a symbolic content that enhances the coffee product and creates excitement for all participants in this specialty supply chain. This targets the marketing venue that one gets more pleasure by knowing that one is

drinking 'one of the best coffees in the world' as opposed to just drinking a 'highly rated coffee'. Furthermore, this type of value emphasizes that quality is really interesting in relative terms and subject to the experts' consensus for defining and measuring it. Such a price structure is the salient feature of the 'winner-take-all' markets.

Fourth, disclosing the information on the sensory and reputation attributes of these coffees to consumers draws attention to the role of coffee growers as crucial participants in the final product quality. In turn, implicit prices inform producers about the product characteristics that are most attractive to consumers, thus providing the producers with a feedback signal of the demand. This suggests a much greater direct participation of growers in specialty coffee as opposed to the commodity and other supply chains, such as Starbucks and fair-trade. Overall, the two-way information flow through implicit prices enhances the integration of production methods into the specialty coffee supply chain and sustainability of the industry.

Finally, we expect new results from hedonic analysis of specialty coffee prices as the industry evolves and more data becomes available. New specialty coffee regions may become important as production programs result in successful specialty coffee production or as the micro-climates change as the global weather changes. Varieties may also become more desired as roasters and consumers develop coffee connoisseurship. Specialty coffees might be or become preferred by characteristics that we have not included in this study (aroma, flavor, acidity and body). In particular, from this study it remains to be analyzed whether altitude and the weather during the coffee growing season are significant quality signals as is the case for wines. The impact on prices of certifications and coffee processing at the grower level also remains to be tested.

THE IMPACT OF E-AUCTIONS IN ADJUSTING PROCUREMENT STRATEGIES FOR SPECIALTY COFFEE

Introduction

Specialty coffee is associated with excellence in the quality of the underlying product materials. This excellence is expressed in the taste, aroma, mouthfeel and other sensory attributes (Daviron and Ponte, 2005). Specialty coffees are a differentiated product that is freshly roasted, is usually released in limited quantities and is marketed to the consumer with origin and processing information. Specialty Coffee supply chains require the producers to utilize special cultivation and production practices to produce beans that, once roasted, will give an outstanding flavor profile in the cup (Davids, 2002; Arvidson, 2003; Mabbett, 2006).[13] Procurement is the key function that coordinates the interface between roaster and producer to identify, develop and sustain quality in the specialty coffee supply chain. In this article we address the procurement approaches that center on the necessary product material quality and therefore are unique to specialty coffee supply chains. We examine both the traditional approach of supply relationships between growers and roasters; and the more recent development enabled by information technologies (IT) of electronic auctions (e-auctions).

The specialty coffee industry emerged when small roasters started to differentiate the coffee product and utilize innovative business strategies to capture new markets for

---

[13] The original definition of specialty coffee ties a coffee's flavor profile to the plant variety, altitude, soil composition, fertilizer, sun, shade, rain, cultivation and harvesting methods all determine this profile. This definition is what we have in mind for the purpose of this paper.

coffee drinking (Roseberry, 1996; Ponte, 2001). Specialty coffee consumers demand high quality and differentiation, i.e. they want coffee that tastes better than regular coffee and displays different flavor profiles according to the variety of coffee origins. Hence, maintaining a fairly broad assortment of products is important for specialty coffee firms. On the other hand, since individual consumers have idiosyncratic preferences over a differentiated product, a specialty coffee firm may find itself targeting a particular niche segment. For example, some consumers prefer a bright coffee (higher acidity) while others prefer it flat (lower acidity), either the roaster carries both types (differentiation strategy) or specializes in one (niche strategy). A result of this differentiation is the fragmentation of the coffee industry, with many small firms competing for small shares of the overall market. Concurrent with this development, e-auctions have emerged as a means for roasters to procure beans.

The objective of this paper is to investigate the role of e-auctions in complementing traditional supply relationships in coordinating supply and demand in specialty coffee supply chains using a newsvendor model. In particular, we concentrate on the impact of auctions in facilitating the adjustment of the roaster's procurement strategy through the possibility of making use of demand information updating. The classic newsvendor model is a suitable starting point for analyzing the procurement problem in specialty coffee for a number of reasons. First, stochastic demand mirrors the roasters uncertainty when planning in the growing stage of the specialty coffee market. Second, the model takes into account shortage costs, which fit the differentiation objective of the specialty coffee business, i.e. satisfaction of individual customers is important and the inability to

meet demand is costly. Third, the model accounts for the perishability, which is convenient due to the importance of freshness for specialty coffee.[14]

Our analysis recognizes that roasters design their procurement strategy at the beginning of the season based on previous years and current information, anticipating that they will sell an approximate number of coffee units based on their market size and market variability. Supply relationships with producers are established early in the season when demand is still uncertain since the specialty coffee firm needs to identify and contact an adequate supplier, negotiate the terms of the relationship and initiate a contract with them in advance of the coffee harvest (Figure 3). Underestimating demand results in a cost to the roaster associated with lost sales and lost customers. Overestimating demand results in a loss of value of the excess beans that will not sell at the full price. If possible, roasters would like to adjust their inventory such that if demand is greater than expected they would adjust their procurement strategy. This is possible whenever there is the alternative of procuring from an auction later in the season when the coffee beans are harvested and processed.

---

[14] Once coffee is roasted, it is difficult to preserve the volatile compounds that make up the coffee aroma, which are the hallmark of specialty coffees. However, there is no consensus on how fresh roasted coffee must be. Retail roasters tend to favor a shorter optimum life-span (3 to 7 days) for the best taste while wholesale roasters contend that the optimum period of time can be greatly expanded into weeks or even months with appropriate packaging technology (Holly, 2005).

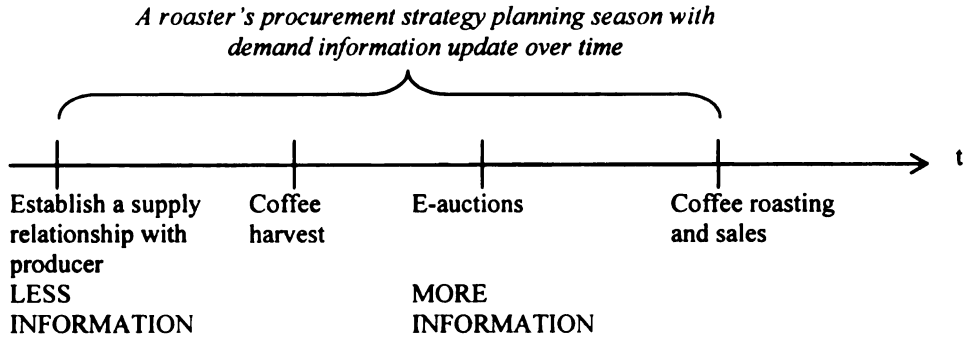

Figure 3: Timing of roaster's procurement decisions in the coffee season

At the beginning of the season, the roaster must decide how to use the alternative procurement forms available to them. It may be that the firm can only purchase through relationships or through relationships supplemented by auctions. In both cases the roaster has to decide which quantity to procure through the relationship. If auctions are not available, the optimal decision balances the cost of buying too much versus the cost of being short. If the roaster has the possibility of utilizing the auction, the decision balances the tradeoff between the costs of using each of the two procurement approaches. Based on our model, we discuss the benefits of having e-auctions in addition to relationships under different market circumstances.

This article proceeds with a literature review on supply chain procurement decisions that we use to frame and model our problem. In the second section we describe supply relationships and e-auctions in specialty coffee and their economic properties. In the third section we present the specialty coffee procurement model and the benchmark case that considers relationships as the sole means of procurement. The fourth section contains the model solution including the optimal use of e-auctions and use of relationships when auctions are available. The fifth section discuses the importance of e-auctions as part of

an optimal procurement strategy. In the final section, we give a brief summary and conclusion. Detailed derivations of the model results are provided in the Appendix.

Framing and Modeling Procurement Decisions

Three bodies of literature are relevant to our analysis. The first concerns the classical question in organizational economics of markets versus hierarchies or the choice of organizational forms; the second arises from strategic management; and the third arises from operational management. In the presence of uncertainty, which emanates from imperfect information, bounded rationality, strategic behavior and incomplete markets, different supply chain organizational forms emerge to reduce transaction costs, improve value creation and incentives (Milgrom and Roberts, 1992; Foss et al., 1999; Williamson, 1999; Foss, 2003). Defining the alternative organizational forms in which a given transaction can be organized and illustrating the tradeoff between them is the goal of the theory of the firm (Gibbons, 2005). Our paper builds on this body of literature, we view procurement decisions as pertaining to the design and choice of organizational forms for coordinating the economic exchange. We emphasize the complementarities between relationship procurement that entails committing to a decision before the uncertainty is resolved and the costly modification of a decision through an auction when uncertainty is resolved.

The main focus of the strategic management literature, as it relates to our work, is to determine when a particular organizational form may be pursued given a number of conditions (Pyke and Johnson, 2003). The choice of procurement strategy depends on several critical variables, hence, usually no single strategy dominates another in all dimensions (Bunn, 1993; Elmaghraby, 2000; Grey, 2005). Therefore, procurement

managers must understand the critical variables that affect the decision and evaluate the performance of each procurement strategy used in the context of the specific institutional conditions (Elmaghraby, 2000; Grey, 2005). This literature is concerned with questions that applications of information technologies increasingly pose in procurement, including when to use auctions and how auctions complement supply relationships (Elmaghraby, 2000; Moss et al., 2003; Pyke and Johnson, 2003; Swaminathan and Tayur, 2003; Cattani et al., 2004; Bunduchi, 2005; Grey, 2005). Our analysis draws on this literature to assist in selecting the relevant factors that affect the procurement decision in specialty coffee and outlining economic properties of relationships and auctions.

The two papers most related to ours are Peleg et al. (2002) and Chang et al. (2005). In terms of operationalizing the procurement management questions, Peleg et al. (2002) also use a newsvendor model. They compare three procurement strategies: first, a short-term contract with an online supplier chosen on the basis of the lowest cost; second, a long-term relationship with a single supplier; and lastly a combined strategy that uses both. The authors compare the three strategies on the basis of their expected costs. They calculate the minimum discount that a supplier should offer in the long-term relationship to be preferred to the lowest cost online supplier. The authors further explore the effect of increasing the supplier base on the price distribution and its relation to the variance of demand. We follow Peleg et al.'s use of the newsvendor model to study the choice of procurement strategy. However, the main difference between our approach and theirs is that in theirs the manufacturer chooses between the alternatives of a relationship, an auction or a combination of the two simultaneously when facing demand uncertainty. In our model, the decisions of procuring from relationships and auctions are sequential, with

uncertainty being resolved between the timing of the two. Thus, we focus on the benefit that the auction adds to the procurement strategy as a complement to the relationship. Moreover, we tailor our analysis to the peculiarities of specialty coffee procurement, whereas Peleg et al. do not specify an industry context.

Chang et al. (2005) also apply the newsvendor model to examine and compare traditional procurement and e-procurement to quantify the effect of the Internet on supply chain procurement management. They model two forms of traditional procurement: a vertically integrated supply chain and a decentralized supply chain. Transaction costs are negligible in the vertically integrated supply chain, whereas in the decentralized supply chain, buyer and seller have competing objective functions. They found that expected profits are greater in the e-procurement strategy if the supplier provides return policies (unit refunds). They also found a maximum cost for IT procurement, above that point they would not participate in the e-market because its expected profits would be lower than that in the traditional procurement strategy. We present a similar analysis based on the comparison of optimal quantities and expected profits. However, we compare the classical newsvendor, for the case when the relationship is used exclusively, with an extended model, which is a combined relationship and auction strategy. Our model, thus, extends the classic newsvendor in two ways: first, by allowing for different states of information concerning demand and second, by considering a strategy that covers more than one period.[15]

[15] See Khouja (1999) for a survey of the traditional newsvendor model with extensions.

Supply Relationships and E-Auctions in Specialty Coffee Procurement

Relationships and e-auction procurement focuses on the evaluation of sensory quality through cupping and remuneration of producers accordingly. In the cupping, roasters evaluate the intrinsic quality of the coffees by testing samples of the roasted and brewed coffee and assessing its aroma, flavor and mouthfeel according to established procedures. The characteristic and common feature of these procurement approaches is the transmission of quality information to the source (producers)(Ponte, 2002).

Relationships have been the traditional procurement approach for roasters concerned with quality (Castle, 2006). They consist of long-term interactions in which roaster and producer work closely together to create a distinctive cup of coffee for the final consumer (Griswold 2000; Intelligentsia 2004). Producer and roaster exchange information about the desired coffee quality attributes and how to obtain them; the roaster 'interpret' the distinctive flavor profile that the grower produces from the unique coffee origin characteristics and cultivation practices (Foley, 2004; Intelligentsia, 2004; Daviron and Ponte, 2005; Castle, 2006). The costs of a relationship are initially high but their benefits are accumulated over time. Incentives, more than price, are provided by means of informal agreements, trust and mutuality. The result is that relationships allow the consistent supply of high quality coffee beans year after year from a limited number of producers.

In relationship procurement, roasters incur expenses in traveling to producing countries to evaluate and select those farmers whose product matches the desired characteristics and to better understand their business partner's operations (Griswold, 2000; Intelligentsia, 2004). Upon identifying potential growers, roasters are faced with negotiating the terms

of the exchange and, upon successful contracting, monitoring the quality of the product. Established relationships usually involve pre-financing and marketing arrangements depending on the degrees of involvement from roasters (Ponte, 2001; Daviron and Ponte, 2005).[16] Once the relationship has been established, roasters have secured a coffee supply at a fixed price in advance of the season which saves them time and expenses and allows them to concentrate on roasting and marketing activities (Griswold, 2000; Daviron and Ponte, 2005; Castle, 2006).

In auctions, coordination is achieved through competitive bidding (i.e. "arms-length" or market coordination) between buyers and sellers so there is a threat of losing business to a competing supplier/buyer. In specialty products, there is scope for this market-type of coordination provided that complex quality information can be embedded in standards, labels and certification procedures (Ponte and Gibbon, 2005). This is what specialty coffee auctions pursue. The evaluation and selection of coffees using a standardized cupping form and procedure allows transparency in the revelation of quality. Moreover, the provision of coffee samples to the potential bidders prior to the auction, allows quality assessment at a relatively low cost. E-auctions increase the supply of specialty coffee through quality training and improvement and the incorporation of previously unknown producers in the countries which host the auctions (United Nations, 2003; Daviron and Ponte, 2005).

---

[16] In 'relationship coffees' the level of involvement is highest and roasters and grower work jointly to define and develop the coffee product quality and the tasting experts of the firms are directly involved in coffee production (Griswold, 2000; Intelligentsia, 2004).

E-auctions offer the possibility of finding high quality at low search cost as the upfront investment for using this procurement approach usually entails only a modest auction fee. This is particularly valuable for small roasters for whom it is more costly to find the right quality of coffee year after year (Daviron and Ponte, 2005). Auctions disclose quality information (including the pre-auction samples to potential buyers) that reduces transactions risks (Daviron and Ponte, 2005). While these factors result in higher prices paid to growers, auctions increase the flexibility of adjusting the procurement strategy of the roaster by allowing access to additional supply if needed.

The Analytical Framework

We begin our analysis by presenting the model. followed by solving a benchmark case in which e-auctions are not available which is the classic Newsvendor case. Next we extend the model to include e-auction and solve.

The Model

We model a specialty coffee supply chain consisting of a grower/producer and a roaster. The roaster sells a consistent coffee product in the final demand market at a given expected price p per unit of a uniform quality level of the coffee beans procured. The desired quality of coffee beans are obtained either through a relationship with the grower or at an auction in which many growers offer their product. In the case of the use of a relationship, the roaster commits to procure an agreed-upon quantity x_R from the producer. For the benchmark analysis, this relationship is the only procurement method available. In the complete strategy, the manager can augment the total procurement quantity by purchasing additional coffee units at an e-auction.

In the relationship, the roaster incurs variable costs c_R per unit, which correspond to the price paid to the producer for the coffee beans plus roasting and packaging costs per unit. In addition, the roaster incurs fixed costs in the relationship K_R, which correspond to the transaction costs of finding a qualified producer, negotiating the terms of the exchange and monitoring quality.

