Food Demand, Food Sensory Preferences and Attributes Explaining Food Price Differences

by

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Abstract

This dissertation evaluates staple food demand in Burkina Faso, specialty coffee sensory attributes and their relation with coffee quality and the effect of material and reputation attributes on specialty coffee quality scores and purchase prices.

Chapter One focuses on determining economic and non-economic factors affecting demand for staple cereal commodities in Burkina Faso using the Almost Ideal Demand System (AIDS) model. Results show that millet, maize, sorghum and rice are the main staple cereals. However, we found that millet, maize, and sorghum are necessities while rice is a superior cereal. Disaggregated analyses reveal that households' consumption patterns change depending on their location, income and education level. The analysis of the evolution of cereal prices shows an overall increase over the period 1996-2009, leaving many people in food insecurity and the country in political instability. Therefore, the government needs to adopt policies that help lower food prices to avoid future food riots.

In Chapter Two, we relate specialty coffee cuppers (tasters) and buyers preferences to sensory attributes using descriptive analyses. Principle component analysis (PCA) shows that specialty coffees can be clustered into five groups based on their flavor profiles. The analysis of variance (ANOVA) reveals a significant difference among the means of the five groups. The Tukey-Kramer (TK) method, used for pairwise comparison of the means for the five groups, shows that coffees with sweet, berry and sour flavor profiles have higher mean quality scores and purchase prices, while coffees with brown sugar, other fruit and brown spice flavor profiles have

lower mean quality scores and purchase prices. Also, the results reveal that complexity and uniqueness are rewarded with high quality scores and high purchase prices.

Since Chapter Two show specialty coffee cuppers and buyers preferences for sensory attributes, the next task is to evaluate the value cuppers and buyers put on those attributes. Therefore, Chapter Three uses the hedonic price technique to measure the value that specialty coffee cuppers and buyers place on material, physical and reputation attributes. The estimation of the quality score equation suggests that material and physical attributes are important determinants of quality. However, reputation attributes have greater explanatory power on quality scores. This result is surprising because the coffee quality score is determined in a blind evaluation, which is independent of reputation attributes. Results of the estimation of the hedonic price show that specialty coffee price is essentially determine by reputation attributes and market conditions such as the number of coffees in the auction.

Overall, the analyses show that demand for food depend on economic and demographic variables, sensory attributes affect food quality and price, and reputation attributes explain more of food quality score and price differences than material or physical attributes.

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1.1 Introduction

Since the structural adjustment programs in the agricultural sector launched in 1991, Burkina Faso's agriculture has become more modernized and mechanized. The increased use of tractors, chemical fertilizers and improved seeds has been followed by an increase in yields, hence production. However, the increase in yields is still low compared to many Sub Saharan-African (SSA) countries. Although the backbone of the economy occupying almost 84% of the active population and accounting for more than 31% of the gross domestic product (GDP), agriculture in Burkina Faso is dominated by small scale family farms, specialized in the production of subsistence crops and heavily dependent on rainfall (INSD, 2010). Like in most SSA countries, cereal commodities occupy a large portion of the area harvested (88%) and satisfy 70% of the food needs in the country (FAO, 2015).

Sorghum, millet and maize also known as "traditional cereals" or "dry cereals" are the main staple food and play a central role in reducing food insecurity and malnutrition, which rates remain chronically high in Burkina Faso (21% of the total population were undernourished in 2015 according to FAO Food Hunger Map). Over the last two decades, traditional cereals production has almost doubled passing from 2.43 million tons in 1992 to 4.29 million tons in 2010 (Figure 1.1) as a result of an increase in areas harvested (Figure 1.2) rather than a substantial increase in yields (Figure 1.3). At the same time, per capita consumption of cereals excluding beer increased from 1,521 kcal/day in 1995 to 1,715 kcal/day in 2010 (FAO, 2015).

The most common use of cereals is *Tô*[1], a cooked paste. Sorghum is mainly used in the preparation of local beer called *dolo* and millet is mainly consumed in the northern part of the country. In addition to the traditional cereals, it is essential to mention the importance of rice in households' consumption habits especially in urban areas. Rice is the fourth most consumed cereal in Burkina Faso and the national consumption of rice is estimated at 450,000 tons/year for a population of 15 million (INSD, 2010). However, with a local production of 130,000 tons/year, the country imports 30 billion FCFA (50 million USD) worth of rice each year to satisfy its demand.

The main drivers of food demand, especially staple cereals in Burkina Faso, are the high population growth (3% annum), and the sustained pace of GDP growth (5% per year). An analysis of the structure of household spending for cereal commodities from the Integrated Households Living Conditions Survey of 2009-2010 shows very different consumption patterns depending on household location (Figure 1.4). Urban households have a strong predominance of their cereal expenditures for rice (27.81% of total cereal expenditures) and maize (48.87% of total cereal expenditures) while rural households have a strong preponderance of their cereal expenditures for millet (26.01% of total cereal expenditures) and sorghum (39.82% of total cereal expenditures). Households (mainly urban) food demand is shifting to higher quality products and imported processed food with an increasing consumption of meats, fruits and vegetables, and drinks (Kaminski, Elbeheri and Zoma, 2013).

An analysis of the evolution of staple food prices shows that prices have fluctuated over the last decade and the highest prices were recorded in 2008. The rise of food prices in 2008 has had important social, economic and political repercussions in Burkina Faso. Consequently, the

[1] *Tô* is the traditional meal in Sahelian countries such as Burkina Faso, Mali and Niger, and is consumed as a paste of hulled cereals with sauce.

government adopted short-term trade oriented policy measures, including the release of cereal emergency stock onto the market, the suspension of customs duty on several imported foods such as rice, wheat, oil and sugar, the negotiations with importers and wholesalers to establish recommended ceiling prices for staple foods, the establishment of community grain banks to ensure food security at the community level, the handling of vouchers for food and the ban of cereal exports. Although beneficial, these policy measures did not hold for long and staple food prices increase after few months.

The Burkinabe diet is changing with differences in the consumption pattern between rural and urban consumers. Price volatility of staple foods and population growth reflect fundamental changes in food demand in Burkina Faso. Thus, the quantification of responses of household to shocks to market prices and commodity supplies is vital to policy analysis. Sound policy analysis of household food demand is particularly important in Burkina Faso, where many households are poor, dependent on a few staple crops, and potentially food unsecured from food price increases.

Most studies that have estimated demand for food in Burkina Faso have either used aggregate time series data (Ruijs et al., 2001) or regional/city level cross-sectional data (Savadogo and Brandt, 1988; Reardon, Thiombiano and Delgado, 1989). Only a few studies have analyzed the demand for individual staple cereals, namely sorghum, millet, maize and rice at the national level. This study contributes to the limited literature on household demand for food in Burkina Faso by analyzing the impact of both economic and demographic variables on the consumption of staple cereals using recent household survey data.

Therefore, the overall objective of this study is to estimate the effects of economic factors (prices and expenditures) and noneconomic factors (demographic variables such as location, size and education) on Burkina Faso's household demand for staple cereals. Specifically, the study has two objectives. The first objective is to estimate a complete demand system for the four staple cereals: sorghum, millet, maize and rice. In light of the unprecedented spike in food prices in Burkina Faso in 2008, the second objective focuses on analyzing of the evolution of the price of staple cereals and evaluating the impact of a price strike on cereal consumption. Results from this study will deepen understanding of household cereals consumption behavior and provide benchmarks for future food policy analyses and recommendations in Burkina Faso.

The rest of the paper is organized as follows. The next section introduces the model specification. Data employed in the analysis and the estimation procedures are then described. Next, the empirical results are presented, followed by an analysis of the evolution of cereals prices and the impact of price increases on cereal consumption. The final section contains policy recommendations and conclusions.

1.2 **Model Specification**

A model of household demand for different types of cereals as well as other food and nonfood groups that compete for household budget allocation requires a complete demand system framework. A major concern in the estimation of demand systems is that the functional form used should be consistent with observed consumer behavior. Also, the choice of the functional form should not only be based on practical criteria of fit, but also on the principles of demand theory (adding-up, homogeneity and symmetry restrictions).

Since Deaton and Muellbauer (1980), researchers widely use the Almost Ideal Demand System (AIDS) in applied demand analysis because of its theoretical consistency. The AIDS[2]

[2] The quadratic almost ideal demand system (QUAIDS), developed by Banks, Blundell and Lewbel (1997), was first fitted but the test of the joint hypothesis of the quadratic was not significant, therefore the AIDS was accepted as the preferred model for analysis.

model is used to estimate a complete demand system for cereals at the household level in Burkina Faso. Assuming weakly separable preferences, the share of total cereal budget allocated to the *i*-th cereal by household *h* is given as:

(1.1) $w_{ih} = \alpha_{ih} + \sum_{j=1}^{N} \gamma_{ij} \ln(p_{jh}) + \beta_i \ln\left[\frac{m_h}{a(p_h)}\right] + \varepsilon_{ih}$

where:

(1.2) $ln\, a(p_h) = \alpha_0 + \sum_{j=1}^{N} \alpha_{jh} \ln(p_{jh}) + 1/2 \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij}\, ln(p_{ih}) ln(p_{jh})$ is the price index.

In equations (1.1) and (1.2) subscripts i and j indicate cereal commodities (maize, millet, sorghum and rice); *h*= 1,…,*H* represents the number of household; γ_{ij}, and β_i is a parameter to be estimated; p_{jh} is the price of the *j*-th cereal commodity; m_h is the *h*-th household total expenditure on cereals, and ε_{ih} is an error term.

Under the hypothesis that socio-economic and demographic factors influence cereal consumption patterns, variables such as household head education, marital status, professional occupation, household size and number of children are incorporated in the model using the demographic translating approach proposed by Pollak and Wales (1981). That is:

(1.3) $\alpha_{ih} = \rho_{i0} + \sum_{k=1}^{K} \rho_{ik} d_{kh}$,

where ρ_{i0} and ρ_{ik} are parameters to be estimated and d_{kh} represents socio-economic and demographic variables considered in the study.

The adding up conditions are imposed as:

(1.4) $\sum_{i}^{N} \rho_{i0} = 1$, $\sum_{i}^{N} \rho_{ik} = 0$, $\sum_{i}^{N} \gamma_{ij} = 0$, and $\sum_{i}^{N} \beta_i = 0$.

Whereas homogeneity requires that:

(1.5) $\sum_{j}^{N} \gamma_{ij} = 0$ for any *j*

And Slutsky symmetry is given by:

(1.6) $\gamma_{ij} = \gamma_{ji}$ for all i and j

1.3 **Data and Descriptive Statistics**

Household data used within the current study are from the Integrated Household Living Conditions Survey conducted between July 2009 and August 2010 by the National Institute of Statistics and Demographics of Burkina Faso (EICVM/INSD[3]-BF). Created in 1974, the INSD is the official statistics office of Burkina Faso and its main tasks are to collect statistical, economic and demographic information, and develop tools and instruments for analysis and decision support. The EICVM is a multi-sectorial household survey whose main objective is to update the indicators of the Strategy for Accelerated Growth and Sustainable Development (SCADD) and the Millennium Development Goals (MDG). The EICVM collected nationwide information on households' education, employment, income, health, nutrition, access to and utilization of basic facilities/services. In contrast to other previous surveys conducted by the National Statistics Institute, the EICVM was the first survey to collect information on consumption and other expenditures of households. The household consumption expenditure data represents the value of acquired consumer goods and services (used or paid) by a household to meet the needs of its members: through direct monetary purchases in the market; through the market but without using money as a means of payment (barter, income in kind) or by self-production within the household (own-production). Collection instruments included a questionnaire of daily records using the account books distributed to eligible household members, retrospective questionnaires where the reference periods were either quarterly (three months prior to the survey) or semi-annual (six months) or yearly (last twelve months) depending on whether the good could be considered as durable or semi- durable. The EICVM

[3] EICVM/INSD is the Enquete Integrale sur le Conditions de Vie des Menages/Institut National de la Statistique et de la Demographie, Burkina Faso.

covered a nationwide sample of 7,056 households living in both rural and urban areas (INSD, 2010). It is worth mentioning that the prices provided by households during the survey were compared with the National Food Security Stock Management Company (SONAGESS[4]) price dataset for consistency purposes. The SONAGESS is the national company that collects daily prices of staple cereals at the central market of each village/province of the country and the prices are transmitted via radio the next day after collection. The summary statistics of household and the definitions of all variables used in the probit and AIDS models are defined in Table 1.1.

According to the EICVM results, the majority of household in Burkina Faso are located in rural areas 72.1%, while urban households account for only 27.9%. The average household size is 6.8 people. This average size varies by location of residence: on average each household has 7.3 people in rural areas against 5.3 people in urban areas. Overall, the average age of household heads is 46.3 years old. This age is 48.9 years old for women heads of households and 45.4 years old for men. The average age of heads of households living in urban areas is 43.3 years old. Among urban men, it is estimated at 42.5 years old and 46.9 years old for women their counterparts. In rural areas, the average age is 46.8 years old. This age is 49.7 years old for women and 46.4 years old for men.

The literacy rate of household heads is low in Burkina Faso despite major efforts by the government and development partners to eradicate illiteracy. According to the EICVM data, 76% of household heads have no level of education, 14.2% have primary education level, and 7.8% have secondary education level, while only 2% of household heads have a tertiary education level. Educational level of household heads varies according to location of residence.

[4] SONAGESS is the Societe Nationale de Gestion du Stock de Securite Alimentaire.

In rural areas, 87% of household heads have no level of education, while almost half (50%) household heads have no level of education in urban areas.

In Burkina Faso, households allocate 52.3% of their total living expenditure on food reflecting a very important weight of food on household budget. Total budget share for food is a decreasing function of the level of education of the household head. Indeed, food budget shares are 57.4% for households whose heads have no education level, 48.7% for primary, 35.9% for secondary and 25.6% for households whose heads have a tertiary education level. Food budget shares by area of residence are 59.5% of household total expenditure in rural areas and 39.5% for urban areas. Furthermore, local growers produce 78.8% of all food commodities and 100% of the three main cereals (millet, sorghum and maize).

Further analysis of household total expenditure shows that 47.77% of total food budget is spent on cereal commodities. It is also shown that urban households have a strong predominance of their cereal expenditures for rice (27.81%) and maize (48.87%) while rural households have a strong preponderance of their cereal expenditures for millet (26.01%) and sorghum (39.82%). Share of household expenditure for rice increases as households move from low (7%) to high (24.16%) income group and from no education to tertiary education (Figure 1.7 and 1.8).

1.4 **Estimation Procedures**

This section describes the key elements of the estimation strategy employed in this paper. The strategy is adopted to address the issue of zero expenditure. When survey data are used, zero expenditure on individual commodities is a common feature, and EICVM surveys are no exception. The dataset used for this study indicates that zero expenditure is reported for sorghum at 16.12%, millet at 8.16%, maize at 10.84%, and rice at 31.44 %. The causes of zero expenditure are fourfold: permanent zero expenditure, zero expenditure during the survey, optimal zero expenditures as a result of the consumer maximization problem and error during the data entry process. Households reporting zero-expenditures can be categorized as genuine non-consumers, non-consumers during the survey and potential consumers (Tafere et al., 2010). The problem of zero expenditure represents a challenging task in econometrics since there is a censored dependent variable.

This study adopts the consistent two-step (CTS) approach initially proposed by Hein and Wessells (1988) and further modified by Shonkwiler and Yen (1999). Following Shonkwiler and Yen (1999), zero expenditure is modelled estimating the system of equations:

(1.7) $w_{ih}^{*} = f(x_{ih}, \mu_i) + u_{ih}, \qquad d_{ih}^{*} = z_{ih}' \theta_i + \vartheta_i.$

$$d_{ih} = \begin{cases} 1 \; if \; d_{ih}^{*} > 0 \\ 0 \; if \; d_{ih}^{*} \leq 0 \end{cases}$$

$$w_{ih} = d_{ih} w_{ih}^{*}$$

where w_{ih}^{*} and d_{ih}^{*} are the latent variables corresponding respectively to observed expenditure shares and the indicator of whether household *h* consumed the *i*-th cereal commodity; x_{ih} and z_{ih} are vectors of explanatory variables, μ_i and θ_i are the vector of parameters to be estimated, and u_{ih} and v_{ih} are the random disturbances.

To estimate the system of equation (1.7), Shonkwiler and Yen (1999) proposes a two-step procedure: the first step of CTS procedure involves estimating a probit regression to determine the probability of a household purchasing a cereal commodity. The explanatory variables used in the probit regression are demographic variables used in equation (1.3), logarithms of the prices for the four cereals under study, and household total expenditure on food and non-food commodities. From the probit estimation, the standard normal cumulative distribution function (cdf) and the standard normal density function (pdf) of $(z_{ih}' \theta_i)$ are calculated for each cereal commodity and by households.

In the second step, the calculated cdf and pdf from the first step are included to generate the following AIDS specification:

(1.8) $s_{ih} = \Phi(z'_{ih}\theta_i) * w_{ih} + \delta_i * \varphi(z'_{ih}\theta_i) + \xi_{ih}$

where s_{ih} is the observed share of total grain expenditure allocated to the i-th grain commodity for household h, w_{ih} is the determinant part of equation (1.1), $\Phi(\cdot)$ and $\varphi(\cdot)$ are the calculated standard normal cdf and pdf for household h for commodity i from the first-step estimation respectively, z'_{ih} and θ_i are defined as above and obtained from the probit estimation, δ_i represents the covariance between the error term in AIDS model and error term of probit model (Shonkwiler and Yen, 1999) and is also the parameter to be estimated in equation above, and ξ_{ih} is the heteroscedastic error term. Shonkwiler and Yen (1999) showed, using Monte Carlo simulation that their two-step procedure for system equations with limited dependent variables yields consistent estimators and behaves better than procedures using inverse Mills ratios as an additional explanatory variable in a demand system.

One issue with the use of CTS procedure is that it is not possible to impose the adding up condition via parametric restrictions as in the case of the uncensored demand system. To address this problem, the approach first recommended by Yen, Lin, and Smallwood (2003) is adopted. The procedure involves treating the n-th good as a residual category and estimating the $n-1$ equations along with the following identity:

(1.9) $s_n = 1 - \sum_{i=1}^{n-1} s_i$

where s_n is defined as the budget share of cereal n as a residual share. For this study, rice fits into the residual good category because it only accounts for only 14.65 % of household total expenditure for the four staple cereals in Burkina Faso.

Therefore, equation (1.8) is estimated for sorghum, millet and maize simultaneously using the Full Information Maximum Likelihood (FIML) procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC), with homogeneity and symmetry imposed. Parameters estimates for rice equation are derived using equation (1.9).

