The Specialty Coffee Quality Rating as a Measure of Product Differentiation and Price Signal to Growers: an Entropy Analysis of E-Auction Data

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Introduction

Specialty coffees are differentiated from regular coffee by their particularly good flavor[1]. Flavor is the simultaneous sensation in the palate of aroma, taste and body stemming from the highly complex chemical composition of coffee (Lingle, 2001). Coffee flavor is assessed through cupping which is the evaluation of the sensory effects of the basic stimulations of coffee aroma, taste and body. Describing quality and creating connoisseurship[2] is the key to differentiating coffee and creating value in the specialty industry. There are several ways in which food products can be differentiated including brand, varietals and origin. In this paper we focus on the coffee quality ratings based on the product's sensory attributes as an instrument of product differentiation and its implications on market segmentation and price signal to producers.

Coffee is comparable to wine in that both products offer a 'taste journey' which enjoyment is related to connoisseurship (LaPoint, 2004; Daviron and Ponte, 2005). The use of the 100-point scale gave an important boost to the industry during the 80' and 90's. There is increasing interest in developing the coffee industry so it is placed with the wine industry (Tea and Coffee). The Specialty Coffee Association of America developed a cupping procedure and description for adoption in the specialty industry to maintain quality in the specialty industry. The evaluation gives each coffee a quality rating which is a 100 point scale that summarizes the coffee flavor. 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). The original idea was that the SCAA would certify coffee lots complying with their cupping standards (ibid.)

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[1] 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, 2004).

[2] I.e. the taste for fine objects.

The quality rating can constitute an important signal to coffee growers to make decisions that integrate them more efficiently in the coffee supply chains. Specialty coffee competitions and auctions, such as the Cup of Excellence (CofE) and Q, present the feature of disclosing information to the grower (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[3]. 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 are 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 imply that the in the medium to long run there is a decline in farmers' income and increasing poverty if a clear price signal is not received. 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).

In this paper we propose to use the cross-entropy measure as an indicator of the differentiation by quality ratings in specialty coffee auctions. We interpret the differences in the entropy measure as informational differences in specialty coffee segments. Using CofE and Q auction data we analyze the effectiveness of alternative supply chains for remunerating high value to growers (translating high retail prices into high producer prices).

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[3] 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).

Most analysis of differentiation of specialty food products utilizes hedonic modeling of prices to determine the marginal impact of product attributes, including grades and ratings. This paper differs from them in three major ways. First, it proposes an information econometrics approach. Second, it focuses on the quality rating alone. Third, it analyzes prices at the procurement level or prices to growers. We proceed with a discussion of quality ratings. The following section we discuss the entropy measure and its application to measuring income inequality. Then, we present our empirical model adapting the entropy measure to product – vertical– differentiation and the data set. We then discuss the results of the empirical estimation and offer a conclusion.

The Specialty Coffee Quality Rating

Robert Parker is credited with creating the 100 point system to market wines which began to be use in the buyers guide The Wine Advocate in the 80's and then imitated by Wine Enthusiast and Wine & Spirits in the 90's (Rivlin, 2006). The power of the 100-point quality rating system is that it is universally understood and conveys an idea of quality straight forward. On the other hand, the disadvantage is that the use of one number may seem to undermine the purpose of describing a unique tasting experience. Nevertheless, the impact of the quality rating in the wine industry changed the way in which wines were marketed as retailers started to use this information –that they had in advance of the actual publication to consumers– to stock highly rated wines (McCoy, 2005).

In coffee, the cupping form designed by Howell is the one used in the industry with modifications by different firms/organizations. In the Cup of Excellence quality rating, a jury of experts blind tastes the coffee samples in three rounds of cupping. The number is accompanied by a verbal description of the coffee, for example 'heavy body, low acidity, ed tones in the cup. The cupping of coffee is an exhaustive procedure to analyze the sensory attributes for the product. The SCAA developed a prototypical cupping form that is used by roasters and labs in the industry with individual variations. The criteria to evaluate specialty coffee include: *aroma*, *defects*, *cleanness of cup*, *sweetness*, *acidity*, *mouth-feel*, *flavor*, *aftertaste*, *balance* and *overall quality*. Firms and organizations in the industry use variations of the SCAA prototypical form. For example, in the CoE form, each category scores range from 0 to 8 and half points are possible (e.g., 7½) so the distinction of these attributes in different coffees is very sharp.

Generally, the *roast* color is indicated but this is not an evaluation criteria. The eight quality criteria are added to give a sub-total. The sub-total plus defects score gives the raw score. The raw score plus 36 gives the final score. The maximum attainable for a coffee is 100. Other information might be provided together with the scores. This includes characteristics the lot size, the juries' particular descriptions about the coffee, for example 'honey', 'smooth', 'mellow, and characteristics of the producing farm, such as location, altitude, total area, coffee growing area and coffee plant variety.