In the auction, variable costs are c_A per unit, representing the roaster's price expectations at the auction at the time that relationship decisions are made.[17] Fixed costs are K_A which include the auction fee. We assume that the (expected) auction variable cost is higher than the relationship variable cost, $c_A > c_R$, because transaction in the relationship are reduced over time (risk and uncertainty).

The selling price, salvage value and all costs are known to both the roaster and the producer at the beginning of the season. Each unit of coffee not sold in the first period has a salvage value of v. All unsatisfied demand is subject to a shortage cost s. We maintain the natural newsvendor assumption for a non-trivial solution that the selling price is larger than the unitary cost and the unitary cost is larger than the salvage value, i.e. product is perishable, $p > c_A > c_R > v$.

The risk neutral roaster determines its procurement strategy based on the maximization of expected profit, given uncertainty in the final demand market. Specifically, the roaster

---

[17] Prior price expectations can be based on past experience, but also on anticipated properties of the coffee sought (on this see Donnet et al., 2007). For more on price formation in auctions see Wolfstetter (1996) in general and Jeitschko (1998, 1999) for applications to agricultural and fisheries wholesale markets. For simplicity, we deliberately abstract from the price formation process in this article in order to highlight the tradeoffs and complementarities between the two procurement methods under consideration.

faces random uniformly distributed demand for the final product with mean μ and dispersion η. The realization of demand D is positive for the range$[\underline{D},\overline{D}]$, so that $\underline{D} = \mu - \eta$ and $\overline{D} = \mu + \eta$.

The sequence of events is illustrated in Figure 4. At the beginning of Stage 1 the roaster decides how many coffee units to purchase from the relationship, x_R, while facing uncertain future demand. After this decision is completed the roaster observes the realization of demand, subsequent to which the firm can go to an auction and get an arbitrary amount of additional coffee units, x_A, to supplement its supply obtained through the relationship. Only after this decision, is the product brought to the final demand market and profits π (x_R, x_A) are realized. The firm chooses its procurement strategy to maximize expected profits $E\pi$ (x_R, x_A).

We calculate the optimal quantity and expected profits for two possible procurement strategies: First, we consider the traditional case in which auctions are not available and supply chains rely on relationships exclusively (this is the benchmark case). Second, we consider the complete strategy involving access to both relationships and e-auctions. Throughout the paper a superscript * denotes the optimal solution to the full model, whereas a superscript B denotes the optimal (benchmark) solution relying solely on relationships without access to auctions.

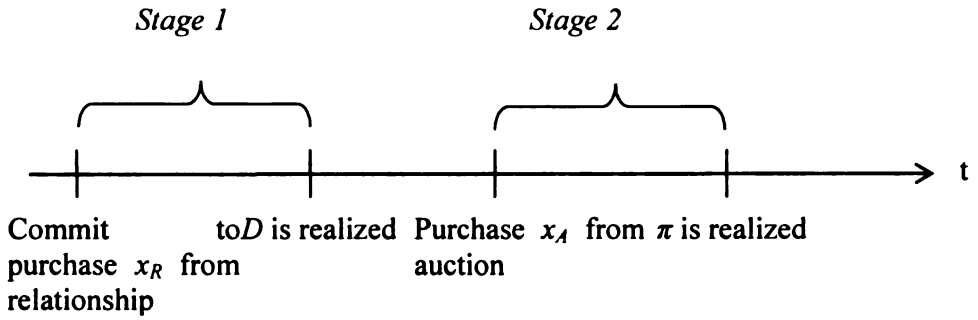

Figure 4: Sequence of events in the specialty coffee procurement model

Relationship procurement without the availability of E-auctions

We first examine the benchmark strategy in which the firm can only utilize a supply relationship. This is the classical newsvendor problem in which the manager's decision is to balance the tradeoff between the costs of procuring excess coffee units and the costs of not meeting the full demand. At the end of Stage 2, if the procurement quantity is larger than the realized demand, the (overage) profit is the simple profit associated with selling D units, augmented by the salvage value of the excess inventory ($x_R - D$). If instead the procurement quantity is smaller than the realized demand, the (underage) profit is the revenue minus costs from selling x_R units minus the shortage cost of not meeting the excess demand ($D - x_R$). That is,

$$\pi^B(x_R, D) = \begin{cases} pD + v(x_R - D) - c_R x_R - K_R & \text{if } \underline{D} < D < x_R \\ (p - c_R)x_R - s(D - x_R) - K_R & \text{if } x_R < D < \overline{D}. \end{cases} \quad (1)$$

Given our assumption on the distribution of demand, the firm's expected profit, when there are no e-auctions to adjust the procurement strategy after the realization of demand, is expressed as:

$$E\pi^{B}(x_R)=\frac{1}{2\eta}\left\{-\frac{1}{2}(p+s-v)x_R^{\,2}-\frac{1}{2}(p-v)\underline{D}^2+(c_R-v)x_R\underline{D}\right.$$
$$\left.+(p+s-c_R)x_R\overline{D}-\frac{1}{2}s\overline{D}^2\right\}-K_R. \tag{2}$$

Taking the first order (sufficient) conditions for profit maximization and simplifying, the optimal quantity to procure can be expressed as a convex combination of the upper and lower bound of the possible states of demand, i.e., the summation of the relationship contribution margin multiplied by the maximum possible demand and the relationship net cost multiplied by the minimum possible demand over the revenue from sales:

$$x_R^{\,B}=\frac{(p+s-c_R)}{(p+s-v)}\overline{D}+\frac{(c_R-v)}{(p+s-v)}\underline{D}=\frac{MP_R}{MR}\overline{D}+\frac{MC_R}{MR}\underline{D}, \tag{3}$$

where MP_R is the marginal profit of selling an extra unit at full price at the relationship variable cost, MC_R is the marginal cost of not selling an additional coffee unit procured through the relationship and MR is the marginal revenue of selling an additional coffee unit at full price. Substituting the optimal procurement quantity into the expected profit function and consolidating gives the optimized expected profit expression for the benchmark case,

$$E\pi^{B}(p,s,c_R,c_A,v,K_R,\mu,\eta)=\frac{1}{4}\frac{\left[(p+s-c_R)-(c_R-v)\right]^2}{(p+s-v)}\eta+\frac{1}{2}\frac{(p+s-c_R)^2}{(p+s-v)}\mu$$
$$-\frac{1}{2}\frac{(c_R-v)^2}{(p+s-v)}\mu-\frac{1}{4}(p+s-v)\eta+\frac{1}{2}(p-s-v)\mu-K_R. \tag{4}$$

Optimal Procurement with the Use of E-auctions

The complete model is solved through backward induction. For the strategy with the availability of an auction we begin by examining the decision of utilizing the auction at the beginning of Stage 2 when the realized demand for the firm's product, D, is known

and the firm has already secured the quantity x_R through its relationship arrangement. Given the optimal continuation profits determined in Stage 2, we then turn to examining the optimal order quantity from the relationship at the beginning of Stage 1 that maximizes overall expected profits.

The optimal use of the e-auction

At the beginning of Stage 2 the firm knows the quantity procured through the relationship x_R and the demand for its product D. If the relationship order quantity is larger than the realized demand, $x_R \geq D$, no further decision is made in the procurement strategy. The firm's profit is given in the top branch of Equation (1). However, if the order quantity is not sufficient to meet realized demand, $x_R < D$, the firm decides whether to supplement its coffee supply by going to the auction. If the firm chooses not to go to the auction, shortage costs of s are incurred per unit of excess demand. Hence, the profit expression at the end of Stage 2 is given by the profit margin multiplied by the procured units, diminished by the relationship fixed costs and the shortage costs incurred on the units in excess demand. Formally,

$$(p - c_R)x_R - K_R - s(D - x_R). \tag{5}$$

In contrast, if the firm chooses to go to the auction, in addition to the profit from the relationship, there is a profit for selling the excess demand at the auction margin, $p - c_A$, while incurring additional auction fixed costs of K_A. Since the cost of procuring additional units at auction, c_A, is smaller than the selling price, p, it follows trivially that conditioned on incurring the fixed cost of attending the auction, K_A, the firm optimally chooses to purchase the entire shortfall $D - x_R$ at the auction. The profit expression at the end of Stage 2 for this event is, thus,

$$(p-c_R)x_R - K_R + (p-c_A)(D-x_R) - K_A. \quad (6)$$

The decision to go to the auction balances the trade-off between equations (5) and (6). The firm optimally chooses to participate in the auction and purchase the excess demand if the profit from participating is larger than the cost of not participating, $-s(D-x_R) \leq (p-c_A)(D-x_R) - K_A$. Rearranging the inequality, the marginal profit for participating has to be larger than the marginal cost of participating, i.e., $K_A \leq (D-x_R)(p+s-c_A)$. This implies a demand threshold $\tilde{x}$ above which it becomes profitable to use the auction

$$\tilde{x}(x_R) := \frac{K_A}{p+s-c_A} + x_R = \frac{K_A}{MP_A} + x_R \left(\leq \overline{D}\right), \quad (7)$$

where MP_A is the marginal profit of selling an additional unit at a full price at the auction variable cost. In other words, the shortfall must be sufficiently large in order to warrant incurring the fixed costs of participating in the auction to supplement supply and replace shortage costs with additional profit.

The use of relationships when e-auctions are available

As just sketched, given the past decision on engaging in the relationship, $x_R \geq 0$, and the realization of demand, D, the firm's profits at the end of Stage 2 fall into three cases. In order to ascertain the optimal relationship strategy, the roaster must determine expected profit across the three cases, given a choice of size of the relationship quantity.

To recap, in a first case, the realized demand is larger than the relationship quantity procured and thus no further decision is required. Profits equal the revenue from realized demand plus the salvage value of the excess units minus unitary costs for the procured units minus the fixed costs incurred in the relationship. In the second possible case, the

realized demand is larger than the relationship quantity procured but the benefits from participating in the auction are insufficient to off set the fixed costs incurred, so the firm chooses not to participate. Profits consist of the margin from the procured units through the relationship minus the relationship fixed costs minus a shortage cost of each unit of excess demand. The third possible case occurs when realized demand is larger than the relationship quantity and the benefits from using the auction are sufficiently large to cover the fixed costs incurred from utilizing the auction. Profits result from the relationship margin over the relationship procured units plus the auction margin over the excess demand minus the fixed costs of the two alternatives:

$$\pi^*(x_R, D) = \begin{cases} pD + v(x_R - D) - c_R x_R - K_R & \text{if } \underline{D} < D < x_R \\ (p - c_R)x_R - s(D - x_R) - K_R & \text{if } x_R < D < \tilde{x} \\ (p - c_R)x_R + (p - c_A)(D - x_R) - K_R - K_A & \text{if } \tilde{x} < D < \overline{D}. \end{cases} \tag{8}$$

Integrating over the possible realizations of demand and consolidating, the expected profit at the beginning of Stage 1 from the strategy that includes using e-auctions is:

$$\begin{aligned} E\pi^*(x_R) = \frac{1}{2\eta}\Bigg\{ & -\frac{1}{2}(c_A - v)x_R^2 - (v - c_R)x_R\underline{D} + (c_A - c_R)x_R\overline{D} \\ & + \frac{1}{2}(p - c_A)\overline{D}^2 - \frac{1}{2}(p - v)\underline{D}^2 \\ & + \frac{1}{2}\frac{K_A^2}{p + s - c_A} - K_A\overline{D} + K_A x_R \Bigg\} \\ & - K_R. \end{aligned} \tag{9}$$

The firm maximizes expression (9) by optimally choosing the relationship quantity x_R. The first order condition gives the optimal relationship quantity in anticipation of being able to access an auction at the beginning of Stage 2:

$$x_R^* = \frac{(c_A - c_R)}{(c_A - v)}\overline{D} + \frac{(c_R - v)}{(c_A - v)}\underline{D} + \frac{K_A}{(c_A - v)} = \frac{\Delta VC}{MC_A}\overline{D} + \frac{MC_R}{MC_A}\underline{D} + \frac{K_A}{MC_A}. \quad (10)$$

Notice that the optimal relationship quantity consists of three terms. The first term is the ratio between the relationship cost advantage over the auction and the auction marginal cost, $MC_A := c_A - v$, multiplied by the maximum demand. The second term is the ratio between the relationship and the auction marginal costs multiplied by the minimum demand. The third term is the ratio between the auction fixed and marginal costs. The first two terms give a weighted average of the end points of the demand support, while the final term augments this convex combination increasingly in the cost of attending the auction.

Substituting the optimal procurement quantity (10) into the expected profit expression (9), optimized expected profit is given by

$$\begin{aligned} E\pi^*(p,s,c_R,c_A,v,K_R,K_A,\mu,\eta) = {} & \frac{1}{4}\frac{[(c_A - c_R) - (c_R - v)]^2}{(c_A - v)}\eta - \frac{1}{4}(c_A - v)\eta \\ & + \frac{1}{2}\frac{(c_A - c_R)^2 - (c_R - v)^2}{(c_A - v)}\mu \\ & + \frac{1}{2}(p - c_A)\mu + \frac{1}{2}(p - v)\mu \\ & + \frac{1}{4\eta^2}K_A^2\left[\frac{(p + s - v)}{(c_A - v)(p + s - c_A)}\right] - K_A - K_R. \end{aligned} \quad (11)$$

The Importance of E-auctions as Part of an Optimal Procurement Strategy

As shown above, in the optimal strategy when auctions are available, the firm's decision concerning the extent of the relationship is based on the relation of marginal costs between the two alternative procurement forms. In the benchmark strategy sans auction (the newsvendor problem), the decision of the firm is based on the relation of marginal profits and marginal costs of the relationship alone.

We now consider how the optimal relationship strategy and overall firm profitability is affected by the availability of the e-auction. In particular, we examine the changes induced in the relationship procurement quantity due to the auction option, and compare the expected profit between the benchmark and the complete strategy. In so doing, we also consider how the impact of the e-auction varies with the roaster firm size; proxied by the firm's expected demand μ, and the demand uncertainty, captured by the dispersion parameter η. From this comparison we evaluate the benefit of accessing e-auctions in specialty coffee procurement and how this is affected by firm size and uncertainty.

The probability of using the auction

Given the distribution of demand and the critical threshold, $\tilde{x}$, above which it is profitable to attend the auction, one can calculate the ex ante probability that the auction will be attended to procure additional coffee units to meet any demand exceeding the units procured through the relationship. Letting $\mathrm{P}\{A\}$ denote the probability that the auction is utilized, one finds

$$P\{A\} = P\{D \geq \tilde{x}\} = (c_R - v) - \frac{K_A}{(p+s-c_A)}\frac{(p+s-v)}{2\eta} = MC_R - \frac{K_A}{2\eta}\frac{MR}{MP_A} = MC_R - \frac{K_A}{2\eta}\frac{1}{GPM_A} \quad (12)$$

Thus, the probability of attending the auction is the difference between two terms. The first term is the marginal cost of the relationship. The second term is the product of two factors, one referring to the auction cost and the other referring to revenue from coffee sales. The cost factor is weighted by the demand variability and the revenue factor is weighted by the auction margin. The first cost factor is the ratio of the auction fixed costs to demand uncertainty, $\frac{K_A}{2\eta}$, and the revenue factor is the ratio of marginal revenue to

marginal auction profits, $\frac{MR}{MP_A}$. This can also be expressed as the inverse of the auction gross profit margin, GPM_A, which is the ratio between marginal profits and marginal revenue, $\frac{MP_A}{MR}$, and measures the gross profit earned on sales.

Note that the probability of attending the auction is increasing with the marginal cost of the relationship, and decreases when auction fixed costs are not expected to be diluted from a large demand variability and when the margin earned is large relative to the revenue from selling an additional coffee unit. This last factor can be expressed as the inverse of auction gross profit margin (Figure 5). Thus, the probability of attending the auction decreases with the inverse of the auction gross profit margin. The product of the two auction factors accounting for costs and revenue can be interpreted as the marginal profit from participating in the auction which is the same as its opportunity cost, i.e. the cost of not participating in the auction.