The Marshallian (uncompensated) own and cross-price elasticities are given as:

$$(1.10)\ E_{ij} = \Phi(z'_{ih}\theta_i) * \frac{[\gamma_{ij} - \beta_i(\alpha_i + \sum_k^N \gamma_{ik} ln p_k)]}{w_i^0} - \delta_{ij}$$

where δ_{ij} is the Kronecker delta taking the value of 1 if $i = j$ and 0 otherwise.

The expenditures elasticities are derived as:

$$(1.11) A_i = 1 + \frac{\Phi(z'_{ih}\theta_i) * \beta_i}{w_i^0}.$$

Price and expenditure elasticities for rice are derived using the adding-up restriction (Equation 1.9) specified as:

$$(1.12)\ \sum_{i=n}^N w_i A_i = 1,\ \sum_{i=n}^N w_i E_{ij} = -w_j, \text{and} \sum_{i=n}^N E_{ij} + A_i = 0.$$

The Hicksian (compensated) price elasticities are given by:

$$(1.13) E_{ij}^c = E_{ij} + w_j A_i.$$

1.5 **Empirical Results**

Parameter estimates from the first-step probit estimation are presented in Table 1.2. Almost all the variables in the choice equations are statistically significant. Variables associated with household head professional occupation, education, number of children, total expenditure, location of residence and prices play an important role in household consumption of staple cereals in Burkina Faso. It is important to note that household total expenditure has a significant influence on the probability of consumption of all cereals. Household total expenditure increases the probability of consuming rice and maize while it decreases the probability of choosing sorghum and millet. All own-price coefficients are statistically significant and have a negative effect on the probability on consuming the studied cereals except for rice.

Parameter estimates of the demand system for cereal commodities are estimated using the AIDS specification developed by Deaton and Muellbauer (1980). All elasticities are evaluated at sample means and based on parameter estimates and explanatory variables. Table 1.3 reports the estimated uncompensated (Marshallian) and compensated (Hicksian) own/cross price and expenditure elasticities at the national level. As predicted by theory, all own-price elasticities are negative and significant for all commodities. The Marshallian own-price elasticities for maize, millet, sorghum and rice are -0.94, -0.87, -0.76 and -1.44 respectively. Similarly, the Hicksian own-price elasticities are negative and -0.79, -0.69, -0.61 and -1.24 for maize, millet, sorghum and rice respectively. The Marshallian and Hicksian own-price elasticities for maize, millet and sorghum are less than one in absolute value. Conversely, the Marshallian own-price elasticity for rice is greater than one in absolute value. The Hicksian own-price elasticities are similar in sign and magnitude to the Marshallian elasticities. The Marshallian cross-price elasticities indicate that among the four major cereals, maize-millet and millet-sorghum are substitutes while maize-sorghum, maize-rice, millet-rice and sorghum-rice are complements. For the Hicksian cross-price elasticities, maize, millet and sorghum are all net substitutes, while rice is a net complement for all other cereal commodities.

The estimated expenditure elasticities are also reported in Table 1.3. The estimated expenditure elasticities are positive (all four reflect normal goods) and significant at the 5 % level of significance. The expenditure elasticities are from 0.60 for sorghum, 0.74 for millet, 0.87 for maize and 1.27 for rice. The inelastic expenditure elasticities for maize, millet and sorghum indicate that those three cereals are necessities while rice is considered as a superior cereal. This result is consistent with Burkinabe households' dietary habits where maize, millet and sorghum are the locally produced and most consumed cereals. Rice is a superior cereal commodity that is consumed during holidays.

1.6 **Further Disaggregated Analysis**

Since demographic variables play a major role in household cereal demand, the AIDS model was fitted to explore consumption behavior of different demographic groups. The AIDS model was first fitted to determine demand responses between rural and urban households.

Table 1.4 compares the estimated expenditure and own-price Marshallian/Hicksian elasticities between the two household groupings. Important differences can be observed: expenditure elasticities for maize are higher in urban areas where rice is not considered a superior cereal. The demand for rice seems to be more price sensitive in rural areas compared to urban areas. More varied and stronger cross-price effects were detected within and between each household group. Specific demand elasticities by income groups and educational levels can be used to evaluate the effects of alternative income and price policies. This is important for designing food policies to improve the adequacy of diets for specific groups. Therefore, we calculated elasticities for five income groups representing the five quintiles, and three household educational levels.

Table 1.5 presents the Marshallian, Hicksian and expenditure elasticities by income groups. Maize, millet and sorghum are necessities across households, while rice is a superior cereal for the first three income groups but a necessity for the fourth and fifth income group. This suggests that consumption of rice increases as household income increases. Own-price elasticities show that maize, sorghum and millet are all price inelastic for all income groups.

Contrasting results were found for rice with the commodity being own-price inelastic across the low income groups (Q1 to Q3) and own-price elastic to the high income groups (Q4 and Q5).

Marshallian, Hicksian and expenditure elasticities by household head educational levels are presented in Table 1.6. Overall, the expenditure elasticities show that maize, millet and sorghum are necessities regardless of household head educational level. However, rice is a superior cereal among households with no education or primary educational level while it is a necessity for more educated household. The Marshallian own-price elasticities show that maize, millet and sorghum are price inelastic across households while rice is price elastic. Taking into account the income effect, the Hicksian elasticities show similar results as their counterpart Marshallian elasticities except that rice becomes price elastic as household head educational level increases.

Our results are not directly comparable with other regional or city level studies that were conducted in Burkina Faso (Ruijs et al., 2001; Reardon, Thiombiano and Delgado, 1989; Savadogo and Brandt, 1988), but they show that maize, millet and sorghum (locally produced cereals) are necessities while rice is a superior cereal whose consumption increases as household income increases. Specific demand estimation by location, income and educational levels show consistent results and similar consumption patterns among households suggesting the robustness of the analysis. Additionally, the results suggest that poorer and uneducated households living in rural areas are much responsive to changes in prices than are the wealthier and educated ones living in urban areas.

1.7 **Evolution of Cereals Prices between 1996 and 2009 and Implications of Food Price Changes.**

Figure 1.5 depicts the evolution of consumer prices of maize, millet, sorghum and rice over the period 1996-2009. There is an almost identical evolution of prices of maize, millet and sorghum due to the fact that they have the same production cycle. The price of rice is usually higher than the price of the three other cereals because rice is mainly imported. In general, prices of cereals have fluctuated but increased overall over the period 1996-2009 in Burkina Faso. These fluctuations can be divided into four phases:

• The period 1996-1998: characterized an average increase of prices by 17%.

• The period 1998-2000: characterized by an average drop of 19% in cereals prices.

• The 2000-2007 period marked by significant price fluctuations. High prices were observed until 2002 before a decrease between the second half of 2003 and the first half of 2004. Prices reached their highest level in 2005. The average price of cereal kilogram peaked at 112 FCFA[5]/kg in 2005 before decreasing in 2007. The high commodity prices in 2005 were the result of a locust attack and a bad harvest season. It was followed by a decrease in production and an alarming food situation in the country.

• The period 2007-2009 characterized by another increase in cereal prices. This period covers the crisis in food prices that has affected most food and energy products including cereals. Indeed, between 2007 and 2008, the rate of increase of cereal prices was about 33%. In 2007, prices of major agricultural food commodities rose sharply and reached their highest level in almost 30 years during the first quarter of 2008. By February 2008, the price of maize increased by 43%, while the price of millet increased by 18%, and that of sorghum by 25%. The high

[5] 1USD = 590F.CFA

international price of rice, in combination with low domestic supply drove up the price of rice by 14%.

Although, they have fluctuated in the same direction, producer prices (Figure 1.6) rose less compared to consumer prices. This imperfect transmission between producer and consumer prices is explained by the relative rigidity of producer prices compared to consumer prices. In fact, producers can rarely influence cereal prices because they have a low bargaining power with wholesalers (Guissou et al., 2012).

Like in most SSA countries, the rise of food prices has had important social, economic and political repercussions in Burkina Faso. Because the majority of the population was not able to feed themselves properly and regularly, scenes of riots took place in several cities of the country (among them, the four biggest cities: Ouagadougou, Bobo-Dioulasso, Banfora, Ouahigouya) in late February 2008. Government buildings, shops and gas stations were damaged; roads blockages were erected and set on fire; and hundreds of people were arrested for stoning government officials. In most demonstrations, protesters have expressed anger not only over high food and fuel prices, but also dissatisfaction with the way the country's political system functions. From 1987 to 2014, Burkina Faso was run by a semi-authoritarian leader, who provided little room for opposition. Protesters argued that if problems such as the high cost of living are to be addressed, there must be political change and greater democracy. Therefore many people saw in these protests the opportunity to exercise their potential political power, put pressure on the government and force them to act.

Consequently, the government adopted short-term trade oriented and market-based policy measures, including the release of cereal emergency stock onto the market, the suspension of customs duty on several imported foods such as rice, wheat, oil and sugar, the negotiations with importers and wholesalers to establish recommended ceiling prices for staple foods, the establishment of community grain banks to ensure food security at the community level, the handling of vouchers for food and the ban of cereal exports. Measures designed to boost domestic production through the distribution of improved seeds, the provision of fertilizers at a subsidized price were adopted as well without much success.

To assess the impact of changes in cereal prices on cereal consumption levels, we run different scenarios using the estimated parameters of Table 1.3. Using the base consumption level of 2015, we consider four scenarios[6] in which the prices of each commodity (maize, millet, sorghum and rice) increase by 10%. Table 1.7 shows cereal consumption level under the various alternatives. With other conditions remaining constant, a 10% increase in maize price leads to a 3.57% decrease in the consumption of staple cereals. If millet price increases by 10%, demand for staple cereals increases by 5.33%. This result is due to the fact that maize and sorghum are both substitutes of millet, therefore their consumption increases when the price of millet goes up. Also, since millet is more nutritious than maize and sorghum, people will have to consume more maize and sorghum to get the same nutritional value as in millet, hence an increase in total cereal demand (FAO, 2011). The consequences of this increase are that if production of maize and sorghum does not increase, many people will be able to satisfy their food needs. Increases in sorghum and rice price by 10%, lead to a decrease in staple cereals consumption by 4.31% and 3.4%.

These results suggest that when cereal prices go up, people adjust their consumption by reducing their daily calories intake, which have negative impact on their health especially children. For producers without access to international markets, a decrease in demand means

[6] Due to the nature of the AIDS model, one cannot estimate the effect of a simultaneous increase in the prices of all staple cereals.

less income. As stated earlier, most farmers in Burkina Faso rely solely on their farm income and any decrease on that income may have devastating consequences because farmers may not be able to pay their family members' hospital fees or their children's school fees.

1.8 **Policy Implications**

Results of the analysis show that maize, millet and sorghum are necessities while rice is still a luxury cereal consumed in complement with the other staple cereals for the majority of household in Burkina Faso. One interesting fact is that staple cereals consumed in Burkina Faso are locally produced; only rice is mainly imported and consumed by wealthiest households. This result suggests any policy targeted to help the poor during food price increases should be targeted towards the three main locally produced cereals (sorghum, millet and maize). With a population increasing at the rate of 3% per annum and agricultural yields slowly increasing over the years, food security will be the main issue hindering the development and political stability of Burkina Faso. Therefore, the country must adopt aggressive agricultural reforms to increase domestic production and stabilize domestic food prices. Moreover, the country can increase agricultural yields by exploiting unfarmed land, building more storage facilities, roads and rural infrastructure, using improved seeds and more fertilizer, and installing drip irrigation. Farm loans, crop insurance and saving schemes can help farmers increase productivity to meet the challenge of food scarcity.

1.9 **Conclusion**

The objectives of this paper were to estimate a complete demand system for major staple cereals (maize, millet, sorghum and rice) and analyze the evolution of cereals' prices in Burkina Faso. Descriptive statistics show that households spend on average 52.3% of their total budget in food and 47.77% of their food expenditure in cereals. Results show that cereal prices have fluctuated over the last two decades and reached their peak in the first quarter of 2008. Consequently, the Government adopted a battery of measures such as the suspension of customs duties and ad valorem tax on a number of imported food products to help the poor meet their basic food needs. Nevertheless, prices of basic staple foods (maize, millet, sorghum and rice) did not come down and millions of people were food unsecured months later. Since the adoption and effectiveness of any food policy should be based on the knowledge of the demand structure, this paper shows that sorghum, millet and maize are necessities while rice is still considered as a superior commodity nationwide. Further disaggregation of the data confirms that sorghum, millet and maize are necessities but the elasticity of rice varies depending on income groups, and level of education. In light of households' consumption structures, it is important to adopt policy measures that will lower the domestic price of basic foods.

This study was limited by the lack of reliable price dataset for other food commodities to estimate a complete demand system for the whole range of food commodities in Burkina Faso. Further analysis is therefore needed to estimate demand for all food commodities. Also, analysis should be taken on the supply side to estimate supply elasticities. This will help implement effective food policies that will increase food supply and help the country improve its food security level.

Table 1.1. Summary Statistics

Variable	Description	N	Mean	Std. Dev	Min.	Max.
Marital Status	(1=Married; 0= otherwise)	7,056	0.63	0.324	0	1
Gender	(1=Male;0=Female)	7,056	0.86	0.34	0	1
Occupation	(1=Agriculture; 0=otherwise)	7,056	0.9184	0.273	0	1
Location	(1=Urban;0=Rural)	7,056	0.279	0.344	0	1
Education	Primary	7,056	0.142	0.344	0	1
	Secondary	7,056	0.078	0.019	0	1
	Tertiary	7,056	0.002	0.139	0	1
Age	HH head age	7,056	46.278	14.7	16	99
Size	HH Size	7,056	6.815	4.039	1	57
Children	Number of children	7,056	3.802	2.8573	0	22
Expenditure in F.CFA	1. Maize	7,056	51,559.23	86,988.48	5,000	732,166
	2.Millet	7,056	46,842.14	97,549.89	4,500	730,000
	3.Sorghum	7,056	69,455.36	119,632.2	7,000	735,750
	4.Rice	7,056	22,440.17	52,192.11	3,500	584,000
Prices in F.CFA	1.Maize	7,056	165.439	15.156	114	198
	2.Millet	7,056	185.009	19.825	143	229
	3.Sorghum	7,056	168.067	18.627	114	209
	4.Rice	7,056	392.762	30.076	327	488

Source: Author based on EICVM, 2009-2010 and SONAGESS prices data.

Table 1.2. Parameter Estimates of the Probit Regression

	Maize		Sorghum		Millet		Rice	
Variable	Estimates	Std. Err.	Estimates	Std. Err.	Estimates	Std. Err.	Estimates	Std. Err.
Constant	15.4697**	1.1292	-6.5853**	1.2144	-9.1608**	1.0807	-0.4112*	1.0603
HH Marital status	-0.0483	0.0452	0.0808	0.0473	-0.0596	0.0444	-0.0898	0.0441
HH Education	-0.0111	0.0619	-0.4990**	0.0720	-0.4779**	0.0629	-0.0617	0.0571
HH Occupation	-0.1078**	0.0393	0.3258**	0.0394	0.2121**	0.0385	-0.0443	0.0387
HH Age	-0.0010	0.0011	0.0044**	0.0011	0.0039**	0.0011	-0.0015	0.0011
Number of Children	-0.0311**	0.0150	0.0328*	0.0153	0.0260*	0.0145	-0.0016	0.0146
HH Size	0.0035	0.0110	0.0045	0.0112	-0.0116	0.0106	-0.0194	0.0107
Location of Residence	0.3264**	0.0404	-0.6530**	0.0408	-0.3301**	0.0397	0.3451**	0.0391
Ln Total Expenditure	0.2976**	0.0271	-0.1313**	0.0276	0.1341**	0.0262	0.3333**	0.0265
Ln maize price	-5.0986**	0.2276	3.2691**	0.2240	3.3259**	0.2122	-0.5089**	0.2088
Ln millet price	0.4631	0.2738	-3.1469**	0.2807	-0.1905	0.2669	0.8662**	0.2711
Ln sorghum price	1.2800**	0.2888	0.8133**	0.2962	-1.2694**	0.2807	-1.2957**	0.2815
Log of rice price	-0.3438	0.1299	0.5704**	0.1690	-0.4119**	0.1222	-0.0805	0.1143

Source: Author based on EICVM, 2009/10.

***=1% level of significance, **=5% level of significance and *=10% level of significance.

Table 1.3. AIDS Estimates at the National Level

Marshallian Elasticities					
Item	Maize	Millet	Sorghum	Rice	Expenditure Elasticities
Maize	-0.941	0.533	-0.629	-0.012	0.867
Millet	1.625	-0.870	0.961	-0.372	0.744
Sorghum	-0.634	0.347	-0.763	-0.412	0.608
Rice	-0.069	-0.568	-0.196	-1.443	1.275

Hicksian Elasticities				
Item	Maize	Millet	Sorghum	Rice
Maize	-0.790	0.696	0.388	-0.012
Millet	1.902	-0.690	0.696	-0.248
Sorghum	0.369	0.176	-0.611	-0.294
Rice	-0.612	-0.127	-0.266	-1.240

Source: Author based on EICVM, 2009-2010.

Table 1.4. AIDS Elasticities at Urban and Rural Areas

	Marshallian		Hicksian		Expenditure	
Item	Urban	Rural	Urban	Rural	Urban	Rural
Maize	-0.976	-0.968	-0.517	-0.771	0.939	0.775
Millet	-1.018	-0.968	-0.909	-0.742	0.750	0.871
Sorghum	-0.928	-0.224	-0.829	0.117	0.830	0.856
Rice	-1.008	-1.177	-0.902	-1.099	0.946	1.063

Source: Author based on EICVM, 2009-2010.

Table 1.5. AIDS Elasticities by Income Level

	Marshallian					Hicksian					Expenditure				
Item	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Maize	-1.002	-0.978	-0.966	-0.937	-0.744	-0.790	-0.753	-0.729	-0.671	-0.592	0.831	0.805	0.805	0.774	0.870
Millet	-0.908	-1.005	-1.007	-0.374	-0.987	-0.675	-0.775	-0.788	-0.168	-0.803	0.896	0.727	0.827	0.923	0.689
Sorghum	-0.790	-0.827	-0.992	-0.948	-0.965	-0.440	-0.501	-0.641	-0.744	-0.806	0.879	0.677	0.774	0.708	0.676
Rice	-1.628	-1.563	-1.427	-1.196	-0.992	1.382	-1.361	-1.002	-0.883	-0.860	1.220	1.127	1.018	0.900	0.893

Source: Author based on EICVM, 2009-2010.