Coffee cupping in specialty coffee transactions has solved the problem of high information cost (quality uncertainty and asymmetric information). The specialty industry developed along with the procedure of coffee cupping that makes quality observable for both transacting parties: the buyer and the grower. Before, cupping was done only at the roasting and processing firm, when the coffee beans were too far away in the chain to trace back and reward any quality. Because growers need to be provided incentives to produce high quality, the specialty industry is based on product evaluation and differential pricing of the different quality coffees.

The Cross-Entropy Measure and Applications

One way of measuring information contained in prices and distinguishing among segments of different information content is by using the entropy measure.

Cross-entropy measure with probabilities

The cross-entropy, also known as Kullback-Leibler (K-L) and relative entropy measure $I(q:p)$ is:

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

where p_i's and q_i's are the prior and posterior probabilities of a set of n mutually exclusive events $\mathbf{E} = \{E_i, ..., E_n\}$ (Theil, 1984; Golan, 2002; Soofi, 2002). The cross-entropy, as other information measures, is a logarithmic measure of discrepancy between two distributions (Soofi, 2002). The measure does not say anything about the content of the message. The basic research objective of information measures is to make inferences about a system from limited

partial information about it (Golan, 2002); in this sense, they are an alternative to traditional statistical analysis (Soofi, 1994).

The cross-entropy measure, as well as 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, 1984). Both prior and posterior probabilities can be aggregated into groups g so that:

$$P_g = \sum_{i \in S} p_i \ , \quad Q_g = \sum_{i \in S} q_i \tag{2}$$

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

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

that is related to $I(q:p)$ by

$$I(q:p) = I_0(q:p) + \sum_{g=1}^{G} Q_g I_g(q:p) \tag{4}$$

where

$$I_g(q:p) = \sum_{i \in Sg} \frac{q_i}{Q_g} \log \frac{q_i / Q_g}{p_i / P_g} \tag{5}$$

is the within-group entropy.

Therefore, (4) states that the total cross-entropy $I(q:p)$ is equal to the between-group cross-entropy H_0 plus the average within-group cross-entropy $\sum_g Q_g I_g$. This decomposition has an informational interpretation in two stages (Theil, 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 $I_0 + \sum Q_g I_g$ (Theil, 1984).

The aggregation properties of information measures allow the comparison between different distributions or groups of probabilities. For making comparisons on the cross-entropy measures it is important to know that they are related to the log-likelihood ratio test and to

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Pearson's χ^2 test (Theil, 1971). However, we consider that the differences are large enough when the measures differ by more than 50% (Moss, 2005).

Product Differentiation by Quality Rating

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 be nonnegative and add up to 1 (Theil appendix H). Since the share of value and the share of quantity of a coffee in a given 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 segments. 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:

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

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

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

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:

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

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. Between groups, the higher is

the value of the cross-entropy, the higher is the information content. Between groups, the individual entropy measure is positive for the higher quality and negative for the lower.

Decomposition of the cross-entropy of value and quality

Using the aggregation properties of information measures we decompose the total information contained in prices I_{Total} into groups (Fig. 2). I_{CofE} represents the information contained in all prices traded at the CofE, which is decomposed into quality scores above and below the score that maximized the difference between the two groups that are formed. I_Q is the information in the Q auction.

Data

Our data consists of 653 coffees at the Cup of Excellence and 59 coffees traded at the Q auction (Fig. 1). 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 previous to the auction. In addition, a remark regarding the ratings is due. Potential bidders receive coffee samples for cupping at their facilities and they would not necessarily rate the coffees in them in the same way the CofE jury[4]. Thus, it is likely that their bidding behavior and resulting prices do not necessarily reflect the CofE rates. With this note, we go on assuming that the average of the individual bidders does.

Results

Results of our estimation of the quality information contained in specialty coffee ratings are presented in Table 1. The entropy measures for the two auctions are significantly different using the 50% difference rule. The information content in the CofE is 0.1844 much higher than the .0043 in the Q auction. Relative to other segments, the information content is greatest in the upper segment of the CofE (coffees rated 90 and above). Buyers are more price sensitive to coffees offered in this segment than in any other. This may indicate noticeable changes in the quality around this rating as well as demand issues, such as the size of a particular market niche.

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[4] Thanks to Thomas Oberthur for this comment.

The second segment in terms of information content is the CofE lowest segment (coffees rated less than 85) indicating that buyers are also more discriminating in this segment.