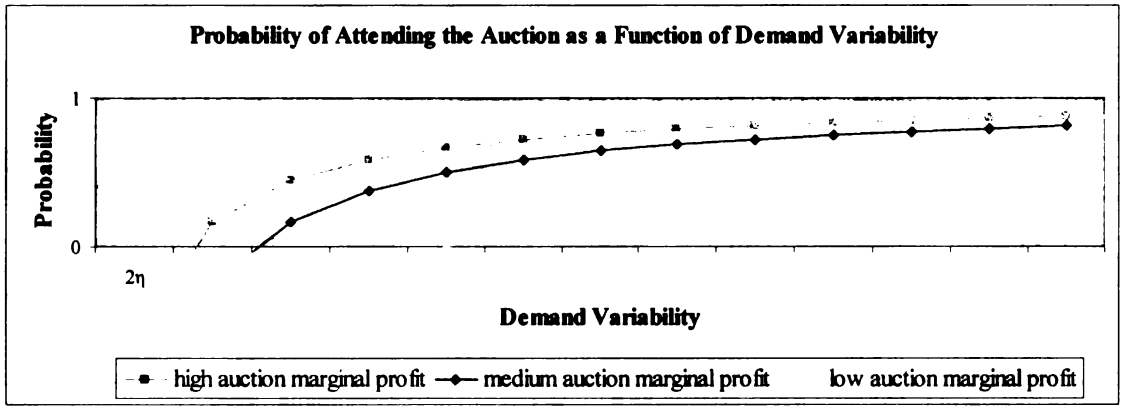

Figure 5: Auction attendance as a function of demand variability and gross profit margins

Proposition 1 *The probability of attending the auction is positive if the marginal cost of purchasing an additional coffee unit from the relationship is larger than the auction opportunity cost, i.e.,* $MC_R > \frac{K_A}{2\eta}\frac{1}{GPM_A}$.

Proof: The proof follows readily from Equation (12).

The fact that the probability of attending the auction is higher for roasters whose relationship marginal costs are higher gives additional insight. Recall that relationship marginal costs are given by $MC_R = c_R - v$, so higher relationship marginal costs includes both the case of increased unitary cost in the relationship c_R as well as the case of facing a lower salvage value v.

The former indicates that auctions are more appealing to roasters who are unable to secure enough benefits through the relationship so as to reduce risk and costs, either through negotiations or through long-term (possibly joint) investment that lower transactions and production costs and thus decrease c_R. As for the latter, i.e., a larger

salvage value v, our model indicates that auctions are more appealing to roasters who emphasize freshness and short product cycles as well as those willing to pay a premium for high aroma; compared to those with a low preference for freshness and aroma. Overall these differences correspond to differences between retail and wholesale roasters; or between top quality specialty roasters and average quality roasters.

In addition, the ex ante probability of attending the auction is higher for roasters who have a larger auction gross profit margin and who can expect to dilute fixed auction costs from expected variability of demand—corresponding to new products and new market niches for example.

For the remainder of the analysis we assume non-trivial parameter values such that there is a positive ex ante probability that the roaster attends the auction.

The impact of auctions on relationship procurement

Let $\Delta x_R := x_R^B - x_R^*$ denote the change in the relationship procurement quantity induced by the inclusion of the auction strategy. That is, Δx_R is the difference between the relationship procurement quantity with and without the availability of the auction. Substituting for the optimal quantities, given in Equations (3) and (10), the change in the relationship quantity from the no auction to the auction strategy depends on the marginal cost of the relationship, the auction marginal profits and marginal and fixed costs and the marginal revenue from coffee sales:

$$\Delta x_R = (c_R - v)\underline{D} - \frac{(p+s-c_A)}{(p+s-v)}\frac{(c_R-v)}{(c_A-v)}\overline{D} + \frac{K_A}{(c_A-v)} = MC_R\underline{D} - \frac{MP_A}{MC_A}\frac{MC_R}{MR}\overline{D} + \frac{K_A}{MC_A} \tag{13}$$

Proposition 2 *The availability of the auction reduces the optimal size of the relationship procurement quantity,* $x_R^* < x_R^B$..

Proof. Given the assumption that there is an ex ante positive probability of attending the auction, Equation (12) implies that $K_A < \frac{(p+s-c_A)(c_R-v)}{(p+s-v)} 2\eta$. Therefore, using Equation (5) while recognizing that 2η is simply the length of the support of the uncertain demand, it follows that $x_R^* < \frac{(c_A-c_R)}{(c_A-v)}\overline{D} + \frac{(c_R-v)}{(c_A-v)}\underline{D} + \frac{(p+s-c_A)(c_R-v)}{(p+s-v)(c_A-v)}\left(\overline{D}-\underline{D}\right)$. However, simple algebra reveals that the right hand side of this inequality is equal to x_R^B, given in Equation (3). Hence $x_R^* < x_R^B$. *Q.E.D.*

The optimal quantity to procure from the relationship is smaller when e-auctions are available versus when e-auctions are not available. Proposition 2 states that less quantity will be purchased through the relationship and any sufficiently large excess demand that results will be fulfilled by participating in the e-auction. The factors that are driving the reduction in relationship exchanges are the perishability of the product and the ability to dilute auction fixed costs with auction profit margin.

Proposition 3 *The change in the relationship procurement quantity, from the benchmark to the strategy with auctions, increases with uncertainty,* $\frac{d\Delta x_R}{d\eta} > 0$.

Proof. The change in quantity procured through relationships with respect to uncertainty is given by,

$$\frac{d\Delta x_R}{d\eta} = \frac{dx_R^B}{d\eta} - \frac{dx_R^*}{d\eta} = \frac{(p+s-c_R)-(c_R-v)}{(p+s-v)} - \frac{(c_A-c_R)-(c_R-v)}{(c_A-v)} = 2\frac{(p+s-c_A)(c_R-v)}{(p+s-v)(c_A-v)} > 0$$

.

Q.E.D.

When demand uncertainty increases, relatively more quantity is procured through the use of auctions versus relationships, i.e., the role of the auction for specialty coffee

procurement is more important when demand uncertainty is higher. Therefore one expects to find more procurement through auctions by roasters who operate in growing markets versus roasters in mature markets. Moreover, as new specialty coffees are not introduced to the market, there is considerably greater uncertainty about their demand than there is for established specialty coffees. Consequently, new specialty coffees are likely to be procured through auctions rather than relationships. This is consistent with the evidence from the industry thus far, in which auctions started to being used for emerging specialty coffee origins (Brazil, Nicaragua, El Salvador).[18]

The impact of demand uncertainty on profits with the optimal use of auctions

We define $\Delta\pi$ as the difference between the expected profit in the strategies with and without e-auctions:

$$\Delta\pi(c_R, c_A, p, v, s, K_A) := E\pi^* - E\pi^B \tag{14}$$

Proposition 4 *The impact of e-auctions decreases with the size of the firm,* $\frac{d\Delta\pi}{d\mu} < 0$, *whenever there are positive shortage costs from excess demand, i.e., if* $s > 0$.

Proof. The impact of the change of firm size on the increase in profit due to the introduction of auctions is given by,

---

[18] More recently, coffees from the already emerged origins of Costa Rica and Guatemala have been traded in auctions; auctions are not used for trading coffees from origins with an established reputation as specialty producers, such as Hawaii (the Kona coffee) and Jamaica (the Blue Mountain). For emerging, emerged and established origins see for example Davids (2004).

$$\frac{d\Delta E\pi}{d\mu} = \frac{dE\pi^{*}}{d\mu} - \frac{E\pi^{B}}{d\mu} = \frac{1}{2}(p - c_R) - \frac{1}{2}(p + s - c_R) = -\frac{1}{2}s < 0, \forall s > 0 .Q.E.D.$$

Proposition 4 states that the positive impact of auctions is larger for smaller versus larger roasters if shortage costs are important. Shortage costs give the economic implication of losing a sale, which entails more than merely the lost revenue from the unsold item. For example, it also accounts for the fact that a customer and their future purchases are lost because they are not satisfied with the roaster's business. This result emphasizes the role of auctions in developing customer's satisfaction and gaining customer's loyalty in the differentiated specialty coffee market. Auctions are more important when customers' loyalty matters, which is especially the case for small firms that compete in a differentiated market. As a corollary, the model indicates that auctions are more valuable in fragmented versus consolidated industries. Thus, if there is imitation of corporative strategies that allow consolidation, auctions become less important.

Proposition 5 *The profitable impact of auctions increases with demand uncertainty,* $\frac{d\Delta\pi}{d\eta} > 0$.

Proof. The impact of auctions is measured by the increase in expected profits due to the use of the auction. This increase is affected by demand variability as follows,

$$\frac{d\Delta E\pi}{d\eta} = \frac{dE\pi^{*}}{d\eta} - \frac{dE\pi^{B}}{d\eta} = \frac{[(c_A - c_R) - (c_R - v)]^2}{(c_A - v)} - \frac{1}{4\eta^2} K_A{}^2 \frac{(p + s - v)}{(c_A - v)(p + s - c_A)} + \frac{(p + s - c_R)(c_R - v)}{(p + s - v)}$$

Solving and rearranging, the condition for the derivative to be positive is that there is a positive probability of attending the auction, implied by Equation (12); $K_A < \frac{(p+s-c_A)(c_R-v)}{(p+s-v)} 2\eta$. *Q.E.D.*

The positive impact of auctions on the roaster's profit is higher when demand uncertainty is higher. This situation is present in new specialty coffee markets as new products whose potential for capturing new customers is yet to be tested and the potential for losing initial customers is high. The importance of auctions may diminish as these market segments mature, i.e. when consumption is established for routine customers and there are no new consumers to capture.[19]

As alluded to above, the model lends itself to additional interpretations of the role of auctions in specialty coffee markets, namely as facilitators of the discovery process. Propositions 4 and 5 jointly indicate that new (i.e., small) market segments, with unknown potential (high variability) are possibly best dealt with by means of procuring quality beans in auctions. That is, auctions can serve as tools in exploring possible market niches which upon maturation (larger, more stable demand) can also easily be accommodated with traditional supply relationships.

Conclusion

This paper analyzes the importance of e-auctions in the procurement strategy of specialty coffee roasters. In establishing relationships, the roaster typically commits to purchasing

---

[19] The analysis is confined to the particular model and market structure we are examining. Clearly auctions may work well for other reasons and play important roles in other contexts, even in mature markets, as is the case in many well-established action markets for agricultural and fisheries products.

a quantity at the beginning of the season when demand is uncertain. E-auctions can be incorporated into the procurement strategy later in the season when more information about demand is available to the roaster. The focus of our analysis concentrates on the importance of e-auctions for adjusting the procurement strategy once information on final demand has been updated. We compare a benchmark strategy in which no e-auctions are available with a combined strategy in which e-auctions are available to complement the specialty coffee firm's prior supply obtained through relationships. The benchmark strategy is a classical newsvendor problem in which the procurement manager balances the marginal profits of selling an additional unit and the marginal costs of not selling an additional unit. The combined strategy is an extended newsvendor model in which the procurement manager balances the marginal costs of the two procurement forms.

Our results indicate that e-auctions matter the most to small roasters (rather than large wholesalers) who concentrate on top end quality and niche markets. The model further suggests that newer markets are best opened and explored by utilizing the auction system, and fragmented markets may also benefit more from the addition of auctions as alternative methods of procurement when compared to more consolidated markets for coffee.

By facilitating the procurement of new specialty coffees in an expanding market, auctions are important in the discovery process that is essential to product innovation and maintaining competitive advantages in the specialty coffee industry.

PRODUCT DIFFERENTIATION THROUGH QUALITY RATINGS IN SPECIALTY COFFEE: A CROSS-ENTROPY ANALYSIS OF E-AUCTIONS DATA

Introduction

Today nearly 90 percent of consumers understand that coffee is a differentiated product, like wine and cheese (Beaver, 2006) [20]. Through product innovation and differentiation roasters and retailers have created value added in what is known as the specialty coffee industry (Roseberry, 1996; Ponte, 2001)[21]. The industry offers a wide variety of coffees differentiated by their origin and the variety of the coffee plant, the roast and form of preparation, the packaging and the ambience of coffee shops and the supermarket aisle. In this paper, we concentrate on the quality rating of specialty coffees as an index of product differentiation and a price signal to growers. Quality ratings summarize the opinion of expert tasters about the sensory quality of a product. Evaluation through quality ratings is a successful differentiation strategy in specialty products that require connoisseurship for a full appreciation of quality, as it is exemplified by wines. We investigate the relation between quality ratings and price in specialty coffee using cross-entropy analysis of quality ratings and prices of specialty coffee traded at e-auctions. We address the following questions: 1) is there vertical differentiation across specialty

---

[20] Specialty coffees are defined by the Specialty Coffee Association of America as the highest quality green coffee beans roasted to their greatest flavor potential by true craftspeople and then properly brewed to well-established standards (Holly, 2005).

[21] Product differentiation refers to the strategic decisions that seek to distinguish the product from competing products, to enhance its value and the revenue it generates (Moulton et al., 2001).

coffees according to the quality rating, 2) how effective is the quality rating as an index of vertical differentiation, 3) how informative is the price signal to the grower with respect to the quality rating, and 4) how strong is the quality rating for remunerating quality.

Product differentiation refers to the strategic decisions that seek to distinguish the product from competing products, to enhance its value and the revenue it generates (Moulton et al., 2001). Product differentiation by quality ratings is a vertical differentiation, as opposed to horizontal, because they order products according to their quality from the highest to the lowest, i.e. it is possible to say that one good is "better" than another (Piana, 2003). Specialty coffee chains are of particular interest because coffee buyers (exporters, importers and roasters) pursuing a differentiation strategy are likely to coordinate quality issues more closely with suppliers relative to buyers in the commodity chains. This 'explicit coordination' suggests that producers can get more informative price signals from upstream buyers in the specialty chains (Gereffi, 2005). A 100-points quality rating has been adopted to summarize different categories of the product sensory evaluation in a number to convey a straight forwards and comparable idea of quality. The Specialty Coffee Association of America (SCAA) developed a cupping form that seeks to serve all segments of the specialty coffee industry (Songer, 2004). By standardizing the cupping, the SCAA intend to prevent the loss of meaning of the term 'specialty' from the addition of milk, water, syrups and others (Daviron and Ponte, 2005).

The quality rating can constitute an important signal to coffee growers to make decisions that integrate them more efficiently in the coffee supply chain. Specialty coffee competitions and auctions, such as the Cup of Excellence (CofE) and Q, present the

important feature of disclosing market information to all buyers and sellers. This is particularly important in the case of growers who typically do not know such detailed quality and price information about their produce (Ponte). An appropriate price signal is one that conveys the market information —consumers' preferences and valuations— so as to allow producers to make decisions about the allocation of their scarce resources in a way that maximizes their profits. The consequences of not receiving an informative price signal from the primary demand are to the disadvantage of farmers[22]. The market fails to provide an incentive to farmers to make the necessary investments to maintain and enhance the high quality that is necessary to sustain the whole specialty business with the consequential risk of the collapse of the supply chain due to an ever declining quality. In addition, new innovations at the producer level are improbable since returns on investment and risk taking is not rewarded. Without continual reinvestment, farmers miss the growth opportunity from the increased value of high quality and differentiated coffee markets. All of the above implies that in the medium to long run there is a decline in farmers' income and increasing poverty if a clear price signal is not received.

Most analysis of differentiation of specialty food products utilizes hedonic modeling of prices. Hedonic analysis has been applied extensively in wine (see for example Combris et al., 1997; Lecocq and Visser, 2003; Schamel and Anderson, 2003). These studies analyze wine characteristics that have an individual impact on the price. Authors distinguish between characteristics that refer to the sensory evaluation by professional tasters (e.g. aromatic intensity and suppleness) and characteristics that relate to

[22] Note that even with good information many coffee producers may not have the capacity for a suitable response due to their limited resources, as well as lack of viable income alternatives in many poor rural areas (Lewin et al., 2004).

production conditions and methods and appear on the wine bottle (e.g. origin, grape variety, and processing method). Applying hedonic analysis to specialty coffees e-auction data, Donnet et al., (2007) found that coffees at the procurement level in the supply chain are differentiated by coffee ratings, rankings, quantity available, and country of origin. In this paper we present an addition to hedonic analysis that focuses on the vertical differentiation by quality ratings. While hedonic analysis evaluates the marginal impact of various variables on price, the cross-entropy measures how strong is correlation between price and one particular variable, quality rating.