Table 1.6. AIDS Elasticities by Educational Level

	Marshallian				Hicksian				Expenditure			
Item	No education	Primary	Secondary	Tertiary	No education	Primary	Secondary	Tertiary	No education	Primary	Secondary	Tertiary
Maize	-0.972	-1.027	-0.941	-0.875	-0.726	-0.622	-0.484	-0.512	0.833	1.300	0.909	0.772
Millet	-0.983	-0.964	-1.044	-0.917	-0.768	-0.792	-0.985	-0.889	0.898	1.500	0.735	0.792
Sorghum	-0.896	-0.917	-1.044	-0.987	-0.588	-0.691	-0.972	-0.983	0.872	0.971	0.880	0.155
Rice	-1.706	-1.645	-1.126	-1.257	-1.249	-1.160	-0.841	-0.933	1.572	1.001	0.999	0.896

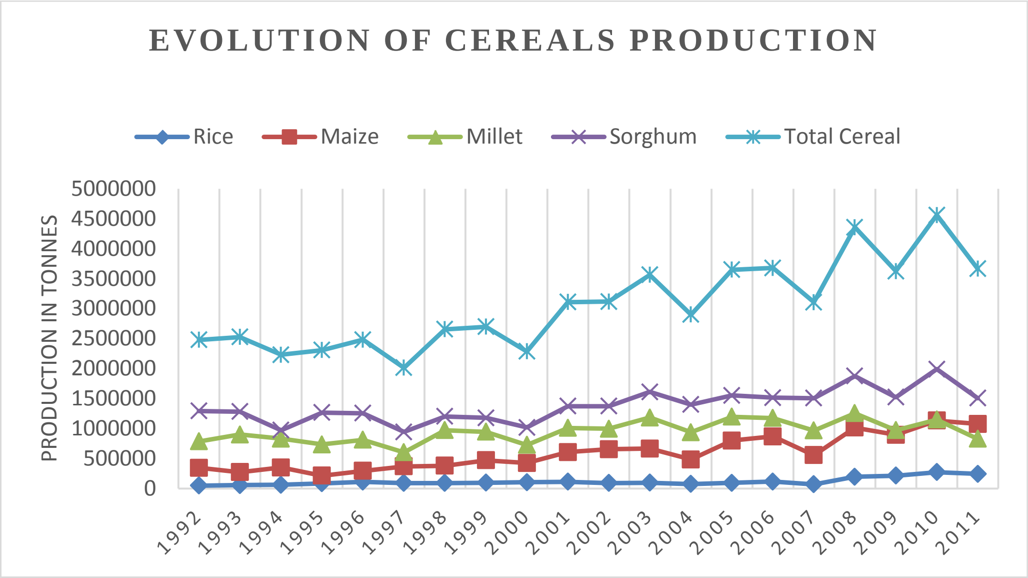
Source: Author based on EICVM, 2009-2010.

Table 1.7. Projected demand for staple cereals in Burkina Faso: effects of maize, millet, sorghum and rice prices increase using Table 3.1 Estimates.

Scenario	Maize	Millet	Sorghum	Rice	Total Cereals	Change (%) in total cereals consumption
Base period 2015 consumption in (Tones*1000)	950	1,000	1,800	450	4,200	-
10% increase in maize price	-89.4	53.3	-113.22	-0.54	-149.86	-3.57
10% increase in millet price	154.38	-87	172.98	-16.74	223.62	5.33
10% increase in sorghum price	-60.23	34.7	-137.34	-18.54	-181.41	-4.31
10% increase in rice price	-6.56	-56.8	-35.28	-64.94	-163.58	-3.4

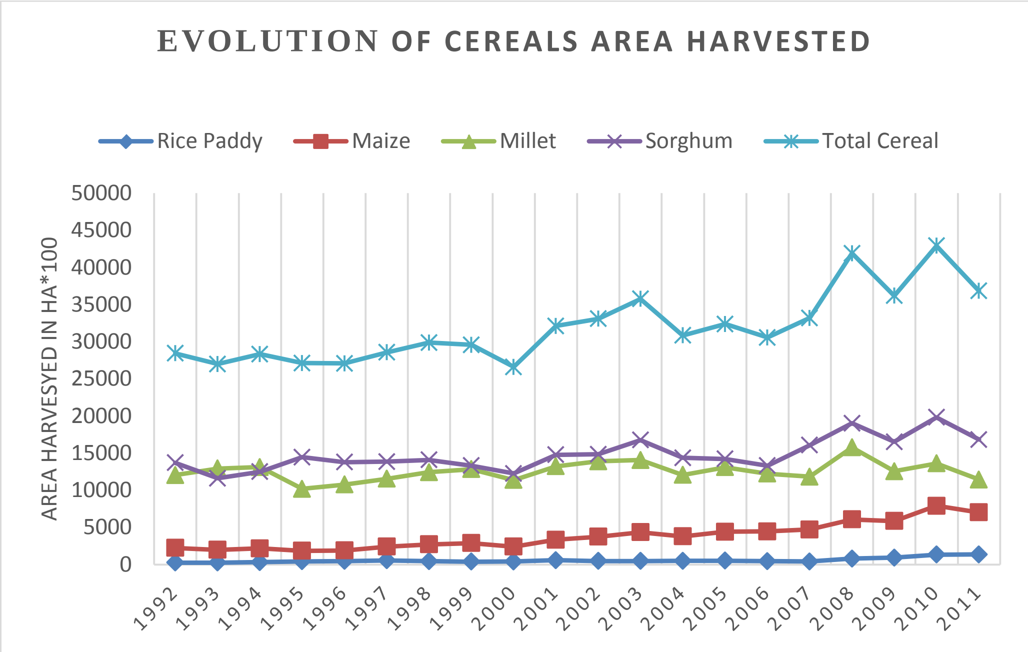
Source: Author based on own estimation and FAO data.

Figure 1.1. Evolution of Staple Cereals' Production.



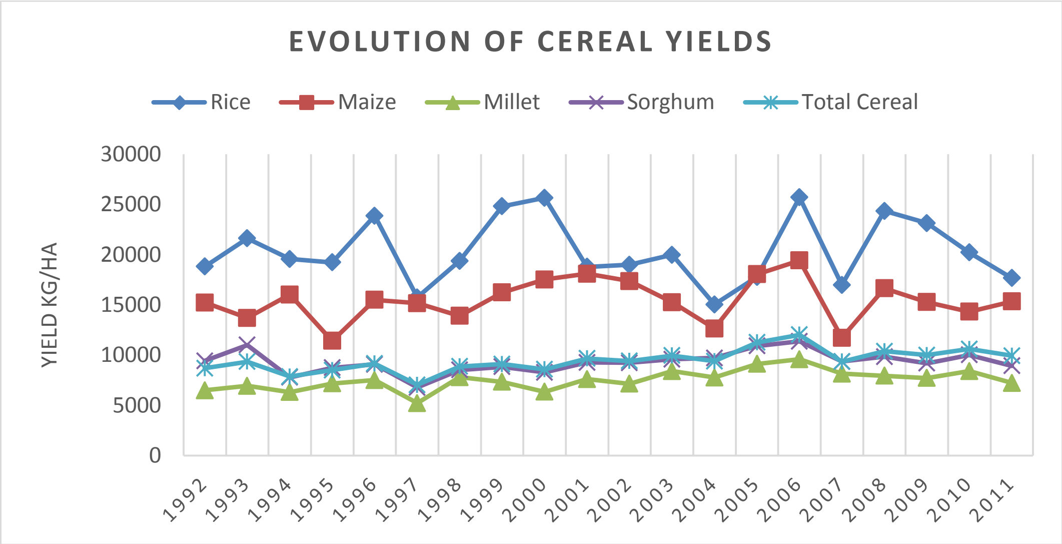
Source: Author based on FAOStat, SONAGESS and INSD data.

Figure 1.2. Evolution of Staple Cereals' Areas Harvested.



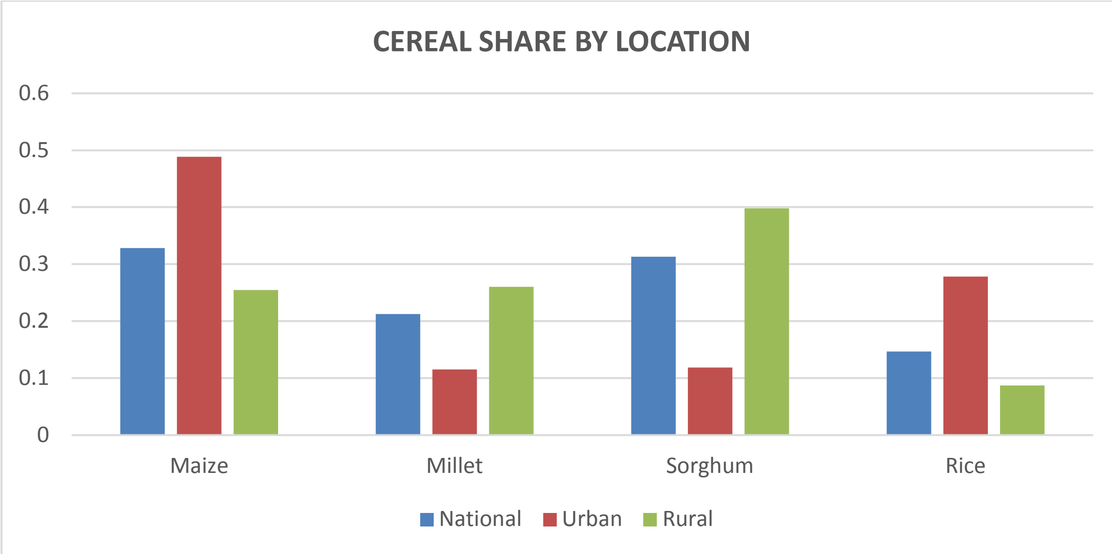
Source: Author based on FAOStat, SONAGESS and INSD data.

Figure 1.3. Evolution of Staple Cereals' Yields.



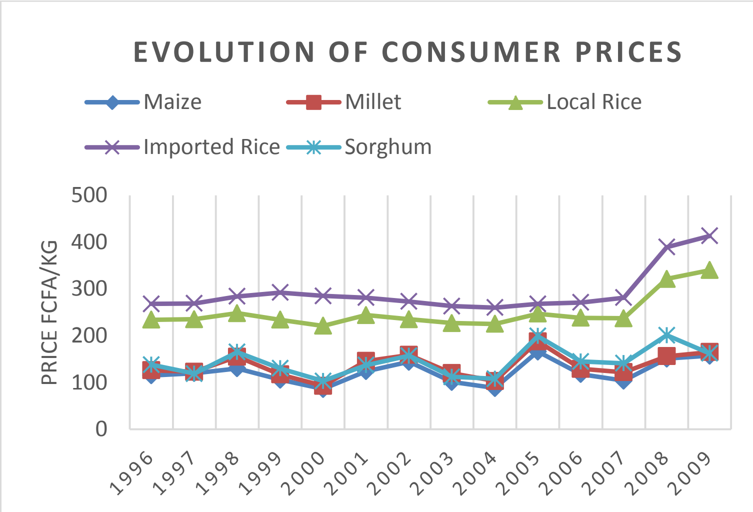
Source: Author based on FAOStat, SONAGESS and INSD data.

Figure 1.4. Share of Staple cereal Expenditure by Household Location.



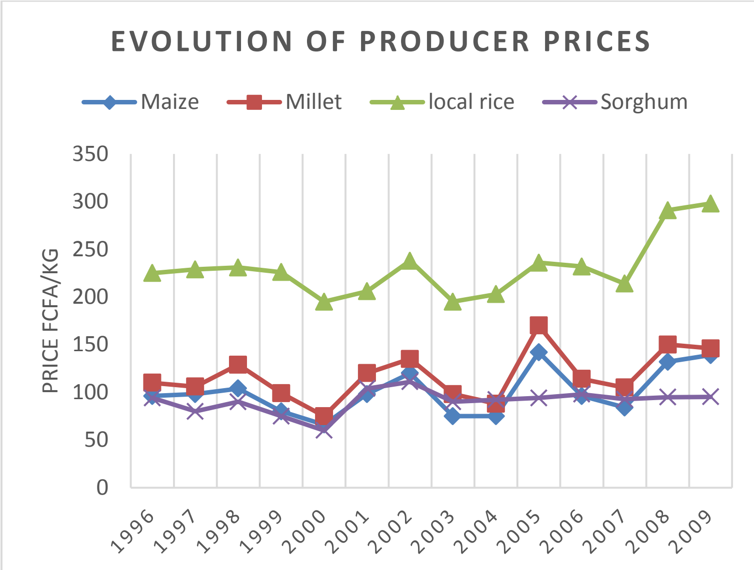
Source: Author based on EICVM, 2009-2010.

Figure 1.5. Evolution of Consumer Prices of Staple Cereals.



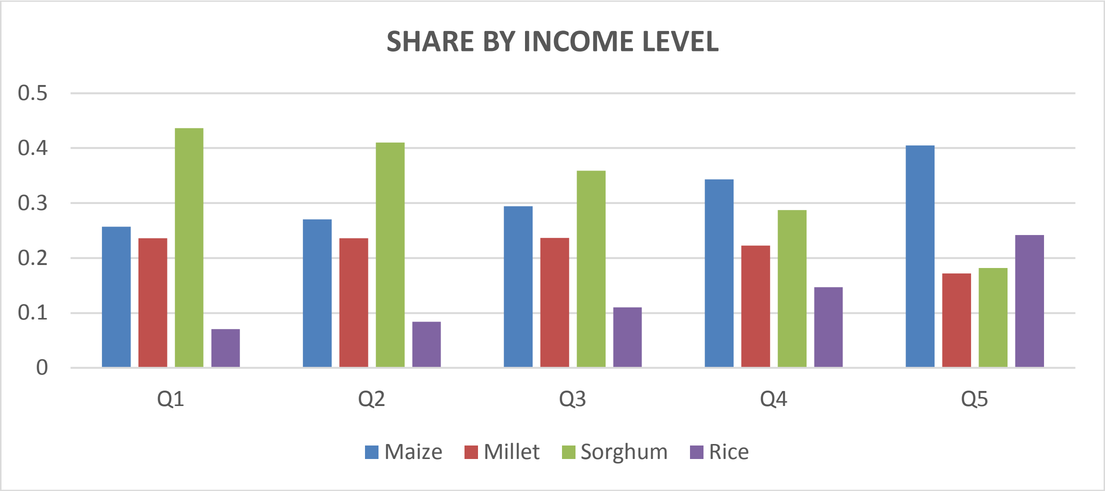
Source: Author based on FAOStat, SONAGESS and INSD data.

Figure 1.6. Evolution of Producer Prices of Staple Cereals.



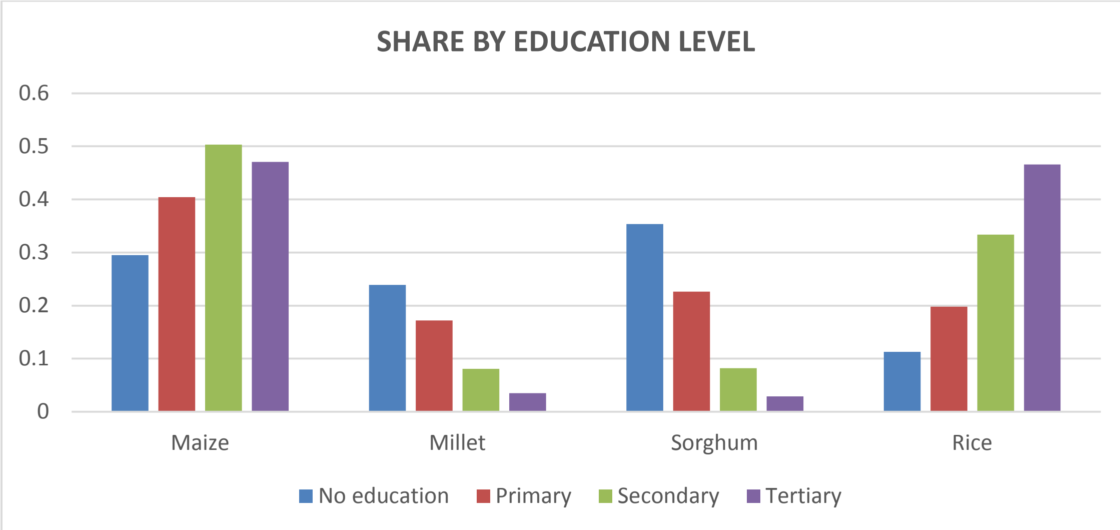
Source: Author based on FAOStat, SONAGESS and INSD data.

Figure 1.7. Share of Staple Cereals' Expenditure by Income Group.



Source: Author based on EICVM, 2009-2010.

Figure 1.8. Share of Cereal Expenditure by Educational Group.



Source: Author based on EICVM, 2009-2010.

Appendix 1.1 Parameter Estimates of the AIDS Model

Variables	Maize	Millet	Sorghum
Intercept	0.1961	-5.0978	2.2765
Marital Status	0.0288*	-0.0036	-0.0311
Education	0.0175	-0.1683*	0.1189
HH Head Occupation	-0.0400	0.0941	-0.0742
Number Children	0.0086**	-0.0027*	-0.0139
Household Size	0.0012*	0.0501***	0.00291**
Log of price of Maize	-0.0081***	1.1373***	-0.0321***
Log of price of Millet	0.0114***	-0.0905***	-0.0179***
Log of price of Sorghum	-0.0321***	-0.0179*	-0.0266**
Log of price of Rice	-0.0100	-0.0013	-0.0203
Log of (income-price index)	-0.0107***	-0.0495***	-0.0884***
Adjusted R-Squared	0.2193	0.1506	0.2027
N	7,056	7,056	7,056

Source: Author based on EICVM, 2009/10.
***=1% level of significance, **=5% level of significance and *= 10% level of significance.

Chapter 2: Relating Cuppers and Buyers Preferences to Sensory Attributes of Specialty Coffees: A Case Study from the Cup of Excellence Program

2.1 **Introduction**

Coffee is one of the most valuable and traded agricultural commodities in the world. According to the International Coffee Organization (ICO, 2011), almost 80% of the world coffee is produced by 25 million smallholders and coffee provides a livelihood to more than 100 million people in coffee producing countries. Coffee grows under various altitudes ranging from 550 meters to 3,000 meters above sea level. The main two types of coffee tree varieties are Arabica and Robusta. Robusta is usually more expensive than Arabica because the four biggest coffee buyers (Kraft, Nestle, Procter & Gamble and Sara Lee) buy more of the former. Coffee is grown in more than 70 countries but over 66% of the world coffee is produced by just five of them namely Brazil, Vietnam, Colombia, Indonesia and Ethiopia. Coffee is exported as raw, roasted or soluble to more than 165 countries worldwide for a business worth up to USD 14 billion annually (Fair Trade, 2012).