Conclusion

The cross-entropy can be interpreted as the relative differences of information about quality differentiation by cupping ratings in the CofE and Q e-auctions. Hence, the cross-entropy measure is useful to analyze the price signal among supply chain participants, in our particular case from coffee buyers to growers. The higher the entropy measure, the higher the information contained in the price differentials. The individual between groups entropy is positive for the higher quality and negative for the lower. The differences in entropy values for different quality rating segments in the CofE and Q show that there is a vertical differentiation within specialty coffees due to this quality indicator. Specialty coffee buyers consider the quality rating when making their bids for coffee. The price signal is significantly different in the CofE than in the Q auction. There is much more information contained in the CofE and within this in the highest segment followed by the lowest. This reflects the exhaustiveness of the criteria and procedure to evaluate the coffees' cup attributes that buyers are willing to pay for and transmit to their specialty customers.

Different quality segments 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 segments. 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. Higher information chains convey more information so there is more scope for farmers to make upgrading. Higher information segments reflect a higher effort in quality definition and more detailed sourcing procedures.

Coffee growers can learn much information about their product from these auctions to help their decision making. By having their coffee rated growers who participate in specialty coffee chains learn valuable information. However, not all the information in the specialty chains is the same. The differentiation measure is a helpful indicator of the potential rewards from supplying to different quality segments. 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.

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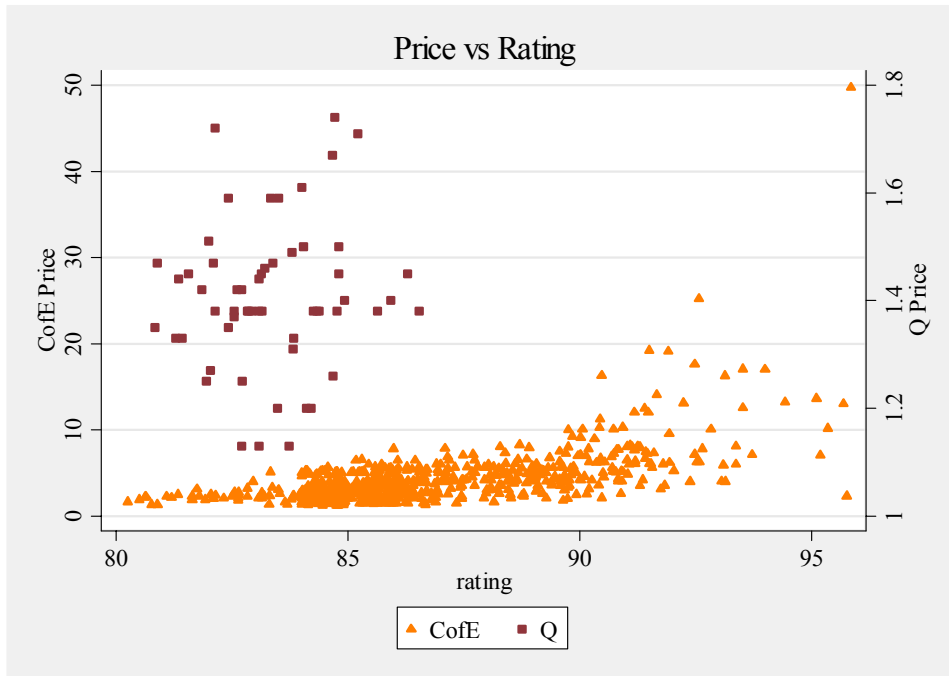
Fig. 1: Quality Rating versus Prices in the CofE and Q Auctions

$$I_{total} \sim \chi^2$$

$$I_{CoE} \qquad\qquad\qquad\qquad I_Q$$

$$I_{CofE>90} \quad I_{CoE\ 87\text{-}90} \quad I_{CofE\ 85\text{-}87} \quad I_{CofE\ <85} \qquad I_{>83} \qquad I_{<83}$$
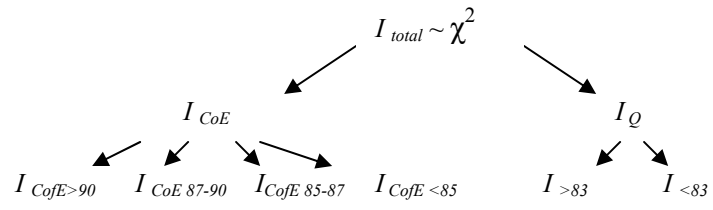
Fig. 2: Decomposition of Differentiation by Quality Ratings in Specialty Coffee E-Auctions

Table 1: Quality Information Decomposition by Ratings of the CofE and Q Specialty Coffee Auctions

Segments of quality rating	Cup of Excellence				Q Auction	
	≥90	90-87	87-85	85>	≥83	83>
n	99	147	216	191	35	24
I individual between groups	0.2508	0.0405	-0.0337	-0.0732	0.0072	-0.0029
I total between groups		0.1844			0.0043	
*I t*otal			0.1887			