The following section offers a discussion of quality ratings and specifically how it is determined in specialty coffees. Next, we present the entropy measure and its application to measuring income inequality which we replicate for measuring product differentiation. Following that section, we present the empirical model, data, decomposition by quality rating groups and results. We finalize with a conclusion.

The Specialty Coffee Quality Rating

Quality ratings are measures of the intrinsic quality of food products evaluated through sensory analysis. Sensory analysis of coffee is called cupping and consists of the olfaction, gustation, and mouthfeel of the coffee components in the cup (Lingle, 2001). Cuppers interpret and record the sensations perceived using flavor attribute descriptors, numeric representations of intensity and additional comments such as "like it/hate it" (Songer, 2004). Because it is likely that discrepancies arise with the rating of most products, especially aesthetic ones, two conditions are considered for the validity of ratings (Benjamin and Podolny, 1999). First that there is a convergent judgment across independent evaluation, i.e. different experts should somehow agree on the quality of one

coffee. Second, the evaluation must derive strictly from the sensory attributes of the product itself and not from external cues such as origin, producer, or price (Benjamin and Podolny, 1999).

Quality ratings have been successful a successful marketing strategy. The use of the 100-point scale gave an important boost to the wine industry during the 1980' and 1990's and wine tasting has become a profession. The success of the 100 point scale over other scales is attributed to the easiness to convey a straight forward and universally understood idea of quality (McCoy, 2005). Interested consumers use the quality rating displayed in store and published buyers' as a guide for their purchases. Ratings given by renown experts have proved to be powerful in influencing consumers' choices and willingness to pay for wines as it is the case of the 'wine emperor' Robert Parker (McCoy, 2005; Rivlin, 2006). Knowing the influence of experts' ratings on consumers, retailers learn about ratings in advance of consumers and utilize this information to stock highly rated wines (McCoy, 2005).

In coffee, the system of rating coffees in the 100-point quality rating has been implemented by individual tasters who write coffee reviews for buyers' guides, such as the Coffee Review. The generally accepted cut-off point for specialty coffees is above 80 points. The quality rating is also used in cupping competitions of specialty coffee e-auctions. Quality ratings are typically determined by blind tasting the roasted and brewed coffee samples. The coffee aroma, sweetness, acidity and flavor are described. There are combined terms that refer to several sensory experiences at once, like balance and complexity. The different categories are added to give a score. The number is accompanied by a verbal description of the coffee, for example "heavy body, low acidity,

evaluation categories: *cleanness of cup*, *sweetness*, *acidity*, *mouth-feel*, *flavor*, *aftertaste*, *balance* and *overall*. Each category scores in a range of 0 to 8 and half points are possible (e.g., 7½). The individual score in each criterion are added to give a sub-total. If the coffee presents any *defects*, i.e. negative or poor such as 'phenolic' and 'ferment' a discount is applied giving the raw score. The raw score plus 36 gives the final score. The maximum attainable for a coffee is 100.

The Cross-Entropy Measure and Applications

Cross-entropy measure with probabilities

The cross entropy measure is based on the concept of entropy in information theory. The concept was initially developed by Shannon (1948) who proposed entropy as a way of measuring the value of the information contained in a message. Kullback-Leibler developed the cross-entropy (CE) which measures the unpredictability of an event E_i given its prior and posterior probabilities of occurrence p_i and q_i of a set of n mutually exclusive events $E = \{E_i,...,E_n\}$ (Theil and Fiebig, 1984; Golan, 2002; Soofi, 2002). The cross-entropy $I(q:p)$ is a logarithmic measure of the discrepancy or distance between the two probability distributions,

$$I(q:p) = \sum_{i=1}^{n} q_i \log \frac{q_i}{p_i} \qquad (1)$$

The interpretation of the cross-entropy as an information quantity depends on the distributions involved in the context of the problem under consideration. The measure provides no implication about the content of the message; it may be used as a measure of information loss or gain due to change from p_i to q_i (Soofi, 1994). The higher the

discrepancy the more unexpected the event and therefore the higher the value of the information contained in the initial message.

The cross-entropy measure, similar to other information measures, has simple aggregation properties that allow the decomposition of the total entropy into a between-group information and a within-groups information (Theil and Fiebig, 1984). Both prior and posterior probabilities can be aggregated into groups g so that:

$$P_g = \sum_{i \in S} p_i \text{ and } Q_g = \sum_{i \in S} q_i . \tag{2}$$

Applying the cross-entropy measure $I(q:p)(1)$ to each group g, the between-group cross-entropy is

$$I_0(q:p) = \sum_{g=1}^{G} Q_g \log \frac{Q_g}{P_g}. \tag{3}$$

The within-group entropy is

$$I_g(q:p) = \sum_{i \in Sg} \frac{q_i}{Q_g} \log \frac{q_i / Q_g}{p_i / P_g}. \tag{4}$$

The total cross-entropy $I(q:p)$ is equal to the between-group cross-entropy H_0 plus the average within-group cross-entropy $\sum_g Q_g I_g$,

$$I(q:p) = I_0(q:p) + \sum_{g=1}^{G} Q_g I_g(q:p) \tag{5}$$

The decomposition of the cross-entropy measure has an informational interpretation in two stages (Theil and Fiebig, 1984). In the first stage, a message provides the information that one group of events occurred: the cross-entropy is I_0. In the second stage a subsequent message provides the information that an event falling under this group occurred: its cross-entropy content is I_g. Finally, the total information content becomes the sum of the two $I_0 + \sum Q_g I_g$.

The aggregation properties of information measures allow the comparison between different distributions or groups of probabilities. Between groups, the higher the value of the cross-entropy, the higher the information content. The individual between groups entropy is positive for the higher quality and negative for the lower (Galbraith and Garcilazo, 2004). The positive contributions are always higher than the negative contributions, so that the Theil measure is always positive overall (Conceição and Ferreira, 2000). To test for statistically significant differences in information measures, they are related to the log-likelihood ratio test and to Pearson's χ^2 test (Theil, 1971). For the purpose of this paper, we consider that the differences are large enough when the measures differ by more than 50% (Moss, 2005).

The Relationship between Measuring Income inequality and Product Differentiation

The basic research objective of information measures is to make inferences about a system from limited partial information about it (Golan, 2002) representing an alternative to traditional statistical analysis (Soofi, 1994). (Theil, 1967) applied the cross-entropy measure to the analysis of income inequality. The problem is analogous to the cross-entropy by using income shares for different population groups instead of probabilities. Consider a geographic area with n regions. The population share of the i^{th} group is p_i and its income share is y_i. The income inequality measure $T(y:p)$ is

$$T(y:p) = \sum_{i=1}^{n} y_i \log \frac{y_i}{p_i}. \qquad (6)$$

The income inequality T measures the expected information of the message that transforms the population shares into the income shares and can be viewed as a measure of the inequality among the per capita incomes of the N regions (Theil and Fiebig, 1984). If income distribution was equal, the T measure would be zero. A relatively low number for T indicates low income inequality and a high number indicates high income inequality. Most usually, this measure is used to compare groups and not individuals[23]. Three types of inequality can be distinguished: 1) total inequality, the overall comprehensive inequality between individuals, 2) inequality between the groups, the comparison of the population share with the income share of each group and 3) residual, the remaining inequality among individuals that is not accounted for by the between-group inequality (Conceição and Ferreira, 2000). Our application to product differentiation by quality rating is similar to the income inequality application. The word 'inequality' is comparable to the word 'differentiation', and the word 'product' to 'income'. We denominate the cross-entropy measure of product differentiation by D. When one or more coffees capture higher prices relative to others, the D measure increases indicating greater differentiation.

Quality Differentiation Measure in Specialty Coffee Procurement

Empirical model

The p_i's, q_i's, P_i's, and Q_i 's can be given an interpretation other than probabilities as long as they qualify as probabilities, i.e. as long as they are nonnegative and add up to 1 (Theil, unknown). Since the share of value and the share of quantity of a coffee in a given

[23] The reality of data collection almost always entails some level of aggregation (Conceição and Ferreira, 2000).

total add up to one, we are able to apply the cross-entropy measure to our purpose of measuring the information contained in prices in different quality rating groups. The value v of a coffee transaction is given by the product of the price and the quantity, $v = p * q$. The unit of prices is dollars per pound ($/lb) and the unit of quantity is pounds (lb). The value of a transaction relative to the value of all transactions is its share v_i:

$$v_i = \frac{p_i q_i}{\sum_{j=1}^{n} p_j q_j} \tag{7}$$

The quantity of a transaction relative to the quantity of all transactions is its share q_i*:

$$q_i^* = \frac{q_i}{\sum_{j=1}^{n} q_j} \tag{8}$$

Let v_i be the observed share of value of coffee and let q_i be the corresponding share of coffee quantity in an individual coffee i. Then the cross-entropy with p_i and q_i of (1) interpreted as v_i's, q^*_i, respectively is:

$$D(v:q) = \sum_{i=1}^{n} v_i \log \frac{v_i}{q_i^*} \tag{9}$$

The problem is therefore analogous to that of the probabilities described above. By relating the value and the quantity shares as prior and posterior probabilities through the summation of the logarithm of their ratio, we can measure how much information one gains when one looks at the value share in relation to the quantity share. D measures the discrepancy between the distribution of value and the distribution of quantity between groups of coffees ordered by a sequence of quality rating.

The differentiation measure can be decomposed into differentiation between and within:

$$D = D_B + D_W \tag{10}$$

The between-group differentiation is

$$D_B(v:q) = \sum_{g=1}^{G} V_g \log \frac{V_g}{Q_g}. \tag{11}$$

where $V_g = \dfrac{\sum_{i \in Sg}^{k} p_i q_i}{\sum_{j=1}^{n} p_j q_j}$ and $q_g = \dfrac{\sum_{i \in Sg}^{k} q_i}{\sum_{j=1}^{n} q_j}$.

The within-group differentiation is

$$D_W(v:q) = \sum_{i \in Sg} \frac{v_i}{V_g} \log \frac{v_i / V_g}{q_i / Q_g}. \tag{12}$$

Data

We use the same data set used by Donnet et al (2007). Our data consists of 653 coffees at the Cup of Excellence and 59 coffees traded at the Q auction (Figure 6). At each auction, the coffees correspond to different years, different countries and regions within countries. They are produced from different coffee tree varieties and at different altitudes. All this information is available to bidders prior to the auction. In addition, potential bidders receive coffee samples for cupping at their facilities and they would not necessarily rate the coffees in them in the same way as the CofE jury[24]. Thus, it is likely that their bidding behavior and resulting prices do not necessarily reflect the CofE rates. With this note, we assume that the average of the individual bidders does.

[24] Thanks to Thomas Oberthur for this comment.

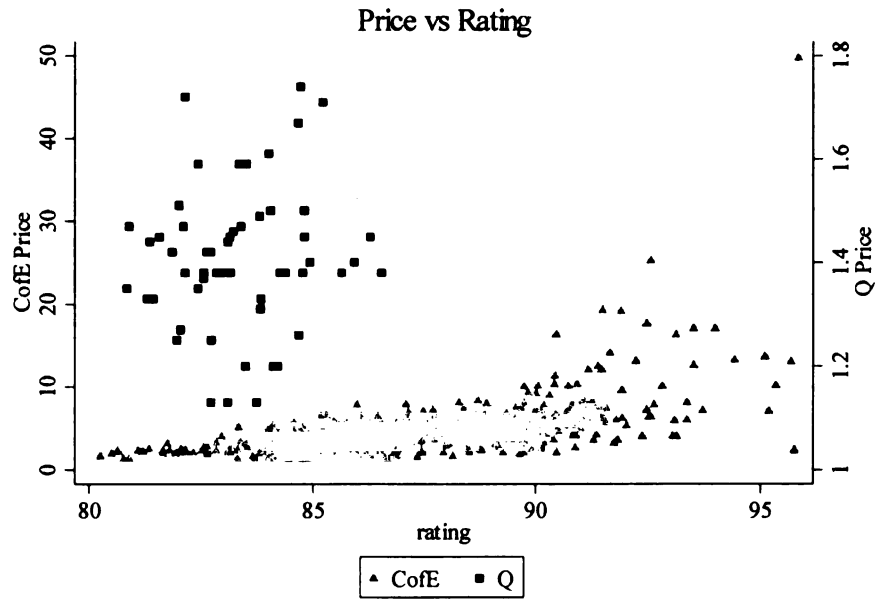

Figure 6: Quality Rating versus Prices in the CofE and Q Auctions

Decomposition of the Cross-entropy of value and quality rating

Using the aggregation properties of information measures we decompose the total information contained in prices D_{Total} (Figure 7). The first hierarchy is the auction, thus we have two groups corresponding to the two auctions D_{CofE} and D_{Q}. D_{CofE} represents the information contained in all prices traded at the CofE and, similarly, D_{Q} is the total information contained in the Q auction prices. Within each group we sub-group the sequence ratings in the specialty product category, i.e. 80 to 100, every 2.5 points. This is done arbitrarily for the purpose of the analysis of this paper. Dividing the 20 points range by 2.5 yields eight groups. Figure 7 shows the actual groups for which there are observations in the data set, six groups in the CofE and three groups in the Q. The number in each group indicates the observations.

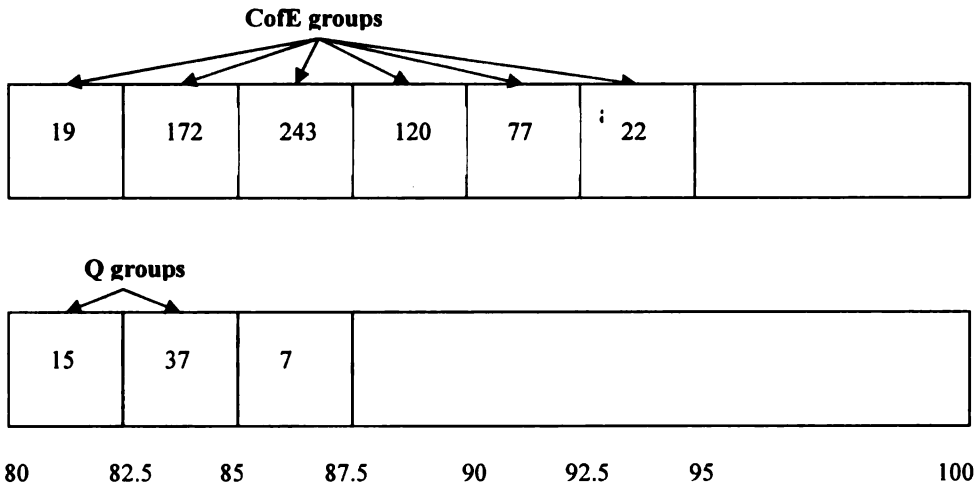

Figure 7: Decomposition of the Differentiation Measure: Groups of Specialty Coffee

Results

Table 7 shows the estimation results of the differentiation measure by quality ratings in specialty coffees traded at the CofE and Q auctions. The differentiation measures computes how much is the quality rating connected to price, or how good is the quality rating to predict price, and therefore constitutes a measure of the degree of differentiation in a product. Three types of differentiation can be distinguished: 1) total differentiation, the overall comprehensive differentiation between coffees, 2) inequality between the groups, represents the contribution of each group to the total differentiation and 3) residual, the remaining differentiation among coffees that is not accounted for by the between-group differentiation.

Table 7: Results of the Quality Differentiation Measure the CofE and Q Specialty Coffee Auctions

	E-Auction					
Groups	**CofE**			**Q**		
	D	D_B	D_W	***D***	D_B	D_W
Total	**0.184424**			**0.004313**		
>92.5		0.090580	0.017809			
90-92.5		0.119440	0.023002			
87.5-90		0.021130	0.012264			
85-87.5		-0.053280	0.026755		0.003780	0.0002087
82.5-85		-0.074380	0.013280		-0.005860	0.0033178
80-82.5		-0.012500	0.000324		0.002170	0.0006962

Interpretation of the Differentiation Measure and Management Implications

To interpret the differentiation measure we go back to questions posed at the beginning of the paper. The first question is whether there is vertical differentiation across specialty coffees according to the quality rating. The first thing to note is that differentiation is 40 times higher in the CofE relative to the Q auction (Table 8).