Historically, coffee was traded under the International Coffee Agreement (ICA) through a system of export quotas and coffee export boards that insured profitable prices to growers. However, with globalization and the dismantlement of trade barriers by the World Trade Organization (WTO), the coffee market has changed and the product is becoming more differentiated. The high-volatility of commodity coffee prices coupled with consumers changing attitudes towards blend coffee have required small coffee farmers to become part of certification schemes and focus on quality required by specialty coffee market in order to benefit from high coffee prices.

Specialty coffee is used to describe coffee beans with the best flavors cultivated under special production practices. Specialty coffees, therefore, differ from commodity coffees because of their unique tastes and flavors, their production practices (environmental friendly, fair wages, etc.), and should not be confused with "gourmet" or "premium" coffee that are marketing terms with no standard definitions (SCAA, 2016).

Aromatic and flavor components play a central role in satisfying consumers' needs as they are the main sensory components experienced by coffee drinkers. Variations in coffee aromas and flavors can occur for several reasons: coffee tree variety, growing region, environmental conditions, processing methods, roasting level, grinding size and brewing methods (Illy and Viani, 2005; Bhumiratana et al., 2011). Since quality is a key factor defining specialty coffee, various techniques have been developed to assess coffee quality.

The most commonly used method to evaluate coffee quality is called "cupping". In the cupping process, highly trained experts appraise sensory attributes of coffees according to the grading system developed by the Specialty Coffee Association of America (SCAA). The grading system consists of evaluating a list of sensory attributes descriptors such as aroma, flavor, aftertaste, acidity, body, balance, clean cup, defects, mouthfeel and sweetness of each coffee. Through this system, cuppers provide "cupping notes" that offer information on the specific sensory characteristics of a coffee (see Appendix 2.1 for the cupping form). In addition to the cupping notes, the cuppers provide a quality score for each coffee.

However, the academic literature suggests that context matters in the cupping process because assessment of organoleptic quality is a demanding exercise. This evaluation is even more difficult because of the challenge to provide a consistent environment in multiple locations around the world. Thus, the environment, emotions, room color, expectations and past experiences can shape perceptions of flavors, which in return affect coffee sensory experience and quality scores (Sage, 2012). Another problem related to cupping is the large and diverse descriptors used by cuppers as can be seen in the SCAA tasting wheel (Di Donfrancesco et al., 2014).

Therefore, the objectives of this study are to: review factors that can affect cuppers' sensory experience and may lead to bias, used descriptive analyses to see if there are flavors patterns that can be used to characterize specialty coffees, group coffees according to their flavor profiles and check if there are differences among coffee flavor profiles in terms of hedonic ratings and hedonic prices. This analysis will reveal if cuppers are consistent in capturing the same flavor profiles and if there is an imbalance between cuppers and buyers' perception of quality for specialty coffees.

The rest of the paper is organized as follows: section two introduces the Cup of Excellence program, section three provides theory and hypotheses, section four examines the data, section five provides the methodology, section six describes the results and the last acquaint to the conclusion and discussion.

2.2 **The Cup of Excellence Program**

Cup of Excellence (CoE) is a competition designed to award top scoring coffee worldwide. Introduced in Brazil in 1999, the competition takes place in 11 countries namely Bolivia, Brazil, Burundi, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Rwanda. In order to participate in the CoE competition, growers submit a sample of their coffees free of charge and each sample is evaluated or "cupped" at least five times by a national and international juries. Each coffee is given a quality score based on the roasting color, aroma, defects, cleanness, sweetness, acidity, mouthfeel, flavor, aftertaste and balance. Only coffees with a quality score of 84 or higher out of a total of 100 earn the CoE award and can participate in the online auction. Roasters, retailers and importers interested in the auction must sign up for a membership with CoE which gives them the opportunity to buy and taste small coffee samples before the live auction (ACE/CoE, 2016). At the auctions, buyers bid against each other and the highest bid wins. After payment, buyers coordinate shipment and information about the winning bid price, the name and country of origin of buyers are made available online. The CoE program auction prices are on average 4.5 times higher than the International Coffee Organization (ICO) composite price (Wilson and Wilson, 2014). Coffee growers receive more than 80 percent of the final price, and the remaining is a commission paid to the in-country organization committee to help run the program (ACE/CoE, 2016).

2.3 **Sensory Theories, Literature and Hypotheses**

2.3.1 ***Factors Affecting the Sensory Experience***

Cupping in the specialty coffee world is the most prominent method to evaluate quality. However, it has been proven scientifically that the tasting experience is an accumulation of multiple senses including smell, touch, sound, sight, temperature, history and context, thus evaluation may be subject to bias. Smell is probably the largest player in the organoleptic experience and sometimes when people talk about taste, they are referring to the combination of at least smell and taste. Smells can suppress or enhance taste. For example, Stevenson et al. (1999) showed that certain sour smells can suppress sweetness and vice-versa. This means that during the cupping process, cuppers' perception of some flavors can be altered by smell, which might lead to biases towards the description of the coffee and ultimately to their quality score.

Tactile sensations are other factors that can influence the perception of taste because the structure (texture and viscosity) of a food or beverage can influence the release of volatile compounds.

Studies conducted on viscosity and how it influences perceived flavor have found that as food hardness increases, perceived flavor intensity decreases (Tournier et al., 2009). The method of food and beverage delivery can also influence the perception of flavor. Piqueras-Fiszman et al. (2012) found that the type of material of a spoon altered perceived bitterness, saltiness and pleasantness.

How we see things influence taste through expectation based on past experiences. The way food or beverages are presented and their color makes them taste different. For example, studies have shown that adding a red color to a solution increases the perceived sweetness of the liquid (Zellner and Durlach, 2003; 2002). The color of ambient lighting can also influence the tasting experience of a food or beverage. In a study on wine, white wine was seemed more pleasing in taste and more valuable in blue or red environments (Oberfeld et al., 2009).

The sound surrounding us can be associated or influence the perception of flavors. Researchers have linked certain tastes with musical pitches and showed how they can alter flavor perception (Crisinel et al., 2012). Temperature can also affect the way aromatic compounds are released or speed up the movement of molecules, thus altering olfactory perception of the beverage. Regional and cultural differences can also influence preferences to odors, which in return can influence taste and flavor.

In the context of specialty coffee, these taste influencers indicate that cuppers' hedonic ratings of specialty coffees may be influenced by their personal expectations and emotions, the environment, color of the room, and sound around them. To illustrate how coffee sensory attributes can change depending on the cuppers or the preparation method, several sensory studies have been conducted. For example, Di Donfrancesco et al. (2014) used two different groups of cuppers: a highly trained sensory cuppers and a group of Q-certified coffee cuppers.

Results indicated little overlap between the two groups of cuppers and a low relationship between the terms they used. Moreover, tasting notes by Q-certified cuppers indicated lack of agreement on terms used to describe samples. Bhumiratana et al. (2011) investigated the impact of degree of roasting, grinding, and brewing on the evolution of aroma in green coffee beans from Ethiopia, Hawaii, and El Salvador. They show that preparation stages and degrees of roasting generate a greater influence on aroma profiles than the coffee variety. Sanchez and Chambers IV (2015) conducted a controlled sensory study to identify how coffee preparation can affect its sensory properties. Results suggest that flavor and aroma attributes both varied with preparation methods. Thus, the authors conclude that using only one method when conducting sensory or quality testing can be a limiting component in the information gathered in a sensory study.

Ultimately, all these studies show cuppers' perception for sensory attributes can be shaped by the method of preparation, the location where the cupping process takes place and past experiences. For that reason, most importers and roasters carry out their own evaluation on pre-purchased samples. Therefore, the main goal of this study is to figure out if there is an imbalance between specialty coffee cuppers' ratings and buyers' purchase prices over time and across countries. That is, we want to see if the highest (lowest) ranked coffees receive the highest (lowest) purchase prices.

2.3.2 ***Literature Review***

Several studies have been conducted using the CoE online auction data set. Using a hedonic price function for Central and South American countries, Donnet et al. (2008) showed that coffee prices are influenced by quality score, ranking, country of origin and coffee tree variety. Comparing the CoE online auction to the Q auction, Donnet et al. (2007) found that CoE auction provides more information about coffee quality score, ranking, lot size and country of origin. The result implies different business models and valuation of product characteristics within the specialty coffee industry. Teuber and Hermann (2012) used a supply-and-demand framework to explain CoE auction prices. The findings revealed that factors such as reputation, quality score and country of origin are the main factors explaining variations in coffee prices. Wilson et al. (2012) examined the prices of CoE coffees from Central America using hedonic regression. Results showed that quality score has a large impact on prices followed by other factors such as altitude, farm size, and country of origin. Wilson and Wilson (2014) estimated price determinants for premium coffee using CoE data from 2004 to 2010. The authors used a modified version of Donnet et al (2008) by including more relevant variables and using a truncated regression. Results showed that quality score, ranking and origin of buyers have a strong effect on coffee prices.

Although these previous studies used extensively the CoE data to predict coffee prices, none assessed how certain flavor profiles impact quality score and purchase prices. This study takes advantage of the cupping notes and the SCAA Coffee Taster's Flavor Wheel to group coffees according to their flavor profiles (see Appendix 2.2 for the Coffee Taster's Flavor Wheel) and to determine which flavor profiles have the highest/lowest average quality score and which ones earn the highest/lowest purchase prices.

2.3.3 ***Hypotheses***

As suggested by the literature, flavor perceptions of cuppers may be bias since it is impossible to remove taste from other senses (smell, touch, sight, and sound), temperature, social and cultural preferences and perception of sensory attributes may depend on method of coffee preparation or cuppers' past experiences. In this study, we use principal component analysis

(PCA) to find the most important flavors used to characterize specialty coffees, then we group them according to their flavor profiles. Analysis of variance (ANOVA) and Tukey-Kramer (TK) method are respectively used to check statistical differences and compare means among the groups of coffees. Finally, we test to see if the same flavor profiles have the same quality ratings as well as purchase prices over time and across regions. Theory predicts that high quality flavor profile will lead to high quality score and purchase prices.

Therefore, we hypothesize the followings:

H_1: The average quality scores of coffees differ by their flavor profiles.

H_2: The mean purchase prices of coffees differ by their flavor profiles.

H_3: Coffees that have flavor profiles with high (low) hedonic ratings have high (low) hedonic prices.

H_4: The flavor groupings hold over time and across groups of countries.

2.4 **Data**

Data for the present study include 2,321 observations from the Cup of Excellence (CoE) e-auctions that took place in 11 countries (Bolivia, Brazil, Burundi, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Rwanda) from 2004 to 2015. CoE hosts at least one competition per year in most participating countries and each competition consists of a total of six cuppings by skilled and highly experienced national and international coffee cuppers. During the evaluation, cuppers note a set of sensory attributes descriptors such as flavor, aroma, aftertaste, acidity, body, balance, clean cup, defects, mouthfeel and sweetness and provide a quality score of each coffee sample. Only coffees with an average score of 84 or higher out of 100 receive the CoE Award and enter the national auction. The data set also includes information on the final auction price of each coffee excluding shipping costs, farm data such as quantity of coffee per lot, coffee tree variety, altitude, processing method, and name and origin of origin of buyers.

2.5 **Methodology**

The cupping notes describe whether a coffee has a particular flavor or aroma, its aftertaste, its body types, whether the cup is balanced or not, whether we have a clean or transparent cup, and the mouthfeel. Over the data, cuppers noted a total of 112 different flavor/aroma descriptors to describe coffee flavors across the data. Each coffee has at least one flavor noted. On average a coffee received 14 different flavor descriptors.

Cuppers use several words to refer to the same flavor through the years, but the Taster's Flavor Wheel created by the Specialty Coffee Association of America (SCAA) using the lexicon developed by World Coffee Research captures most of them with very few exceptions. Therefore, we use the Taster's Flavor Wheel to classify the 112 flavor descriptors into 19 groups according to Table 2.1. To explore the flavors, we use descriptive analyses (DA) such as principal component analysis (PCA), analysis of variance (ANOVA) and Tukey-Kramer multiple comparison method. PCA is a technique used to retain important variables that explain a phenomenon, and provides a smaller number of variables that can be used to compare individual coffees. ANOVA can be used to check whether there is a significant different among groups and Tukey-Kramer method can be used to do pairwise comparisons among means. To find patterns in the data, principal component analysis (PCA), carried out on covariance matrices, is used on the 19 flavor group profiles. This procedure was conducted to determine whether the 19 groups of flavor could be explained by a smaller number of composite vectors (principal components, PCs). This type of analysis reduces large number of variables into smaller groups with similar properties and can indicate covariance relationships among the sample attributes (Johnson 1998; Lotong et al., 2000). The scoring from PCA is used as input for grouping individual coffee. This allows us to group all coffees into five groups with similar flavor profiles as in the PCA.

To determine whether having a certain flavor profile affects a coffee quality score and price, analysis of variance (ANOVA) was performed. Pairwise comparisons across means of flavor groups are tested using the Tukey-Kramer (TK) method ($p=0.05$) to find out which flavor groups are statistically different. The normality and the homogeneity of variance tests (Bartlett and Levene's test) were performed as well.

2.6 **Results**

After performing the principal component analysis (PCA), five principal components (PCs) are retained as described in Table 2.2. The five PCs explain 74.7% of the variability of flavor with PC1 explaining 20.48% of the variability and PC2 explaining 16.76%. PC1 is positively related to brown sugar, other fruit, brown spice, floral, burnt, and citrus fruit. PC2 is positively related to burnt, nutty, cocoa, brown sugar, and negatively related to tea flavor. PC3, which explained 15.36% of the variability of flavor, is positively related to papery/chemical, cocoa and alcohol/ fermented. PC4 explained 11.67% of the variability of flavor and is positively related to other sweet, berry, sour and floral, and negatively related to pepper, brown spice, tea and tobacco flavors. Finally, PC5 that explained 10.42% is positively related to sour, other sweet, vegetative and tobacco, but negatively related papery/chemical, dried fruit, berry, and tea flavors. The PC plots related to the PCs are shown in Figure 2.1.

Summary statistics for the grouping presented in Table 2.3 shows that coffees in PC4 have the highest mean quality score (87.20), the highest mean purchase price ($1.85) and number of flavor descriptors (16.16) but they represent the fewest coffees (331), while coffees in PC1 has the most coffees (644) but the lowest mean quality score (86.54), mean purchase price ($1.75) and flavor descriptors (12.97). Coffees in PC5 have an average quality score of 87.02, a mean purchase price of $1.80 with 15 flavor descriptors on average and the number of coffees in that PC group is 431. The 447 coffees in PC2 have a quality score of 86.9, mean purchase price of $1.83 with 14.95 descriptors. PC3 consists of 468 coffees with a mean quality score, purchase price and descriptors of 86.85, $1.78 and 14.5.

2.6.1 ***Analysis of Variance (ANOVA) and Tukey-Kramer (TK) Method for Mean Quality Score Difference Among PC Flavor Groups***

The univariate analysis (ANOVA) calculated on the overall data set (Table 2.4) show highly significant differences among the five groups of coffee based on their quality score ($F_{4,2225}$=9.29, $p < 0.0001$). To find out which groups differ, we use the TK method to identify difference in means among the five groups of coffees. The TK method for average quality score in Table 2.5 shows no significant difference between mean quality scores of coffees present in PC4, PC3, PC5 and PC2, but a significant difference was found between the mean quality score of coffees in PC1 and quality score of coffees in every other PC group (p=0.05). Diagnostic analyses show that the assumptions of normality (QQ-plot not shown) and homogeneity of variance (Levene's test ($F_{4,\ 2321}$=1.62, p=0.1673) and the Bartlett's test (Chi-Square=4.00, p=0.4047) are satisfied, and no outliers were detected (Appendix 2.3).

2.6.2 ***Further Disaggregated Analysis for Mean Quality Score***

To check the consistency of our analysis, we conducted disaggregated analysis of the effect of having a flavor profile on average quality score by time period and groups of country from the same geographical region.

Since region of origin and time can affect coffees flavor profiles, ANOVA and TK method were used to check significant differences among the means quality scores of the five groups of coffees. Coffees from the CoE programs are from three geographical regions: Africa (Burundi, Rwanda), Central America (Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua) and South America (Bolivia, Brazil, Colombia).

The ANOVA for Central America (Table 2.4) reveals a statistically significant difference of the means quality scores among the groups ($F_{4,\ 1407}$=6.35, p<0.0001). The mean quality score ranking is consistent with the aggregated data. PC4 has the highest quality score (87.13) followed by PC5 (86.95), PC3 (86.84), PC2 (86.81) and PC1 has the lowest average quality score with 86.44. To determine which groups differ, we used the TK method. Results (Table 2.5) reveal that mean quality score of coffees in PC4, PC5 and PC3 are statistically different than those in PC1, but no difference could be detected between mean quality score of coffees in PC2 and PC1.

For South America, the ANOVA (Table 2.4) shows a significant difference of the means quality score and the groups ($F_{4,\ 581}$=4.22, p=0.0022). Once again, coffees in PC4 have the highest quality score (87.41) and coffees in PC1 have the lowest quality score (86.55). Coffees in PC2, PC3 and PC5 are ranked second, third, and fourth with an average quality score of 87.30, 87.23 and 87.07 respectively. The TK method reveals a statistical difference between mean quality score of coffees in PC4, PC2, PC3 and PC1. However, no statistical difference is detected between mean quality score of PC5 and PC1 coffees (Table 2.5).

No significant difference is detected among the mean quality scores for African countries according to ANOVA ($F_{4,\ 234}$=1.12, p=0.3091). These countries are relatively new in the CoE program. Further, the coffees from Burundi and Rwanda are grown under similar climatic and geographical conditions thus the variations among coffees may be limited.

To test if the grouping holds over time, the data is divided into two time periods 2004-2010 and 2011-2015 to account for the introduction of new countries such as Burundi, Rwanda and Mexico that happened after 2010, and the drop out of Bolivia from the CoE program in 2010. The ANOVA (Table 2.4) shows highly significant differences among the groups for the period 2004-2010 ($F_{4, 1097}$=13.17, p<0.0001) and the period 2011-2015 ($F_{4, 750}$=5.19, p=0.0004).