Table 8: Degrees of Differentiation by Quality Rating Groups in the Cup of Excellence

Quality Rating Group	D_B	Degree of differentiation
	0.090580	
>92.5		1
	0.119440	
90-92.5		1
	0.021130	
87.5-90		3
	-0.053280	
85-87.5		2
	-0.074380	
82.5-85		2
	-0.012500	
80-82.5		3

Differentiation means a higher discrepancy between the quantity and value shares of each group in the total (Figure 8). The upper group accrues 8 percent of the total value with 3 percent of the total quantity. The second group accrues 22 percent of value with 11 percent of quantity. These two groups contribute to the total differentiation the most.

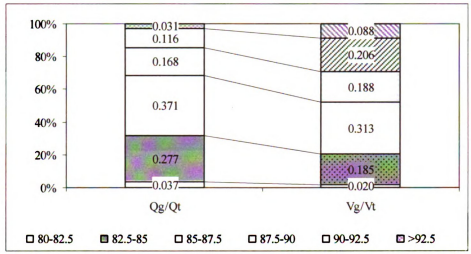

Figure 8: Product Differentiation in Specialty Coffees: Quantity and Value Shares of 653 CofE Lots Grouped by Quality Ratings

In the Q auction, the shares of quantity and value are similar in the groups, there is no discrepancy between the distributions of value and quantity and therefore differentiation is low relative to the CofE (Figure 9).

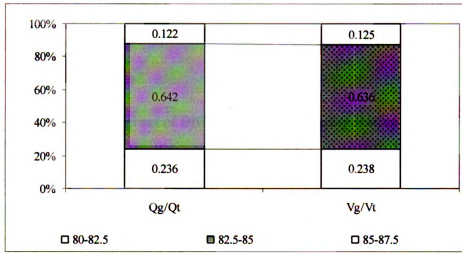

Figure 9: Product Differentiation in Specialty Coffees: Quantity and Value Shares of 59 Q Lots Coffees Grouped by Quality Ratings

We can further analyze differentiation degrees across groups in each auction separately by looking at the between-groups differentiation, D_B, and using the 50% rule of significance. In the CofE, three degrees of differentiation can be distinguished (Table 9). Differentiation is highest (first degree) in the groups 90 to 92.5 and 92.5 to 95; second highest in the groups 82.5 to 85 and 85 to 87.5; and third highest in the groups 80 to 82.5 and 87.5 to 90. Buyers distinguish coffees from 90 to 95 more carefully than in any other group. This group has the highest contribution to the total differentiation measure. Buyers are less discriminating in the lowest and middle quality groups. A medium degree of discrimination corresponds to the 82.5 to 87.5 possibly indicating the range for a lower limit for truly specialty coffee. In the lowest quality group, 80 to 82.5, and 87.5 to 90, buyers discriminate the least. We may say that buyers are most concern with finding extraordinary quality. They are concerned secondly with establishing a lower limit for specialty coffees. And they are least concerned with the coffees in between. With respect

to the very lowest group, looking at the data, this is a small group with coffees traded in the early years of the competition-auctions. It makes sense to not pay much attention to this group.

Table 9: Degrees of Differentiation by Quality Rating Groups in the Q

Quality Rating Group	D_B	Degree of differentiation
85-87.5	0.003780	2
82.5-85	-0.005860	1
80-82.5	0.002170	2

Similarly, we can distinguish degrees of differentiation in the three groups formed by the quality ratings in the Q auction. Following the 50% significance rule, we find that the opposite that we find in the CofE. The group with the highest degree of differentiation is the middle one. This group is below average. It seems that for Q coffees that are either highest or lowest quality, the quality rating is less related to price than for the middle group. Since the Q coffees represent a more homogeneous group relative to the CofE (as our D shows) we may infer that the grading is better calibrated for distinguishing around average coffees. Another interesting observation from the differentiation-between is that coffees in the Q auction converge to the average (see (Conceição and Ferreira, 2000).

The answers to the remaining questions regarding 2) how effective is the quality rating as in index of vertical differentiation, 3) how informative is the price signal to the grower with respect to the quality rating, and 4) how strong is the quality rating for remunerating quality, follow from the answer above. The quality rating is a more effective index of vertical differentiation in the CofE and within this around the highest and lowest quality coffees. The price signal is 40 times more informative in relation to the quality rating in

the CofE versus the Q auction. Finally, the quality rating is a strong index of quality remuneration in the CofE.

Implications from the results can be determined at all levels in the supply chain. Increased differentiation means higher value and higher revenue for participants. Roasters are creating this value and revenue by distinguishing material quality using the quality rating. Although the rating is the same in different marketing channels, e.g. the CofE and Q auctions, its effectiveness is not the same. This reflects the more exhaustive criteria and procedure to evaluate the coffees' cup attributes that buyers are willing to pay for and transmit to their specialty customers. This might indicate that buyers regard other information more importantly in the Q auction, for example, the price of the commodity. For example, since the Q is a larger volume auction, quality is relaxed relative to the CofE which is a small volume auction.

Because our analysis is at the procurement level, differentiation means increasing remuneration to coffee growers relative to quality. Different quality rating groups can be seen as indicating producers of the value of their actual resources and the returns of possible investments to upgrade quality to move up (or down) in groups. With this information, growers can select which chain to participate, and in which category within a given chain, on the basis of which one remunerates the quality of their coffee more advantageously.

Conclusion

In this paper, we proposed an index of vertical differentiation in specialty coffees using cross-entropy analysis in an analogous way to the income inequality index. We illustrated how the index works and interpreted its values for two e-auctions. The differentiation

measure can be interpreted as an index of the information contained in specialty coffee prices. Higher information chains convey more information so there is more scope for farmers to make upgrading. Higher information groups reflect a higher effort in quality definition and more detailed sourcing procedures.

The differentiation measure is a helpful index of the potential rewards from supplying to buyers in different marketing channels and quality groups (products). Interpreting this measure in relation to the costs of meeting the quality and participation requirements of the different segments can help the matching between producers and buyers in a more efficient way. Sending appropriate price signals (as through e-auctions) and interpreting them correctly is important for supporting the origin of quality and thus achieving sustainability of specialty coffee supply chains.

CONCLUSION

This dissertation examines coordination at the procurement level in the specialty coffee supply chain. The research utilizes economics and management tools in the case of e-auctions.

The first paper shows that prices of specialty coffee are determined by sensory as well as reputation attributes. Sensory attributes are responsible for the superior sensorial experience offered by specialty coffees. Reputation attributes denote what is behind this superior experience. Reputation attributes provide extra information that helps ascertain complex quality and reduce quality risk. Together, they constitute a signal that enhances coordination of the supply chain.

The second paper illustrates the role of auctions in the design of the roaster's procurement strategy to complement supply relationships and adjust the procurement strategy during the planning season. The impact of e-auctions is more important in more uncertain environments and for smaller roasters. These results further suggest that e-auctions greatly facilitate the discovery process.

The third paper proposes an index of product differentiation of specialty coffees according to their sensory quality as summarized in the quality rating. The application of the index to data from two e-auctions indicates that the quality rating is used to vertically differentiate specialty coffees.

The dissertation research elucidates value creation in the specialty coffee industry. It shows: product differentiation by sensory and reputation attributes; the role in adjusting procurement in quantity; and product vertical differentiation by sensory attributes. This study of e-auctions shows the provision of quality incentives, increased information

transmission and risk reduction in specialty coffee supply chains. These are the coordination elements that allow producing and delivering quality and thus enhancing the value of the product and the remuneration/satisfaction of the supply chain participants.

Roasters are achieving coordination of supply chains with scope for simultaneously increasing consumers' satisfaction and producers' income. This explicit, high level coordination of the complex coffee supply chain signifies a profound change of the management role and the potential benefits to all participants, relative to the commodity.

This increased information in the specialty coffee chains, unlike the commodity coffee chain, means that growers can now learn about the value of their produce to make strategic decisions to sustain prices and income. In this context, strategic and operations management decisions become relevant, for example, entering relationships, organizing auctions, upgrading quality through improved practices, and erecting barriers to entry. For producers managing coffee farms and cooperatives that are currently in or soon to enter into high value supply chains there are more factors to consider given the marketing opportunities offered through the e-auction supply chain.

The propositions on price determinants at the procurement level in this dissertation can test be tested and expanded as more data becomes available from e-auctions and other procurement channels. In addition, research on prices at the retail level can show how the prices of attributes at the procurement level translate into the prices of attributes for the consumer, clarifying marketing strategies of roasters and tracing the price signal from the consumer. Moreover, analysis at the production level can clarify how specialty coffee procurement strategies translate into income to the producers. Finally, the concepts,

methods and findings can be incorporated into a framework and theory of specialty products.

APPENDIX

A. The Coffee Supply Chain

A coffee supply chain is the sequence of stages involved in delivering a coffee product to the final consumer. It includes production (cultivation, harvest and initial processing), roasting, distribution and consumption. Coffee production takes place in coffee estates[25] and small farms in approximately 60 countries in tropical and equatorial regions. This stage entails the planting, growing and harvest of the coffee cherry and initial processing to separate the beam from the skin and pulp of the cherry. The result of this stage is a green bean. Since the majority of coffee is consumed in non-producing countries, coffee is exported to the consuming places largely in the form of green beans. Several firms may be involved in the international trade of coffee including exporters, importers and roasters. The trade can also take place directly from grower to roaster. Moreover, growing and roasting can be vertically integrated in ownership and management[26]. Green beans need to be processed in order to display its aromatic and flavor characteristics. This processing is called coffee roasting and consists of the heating of the coffee that transforms the physical and chemical properties of the green bean into roasted coffee

---

[25] Estates are medium and large scale individual farms. Size varies from large estates of over 500 ha down to only a few coffee trees on small holdings. Medium-size farms, between 5 and 30 ha, mainly occur in Latin America. In about 80% of the countries that have distinct estate and smallholder subsectors among coffee producers, the smallholdings predominate (de Graaff, 1986).

[26] This happens in the case of coffees from production origins with well-established reputation for outstanding growing conditions such as Kona and Blue Mountain coffees. For example, the roasting firm Wataru opted for vertically integrating the production of coffee and own a plantation in Jamaica for their premier coffee Blue Mountain (Wataru & Co., 2004).

products. Finally, coffee is ground and brewed for consumption as a hot or cold beverage. Brewing methods include the use of a dip brewer, an espresso machine, a French press or a vacuum pot, among others. Coffee may be further processed to make instant coffee, which only requires adding water to consume.

Coffee growing and processing

Coffee trees are grown in tropical regions since the species requires even temperatures between 15 to 24°C year round. In order to fall within this temperature range, the altitude at which coffee is actually cultivated depends on the latitude (de Graaff, 1986). For example, in the equatorial regions (e.g. Colombia, Mexico), coffee is grown at altitudes between 1200 and 2000 meters while in the subtropical regions (e.g. Brazil, Jamaica), at 500 to 1200 meters. The ideal precipitation is 1500-2500 mm over a nine month period with a three month dry season coinciding with the harvest. Propitious soils for coffee are humus, porous, and with a neutral to slightly acidic pH. The microclimate is also important and is provided by taller trees which maintain high humidity, moderate temperatures, prevent direct exposure to sunlight and heavy precipitation and improve soil conditions.

There are two main botanical species of coffee in commercial trade, Arabica and Robusta. Arabica is grown at higher altitudes and its cultivation demands great care. The cultivation of Arabica varieties is analogous to the cultivation of the finest grapes in the best vineyards terroirs. Robusta, as the name suggests, is a hardier plant, which displays greater resistance to climate and weather conditions, diseases and heat. In the cup, Arabica is distinctly milder and more aromatic with fewer sharp and bitter tastes than Robusta. This is the reason why most specialty coffees come from this species. The

Robusta species displays higher caffeine content, which is why Robustas are used for espresso. The fruit of the coffee plants are the berries which grow in clusters and typically carry two coffee beans each. Each tree can produce between one to twelve pounds of coffee per year depending on the soil, the climate, and other factors. Coffee berries do not ripen uniformly so the harvest has to be done manually for obtaining the highest quality of homogeneous ripened berries.

The harvested cherries enter the processing, by which coffee beans are obtained. The first step is the pulping of the cherries, to separate the pulp from the beans, which are covered by mucilage. The beans covered in the mucilage can then be sent to patios to dry as pulped natural coffees or can be sent to fermentation tanks for wet processing; the first method is the most common in Brazil and the second in the other Latin-American countries. The wet processing is the fermentation of the pulped beans with water for16-36 hours depending on the water temperature which is related to the altitude. After this, the beans are dried to 11-12 percent of moisture content in drying patios. This stage is called the parchment. What remains is the removal of the outer skin by hulling. The product is the green beans that are the form in which coffee is exported to consuming countries.

Trade and Procurement

Coffee is traded from producing to consuming countries largely in the form of green coffee beans packed in 60 or 69 kg bags. The largest trading companies of green coffee worldwide are the Neumann and Volcafe with 29 percent of the market share. These companies together with Cargill, Esteve, Aron and Man have 50 percent of the green coffee market (Ponte, 2001). Prices in the trade of Arabica coffees are set with reference

to the New York Board of Trade NYBOT, while the London International Financial Futures and Options Exchange (LIFFE) is the reference market for Robusta coffees.

Coffee is traded on the basis of its type (Arabica or Robusta), primary processing (wet or dry), country of origin and grade. Grades are determined by defective bean count, bean size standards, moisture content limits, confirmation of good uniformity, good color and freshness (Ponte, 2001). There are five grades in use: 1) the highest is specialty coffee; 2) the second is premium coffee; 3) the third represents the quality of coffees that are acceptable for trade at the New York Board of Trade (NYBOT); 4) grade four is usually purchased by institutional roasters through private contracts with producers and brokers; and 5) grade five is often traded by soluble coffee manufactures and institutional decaffeinators (Barker, 2003). In addition, lower grades are relegated to internal consumption within the producing countries (ibid.).

Green coffee prices are recovering from a low of 50 cents per pound level in 2001 and 2002 to almost one dollar per pound in 2005 (Figure 10). Green coffee prices are very volatile due to the crop sensitivity to changes in temperature, rainfall, and diseases. Additional volatility factors have been added in the 90s which include: the end of the stabilization mechanisms of the quota system by the International Coffee Association (ICA) in 1989 which used to stabilize prices; the increased activity in the coffee futures market which consequently increased speculative activity and thus price fluctuation (Ponte, 2001); and the adoption of supplier-managed inventory system by roasters which transferred the supply and quality risk to trading houses, this system is very sensitive to supply shortages and is prone to trigger panic-buying situations causing major price hikes (ibid.). This situation is illustrated by the 1990s Brazilian coffees case.

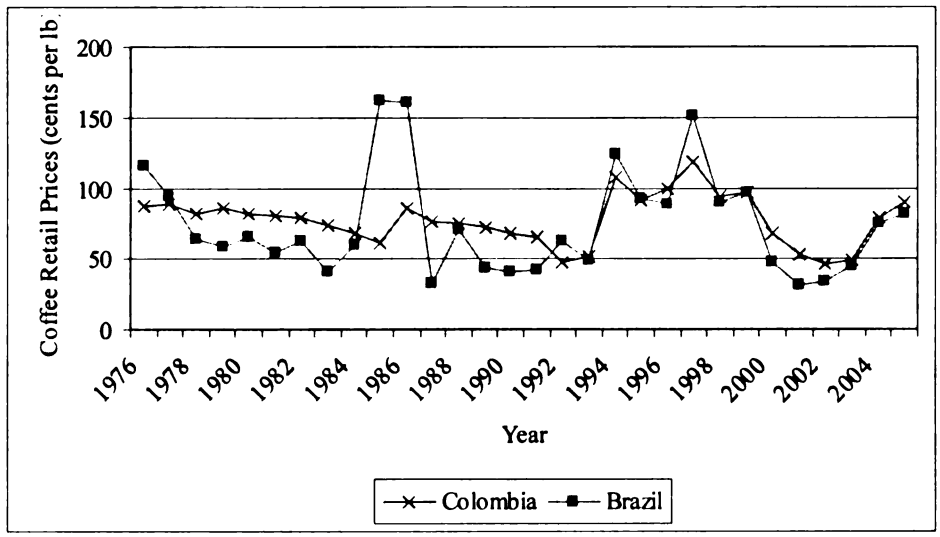

Figure 10: Prices paid to growers in exporting countries: December monthly average (cents per lb) (Arabica). Source: International Coffee Organization.