Like in the aggregate data set, the analysis for the period 2004-2010 shows that coffees in PC4 score the highest (87.19) and coffees in PC1 scores the lowest (86.04). Coffees in PC5 are second with a mean quality score of 87.01, followed by those in PC3 (86.77) and coffees in PC2 are ranked fourth with a mean quality score of 86.70. To determine which groups were statistically different, the TK method was applied. Results showed that mean quality score of coffees in group 1 are statistically different than those all other groups, while no statistical differences are detected between mean quality scores of coffees in PC 4, 5, 3, and 2 respectively (Table 2.5).

For the period 2011-2015, PC 4 still has the highest mean quality score (87.33) while PC 1 has the lowest average quality score (86.52). Coffees in PC 2, 3, and 5 have mean quality scores of 87.16, 87.1 and 86.89 respectively. The TK method showed that mean quality score of coffees in PC 4, 2 and 3 were statistically different than those in PC 1, while no statistical differences were found between mean quality score of coffees in PC 5 and PC 1 (Table 2.5).

2.6.3 ***Analysis of Variance (ANOVA) and TK Method for Average Purchase Prices Difference among PC Flavor Groups***

ANOVA was used to determine if the logarithm average purchase prices are different among the groups of flavors. We use the logarithm of the average purchase prices to normalize the data. Results in Table 2.4 show there are differences among the groups ($F_{4,\ 2158}$=5.19, p=0.0004). Like in the analysis of the mean quality score, we found that coffees in PC4 have the highest mean purchase prices ($1.85) and coffees in PC1 have the lowest mean purchase prices ($1.75). Coffees in PC 2 are ranked second with a mean purchase prices of $1.83, followed by coffees in PC 5 ($1.80) and coffees in PC 3 have a mean purchase prices of $1.78. To identify statistical differences among the means purchase prices, pairwise comparison (TK method) was used (Table 2.6). Results show that mean purchase prices of coffees in PC 4 and 2 are statistically different than those in PC1 respectively (p=0.05). Diagnostic analysis showed that the assumptions of normality (QQ-plot not shown) and homogeneity of variance (Levene's test ($F_{4,\ 2158}$=0.53, p=0.710) and the Bartlett's test (Chi-Square=2.092, p=0.7189) are satisfied, and no outliers were detected (Appendix 2.3).

2.6.4 ***Further Disaggregated Analysis for Mean Purchase Prices***

To check whether our overall data set analysis is consistent across time and by region, we conducted disaggregated analysis of the effect of having a flavor profile on average purchase prices. Region of origin and time can affect coffees flavor profiles, ANOVA and the TK method were used to check if there were significant differences of the mean purchase prices among the five PC groups of coffees. Three groups of countries namely Africa (Burundi, Rwanda), Central America (Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua) and South America (Bolivia, Brazil, Colombia) were used in the analysis.

The ANOVA for Central America countries (Table 2.4) reveals statistical differences in the means purchase prices of the groups ($F_{4,\ 1361}$=4.04, p=0.0029). The highest average purchase price of $1.83 is for coffees in PC4 while the lowest mean purchase price of $1.71 is in PC1. Coffees in PC 2, 5, and 3 have mean purchase prices of $1.80, $1.79 and $1.76 respectively. The TK method reveals a significant difference between mean purchase prices of coffees of PC 4, 2, and coffees in PC1. However, there is no statistical difference between mean purchase prices of coffees in PC 5, 3 and PC 1 (Table 2.6).

For South American countries, the ANOVA (Table 2.4) shows differences in the means purchase prices ($F_{4,\ 574}$=2.11, p=0.078) with coffees in PC4 having the highest purchase prices ($1.88) and coffees in PC1 the lowest mean purchase prices ($1.78). Coffees in PC 2, 3, and 5 have a mean purchase price of $1.85, $1.83 and $1.80 respectively. Results from the TK method show only mean purchase price of coffees in PC1 is significantly different than the mean purchase price of the other PC groups (Table 2.6).

For African countries, there was no differences among the group mean purchasing prices according to ANOVA ($F_{4,\ 222}$=0.52, p=0.7191). As stated earlier, coffees from Burundi and Rwanda are grown under similar climatic and geographical conditions; therefore no difference was detected among the mean purchase prices.

When dividing the data into two time periods (2004-2010 and 2011-2015), the ANOVA (Table 2.4) shows highly significant differences in log prices among the PC groups for the period 2004-2010 ($F_{4,\ 1063}$=14.6, p<0.0001) and the period 2011-2015 ($F_{4,\ 726}$=3.27, p=0.0113).

Consistent with early findings, for the period 2004-2010 coffees in PC4 have the highest purchase prices ($1.83) while coffees in PC1 have the lowest purchase prices ($1.58). Coffees in PC 2, 5, and 3 have average purchase prices of $1.77, $1.75 and $1.71 respectively. The TK method shows mean purchase prices of coffees in PC4 are statistically different than coffees in PC 3 and 1. Also, it is shown that mean purchase prices of coffees in PC 2, 5, and 3 are statistically different than those in PC1 (Table 2.6).

For the period 2011-2015, coffees in PC 4 have the highest purchase prices ($1.95), followed by coffees in PC2, PC5, PC3 and PC 1 with an average purchase prices of $1.90, $1.86, $1.85 and $1.78 respectively. Results of the TK method show a statistical difference among mean purchase prices of coffees in PC 4, 2 and those in PC 1; however, no statistical difference is detected between mean purchase prices of coffees in PC 5, 3 and 1 (Table 2.6).

2.7 **Conclusion and Discussion**

The objective of this study was to describe the relationship between specialty coffees' quality score and purchase prices based on sensory profiles. Five flavor profiles were retained from the principle component analysis (PCA), and then coffees were clustered according to the flavor profiles. Analysis of variance (ANOVA) was used to check differences among the mean quality score and purchase prices of each PC group and the Tukey-Kramer method was used for pairwise comparison. Results show that coffees with the highest (lowest) mean quality score have the highest (lowest) mean purchase prices, which confirm that cuppers and buyers have the similar taste preferences and perceptions of coffee quality. The results are consistent regardless of the country of origin (except African countries) and the time the auction has taken place. These are very interesting results and show that although several factors can affect the tasting experience, coffee cuppers have been consistent in finding and differentiating high quality from low quality coffees.

The practical application of this study is that sensory attributes are used to cue quality of specialty coffees. Therefore, coffees can be grouped into five main flavor profiles and based on these flavors, one can determine if a coffee is going to have a high or low score or if the coffee is going to have a high or low purchase price. The descriptive analysis show cuppers and buyers have similar preferences for coffees' flavor profiles, thus the same perception of specialty coffees' quality. Coffees with sweet, berry, and sour flavor profiles are perceived as being of high quality while coffees with sugar, brown spice, and fruity flavor profiles are considered of low quality. Also, the study shows that more complex and unique coffees are rewarded with high quality scores and purchase prices. The robustness of the analysis through time and over Central and South America shows consistency in the tasting process. This result is of great importance for the specialty coffee industry since cupping is a very complex activity that can be influenced by other senses. Now, they can use the cupping notes as a decision making tool to buy high quality flavor profiles.

Table 2.1. Flavor Group Composition

Vegetative	**Cocoa**	**Dried Fruit**	**Sour**
Herb	Cocoa	Raisin	Sour
Thyme	Chocolate	Currant	Acid
Olive	Milk chocolate	Date	Mascarpone
Fresh	Dark Chocolate	Prune	Malic
Ripe	**Brown Sugar**	Dried Fruit	Tart
Papery/Chemical	Molasses	**Other fruit**	**Alcohol/Fermented**
Woody	Syrup	Coconut	Wine
Cedar	Caramelized	Cherries	Whiskey
Sandalwood	Honey	Pomegranate	Champagne
Leather	Maple	Pineapple	Rum
Bitter	Sugar	Mango	Cognac
Salty	**Other Sweet**	Papaya	Grand Marnier
Earthy	Vanilla	banana	
Tobacco	Sugar Cane	Grape	
Tobacco	Sweet	Apple	
Pipe	Butterscotch	Peach	
Burnt	marzipan	Plum	
Smoky	Aromatics	Guava	
Brown	**Tea Flavor**	Plantain	
Roast	Tea	Pear	
Cereal	**Floral**	Kiwi	
Grain	Rose	Honeydew	
Malt	Jasmine	Melon	
Pepper	Hibiscus	Apricot	
Pepper	Lavender	Pumpkin	
Pungent	Sassafras	Cucumber	
Peppercorn	Potpourri	Tangerine	
Brown Spice	Patchouli	Grenadine	
Anise	Bouquet	Nectarine	
Licorice	Sandalwood	**Citrus fruit**	
Nutmeg	Flowery	Grapefruit	
Cardamom	Orchid	Orange	
Cinnamon	Florals	Mandarin	
Clove	**Berry**	Lemon	
Nutty	Blackberry	Lime	
Peanut	Raspberry	Citrus	
Hazelnut	Blueberry	Citric	
Almond	Strawberry	Tomato	
Nut			

Source: Authors based on SCAA flavors' wheel and CoE data 2004-2015
Bold is the flavor group name according to SCAA Flavor' Wheel

Table 2.2. Principal Components

Flavor	Compont1	Compont2	Compont3	Compont4	Compont5	KMO
Vegetative	0.1244	-0.1841	0.1364	0.0124	-0.3699	0.5744
Chemical	0.0272	0.2011	**0.4325**	-0.0081	**0.4971**	0.5267
Tobacco	0.2240	-0.0235	0.2482	-0.2461	-0.3956	0.6351
Burnt	0.3898	**0.6210**	-0.2055	0.0196	0.0527	0.5268
Cereal	0.0569	-0.0319	0.1889	-0.0134	0.0652	0.4950
Pepper	0.2489	-0.0403	0.2081	-0.3610	-0.3571	0.6113
Brown spice	**0.3968**	-0.1104	0.0292	-0.3787	-0.1012	0.6077
Nutty	0.1687	0.3713	0.1555	-0.2061	-0.0940	0.6016
Cocoa	0.0267	**0.4577**	**0.4799**	-0.0019	0.2066	0.5365
Brown sugar	**0.4949**	**0.4651**	-0.2917	0.0808	-0.0051	0.5581
Other sweet	0.1499	0.1635	0.1825	**0.5432**	-0.3109	0.5426
Tea	0.2089	-0.3043	-0.2306	-0.3202	0.2459	0.5931
Florals	0.3856	-0.2259	-0.1178	0.3645	0.0871	0.6460
Berry	0.1938	-0.2302	0.1696	**0.5245**	**0.4064**	0.5752
Dry fruit	0.2409	-0.0452	0.1429	-0.0866	**0.4254**	0.6552
Other fruit	**0.4772**	-0.1680	-0.0838	0.1137	0.1408	0.6340
Citrus fruit	0.3626	-0.0298	-0.4287	0.1069	-0.0528	0.6162
Sour	0.1117	-0.0916	0.0985	**0.4908**	-0.3946	0.5298
Alcohol	0.2105	-0.2026	**0.4906**	0.1589	0.0660	0.6042
Overall						0.5832

Source: Author, based on CoE data 2004-2015.
Bold are leading three flavors that can be used to brand each component.
KMO shows the goodness of fit.

Table 2.3. Summary Statistics

PC	N	Mean Score	Mean Logged Price	Mean number of descriptors
1	644	86.54	1.75	12.97
2	447	86.90	1.83	14.95
3	468	86.95	1.78	14.49
4	331	87.20	1.85	16.16
5	431	87.02	1.80	15.02

Source: Author, based on CoE data 2004-2015

Table 2.4. Analysis of Variance (ANOVA) Test Results

	Price		Quality	
	F-Stat	*p*-value	*F*-Stat	*p*-value
Overall	5.19	0.0004	9.29	<.0001
South America	2.11	0.0788	4.22	0.0022
Central America	4.04	0.0029	6.35	<.0001
Africa	0.52	0.7191	1.21	0.3091
Time Period (2004-2010)	14.6	<.0001	13.17	<.0001
Time Period (2011-2015)	3.27	0.0113	5.19	0.0004

Source: Author, based on CoE data 2004-2015

Table 2.5. Tukey-Kramer Adjustment for Mean Quality Score Difference by PC groups

Tukey-Kramer Adjustment for Mean Quality Score Difference by PC groups														
Means with the same letter are not significantly different (p=0.05).														
Overall			South America			Central America			Time Period 2004-2010			Time Period 2011-2015		
PC	Estimate 95%CI		PC	Estimate 95%CI		PC	Estimate 95%CI		PC	Estimate 95%CI		PC	Estimate 95%CI	
4	87.2037	A	4	87.4119	A	4	87.1274	A	4	87.1905	A	4	87.3312	A
	87.03,87.38			87.06,87.77			86.90,87.35			86.92,87.46			87.03,87.63	
5	87.0213	A	2	87.3013	A	5	86.9483	A	5	87.01	A	2	87.1582	A
	86.82,87.22			86.96,87.64			86.69,87.2			86.71,87.31			86.87,87.45	
3	86.9518	A	3	87.2313	A	3	86.8373	A	3	86.7767	A	3	87.1046	A
	86.78,87.12			86.90,87.56			86.62,87.06			86.50,87.05			86.83,87.38	
2	86.8958	A	5	87.0742	AB	2	86.8051	AB	2	86.7074	A	5	86.8907	AB
	86.72,87.07			86.69,87.45			86.58,87.02			86.42,86.99			86.53,87.25	
1	86.5388	B	1	86.5542	B	1	86.4427	B	1	86.0426	B	1	86.5189	B
	86.39,86.68			86.24,86.86			86.27,86.62			85.83,86.26			86.27,86.77	

Source: Author, based on CoE data 2004-2015

Table 2.6. Tukey-Kramer Adjustment for Mean Purchase Log Price Difference by PC Groups

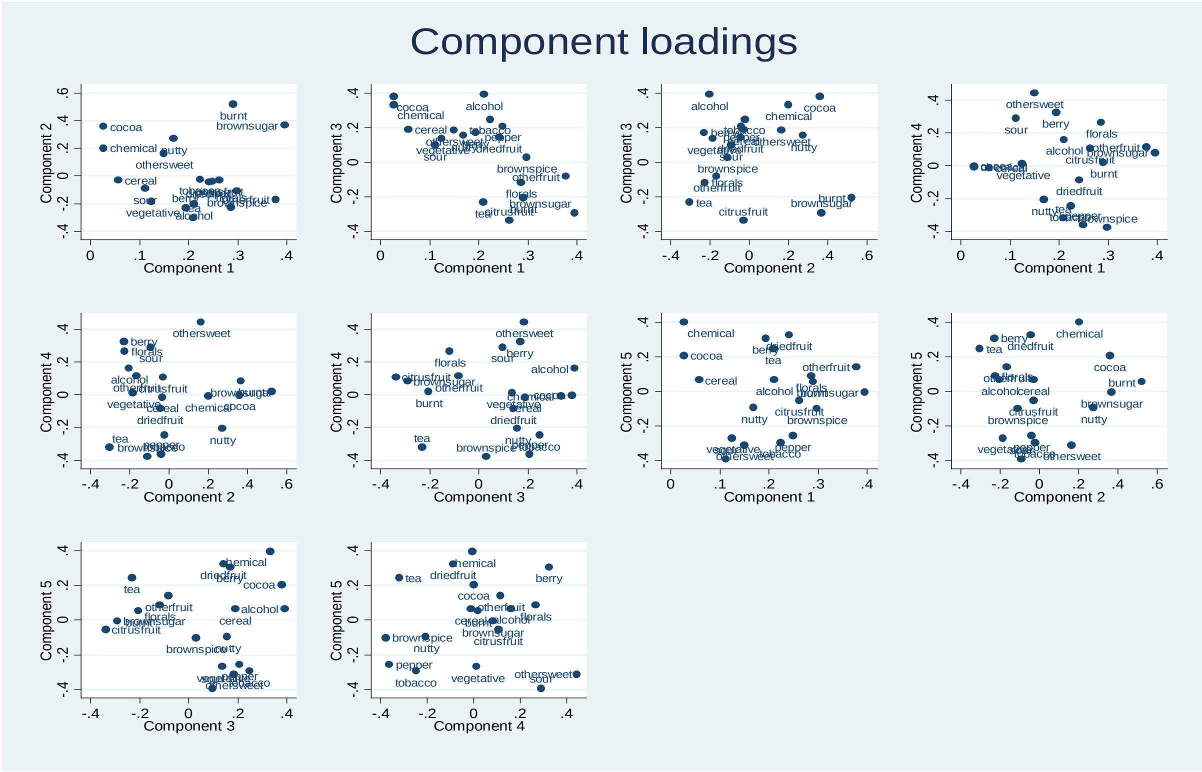
Overall			South America			Central America			Time Period 2004-2010			Time Period 2011-2015		
PC	Estimate 95%CI		PC	Estimate 95%CI		PC	Estimate 95%CI		PC	Estimate 95%CI		PC	Estimate 95%CI	
4	1.8499	A	4	1.8857	A	4	1.8342	A	4	1.8291	A	4	1.9483	A
	1.81,1.88			1.83,1.94			1.78,1.88			1.78,1.88			1.88,2.02	
2	1.826	A	2	1.8455	A	2	1.8032	A	2	1.7664	AB	2	1.8979	A
	1.79,1.86			1.79,1.90			1.75,1.85			1.71,1.82			1.83,1.97	
5	1.8013	AB	3	1.8254	A	5	1.786	AB	5	1.7518	AB	5	1.8649	AB
	1.76,1.84			1.77,1.88			1.73,1.85			1.69,1.81			1.78,1.95	
3	1.7844	AB	5	1.8011	A	3	1.7635	AB	3	1.7069	B	3	1.8571	AB
	1.75,1.82			1.74,1.86			1.71,1.88			1.65,1.76			1.79,1.92	
1	1.7481	B	1	1.7801	B	1	1.7106	B	1	1.5836	C	1	1.7857	B
	1.72,1.78			1.73,1.83			1.67,1.75			1.54,1.63			1.72,1.85	

Tukey-Kramer Adjustment for Mean Purchase Log Price Difference by PC groups

Means with the same letter are not significantly different (*p*=0.05).