Roasting

In order to bring out flavor and aroma coffee must be roasted. During roasting green coffee beans expand in size, change in color and density and display the oils that give coffee its characteristic taste. As the bean progressively absorbs heat, the color changes from green to yellow to light brown and then finally to a dark brownish oily color. The grades of coffee roasting include, progressively: unroasted, light, cinnamon, medium, high, city, full city, French, and Italian. Lighter roasts showcase the coffee's origin flavor, i.e. the flavors created in the bean by the soil and weather conditions in the location where it was grown. As the beans darken past a certain point the roast flavors begin to overtake the origin flavors of the bean (The Real Estate Blend, 2006).

Roasters are the leading firms in the traditional coffee supply chains[27]. The concentration ratio is high at this level in the supply chain with a CR4 of 63 percent in 1998 (Daviron and Ponte, 2005). The four largest firms are Altria (ex Philip Morris), Nestle, Sara Lee, and Procter and Gamble. However, fragmentation of the market started to take place as coffee became more differentiated and new firms entered with innovative business strategies to capture the demand of coffee drinkers (Roseberry, 1996; Ponte, 2001). While in 1969 there were approximately 20 small roasters, by 1979 the number had doubled, and in 1989 it was 385; since 1990, the number of small roasters opening annually increased by increments of 100 with an estimation of 1,400 by 1999 (Lingle, 2001b). According to the SCAA, this fragmentation was the most fundamental change in the coffee industry (ibid.).

Retailing

Coffee retailing can be divided into sales of coffee-per-pound or retail store sales and coffee-per-cup or food services sales. Supermarkets are the most important retail outlet for coffee for in-home consumption (Ponte, 2001). Retailers became more interested in the higher margins obtained from differentiated coffee vs. the commodity and dedicate more shelf space, advertising and promotion to the product (Duff, 2002). In addition to

---

[27] Leading firm, in the global value chain framework of political economy, refers to the companies that play the 'driving' or 'lead' role in the structuring and management of the supply chain. Lead firms govern the supply chain by explicitly coordinating "globally dispersed and organizationally fragmented production and distribution networks" (Gereffi, 2005). The analogous concept in the logistics and distribution of the business literature is 'channel captain', i.e. the firm or economic stage that controls the channel.

supermarkets, coffee-per-pound can be purchased in specialty stores and increasingly on-line directly from roasters.

Foodservice is gaining ground on retail stores for the last decade. Coffee sales at retail stores in the US accounted for 46 percent in 2005 compared to 55 percent in 1994 (Ganes-Chase, 2006). Starbucks is the leader in selling coffee-per-cup with 5,393 company-operated coffeehouses and 2,952 licensed locations in the US (Starbucks, 2006). Diedrich Coffee is the number two company with about 200 company-owned and franchised locations in California and other states (Hoover's, 2006). Peet's and Tully's have 120 and 110 stores respectively. Peet's is considered to be the oldest specialty coffee company in the US with a history of 40 years while Starbucks is considered to be its child of age 35. Coffee-per-cup can also be purchased in coffee shops, convenience stores and supermarkets.

Retail coffee prices follow the pattern of the green coffee prices (Figure 13). Major hikes at the retail level in the 1990s reflect the supply shortage from Brazil, the major producing country.

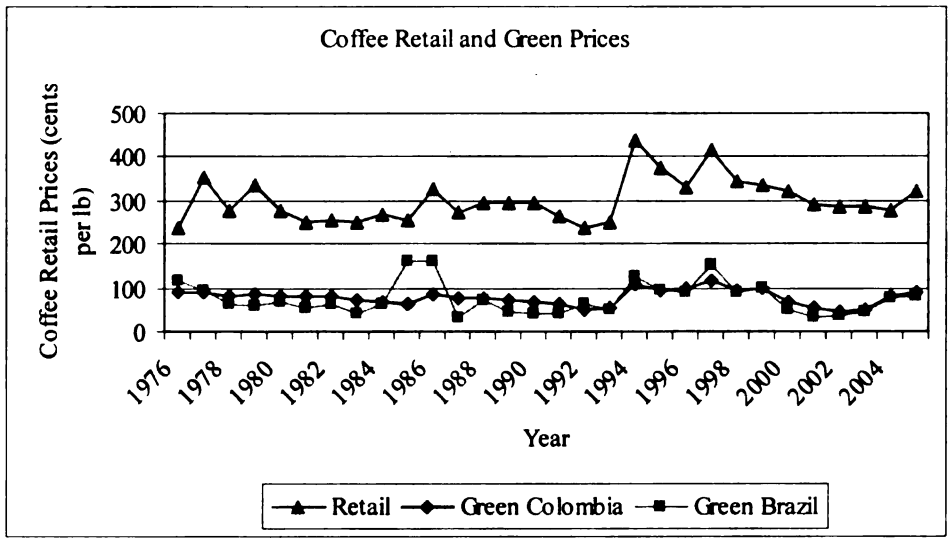

Figure 13: Retail prices in the US: December monthly averages (cents per lb). Source: International Coffee Organization.

Consumption

The coffee market can be judged as being in its maturity phase since consumption is stagnant or even declining with income on a per capita basis (Ponte, 2001; Beaver, 2006). Coffee entered a downward spiral of declining consumption and market share loss to other beverages since the early 1960s. In the early 2000s, consumption was roughly a half of its highest which occurred in 1962 (Figure 14). Although total consumption is stagnant, there is a change in consumer preferences from quantity to quality which is shown in Figure 4 by the appearance of the category 'specialty coffee' in 2000. Consistent with the general trend of food upgrading people are drinking less but a better quality coffee.

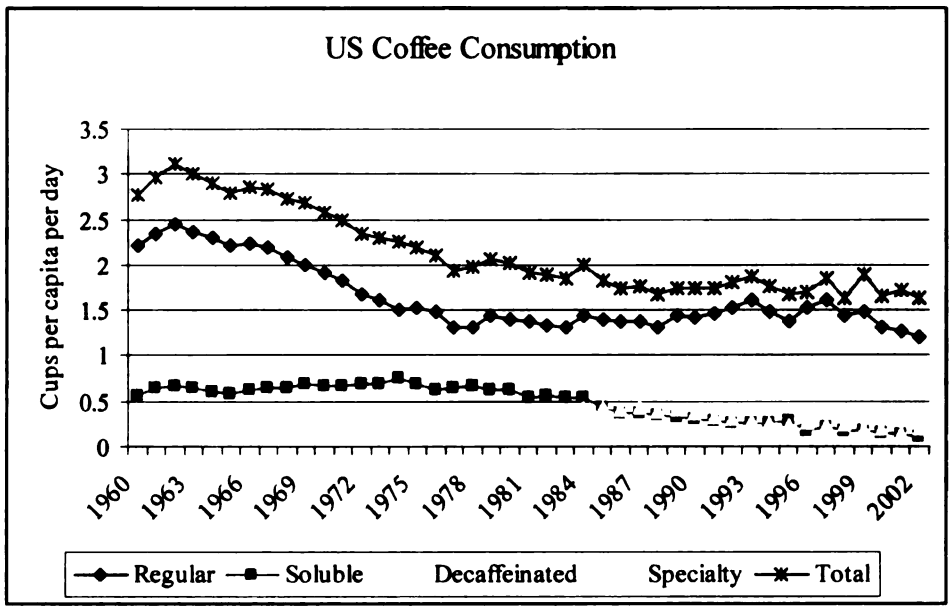

Figure 14: US per Capita Coffee Consumption. Source: Horticultural and Tropical Products Division, FAS/USDA

Overall, the coffee market is becoming increasingly differentiated and quality is being distinguished and valued at a higher level. Thus, coffee is considered to be where the wine industry was 10-15 years ago (Ron Wiegand SCAA presentation cited in Sweet Marias). Of a total coffee market of $20 billion in the US, differentiated coffees represented $7.76 and $9.62 billion in 2000 and 2004 respectively, indicating the increasing market share accruing to non-commodity coffees relative to all coffees (NCA and SCAA). According to the National Coffee Association (NCA), the share of adult population in the US drinking differentiated quality coffee increased from 9 percent in 2000 to 15 percent in 2005.

B. Definition of Specialty Coffee

Specialty coffee refers to the highest quality green coffee beans roasted to their greatest flavor potential by true craftspeople and then properly brewed to well-established standards (SCAA definition)[28]. Thus, a specialty coffee is defined in the cup. The process of assessing the quality of a coffee in the cup is called cupping. Coffee cupping is the analogous to wine tasting and consists of the examination and evaluation of the coffee attributes in the cup including the olfaction, gustation, and mouthfeel of the coffee (Lingle, 2001). The SCAA developed a cupping procedure and description for adoption in the specialty industry to maintain quality in the specialty industry[29]. The evaluation gives each coffee a quality rating which is a 100 point scale that summarizes the coffee quality in the cup, also called sensory quality. By standardizing the cupping, the SCAA intend to prevent the loss of meaning of the term 'specialty' from the auditioning of milk, water, syrups and others (Daviron and Ponte p. 155)[30].

In Green Coffee Beans

At the core of the specialty coffee concept is that special geographic microclimates and cultivation conditions and methods produce beans that will give unique coffee flavor profiles (Ponte, 2002). The potential for flavor and aroma resides in the precursor

---

[28] The term 'specialty coffee' was first coined by Erna Knutsen, of Knutsen Coffee Ltd., in a speech to the delegates of an international coffee conference in Montreuil, France, in 1978.

[29] The cupping form designed by Howell is the one used in the industry with modifications by different firms/organizations. For example, the CofE uses a most exhaustive one, but they are all similar and rate the coffees in a 100 scale according to quality in the cup.

[30] The original idea was that the SCAA would certify coffee lots complying with their cupping standards (Ponte and Daviron 2005 p. 155).

compounds in the green coffee beans (Mabbett, 2006). Also the chemicals responsible for the color and body in the cup are locked away in green coffee (ibid). Coffee is a naturally differentiated product. The attributes of a cup of coffee result from a particular combination of chemical compounds which is unique to the conditions and methods of cultivation, to the coffee origin. These conditions govern the coffee sensory attributes, i.e. its organoleptic signature, stimulating the taste buds on the tongue and sensory cells in the nose (Davids, 2002; Arvidson, 2003; Mabbett, 2006).

The Specialty Coffee Association of America (SCAA) continues to define specialty in this context, as Don Holly remarks (Holly, 2005): "This is the craft of the specialty coffee industry that had been slowly evolving during the twenty-year period preceding this speech.". The key in the definition of specialty is that it must taste notably good; the premium grade (second grade) also has no primary defects, but does not necessarily evidence a distinctive character in the cup. This is the definition that is increasingly being accepted in the industry and emphasizes that specialty stands for an outstanding cup quality trait, and not for process and credence attributes such as organic, fair-trade, and so on (Oberthur, 2006).

In Roasted Coffee

In roasted coffee, most experts agree freshness is part of the definition for specialty. Freshness is critical because if the coffee is not highly aromatic it no longer deserves to be called specialty (Holly, 2005)[31]. Supply chain players, however, do not show consensus about how fresh roasted coffee must be. Retail roasters tend to favor a shorter optimum life-span (3 to 7 day) for best taste while wholesale roaster contend that the

[31] "While the tongue may tell, only the nose knows for certain" (Holly 2005).

optimum period of time can be greatly expanded into weeks or even months with appropriate packaging technology. The question remains whether there is such technology that can retain the aromatic properties of a specialty coffee (ibid.).

In the Coffee Beverage

Finally, specialty coffee requires a correct preparation: the right recipe of coffee to water, the right grind suited to the method and the coffee's physical characteristics, and the proper water temperature and contact time (Holly, 2005). A good preparation of a specialty coffee can be done by different methods. 'Barista' is the term used to refer to experts and professionals of the preparation of espresso-based coffee drinks. The meaning of a barista is expanded within certain circles, to include what could be called a coffee sommelier, i.e. a professional who is highly skilled in coffee preparation, with a comprehensive understanding of coffee, coffee blends, espresso, quality, coffee varieties, roast degree, espresso equipment, maintenance, latte art, etc.

It follows from this definition that delivering a cup of specialty coffee entails new ways of doing things at each level of the supply chain.

C. The Emergence of Specialty Coffee

Changes in Roasting and Retailing

The gradual rise to dominance of industrial capital did not mean that the consumer market was very price-sensitive and susceptible to new coffee product lines and advertising. The expansion of large roasting companies with their superior technology, greater efficiency, more reliable and cheaper product, and marketing sophistication did not expand coffee consumption as one might have expected. On the contrary, just as consolidation was beginning to occur, per capita consumption in the United States was stagnating. It would take forty years for U.S. consumers to again reach the thirteen pound per capita level of 1902.

The development of specialty coffee is a response of firms to the decline of coffee quality and consumption in the 1970s and 1980s. This decline is associated with increasing production of Robusta and higher yielding Arabica varieties and the technologies and trends in roasting towards using lower quality green beans. Coffee firms were used to selling large quantities of relatively homogeneous and undifferentiated blends of mediocre to poor quality (Ponte, 2001), a "bizarre" strategy for a naturally differentiated product (Roseberry 1996). In Lingle's words, the coffee industry was "a caffeine delivery system that the consumer would drink regardless of how it tasted" (Beaver, 2006). The move toward quality was not initiated by the large coffee firms but by small regional roasters who developed new sources of supply and new modes and networks of distribution (Roseberry, 1996). As noted by Ted Lingle, "it was the core belief of a small group of people that felt they could fulfill the needs of consumers for a good-tasting product" that led to the growth of the specialty industry (Beaver, 2006). Roasters and

retailers started to invest in product innovation and segmentation in order to increase value added as shown in the explosive growth of specialty coffee retail chains (Ponte, 2001). The idea of quality was not well received by the traditional coffee industry and it took 30 years for the specialty industry to reach the critical mass to crystallize the changes (Beaver, 2006).

The changes at the roasting level include the roast of varietals and origin identified coffees to an appropriate roast to display their aromatic and flavor attributes. The changes at the retail level are what characterizes the specialty coffee experience, which includes the: coffees' nice aromas and tastes; variety in coffee origin and form of preparation; and the ambience of the coffee shop or the specialty retail or the supermarket aisle. Starbucks is the company that led the popularization of these characteristics at both roasting and retail and thus became the specialty coffee icon. As Howard Schultz put it "We created an industry that did not exist" (Pelley, 2006).

Changes in Consumption

At the same time that roaster and retailers were developing an alternative to poor quality, consumption preferences were changing from a past characterized by mass consumption (Roseberry, 1996). These changes in preference were accompanied and guided by the promotional and educational activities led by the Coffee Development Group (CDG) (Chwat, 1991; Beaver, 2006). As stated by Ted Lingle, the demand for Starbucks products might never have happened without the work of the CDG (Beaver 2006). The CDG got funds from the International Coffee Organization (ICO) and set up 300 coffeehouses on college campuses to introduce the youth to a menu of coffee beverages in the 1970s, i.e. long before the specialty coffee explosion. This promotion work set the

stage for Starbucks to successfully introduce its products (such as skinny latte and ice blended mocha) and turn an industry from bean-based to beverage-based (ibid). Thus, the development of the early specialty coffee industry was the result of a two-way exchange of information on taste, roasting styles and origins of coffee that allowed roasters to experiment with new roasting methods, packaging and procurement (Daviron and Ponte, 2005). Today nearly 90 percent of consumers understand that coffee is a differentiated product, like wine, cheese or ice cream, and that quality coffee demands premium prices (Beaver 2006).