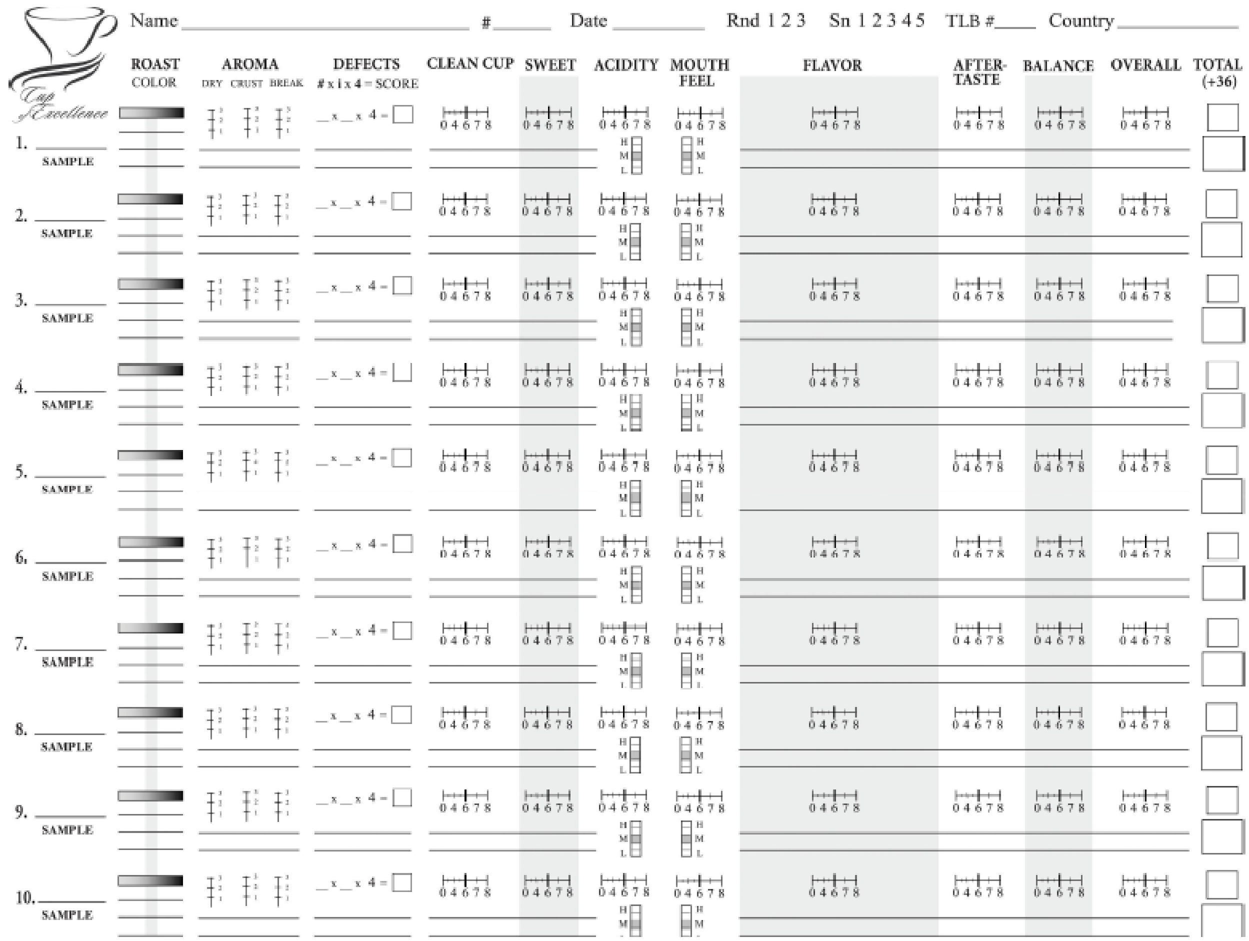
Source: Author, based on CoE data 2004-2015

Figure 2.1. Principle Component Loadings



Source: Author, based on CoE data 2004-2015

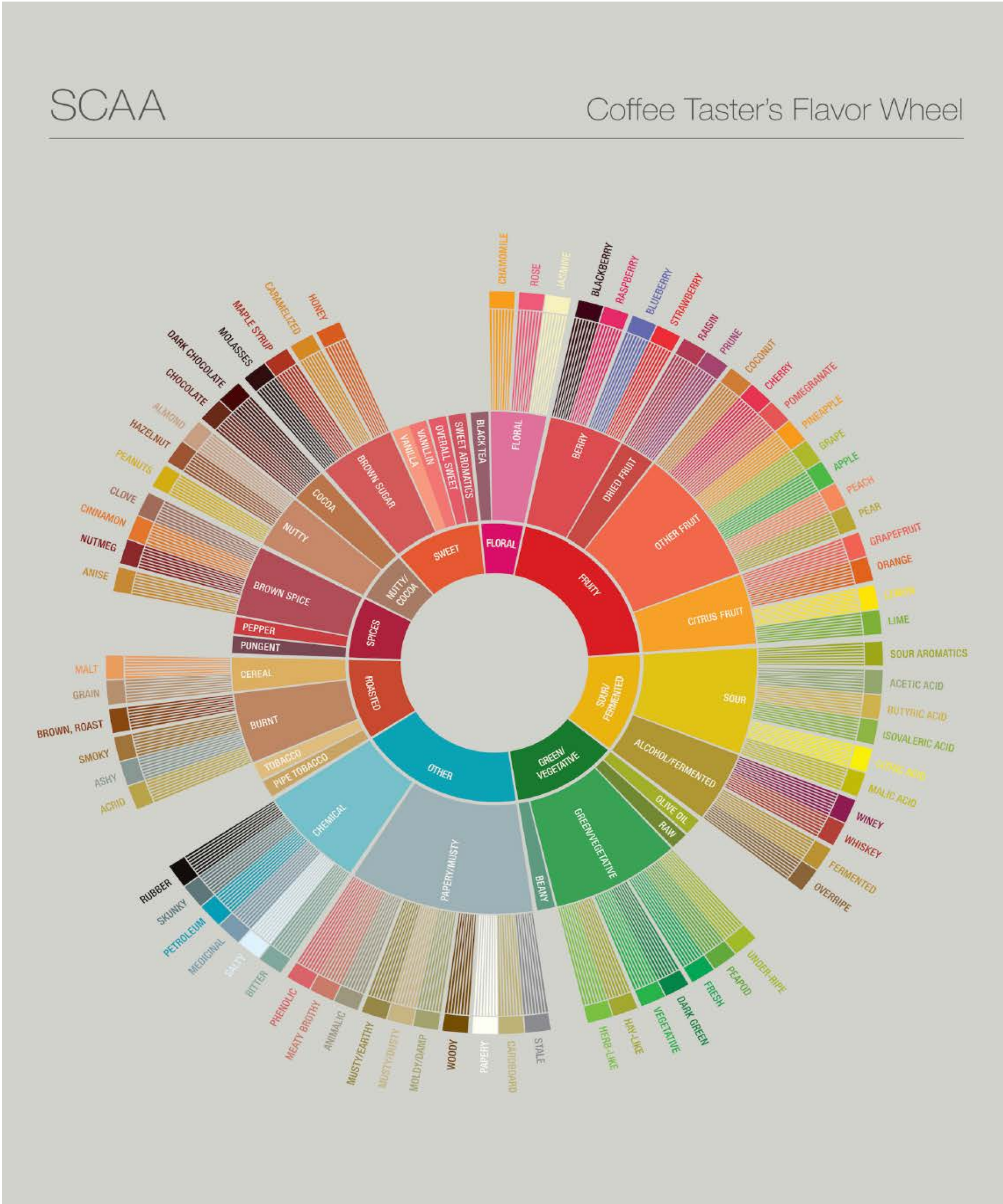
Appendix 2.1. Cup of Excellence cupping form


Cup of Excellence

Name ____________ # ____ Date ________ Rnd 1 2 3 Sn 1 2 3 4 5 TLB #____ Country ________

	ROAST COLOR	AROMA (DRY CRUST BREAK)	DEFECTS (# x i x 4 = SCORE)	CLEAN CUP	SWEET	ACIDITY	MOUTH FEEL	FLAVOR	AFTER-TASTE	BALANCE	OVERALL	TOTAL (+36)
1. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
2. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
3. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
4. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
5. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
6. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
7. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
8. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
9. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M L)	0 4 6 7 8 (H M L)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐
10. ______ SAMPLE			__ x __ x 4 = ☐	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 (H M)	0 4 6 7 8 (H M)	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	☐

Appendix 2.2. SCAA Coffee Taster's Flavor Wheel.



Appendix 2.3. Levene's and Bartlett's Tests Results

Variables	Quality Score				Log of Price			
	Leven's Test		Bartlett's Test		Levene's Test		Bartlett's Test	
	F-Stat	*p*-value	Chi-Square	*Pr>Chi-Square*	F-Stat	*p*-value	Chi-Square	*Pr>Chi-Square*
Overall	0.53	0.71	2.09	0.72	1.62	0.17	4.01	0.40
South America	0.5	0.74	1.96	0.74	0.72	0.58	1.97	0.74
Central America	0.73	0.57	2.82	0.59	1.24	0.29	3.09	0.54
Africa	-	-	-	-	-	-	-	-
Time Period 2004-2010)	1.66	0.16	6.93	0.14	3.66	0.50	9.64	0.47
Time Period (2011-2015)	0.09	0.99	0.46	0.98	0.67	0.61	1.60	0.81

Source: Author, based on CoE data 2004-2015

Chapter 3: What Explains Specialty Coffee Quality Scores and Prices: A Case Study from the Cup of Excellence Program

3.1 Introduction

Coffee is one of the most popular drinks and the most valuable agricultural commodity traded in the world. Coffee provides a livelihood for nearly 125 million people around the world, generating cash returns in subsistence economies and providing employment to both men and women living in rural areas (Fairtrade, 2012). From 1962 to 1989, coffee market was regulated by the International Coffee Agreement (ICA). The ICA was a collection of agreements that set the production and consumption quotas and governed quality standards for most coffee producing countries. After the disintegration of the ICA and market liberalization, global coffee production increased leading to declining prices paid to producers and a subsequent decline in coffee quality (Ponte, 2002a). As a reaction to the decline in coffee quality offered by mainstream roasters, specialty coffee was born. Specialty coffee is defined as coffee grown in special and ideal climates, with a distinctive taste and flavor and has little to no defects. In general, specialty coffees are coffees with a quality score of 80 or higher on a 100-point scale (SCAA, 2016).

The market of specialty coffee is growing rapidly in many countries and the USA has the most developed specialty coffee market followed by Europe and Asia (SCAA, 2016). In the USA for example, specialty coffee has increased its market share from 1% to 25% over the last 20 years and the percentage of adults drinking specialty coffee daily has increased from 9% in 1999 to 34% in 2014 (SCAA, 2016). The growing demand for specialty coffee is due to consumer awareness regarding issues of quality, taste, health, environment, equity and fair-wages (Bacon, 2004).

Quality standards and quality control are key aspects of the development of specialty coffee market. Specialty coffee companies often distinguish themselves to mainstream coffee companies because of their strict quality requirements. Quality control from the bean to roasting brings the best flavor and aroma. Aromatic and flavor components are the main sensory components experienced by coffee drinkers and they play an important role in satisfying consumer demand. Quality can be measured based on three attributes: material and physical attributes, symbolic or reputation attributes and in-person service attributes (Daviron and Ponte, 2005). Much of the economic literature pertaining to specialty coffee focuses on determining the value buyers place on symbolic or reputation attributes (Donnet et al., 2008; Teuber and Hermann, 2012; Wilson and Wilson, 2014). While we recognize the importance of these attributes in coffee price formation, we believe that coffee quality is not limited to those attributes only. Therefore, the goal of this study is to measure the impact of material and physical as well as reputation attributes on specialty coffee quality score and purchase prices.

The rest of the paper is organized as follows: Section two describes the Cup of Excellence program; Section three presents the literature of commodity quality and their relation with price, and the hypotheses; Section four is devoted to data and descriptive statistics; Section five provides the methodology and explains the results. The last section is dedicated to conclusion and discussions.

3.2 **The Cup of Excellence program**

Introduced in Brazil in 1999, Cup of Excellence (CoE) is a competition designed to award top quality coffees worldwide. The competition currently takes place in 10 countries (Brazil, Burundi, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Rwanda) since Bolivia dropped out of the competition in 2010. Each participating coffee in the

CoE competition is tasted or cupped at least five times by a panel of local and international jury, and the competition is open to any coffee grower free of charge. At the end of the cupping evaluation, each coffee is given a quality score based on the roasting color, aroma, defects, cleanness, sweetness, acidity, mouthfeel, flavor, aftertaste and balance. Only coffees with a quality score of 84 or higher out of a total of 100 earn the CoE award and can participate in the online auction. Buyers can purchase samples to do their own evaluation before the live auction (ACE/CoE, 2016).

The CoE live auction is an eBay style auction where buyers bid against each other. As an English auction, the highest bid wins (Wilson, 2015). The CoE program auction prices are on average 4.5 times higher than the International Coffee Organization (ICO) composite price (Wilson and Wilson, 2014). Coffee growers receive more than 80% of the final price, and the remaining is a commission paid to the in-country organization committee to help run the program (ACE/CoE, 2016).

3.3 **Theories and hypotheses**

*3.3.1 **Theory on Product Quality Attributes***

Specialty coffee roasters and buyers depend on a higher quality bean and are generally willing to pay producers premium prices for better beans. Coffee quality can be assessed either based its material, symbolic or in-person service attributes (Daviron and Ponte, 2005). Material quality attributes of a product are attributes embedded or intrinsic to the product and exist regardless of the identity of sellers and buyers. They result from physical, chemical or biological processes that create specific characteristics. These characteristics can be measured using human senses (taste, smell, vision, hearing or touch) or by using sophisticated devices such as spectrographs (Daviron and Ponte, 2005). In the specialty coffee market, material qualities are measured through "cupping", a process through which highly trained experts estimate aroma, taste and flavor according to the grading system developed by the Specialty Coffee Association of America (SCAA). The grading system consists of evaluating a list of sensory attributes descriptors such as aroma, flavor, aftertaste, acidity, body, balance, clean cup, defects, mouthfeel and sweetness of each coffee before an average quality score is attributed. Through this system, cuppers provide "cupping notes" that offer information on the specific sensory characteristics of a coffee (see Appendix 3.1 for the cupping form). In addition to the cupping notes, the cuppers provide a score for each coffee and generally, a higher quality score is usually associated with a higher price (Donnet et al., (2008); Teuber and Hermann (2012); Wilson and Wilson (2014)).

Symbolic quality attributes are based on reputations, trademarks, geographical origins and sustainability practices (Daviron and Ponte, 2005). Trademarks and geographical origin are similar in many ways as they enable consumers or buyers to differentiate products, reduce asymmetries of information and create value. Specialty coffees are single origin coffees that are valued by buyers differently depending on the country of origin. Many organizations such as Fairtrade, Rainforest alliance and Utz work with specialty coffee producers to make sure they have fair wages or prices that take into account the cost of production. Therefore, a coffee with those certifications may attain a price premium.

In-person service quality attributes are the result of the interaction between producers/retailers and consumers. In-person service quality involves effective and affective work from the producer or retailer to get attention or trust from consumers, who in return are willing to pay premium prices. In the specialty coffee industry, in-person service quality attributes can take place between producers and green coffee buyers or between roasters and final consumers. These attributes include the quality when the product is delivered to the buyer or final consumer and the quality of the physical transformation of the product (quality of the roaster to present consumers with the best flavored coffee). The CoE program does not collect information on the relationship between producers and buyers after the live auction; therefore, the rest of the analysis is based on material, physical and symbolic attributes only.

3.3.2 ***Literature Review***

Since Waugh (1928) and Rosen (1974), the hedonic price modeling has been widely been used to relate the price and attributes of various agricultural, food, real estate and environmental products. The hedonic price method consists of measuring the contribution of the attributes of a product to its price. The analysis involves modeling the price of the product as a function of its attributes in order to estimate the marginal money value of each attribute. Consequently, we used a regression to predict the quality score and price of coffees based on various attributes:

(3.1) $p(z) = (a_1, a_2, \ldots, a_n)$

where p is the price of product *z* and $(a_1, a_2, \ldots, a_n)$ represent a set of attributes of product z. The implicit or hedonic price is defined as:

(3.2) $\frac{\partial p}{\partial a_1} = p_i(a_1, a_2, \ldots, a_n)$

For specialty coffees, hedonic price method enables to determine the impact of material and physical attributes as well as symbolic or reputation attributes on specialty coffee quality score or price. That is through hedonic price analysis; one can determine the price or the value buyers attach to the intrinsic (material and physical) and the reputation attributes of each coffee (Wilson and Wilson, 2014).

An industry comparable to specialty coffee where the use of hedonic technique is well-established is the wine industry. The wine industry uses a tasting system to assess sensory attributes of each wine and a quality score is then assigned by expert tasters. These sensory attributes and quality scores signaled through labels. These signals reduce problems with asymmetric information. Generally, the price of each bottle of wine is correlated to the quality grade. Using the hedonic method, several studies assess factors explaining differences in the price of wines from numerous regions/countries of the world. Combris et al. (1997) applied the hedonic price method to Bordeaux wines and found that the market price is mainly determined by the reputation attributes while the score is essentially determined by the sensory characteristics. Oczkowski (2001) used the same technique to study Australian premium wines' prices and found that only reputation attributes had a significant effect of prices. Schamel and Anderson (2003) estimated hedonic price functions for premium wines from Australia and New-Zealand. Results showed that price premium was associated with sensory quality ratings. Lecocq and Visser (2006) applied the hedonic technique to Bordeaux and Burgundy wines, two of the most important French wine regions. The authors found that reputation attributes explain the major part of the price differences while sensory attributes did not appear to play an important role.

Focusing on specialty coffee, the more recent applications of the hedonic technique are: Donnet (2008), Teuber and Hermann (2012), Wilson et al. (2012), and Wilson and Wilson (2014). Donnet et al. (2008) were pioneers in showing that specialty coffee prices are significantly influenced by quality score, ranking, country of origin and coffee tree variety. Teuber and Hermann (2012) used a supply-and-demand framework to explain CoE auction prices. The findings revealed that factors such as reputation, quality score and country of origin are the main factors explaining variations in coffee prices. Wilson et al. (2012) examined the prices of CoE coffees from Central America using hedonic regression. The paper showed that the quality score has the greatest impact on prices followed by other factors such as altitude, farm size, and country of origin. Wilson and Wilson (2014) estimated price determinants for premium coffee using CoE data from 2004 to 2010. The authors used a modified version of Donnet et al (2008) by including more relevant variables and using a truncated regression. Results showed that quality score, ranking and origin of buyers have a strong effect on coffee prices. Although these previous studies used extensively the CoE data to predict coffee prices, none assessed how material attributes influence specialty coffee quality scores and purchase prices.

3.3.3 ***Hypotheses***

Theory suggests that material quality attributes assessment is not affected by symbolic quality attributes. However, we predict that coffee price like the price of any other commodity is based not only on material attributes, but also on symbolic or reputation attributes.

Therefore, we hypothesize the followings:

H_1: Specialty coffee quality score is based solely on material and physical attributes, which means that symbolic attributes have no influence on the rating.

H_2: Specialty coffee purchase price is based on both material and symbolic attributes.

3.4 **Data**

Data for the present study includes 2,123 observations from the Cup of Excellence (CoE) e-auctions that took place in 11 countries (Bolivia, Brazil, Burundi, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Rwanda) from 2004 to 2015. CoE hosts at least one competition per year in most participating countries and each competition consists of a total of six cuppings by skilled and highly experienced national and international coffee cuppers. During the evaluation, cuppers note a set of sensory attributes descriptors such as flavor, aroma, aftertaste, acidity, body, balance, clean cup, defects, mouthfeel and sweetness, and provide an average quality score for each coffee sample. Only coffees with an average score of 84 or higher out of 100 receive the Cup of Excellence Award and can participate to the national auction. The data set also includes information on the final auction price of each coffee excluding shipping costs, rank of the coffee, the number of coffee in the market, farm data (quantity of coffee bags per lot, certification, coffee tree varietals, altitude, and processing method) and name/origin of origin of buyers.

Sensory variables for each coffee participating at the CoE are recorded in the cupping notes (see Appendix 3.1 for cupping form). Cuppers use several words to describe sensory properties of coffees through the years. A total of 112 different flavor/aroma descriptors were used by cuppers to describe coffee flavors and aroma across our data. To reduce the number of sensory variables, we used the Taster's Flavor Wheel (see Appendix 3.2 SCAA flavor's wheel) created by the Specialty Coffee Association of America (SCAA) using the lexicon developed by World Coffee Research (SCAA, 2015). Therefore, we were able to classify the 112 flavor/aroma descriptors into 9 groups according to the SCAA Taster's Flavor Wheel. The most recurrent coffee body types, mouthfeel, and aftertaste descriptors were used, and dummy variables were created to indicate whether the cup was clean and balance.

3.5 **Estimation Procedures**

This paper estimates equations to explain how material, physical, and symbolic attributes affect specialty coffees' quality score. Another set of equations estimate how similar factors affect coffee purchase prices from the CoE program.

In the first step, the method estimates the quality score equation since price depends on quality score mainly:

(3.3a) $Q_i = M_i'\beta + \varepsilon_i$

where Q_i is the quality score, M_i represents the vectors of material and physical attributes (flavors, cup type, body characteristics, mouthfeel, and aftertaste) that influence coffee quality score and ε_i is an error term. Equation (3.3a) is also run with the incorporation of symbolic or reputation attributes in order to assess their impact on coffee quality score:

(3.3b) $Q_i = M_i^{\prime}\alpha + R_i^{\prime}\gamma + \mu_i$

where R_i is the vector of reputation variables (coffee tree variety, certification, altitude and country of origin). In each case, these variables are dummies taking the value 1 if the coffee has the attributes and 0 otherwise, or continuous variables for altitude, number of coffees in the market or lot size (see Table 3.1 for the data summary). Variable M_i is defined as in equation (3.3a) and μ_i is an error term. Theoretically, the reputation attributes should not have any impact on a coffee quality score. However, many people in the coffee industry argue otherwise. They believe that reputation attributes such as country of origin, coffee tree varietal or number of coffee in the market influence specialty coffee quality score. Therefore, equation (3.3b) is a way to test those allegations.

To participate in the CoE live auction, a coffee must obtain a quality score of 84 or higher. This causes a truncation of the quality score and the estimation of equation (3.3a) and (3.3b) is therefore conducted using truncated maximum likelihood regression model with 84 as a truncation point.

Once the quality score is determined, the second step involves estimating the price equation as follows:

(3.4a) $LnPrice = Q_i^{\prime}\varphi + Q_i^{\prime 2}\Omega + R_i^{\prime}\eta + \vartheta_i$

where $LnPrice$ is the logarithm of the deflated price of coffee i (i= 1 to 2,123), Q_i and R_i are defined as above, and ϑ_i is the error term. The use of logarithm is to normalize price. Equation

(3.4a) is also estimated by including material and physical attributes in order to assess their direct impact on coffee prices:

(3.4b) $LnPrice = M_i'\sigma + R_i'\zeta + \psi_i$

where $LnPrice$, M_i, R_i are defined as above and ψ_i is the residual.

To estimate the effect of having a flavor combination on the market price, equation (3.4c) is estimated by replacing the individual flavors by the group of flavors determined in chapter 2:

(3.4c) $LnPrice = F_i'\rho + R_i'\tau + \omega_i$

where $LnPrice$, R_i are defined as above, F_i is the flavor groups obtained from chapter 2 and ω_i is the disturbance term.

Recall that any coffee participating in the CoE live auction has a score of 84 or higher; thus, the distribution of price is incidentally truncated taking the form:

(3.5) $P_i = \begin{cases} P_i^* & when\ Q \geq 84 \\ unobserved & when\ Q < 84 \end{cases}$

We, therefore, estimate equations (3.4a), (3.4b) and (3.4c) using a truncated maximum likelihood method with the lowest price for each auction as the truncation point (Wilson and Wilson, 2014; Hausman and Wise, 1997; Maddala, 1983).

3.6 **Results**

3.6.1 ***Descriptive Statistics***

Descriptive statistics presented in Table 3.1 show that coffees participating have an average quality score of 87 with 95.76 has the highest score, and a mean purchase price of $7.4 per pound. The most common flavors and aromas are fruity occurring in 95.7% of the coffees, sweet in almost 85% of the coffees, and sour acid in 58% of the coffees. Wet processing method is widely used by farmers and almost 66% of the coffees are processed through this method. In terms of coffee tree varieties, the data show that bourbon, caturra and catuai are the most popular coffee tree variety planted by respectively 23%, 14% and 11% of farmers. The average farm is located at an altitude of 1,500 meters above sea level and very few of the farms (only 4%) have some type of certification (organic, Rainforest Alliance or Utz). On average, growers submit 30 bags, where each bag weighs 70kg to the CoE live auction. The average number of coffee in each auction is 27 coffees. The CoE program is held in 11 coffee producing countries worldwide. However, El Salvador (14.3%), Honduras (13.9%), Brazil (13%) and Nicaragua (12.7%) have the most coffees in the data set. The CoE live auction attracts buyers from around the world, nearly 50% of buyers are from Asia and 29% of buyers are group of buyers from multiple countries.

3.6.2 ***Quality Score Equations***

Equation (3.3a) estimated through truncated regression shows that the relationship between coffee quality score and, material and physical attributes is positive and significant except for other and roasted flavors that have a significant but negative impact on quality score (Table 3.2). Sweet, floral, fruity and sour acid flavors/aromas have the largest effect on quality score. For example, having an extra flavor/aroma of sweet, floral and fruity increases quality score by 3.3, 1.3 and 1.01 points respectively. Having a lot of flavors and aromas is good but a balance combination of them is rewarding an extra 0.35 quality score point. Clean and transparent attributes have a significantly positive effect on quality score, confirming the expectation that specialty coffees have little or no defects. Mouthfeel is another important factor affecting coffee quality score. Smooth and juicy mouthfeel are all positive and significant at the 1% level, while a buttery mouthfeel is positive and significant at the 5% level. Aftertaste is another attribute valued by cuppers. Long aftertaste is positive and significant at the 5% level but a lingering aftertaste is not significant. These latter results suggest that sensory attributes influence significantly coffee quality score, which confirm our first hypothesis.

The introduction of reputation attributes in equation (3.3b) improves tremendously the grading equation. Equation (3.3a) has an AIC of 9,661 and a BIC of 9,789, whereas the additional inclusion of the processing method, coffee tree variety, certification, number of coffee in the market, country of origin and year decreases the AIC to 8,264 and the BIC to 8,576. Pacamara variety, Rainforest Alliance certification and altitude have a positive and significant effect on quality score, while the number of coffees in the market has a negative and significant effect on quality score. For example, being certified is worth almost an extra 1.5 point in quality score, while an extra meter in altitude is worth 0.3 point in quality score, but a unit increase in the number of coffees in the market decreases quality score by 0.028 point. The estimated coefficients for all countries of origin were significant but negative, which means that compare to Brazil, coffees from other countries have lower quality scores. Introduced as correction variables, the coefficients for competition year are negative and significant. This means that quality score has been decreasing over the years 2004-2015. This is indeed true since the year 2004 has the highest mean quality score and the highest single score ever recorded in the CoE program (95.76). The improvement of the grading equation (3.3a) with the inclusion of reputation attributes suggests their importance in the grading system.

The conclusion is that quality score depends on the country of origin, certification, number of coffee in the market and altitude. This result confirms what has been said in the coffee industry about specialty coffee quality score and show that reputation matters in the grading process, which in principle should not be the case.

3.6.3 ***Purchase Price Equations***

Equation (3.4a), which is an extension of Wilson and Wilson (2014), confirms the nonlinear relationship between quality score and price (Table 3.3). The coefficients of score and square term are both positive and significant (99% significance level). The model (equation 3.4a) predicts an additional quality score point[7] increases price by 18.68%. However, after 93.10 the effect of a one unit increases lowers the score. As in Wilson and Wilson (2014), this result is supported by examples in the data set where higher scoring coffees garnered lower price than lowered scoring coffees in another auction. The number of descriptors used to describe coffees is a significant predictor of prices and any additional descriptor is associated with a 0.74% increases in price.

Ranking matters and according to the estimates, obtaining the first place[8] gives the highest premium at 133.5% more than coffees not ranked in the top four coffees, while obtaining the second, third or fourth place gives a premium at 44.44%, 26.84% and 15.08% respectively. This results suggests that ranking, which is based on quality score, is perhaps more important than having the quality score alone (Wilson and Wilson, 2014).

The effect of variables such as market size (number of coffees in the auction) and processing methods have significant impact on coffee prices. When the number of coffee in the market increases by one coffee, price decreases by 0.76%. Our results show that the effect of other processing methods (semi-washed, pulped natural, honey processing) is positive and highly significant (99% level).

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[7] The derivative of $ln(P_i)$ with respect to quality is $\frac{\partial \ln(P_i)}{\partial Quality_i} * \frac{1}{P_i} = 0.3096 + 2 * (-0.0153 * Quality)$.

[8] Since the dependent variable is logged, the percentage impact of a dummy variable *i* is calculated as $e^{(\beta_i - 0.5 * var(\beta_i))} - 1$, multiplied by 100% (Kennedy; 1981).

Altitude has a positive and highly significance effect on price, which suggests that coffee grown in high altitude are regarded as superior quality coffee by buyers. As in Wilson and Wilson (2014), our results show that tree variety has little effect on price. However, this study shows that organic certification is valued and compared to farms with no certification, being certified organic increases price by 14.9%.

Another attribute valued by buyers is the size of the lots which represents the quantity of coffee supplied by farmers. Buyers prefer small lot sizes and a 1% increases in lot size decreases price by 0.47%. Country of origin affects coffee prices as well. For example, coffees from Bolivia, Colombia, Costa Rica, El Salvador, Guatemala and Mexico have a higher purchase price compare to Brazil. Also, we notice that coffees from African countries (Burundi and Rwanda) are not different compare to Brazilian coffees.

The variables for year used as correction variables exhibit a positive and highly significant trend suggesting an increasing demand for CoE coffees due to their quality or perhaps popularity of specialty segment of the coffee industry. This result is in contrast to what was found in the grading equation and suggests that buyers are making decisions based on factors other than the coffee quality score alone. Origin of buyers has a little effect on coffee price since only estimate for Asian buyers is significant but negative. This means that compare to North American buyers, Asian buyers value less CoE coffees or since they are main buyers of CoE coffees they buy a wider range of coffees.

The biggest contribution and the most significant difference between this study and others is inclusion of material and physical attributes. In equation (3.4b) quality score is replaced by sensory characteristics. Results show that all aroma and flavor attributes have a positive impact on price except chemical and papery flavors. Spices (3.20%), sweets (3.75%), florals (3.23%), fruity (40.32%), and sour acid (6.02%) have positive and significant effects on coffee prices. As stated earlier, having a coffee balanced in flavors is rewarded by a 6.02% increases in price. Transparent and coffee with a smooth mouthfeel are also valued by buyers at a 3.35% and 5.09% price premium. The effect of aftertaste (lingering and long aftertaste) was negative but not significant, which probably means that buyers do not value those sensory attributes. This result might be due to the fact that most buyers do not taste the coffees before buying them and therefore do not put any value on those attributes. Surprisingly, we notice the significance of body types in the price equation. This result is surprising since body types were not significant in the quality score equations, suggesting that buyers and cuppers value differently specialty coffee attributes. Since many buyers of the CoE are roasters, body type is an important quality characteristic in their process.

Like in equation (3.4a), the reputation attributes have the same effect with tree variety having little effect, while altitude, lot size, number of coffee in the market, and rank were all significant with the same sign and magnitude. The country of origin effect was less pronounced but still present with four countries being highly significant. The variable for year was positive and significant except for year 2005. Regression with the inclusion of sensory variables shows all buyers-origin are significant. However, only buyers from Nordic countries and group of buyers were paying a high price compare to North American buyers.

The replacement of individual flavors by group of flavors shows that all flavor groups have a positive effect on price; however only PC 4 and 2 are statistically significant. Having a flavor profile corresponding to that of PC4 increases coffee price by 4.14%, while having a PC2 flavor profile increases price by 1.22%. The effect of the reputation variables is consistent with that of equation (3.4a) and (3.4b), which confirms the robustness of the analysis.

3.7 **Conclusion and Discussion**

The objectives of this study are three-fold: first, we intend to add to the existing literature on specialty coffees by estimating factors affecting coffee quality scores. The second objective is to determine the effects of material and physical attributes on coffee prices and the last objective is to provide coffee professionals with information that allow them to make accurate investment decisions. With this in mind, the question is then: what are the practical implications of our analysis?

The first implication of the study is that although specialty coffee quality scores should in theory be based on sensory variables only, reputation attributes such as altitude, certification, market size and country of origin play a major role on its determination as well. As an indicator of quality and primary requirement to enter the market, the relationship between quality and reputation suggests that one can improve the quality score by having a farm in high altitude, planting single tree variety such as pacamara and having a certification (Organic or Rainforest). The increase in quality score pays off in two ways: at least 18% increases in price for each additional point and from 15% to 133% increases in price for being ranked in the top four. Results of the price equation estimations show that buyers favored small quantities, pulped, semi-dry or honey processing methods and coffee tree varieties such as caturra and pacamara. These are some factors that farmers can take into account in order to make sounded investments and maximize their profits.

For the coffee industry, our analysis revealed buyers and therefore consumers' preferences for aromas and flavors. On the on hand, results show that fruity, florals, sweet and sour acid aromas and flavors are the ones favored. On the other hand, we see that chemical and papery flavors or aromas are disfavored. Also, the analysis reveals that buyers (consumers) like also balanced coffee. The recognition of these sensory attributes is important especially for buyers because it allows them to buy coffees that can have high retail values. Moreover and like in the wine industry, the analysis shows that buyers put more value on reputation attributes than material or physical attributes.

Table 3.1. Summary Statistics

Variable	N	Mean	Std. Dev.	Min.	Max.
Market Characteristics					
Price (2010 US$/pound)	2,123	7.4013	5.4311	1.2	80.2
Quality Score (84-100)	2,123	87.0883	2.0797	84	95.76
Lot size (70kg bags)	2,123	30.8208	14.7662	8	145
Number of coffees	2,123	27.4702	5.9887	10	42
Material Attributes					
Number of descriptors	2,123	14.3826	4.9197	2	28
Green vegetative flavor	2,123	0.1398	0.3469	0	1
Other flavor	2,123	0.0276	0.1638	0	1
Roasted flavor	2,123	0.2258	0.4182	0	1
Spices flavor	2,123	0.2424	0.4286	0	1
Nutty/Cocoa flavor	2,123	0.5671	0.4956	0	1
Sweet flavor	2,123	0.8476	0.3595	0	1
Floral flavor	2,123	0.5387	0.4986	0	1
Fruity flavor	2,123	0.9574	0.2019	0	1
Sour acid	2,123	0.5780	0.4940	0	1
Clean and clear cup	2,123	0.2128	0.4094	0	1
Balance cup	2,123	0.2396	0.4269	0	1
Transparent cup	2,123	0.0750	0.2634	0	1
Creamy body	2,123	0.3167	0.4650	0	1
Big body	2,123	0.1066	0.3087	0	1
Round body	2,123	0.1763	0.3812	0	1
Buttery mouthfeel	2,123	0.1743	0.3794	0	1
Smooth mouthfeel	2,123	0.2412	0.4279	0	1
Juicy mouthfeel	2,123	0.1759	0.3808	0	1
Lingering aftertaste	2,123	0.0677	0.2513	0	1
Long aftertaste	2,123	0.1459	0.3531	0	1
Reputation Attributes					
Wet processing	2,123	0.6559	0.3741	0	1
Dry processing	2,123	0.0624	0.2420	0	1
Other processing	2,123	0.2817	0.4499	0	1
Bourbon variety	2,123	0.2323	0.4224	0	1
Catuai variety	2,123	0.1184	0.3231	0	1
Caturra variety	2,123	0.1463	0.3535	0	1
Typica variety	2,123	0.0182	0.1338	0	1
Pacamara variety	2,123	0.0928	0.2902	0	1
Other variety	2,123	0.0799	0.2711	0	1
Mixed variety	2,123	0.2493	0.4327	0	1

Organic certified	2,123	0.0276	0.1638	0	1
Rainforest certified	2,123	0.0113	0.1060	0	1
Altitude	2,123	1502.6600	237.5356	600	2,300
Brazil	2,123	0.1305	0.3369	0	1
Bolivia	2,123	0.0474	0.2126	0	1
Colombia	2,123	0.0981	0.2975	0	1
Costa Rica	2,123	0.0880	0.2833	0	1
El Salvador	2,123	0.1427	0.3498	0	1
Guatemala	2,123	0.0985	0.2981	0	1
Honduras	2,123	0.1386	0.3456	0	1
Nicaragua	2,123	0.1269	0.3329	0	1
Mexico	2,123	0.0247	0.1553	0	1
Burundi	2,123	0.0340	0.1814	0	1
Rwanda	2,123	0.0705	0.2561	0	1
Buyers Origin					
Asian buyer	2,123	0.4816	0.4998	0	1
North American buyer	2,123	0.0863	0.341	0	1
European buyer	2,123	0.0576	0.2330	0	1
Nordic buyer	2,123	0.0786	0.2692	0	1
Other buyer	2,123	0.0089	0.0940	0	1
Group of buyer	2,123	0.2870	0.4524	0	1
Coffee PC Group					
PC 1	2,123	0.2732	0.4457	0	1
PC 2	2,123	0.1954	0.3966	0	1
PC 3	2,123	0.2023	0.4018	0	1
PC 4	2,123	0.1893	0.3918	0	1
PC 5	2,123	0.1384	0.3469	0	1