Results in Product Differentiation

The specialty changes in the coffee supply chain resulted in a much differentiated market in which coffee firms distinguish their product from the competition to enhance value and revenue and move away from the commodity aspect of the product. Changing approaches from quantity to quality allowed the opportunity to make consumers aware of varietals and origins, roasts and methods of preparation. The industry is now believed to be coming of age as a true specialty beverage (Davids, 2006). Davids notes that the seasonal offerings of small lots of exceptional coffees are a sure sign of this. Specialty coffee differentiation is increasingly being described using wine-influenced language like "Special Reserve," "Limited Edition," "Roastmaster's Reserve" and so on. These are the cream of the specialty coffee and represent coffees from a single crop and single farm or hillside. Different from mass coffees, these are sold not on the basis of consistency or brand, but as an opportunity to experience the flavor associated with a unique moment in time and space and the dedication of a single farmer or group of farmers (ibid.).

D. Detailed derivations and proofs of propositions for second paper

Derivation of Equation (4): Substituting the optimal procurement quantity (3) into the expected profit function (2) and consolidating yields

$$E\pi^B = \frac{1}{2\eta}\left\{\frac{1}{2}\frac{(p+s-c_R)^2\overline{D}^2}{(p+s-v)} + \frac{1}{2}\frac{(c_R-v)^2\underline{D}^2}{(p+s-v)} - \frac{1}{2}(p-v)\underline{D}^2 + \frac{(c_R-v)(p+s-c_R)\underline{D}\overline{D}}{(p+s-v)} - \frac{1}{2}s\overline{D}^2\right\} - K_R.$$

Replacing the expressions of the maximum and minimum demands,

$$E\pi^B = \frac{1}{2\eta}\left\{\frac{1}{2}\frac{(p+s-c_R)^2}{(p+s-v)}\left(\mu^2+\eta^2+2\mu\eta\right) + \frac{1}{2}\frac{(c_R-v)^2}{(p+s-v)}\left(\mu^2+\eta^2-2\mu\eta\right) - \frac{1}{2}(p-v)\left(\mu^2+\eta^2-2\mu\eta\right) + \frac{(c_R-v)(p+s-c_R)}{(p+s-v)}\left(\mu^2-\eta^2\right) - \frac{1}{2}s\left(\mu^2+\eta^2+2\mu\eta\right)\right\} - K_R.$$

Distributing $\frac{1}{2\eta}$

$$E\pi^B = \frac{1}{4}\frac{(p+s-c_R)^2}{(p+s-v)}\frac{\mu^2}{\eta} + \frac{1}{4}\frac{(p+s-c_R)^2}{(p+s-v)}\eta + \frac{1}{2}\frac{(p+s-c_R)^2}{(p+s-v)}\mu + \frac{1}{4}\frac{(c_R-v)^2}{(p+s-v)}\frac{\mu^2}{\eta} + \frac{1}{4}\frac{(c_R-v)^2}{(p+s-v)}\eta - \frac{1}{2}\frac{(c_R-v)^2}{(p+s-v)}\mu - \frac{1}{4}(p-v)\frac{\mu^2}{\eta} - \frac{1}{4}(p-v)\eta + \frac{1}{2}(p-v)\mu + \frac{1}{2}\frac{(c_R-v)(p+s-c_R)}{(p+s-v)}\frac{\mu^2}{\eta} - \frac{1}{2}\frac{(c_R-v)(p+s-c_R)}{(p+s-v)}\eta - \frac{1}{4}s\frac{\mu^2}{\eta} - \frac{1}{4}s\eta - \frac{1}{4}s\mu - K_R.$$

Consolidating,

$$E\pi^B = \frac{1}{4}\frac{\left[(p+s-c_R)+(c_R-v)\right]^2}{(p+s-v)}\frac{\mu^2}{\eta} + \frac{1}{4}\frac{\left[(p+s-c_R)-(c_R-v)\right]^2}{(p+s-v)}\eta$$
$$+\frac{1}{2}\frac{(p+s-c_R)^2}{(p+s-v)}\mu - \frac{1}{2}\frac{(c_R-v)^2}{(p+s-v)}\mu$$
$$-\frac{1}{4}(p+s-v)\frac{\mu^2}{\eta} - \frac{1}{4}(p+s-v)\eta + \frac{1}{2}(p-s-v)\mu - K_R$$

In this expression the first and the fifth term cancel to yield Equation (4).

Derivation of Equation (9): Expected profits are

$$E\pi(x_R) = \int_{\underline{D}}^{\overline{D}} \pi(x_R, D) f(D) dD.$$

Given the uniform distribution of demand with probability density function $\frac{1}{2\eta}$ and profit in Equation (8),

$$E\pi^*(x_R) = \frac{1}{2\eta}\left\{\int_{\underline{D}}^{x_R}[pD + v(x_R - D) - c_R x_R - K_R]dD \right.$$
$$+ \int_{x_R}^{\tilde{x}}[(p-c_R)x_R - s(D-x_R) - K_R]dD$$
$$\left. + \int_{\tilde{x}}^{\overline{D}}[(p-c_R)x_R + (p-c_A)(D-x_R) - K_R - K_A]dD \right\}.$$

Integrating and consolidating yields (9).

Derivation of Equation (10): The first order conditions for maximizing (9) is

$$\frac{dE\pi(x_R)}{dx_R} = -(c_A - v)x_R + (c_R - v)x_R\underline{D} + (c_A - c_R)\overline{D} + K_A = 0.$$

Derivation of Equation (11): Substituting (10) into (9) gives,

$$E\pi^{*} = \frac{1}{2\eta}\left\{\frac{1}{2}\frac{(c_A - c_R)^2 \overline{D}^2}{(c_A - v)} + \frac{1}{2}\frac{(c_R - v)^2 \underline{D}^2}{(c_A - v)} + \frac{(c_A - c_R)(c_R - v)\overline{D}\,\underline{D}}{(c_A - v)} \right.$$
$$+ \frac{1}{2}(p - c_A)\overline{D}^2 - \frac{1}{2}(p - v)\underline{D}^2 + K_A \frac{(c_R - v)}{(c_A - v)}\underline{D}$$
$$\left. + K_A \frac{(c_A - c_R)}{(c_A - v)}\overline{D} + \frac{1}{2}\frac{K_A^{\,2}}{(c_A - v)} + \frac{1}{2}\frac{K_A^{\,2}}{p + s - c_A} - K_A \overline{D}\right\} - K_R.$$

Replacing the expressions of the maximum and minimum demands by the distribution parameters yields

$$E\pi^{*} = \frac{1}{2\eta}\left\{\frac{1}{2}\frac{(c_A - c_R)^2}{(c_A - v)}(\mu^2 + \eta^2 + 2\mu\eta) + \frac{1}{2}\frac{(c_R - v)^2}{(c_A - v)}(\mu^2 + \eta^2 - 2\mu\eta)\right.$$
$$+ \frac{(c_A - c_R)(c_R - v)}{(c_A - v)}(\mu^2 - \eta^2) + \frac{1}{2}(p - c_A)(\mu^2 + \eta^2 + 2\mu\eta)$$
$$- \frac{1}{2}(p - v)(\mu^2 + \eta^2 - 2\mu\eta) + K_A \frac{(c_R - v)}{(c_A - v)}(\mu - \eta)$$
$$\left. + K_A \frac{(c_A - c_R)}{(c_A - v)}(\mu + \eta) + \frac{1}{2}\frac{K_A^{\,2}}{(c_A - v)} + \frac{1}{2}\frac{K_A^{\,2}}{p + s - c_A} - K_A(\mu + \eta)\right\} - K_R.$$

Distributing $\frac{1}{2\eta}$,

$$
\begin{aligned}
E\pi^{\bullet} = & \frac{1}{4}\frac{(c_A - c_R)^2}{(c_A - v)}\frac{\mu^2}{\eta} + \frac{1}{4}\frac{(c_A - c_R)^2}{(c_A - v)}\eta + \frac{1}{2}\frac{(c_A - c_R)^2}{(c_A - v)}\mu \\
& + \frac{1}{4}\frac{(c_R - v)^2}{(c_A - v)}\frac{\mu^2}{\eta} + \frac{1}{4}\frac{(c_R - v)^2}{(c_A - v)}\eta - \frac{1}{2}\frac{(c_R - v)^2}{(c_A - v)}\mu \\
& + \frac{1}{2}\frac{(c_A - c_R)(c_R - v)}{(c_A - v)}\frac{\mu^2}{\eta} - \frac{1}{2}\frac{(c_A - c_R)(c_R - v)}{(c_A - v)}\eta \\
& + \frac{1}{4}(p - c_A)\frac{\mu^2}{\eta} + \frac{1}{4}(p - c_A)\eta + \frac{1}{2}(p - c_A)\mu \\
& - \frac{1}{4}(p - v)\frac{\mu^2}{\eta} - \frac{1}{4}(p - v)\eta + \frac{1}{2}(p - v)\mu \\
& + \frac{1}{2}\frac{(c_A - c_R)}{(c_A - v)}K_A\frac{\mu}{\eta} + \frac{1}{2}\frac{(c_R - v)}{(c_A - v)}K_A\frac{\mu}{\eta} + \frac{1}{2}\frac{(c_A - c_R)}{(c_A - v)}K_A - \frac{1}{2}\frac{(c_R - v)}{(c_A - v)}K_A \\
& + \frac{1}{4\eta}\frac{K_A^{\,2}}{(c_A - v)} + \frac{1}{2}\frac{K_A^{\,2}}{p + s - c_A} - \frac{1}{2}K_A\frac{\mu}{\eta} - \frac{1}{2}K_A - K_R.
\end{aligned}
$$

Consolidating and rearranging this gives Equation (14).

Derivation of Equation (12):

$$
\begin{aligned}
P\{A\} = P\{D \geq \tilde{x}\} &= 1 - \frac{\tilde{x} - \underline{D}}{\overline{D} - \underline{D}} = 1 - \frac{\dfrac{K_A}{p + s - c_A} + x_R^{\bullet} - \underline{D}}{\overline{D} - \underline{D}} \\
&= 1 - \frac{\dfrac{K_A}{p + s - c_A} + \dfrac{(c_A - c_R)\overline{D} + (c_R - v)\underline{D} + K_A}{(c_A - v)} - \underline{D}}{\overline{D} - \underline{D}} \\
&= 1 - \frac{K_A}{2\eta(p + s - c_A)} - \frac{(c_A - c_R)\overline{D}}{2\eta(c_A - v)} - \frac{(c_R - v)\underline{D}}{2\eta(c_A - v)} - \frac{K_A}{2\eta(c_A - v)} + \frac{\underline{D}(c_A - v)}{2\eta(c_A - v)} \\
&= 1 - \frac{(c_A - c_R)}{(c_A - v)} - \frac{K_A(p + s - v)}{2\eta(p + s - c_A)(c_A - v)} \\
&= (c_A - v) - (c_A - c_R) - \frac{K_A(p + s - v)}{2\eta(p + s - c_A)} \\
&= (c_R - v) - \frac{K_A(p + s - v)}{2\eta(p + s - c_A)}
\end{aligned}
$$

Detailed Proof of Proposition 3: The relationship procurement quantity in the benchmark strategy increases with uncertainty if the marginal profit from the relationship is larger than its marginal cost.:

$$\frac{dx_R^B}{d\eta} = \frac{(p+s-c_R)}{(p+s-v)}\overline{D}_\eta + \frac{(c_R-v)}{(p+s-v)}\underline{D}_\eta = \frac{(p+s-c_R)}{(p+s-v)} - \frac{(c_R-v)}{(p+s-v)} > 0 \text{ if}$$

$$p+s-c_R > c_R - v.$$

The relationship procurement quantity in the optimal strategy using e-auctions increases with uncertainty if the relationship cost advantage is larger than the relationship marginal cost:

$$\frac{dx_R^*}{d\eta} = \frac{(c_A-c_R)}{(c_A-v)}\overline{D}_\eta + \frac{(c_R-v)}{(c_A-v)}\underline{D}_\eta = \frac{(c_A-c_R)-(c_R-v)}{(c_A-v)} > 0 \text{ if } c_A - c_R > c_R - v.$$

Note: $\overline{D}_\eta = 1$ and $\underline{D}_\eta = -1$. The result of the proposition follows.

Detailed Proof of Proposition 4: The expected profits in the benchmark strategy increase with size by half of the relationship marginal profit including the shortage costs:

$$\frac{dE\pi^B}{d\mu} = \frac{1}{2}\frac{(p+s-c_R)^2}{(p+s-v)} - \frac{1}{2}\frac{(c_R-v)^2}{(p+s-v)} + \frac{1}{2}(p-s-v) = \frac{1}{2}(p+s-c_R) = \frac{1}{2}MP_R > 0.$$

The expected profits in the combined strategy increase with size by half of the relationship marginal profit not including the shortage costs:

$$\frac{dE\pi^*}{d\mu} = \frac{1}{2}\frac{(c_A-c_R)^2-(c_R-v)^2}{(c_A-v)} + \frac{1}{2}(p-c_A) + \frac{1}{2}(p-v) = \frac{1}{2}(p-c_R) > 0.$$

The result of Proposition 4 follows.

Detailed Proof of Proposition 4: The change in expected profit in the benchmark strategy is

$$\frac{dE\pi^N}{d\eta} = \frac{1}{4}\frac{[(p+s-c_R)-(c_R-v)]^2}{(p+s-v)} - \frac{1}{4}(p+s-v) = -\frac{(p+s-c_R)(c_R-v)}{(p+s-v)} < 0.$$

The change in expected profits in the combined strategy is

$$\frac{dE\pi^*}{d\eta} = -\frac{[(c_A-c_R)-(c_R-v)]^2}{(c_A-v)} - \frac{1}{4\eta^2}K_A{}^2\left[\frac{(p+s-v)}{(c_A-v)(p+s-c_A)}\right] < 0.$$

The change in the difference in expected profits is the difference between the two:

$$\frac{d\Delta E\pi}{d\eta} = \frac{dE\pi^*}{d\eta} - \frac{dE\pi^N}{d\eta} = \frac{[(c_A-c_R)-(c_R-v)]^2}{(c_A-v)} - \frac{1}{4\eta^2}K_A{}^2\left[\frac{(p+s-v)}{(c_A-v)(p+s-c_A)}\right] + \frac{(p+s-c_R)(c_R-v)}{(p+s-v)}$$

Solving and rearranging, the condition for the derivative to be positive is:

$$\frac{(p+s-c_R)(c_R-v)}{(p+s-v)} - \frac{[(c_A-c_R)-(c_R-v)]^2}{(c_A-v)} > \frac{1}{4\eta^2}K_A{}^2\left[\frac{(p+s-v)}{(c_A-v)(p+s-c_A)}\right],$$

which is the same condition for a positive probability of attending the auction.

REFERENCES

Ali, Hela Hadj, Sebastien Lecocq and Michael Visser (2005). The impact of gurus: Parker grades and en primeur wine prices. INRA Research Unit Working Paper 0507. Laboratoire d'Economie Appliquee.

Arvidson, Ed. (2003, 01.20.03). Coffee Varietals: A Taste Experience. Bellissimo Coffee Newsletter. From http://espresso101.com/newsletter/397.

Ashenfelter, Orley, David Ashmore and Robert Lalonde (1995). Bordeaux Wine Vintage Quality and the Weather. Chance 8(4): 7-14.

Bacon, Christopher (2005). "Confronting the Coffee Crisis: Can Fair Trade, Organic, and Specialty Coffees Reduce Small-Scale Farmer Vulnerability in Northern Nicaragua?" World Development 33(3): 497-511.

Barker, Robert (2003). "Green Coffee Grading Part I." Tea & Coffee Trade Journal(November).

Barker, Robert (2004). "Green Coffee Grading Part II." Tea & Coffee Trade Journal 179(5).

Bates, Robert (1997). Institutions and Development. Coffee Institutions and Economic Development. Diego Pizano and Jose Chalarca. Santa Fe de Bogota, Commemorative Symposium of the 70th Anniversary of the National Federation of Coffee Growers of Colombia (1927-1997).

Beaver, Jennifer (2006). "Charting the Coffee Course." The Specialty Coffee Chronicle.

Beaver, Jennifer (2006). Charting the Coffee Course. The Specialty Coffee Chronicle.

Benjamin, Beth A. and Joel M. Podolny (1999). Status, Quality, and Social Order in the California Wine Industry. Administrative Science Quarterly 44(3): 563-589.

Boccaletti, Stefano (1999). Signaling quality of food products with Designations of Origin: Advantages and limitations. IAMA Agribusiness Forum, Florence, Italy.

Bunduchi, Raluca (2005). Business relationships in Internet based electronic markets: the role of goodwill trust and transaction costs. Information Systems Journal 15(4): 321-341.

Bunn, M.D. (1993). Taxonomy of buying decision approaches. Journal of Marketing 57: 38-56.

California Libraries Association Conference (2005). Getting Started with Opening a Coffee Cafe, Kiosk or Cart in Your Library. From http://www.cla-

net.org/included/docs/handout25.pdf#search=%22getting%20started%20with%20opening%20a%20coffee%20cafe%22

Carriquiry, Miguel and Bruce A. Babcock (2004). Reputation, Quality Observability, and the Choice of Quality Assurance Systems. Center for Agricultural and Rural Development (CARD) Working Paper 04-WP 373 (September).

Castle, Timothy J. (2006). Assessing and Reflecting on Estate Coffees. Tea & Coffee Trade Journal 178(3).

Cattani, Kyle D., Wendell G. Gilland and Jayashankar M. Swaminathan (2004). Coordinating Traditional and Internet Supply Chains. Handbook of Quantitative Supply Chain Analysis: Modeling in the E-Business Era. D. Wu D. Simchi-Levi, and M. Shen, Kluwer Academic Publishers. International Series in Operations Research and Management Science.

Chang, Guangshu, Jichao Xu, Jianfeng Yang, Jinfeng He and Li Zhang (2005). Comparative analysis on traditional procurement and e-procurement strategy of supply chain. Journal of Systems Science and Systems Engineering 14(4).

Chwat, John (1991). Coffee promotion and education in the U.S.: The end of an era. (interview with Mike Levin formerly of the International Coffee Organization's Coffee Development Group). Tea & Coffee Trade Journal. February.

Clarence-Smith, William Gervase and Steven Topik (2003). The Global Coffee Economy in Africa, Asia, and Latin America, 1500-1989. New York, Cambridge University Press.

Combris, Pierre, Sebastien Lecocq and Michael Visser (1997). Estimation of a Hedonic Price Equation for Bordeaux Wine: Does Quality Matter? Economic Journal 107: 390-402.

Combris, Pierre, Sebastien Lecocq, and Michael Visser (2000). Estimation of a hedonic price equation for Burgundy wine. Applied Economics 32(8): 961 - 967.

Conceição, Pedro and Pedro Ferreira (2000). The Young Person's Guide to the Theil Index: Suggesting Intuitive Interpretations and Exploring Analytical Applications. Massachusetts Institute of Technology (MIT) - UTIP Working Paper No. 14.

Cox, Daniel C. (2005). CQI Presentation to the ICO Executive Board.

Davids, Kenneth (2004). Emerging Origins. The Coffee Review (March).

Davids, Kenneth (2006). "Now or Never: Special Reserve Coffees." Coffee Review(August).

Davids, Kenneth. (2002, 01.23.02). "The Coffee Review: Building a Culture of Connoisseurship Around Coffee." from http://espresso101.com/newsletter/420.

Daviron, Benoit and Stefano Ponte (2005). The coffee paradox: Global markets, commodity trade and the elusive promise of development. London and New York, Zed Books.

de Figueiredo, John M. (2000). Finding sustainable profitability in electronic commerce. Sloan Management Review 41(4): 41-52.

de Graaff, J. (1986). The Economics of Coffee. Wageningen, Centre for Agricultural Publishing and Documentation (Pudoc).

Donnet, Laura, Dave Weatherspoon and John Hoehn (2007). What Adds Value in Specialty Coffee? Managerial Implications from Hedonic Price Analysis of Central and South American E-Auctions. International Food and Agribusiness Management Review IFAMAR 10(3).

Duff, Mike (2002). Margins are brewing in the coffee aisle: in-store cafes offer visability, while grocery shelves increase flavored varieties. DSN Retailing Today.

Elmaghraby, Wedad J. (2000). Supply Contract Competition and Sourcing Policies. Manufacturing & Service Operations Management 2(4): 350-371.

Fitter, Robert and Raphael Kaplinsky (2001). Who gains from product rents as the coffee market becomes more differentiated? A value-chain analysis. IDS Bulletin 32(3): 69-82.

Foley, Karen (2004). Deconstructing Relationship Coffee: How This Emerging Business Model Fits Into the Industry. The Specialty Coffee Chronicle.

Foss, Nicolai J. (2003). The strategic management and transaction cost nexus: past debates, central questions, and future research possibilities. Strategic Organization 1(2): 139-69.

Foss, Nicolai J., Henrik Lando and Steen Thomsen (1999). The Theory of the Firm, Institute of International Business, Aarhus Business School. Copyright 1999 Nicolai J. Foss, Henrik Lando, and Steen Thomsen

Frank, Robert H. and Philip J. Cook (1995). The Winner-Take-All Society. Penguin Book, New York.

Galbraith, James and Enrique Garcilazo (2004). The Mathematics and Logic of The Theil Statistic. Measuring inequality: A practical workshop on theory and technique. Costa Rica, The University of Texas Inequality Project.

Ganes-Chase, Judith (2006). State of the Industry Report: Global Supply and Demand Outlook. Charlotte, Specialty Coffee Association of America.

Gereffi, Gary, John Humphrey and Timothy Sturgeon (2005). The governance of global value chains. Review of International Political Economy 12(1): 78-104.

Golan, Amos (2002). Information and Entropy Econometrics-Editor's View. Journal of Econometrics 107(1-2): 1-15.

Grey, W., T. Olvason and D. Shi (2005). The Role of E-marketplaces in The Relationship-based Supply Chain. IBM Systems Journal 44(1): 109-123.

Griswold, David (2000). Relationship Coffees. Badgett's Coffee eJournal 1(29).

Halvorson, Robert and Henry Pollakowski (1981). Choice of Functional Form for Hedonic Price Equations. Journal of Urban Economics 10 (1): 37-49.

Hillside Agricultural Program (2002). Specialty Coffee. Product Bulletin (3).

Holly, Don. (2005). The Definition of Specialty Coffee. From http://kaffee.netfirms.com/Coffee/SCAASpecCofDef.html.

Hoover's. (2006). Diedrich Coffee, Inc.From http://www.hoovers.com/diedrich-coffee/--ID__51942--/free-co-factsheet.xhtml.

Howell, George. (2005). Cupping Form. Retrieved August 18, 2005, from http://www.cupofexcellence.org/DesktopDefault.aspx?tabid=154.

Institute of Development Studies (2001). The cost of coffee: how consumer education could help coffee farmers fight the price war. IDS News.

Intelligentsia. (2004). Intelligentsia Direct Trade. From http://www.intelligentsiacoffee.com/origin/directtrade.

Jeitschko, Thomas D. (1998). Learning in Sequential Auctions. Southern Economic Journal 65 (1): 98–112.

Jeitschko, Thomas D. (1999). Equilibrium Price Paths in Sequential Auctions with Stochastic Supply. Economics Letters 64(1): 67–72.

Kaplinsky, R. and R. Fitter (2004). Technology and globalisation: who gains when commodities are de-commodified?" International Journal of Technology and Globalisation 1(1): 5-28.

Khouja, M. J. (1999). The single-period (newsvendor) problem: literature review and suggestions for future research. Omega 27(5): 537-553.

Knox, Kevin (2006). Price, Quality and Value: Questioning Competition Coffees. The Coffee Review. December.

Knox, Kevin and Julie Sheldon Huffaker (1997). Coffee Basics: A Quick and Easy Guide, John Wiley & Sons.

Kreps, David and Robert Wilson (1982). Reputation and Imperfect Information. Journal of Economic Theory 27(2): 253-279.

Lancaster, K. J. (1966). A New Approach to Consumer Theory. Journal of Political Economy 74(2): 132-157.

Landon, Stuart and Constance Smith (1997). The Use of Quality and Reputation Indicators by Consumers: The Case of Bordeaux Wine. Journal of Consumer Policy 20: 289 - 323.

Lecocq, Sebastien and Michael Visser (2003). What Determines Wine Prices: Objective vs. Sensory Characteristics. The Handbook of Wine Economics. O. Ashenfelter and V. Ginsburgh, Princeton University Press.

Lee, Hyon Jung. (2006, 07.20.06). Most Expensive Coffee. Forbes.com.

Lewin, Bryan, Daniele Giovannucci and Panos Varangis (March 2004). Coffee Markets New Paradigms in Global Supply and Demand. Agriculture and Rural Development Discussion Paper 3. Agriculture and Rural Development Department. Washington, DC 20433, The International Bank for Reconstruction and Development (The World Bank).

Lingle, Ted R. (2001). The Coffee Cuppers Hand Book. Long Beach, SCAA.

Lingle, Ted R. (2001b, 11.15.01). What a Difference a Decade Makes. from http://espresso101.com/newsletter/422.

Mabbett, Terry (2006). "Essence of Coffee Roasting." Tea & Coffee(August/September).

Mabbett, Terry (2006). Essence of Coffee Roasting. Tea & Coffee Trade Journal (August/September).

Mathieu, Paula (1999). Economic Citizenship and the Rhetoric of Gourmet Coffee. Rhetoric Review 18(1): 112-127.

McCoy, Elin (2005). The Emperor of Wine: The Rise of Robert M. Parker, Jr. and the Reign of American Taste, Harper Collins.

Milgrom, Paul and John Roberts (1992). Economics, Organization & Management, Prentice Hall, Englewood Cliffs, New Jersey 07632.

Mocha Joe's (2006). Mocha Joe's Roaster Notes. Brattleboro Vermont.

Moss, Charles (2005). Using entropy to measure information content in prices. L. Donnet. East Lansing.

Moss, Charles B., Troy G. Schmitz, Albert Kagan and Andrew Schmitz (2003). Institutional Economics and the Emergence of E-Commerce in Agribusiness. Journal of Agribusiness 21(1): 83-101.

Moulton, Kirby, Anthony Spawton and Michel Bourqui (2001). Introduction: Consumer Behavior and Marketing Strategies. Successful Wine Marketing. Kirby Moulton aand by James Lapsley.

Nelson, Phillip (1970). Information and consumer behavior. Journal of Political Economy (78): 311-329.

Oberhänsli, Herbert. (2001, 18 May). The cost of coffee - how consumer education could help coffee farmers fight the price war." IDS News.

Oberthur, Thomas (2006). Comments on L. Donnet Dissertation Proposal. L. D. East Lansing.

Oczkowski, Edward (1994). A Hedonic Price Function for Australian Premium Table Wine. Australian Journal of Agricultural Economics 38(1): 93-110.

Oczkowski, Edward (2001). Hedonic Wine Price Functions and Measurement Error. The Economic Record 77(239): 374-382.

Peleg, Barchi, Hau Lee and Warren Hausman (2002). Short-Term E-Procurement Strategies vs. Long-Term Contracts. Production and Operations Management 11(4): 458 (22 pages).

Pelley, Scott (2006). Howard Schultz: The Star Of Starbucks. CBS News.

Piana, Valentino. (2003). Product Differentiation. Economics Web Institute. Retrieved June, 2007, from http://www.economicswebinstitute.org/glossary/product.htm#vertical.

Ponte, Stefano (2001). The 'latte revolution'? winners and losers in the restructuring of the global coffee marketing chain. Copenhagen, Centre for Development Research (CDR).

Ponte, Stefano (2002). Standards, trade and equity: Lessons from the specialty coffee industry. CDR Working Paper 02.13. Centre for Development Research, Copenhagen.

Ponte, Stefano and Peter Gibbon (2005). Quality standards, conventions and the governance of global value chains. Economy and Society 34(1): 1-31.

Pyke, David F. and M. Eric Johnson (2003). Sourcing Strategy and Supplier Relationships: Alliances vs. eProcurement. The Practice of Supply Chain Management. H. Lee C. Billington, J. Neale, T. Harrison, Kluwer Publishers: 77 - 89.

Rivlin, Gary (2006). Wine Ratings Might Not Pass the Sobriety Test. The New York Times.

Rodríguez, Germán. (2002). Generalized Linear Models: Transforming the Data. From http://data.princeton.edu/wws509/stata7/c2s10.html.

Roseberry, William (1996). The Rise of Yuppie Coffees and the Reimagination of Class in the United States. American Anthropologist 98(4): 762-775.

Rosen, Sherwin (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. Journal of Political Economy 82(1): 34-55.

Rosen, Sherwin (1981). The Economics of Superstars. The American Economic Review 71(5): 845-858.

Samper, Mario K. (2003). The historical construction of quality and competitiveness: a preliminary discussion of coffee commodity chains. The Global Coffee Economy in Africa, Asia, and Latin America, 1500-1989. W. Clarence-Smith and S. Topic eds. Cambridge University Press.

SCAA, website. (2007, May 29). "What is Specialty Coffee?" from http://www.scaa.org/what_is_specialty_coffee.asp.

Schamel, Gunter and Kym Anderson (2003). Wine Quality and Varietal, Regional and Winery Reputations: Hedonic Prices for Australia and New Zealand. The Economic Record 79: 357-369.

Schultz, Henry (1938). The Theory and Measurement of Demand, University of Chicago Press.

Shapiro, Carl (1983). Premiums for High Quality Products as Returns to Reputations. The Quarterly Journal of Economics 98(4): 659-680.

Songer, Paul (2004). Sensory Analysis of Coffee. Scales, Scores, Forms and Perception. The Specialty Coffee Chronicle: 14-15.

Soofi, E. S., and Retzer, J.J. (2002). Information Indices: Unification and Applications. Journal of Econometrics 107: 17-40.

Soofi, Ehsan (1994). Capturing the intangible concept of information. Journal of the American Statistical Association 89(428): 1243-1254.

Starbucks. (2004). C.A.F.E. Practices Overview. From http://www.scscertified.com/csrpurchasing/docs/CAFEPracticesOverview112204.pdf.

Starbucks. (2006). "Company Fact Sheet." from http://www.starbucks.com/aboutus/Company_Fact_Sheet_Feb06.pdf#search=%22starbucks%20company%20fact%20sheet%22.

Swaminathan, JM and SR Tayur (2003). Models for Supply Chains in E-Business. Management Science 40(10): 1387-1406.

Sweet Maria's (2006). Colombia CoE -Hacienda La Virginia.

The Real Estate Blend. (2006). "Dark Roast vs Light Roast." from http://www.howardawalker.com/blog/?p=13.

Theil, Henri (1967). Economics and Information Theory. Amsterdan, North Holland Publising Company.

Theil, Henri (1971). Principles of Econometrics. New York, Wiley.

Theil, Henri and Denzil Fiebig (1984). Exploiting Continuity, Maximum Entropy Estimation of Continuous Distributions. Cambridge, Massachusetts, Ballinger Publishing Company.

Topik, Steven (2003). The Integration of the World Coffee Market. The Global Coffee Economy in Africa, Asia, and Latin America, 1500-1989. W. a. S. T. Clarence-Smith. Cambridge, University Press.

Troncoso, Javier L. and María J. Aguirre (2006). Short communication. Price determinants of Chilean wines in the US market: a hedonic approach. Spanish Journal of Agricultural Research 4(2): 124-129.

United Nations, Conference on Trade and Development (2003). E-commerce and Development Report 2003. UNCTAD/SDTE/ECB/2003/1. United Nations Publication, United Nations: 228.

Wataru & Co. (2004). "Company profile." from http://www.wataru.co.jp/navi/navi_01_main_e.html.

Waugh, Frederick (1928). Quality Factors Influencing Vegetable Prices. Journal of Farm Economics 10(2): 185-196.

Williamson, Oliver (1999). Strategy research: governance and competence perspective. Strategic Management Journal 20(12): 1087-108.

Wolfstetter, Elmar (1996). Auctions: An Introduction. Journal of Economic Surveys 10: 367-420.