Source: Author based on CoE data 2004-2015

Table 3.2. Quality Score Equations Estimation

Variable	Estimate Equation 3.3a	Std. Err.	Estimate Equation 3.3b	Std. Err.
Green vegetative	0.7757***	(0.1815)	0.6916***	(0.1881)
Other flavor	-0.9366**	(0.4575)	-0.8849*	(0.4657)
Roasted	-0.4346***	(0.1628)	-0.3490**	(0.1702)
Spices	0.4832***	(0.1521)	0.5535***	(0.1588)
Cocoa/ Nutty	0.0722	(0.1358)	0.2486*	(0.1436)
Sweet	1.0162***	(0.2111)	1.0470***	(0.2211)
Floral	1.3401***	(0.1419)	1.3430***	(0.1457)
Fruity	3.3164***	(0.5373)	3.1910***	(0.5215)
Sour acid	0.8668***	(0.1401)	1.0763***	(0.1467)
Clean and clear	0.4175***	(0.1594)	0.5894***	(0.1603)
Balance cup	0.3563**	(0.1539)	0.3990**	(0.1554)
Transparent cup	0.6656***	(0.2352)	0.5695**	(0.2448)
Creamy body	0.1038	(0.1431)	0.1666	(0.1466)
Big body	0.1552	(0.2123)	0.0854	(0.2159)
Round body	0.0409	(0.1742)	0.2247	(0.1790)
Buttery mouthfl	0.3366***	(0.1707)	0.4217**	(0.1741)
Smooth mouthfl	0.5246***	(0.1534)	0.5447***	(0.1578)
Juicy mouthfl.	0.7535***	(0.1671)	0.7098***	(0.1748)
Lingering aftert.	0.2885	(0.2576)	0.3146	(0.2554)
Long aftert.	0.4037***	(0.1804)	0.3853**	(0.1832)
Dry processing			0.3050	(0.3264)
Other processing			0.2092	(0.2562)
Catuai			0.0931	(0.2904)
Caturra			-0.0836	(0.3073)
Typica			-0.0127	(0.5480)
Pacamara			1.2808***	(0.2906)
Other variety			0.3002	(0.3132)
Mixed variety			-0.1400	(0.2466)
Organic certif.			-0.0876	(0.4046)
Rainforest certif.			1.4938***	(0.6340)
Altitude			0.2907***	(0.0441)
Number coffee			-0.0288*	(0.0148)
Bolivia			-1.3564***	(0.5109)
Colombia			-1.4440***	(0.4454)
Costa Rica			-1.6886***	(0.4311)
El Salvador			-1.3276***	(0.4011)
Guatemala			-1.8498***	(0.4440)

Honduras			-1.7031***	(0.4197)
Nicaragua			-0.8001**	(0.3919)
Mexico			-1.0937*	(0.5781)
Burundi			-1.9906***	(0.5781)
Rwanda			-1.7353***	(0.5022)
Year 2005			-1.6320***	(0.4407)
Year 2006			-0.8723**	(0.4398)
Year 2007			-1.1875***	(0.4189)
Year 2008			-2.0486***	(0.4278)
Year 2009			-2.2413***	(0.4253)
Year 2010			-2.1644***	(0.4407)
Year 2011			-2.5143***	(0.4365)
Year 2012			-1.2506***	(0.4216)
Year 2013			-1.4088***	(0.4244)
Year 2014			-1.8526***	(0.4313)
Year 2015			-0.8217	(0.5031)
Sigma	2.5184***	(0.0647)	2.4075***	(0.0638)
Intercept	79.9904***	(0.6133)	78.8940***	(0.9368)
N	2,123		2,123	
Log Likelihood	-4,809		-4,077	
AIC	9,661		8,264	
BIC	9,789		8,576	

Source: Author based on CoE data 2004-2015

Table 3.3. Price Equations Estimation

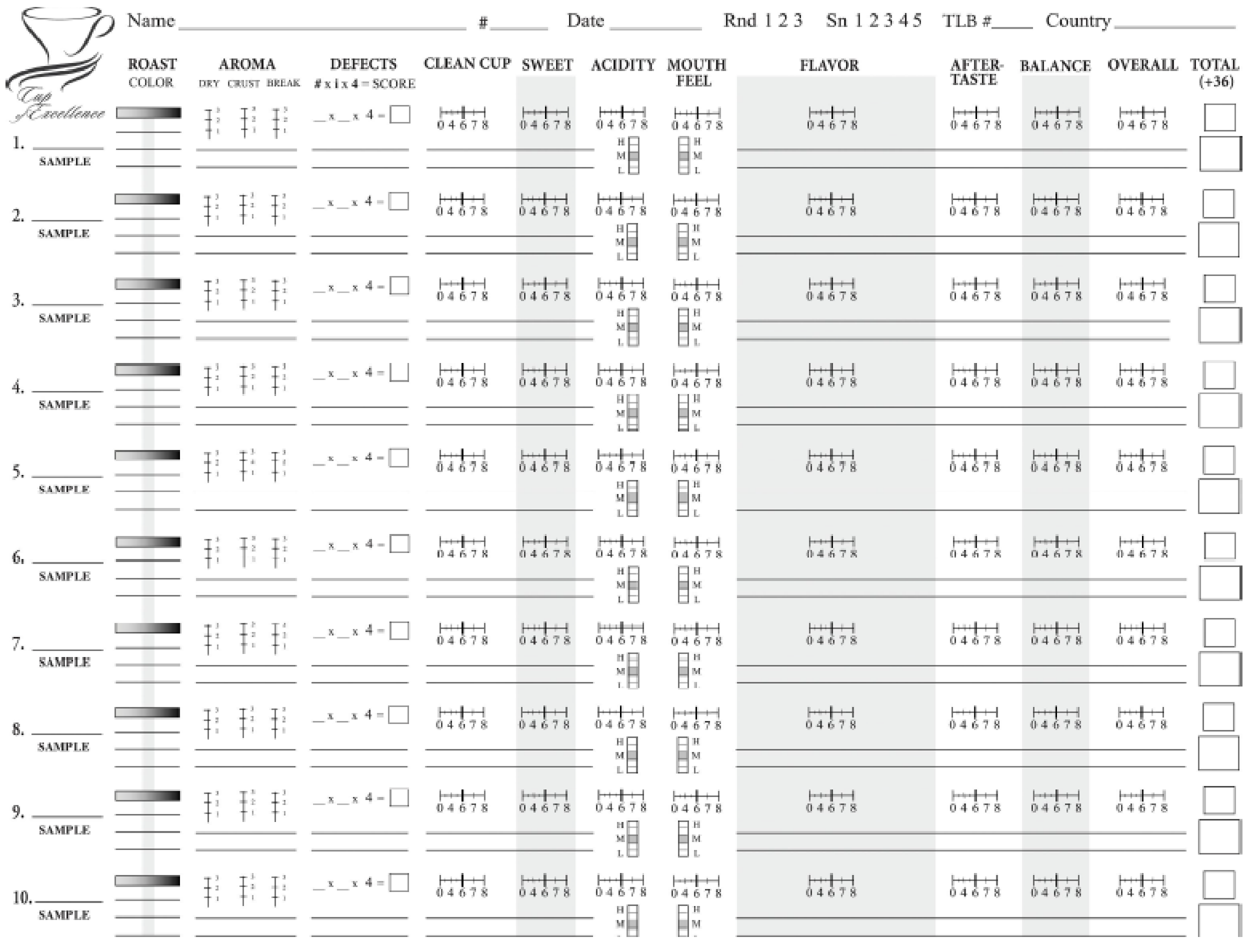
Variable	Estimate Eq. 3.4a	Std.Err.	Estimate Eq. 3.4b	Std.Err.	Estimate Eq. 3.4c	Std.Err.
Score	0.3092***	(0.0203)				
Score^2	-0.0153***	(0.0019)				
Descriptors	0.0074**	(0.0025)				
Group2					0.0664**	(0.0352)
Group3					0.0517	(0.0353)
Group4					0.0809***	(0.0353)
Group5					0.0555*	(0.0394)
Green vegetative			0.0294	(0.0305)		
Other flavor			-0.0306	(0.0752)		
Roasted			-0.0248	(0.0277)		
Spices			0.0593***	(0.0258)		
Cocoa/Nutty			0.0359	(0.0233)		
Sweet			0.1014***	(0.0343)		
Floral			0.0914***	(0.0235)		
Fruity			0.3592***	(0.0790)		
Sour acid			0.0599**	(0.0234)		
Clean and clear			0.0372	(0.0259)		
Balance			0.0570**	(0.0254)		
Transparent			0.0844**	(0.0403)		
Creamy body			0.0762***	(0.0237)		
Big body			0.0421	(0.0345)		
Round body			0.0661**	(0.0289)		
Butter mouthfl			0.0297	(0.0284)		
Smooth mouthfl			0.0572**	(0.0258)		
Juicy mouthfl			0.0423	(0.0287)		
Lingering aftert.			0.0089	(0.0427)		
Long aftert.			0.0121	(0.0303)		
Dry processing	0.0158	(0.0411)	0.0351	(0.0515)	0.0487	(0.0542)
Other processing	0.0971***	(0.0329)	0.1173***	(0.0418)	0.0865*	(0.0443)
Catuai	0.0239	(0.0385)	0.0085	(0.0484)	0.0009	(0.0513)
Caturra	0.1057***	(0.0392)	0.0906*	(0.0497)	0.0943*	(0.0525)
Typica	-0.1454*	(0.0757)	-0.1328	(0.0961)	-0.1259	(0.1026)
Pacamara	0.0744**	(0.0358)	0.1247***	(0.0448)	0.1433***	(0.0469)
Other variety	0.0512	(0.0411)	0.0330	(0.0519)	0.0239	(0.0551)
Mixed variety	-0.0105	(0.0318)	-0.0135	(0.0406)	-0.0168	(0.0431)
Organic certif.	0.1522***	(0.0480)	0.1457**	(0.0594)	0.1738***	(0.0628)

Rainforest certif.	-0.0960	(0.0877)	-0.0109	(0.1111)	-0.0196	(0.1164)
Altitude	0.0210***	(0.0056)	0.0319***	(0.0070)	0.0353***	(0.0074)
Number coffee	-0.0076***	(0.0019)	-0.0047*	(0.0025)	-0.0052**	(0.0026)
Ln (lot size)	-0.4724***	(0.0306)	-0.5630***	(0.0393)	-0.5857***	(0.0417)
First place	0.8666***	(0.0494)	1.4712***	(0.0451)	1.5353***	(0.0477)
Second place	0.3860***	(0.0425)	0.9166***	(0.0468)	1.0172***	(0.0495)
Third place	0.2563***	(0.0391)	0.7432***	(0.0458)	0.8267***	(0.0483)
Fourth place	0.1591***	(0.0376)	0.6263***	(0.0452)	0.6811***	(0.0480)
Bolivia	0.1960***	(0.0666)	0.0942	(0.0833)	0.1118	(0.0882)
Colombia	0.1779***	(0.0587)	0.1220	(0.0744)	0.0850	(0.0793)
Costa Rica	0.0965*	(0.0560)	0.0087	(0.0710)	-0.0195	(0.0755)
El Salvador	0.2254***	(0.0524)	0.1678**	(0.0660)	0.1409**	(0.0701)
Guatemala	0.3650***	(0.0588)	0.2522***	(0.0748)	0.2066***	(0.0794)
Honduras	0.0206	(0.0550)	0.0662	(0.0701)	-0.0904	(0.0737)
Nicaragua	0.0761	(0.0525)	0.0152	(0.0669)	0.0112	(0.0711)
Mexico	0.1881**	(0.0739)	0.1258	(0.0928)	0.0781	(0.0983)
Burundi	-0.0440	(0.0764)	-0.1679*	(0.0981)	-0.1965*	(0.1037)
Rwanda	-0.0518	(0.0669)	-0.1613*	(0.0854)	-0.2233**	(0.0906)
Year 2005	0.0629	(0.0544)	0.0804	(0.0685)	0.0319	(0.0708)
Year 2006	0.1462***	(0.0538)	0.0455	(0.0681)	0.1229*	(0.0705)
Year 2007	0.2737***	(0.0523)	0.1443**	(0.0670)	0.2467***	(0.0692)
Year 2008	0.4970***	(0.0500)	0.3108***	(0.0632)	0.4346***	(0.0646)
Year 2009	0.7165***	(0.0529)	0.5837***	(0.0667)	0.7025***	(0.0687)
Year 2010	0.9739***	(0.0608)	0.8402***	(0.0780)	1.0080***	(0.0804)
Year 2011	0.8772***	(0.0572)	0.7068***	(0.0725)	0.8663***	(0.0748)
Year 2012	0.7393***	(0.0589)	0.7012***	(0.0749)	0.8401***	(0.0777)
Year 2013	0.8863***	(0.0562)	0.7996***	(0.0717)	0.9645***	(0.0736)
Year 2014	0.7297***	(0.0556)	0.5928***	(0.0720)	0.7710***	(0.0728)
Year 2015	0.7059***	(0.0684)	0.6739***	(0.0876)	0.7814***	(0.0905)
Asian buyer	-0.0932***	(0.0331)	-0.0995***	(0.0414)	-0.1368***	(0.0437)
European buyer	-0.0637	(0.0491)	-0.1298**	(0.0625)	-0.1334**	(0.0661)
Nordic buyer	0.0374	(0.0417)	0.1217**	(0.0522)	0.1089**	(0.0553)
Other buyer	-0.1078	(0.1318)	-0.4189**	(0.1777)	-0.4981***	(0.1920)
Group of buyer	0.0302	(0.0337)	0.0728*	(0.0419)	0.0646	(0.0443)
Sigma	0.2847***	(0.0066)	0.3393***	(0.0088)	0.3551***	(0.0095)
Intercept	1.2940***	(0.1366)	1.6838***	(0.1796)	2.2164***	(0.1704)
N	2,123		2,123		2,123	
Log Likelihood	951.321		650.3		593.593	

AIC	-1,809	-1,171	-1,089
BIC	-1,543	-802.663	-811.82

Source: Author based on CoE data 2004-2015

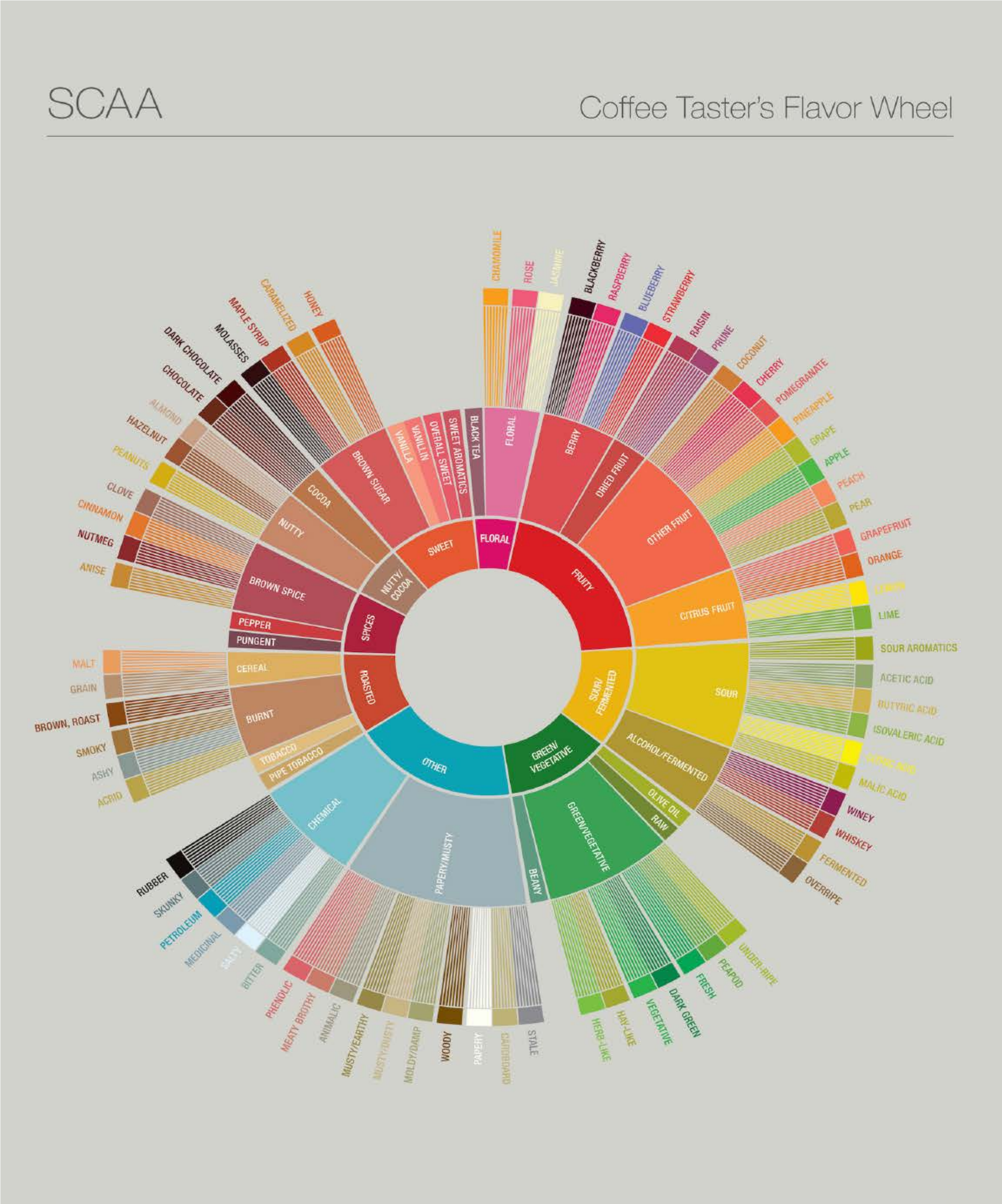
Appendix 3.1. Cup of Excellence cupping form



Name ______ # ______ Date ______ Rnd 1 2 3 Sn 1 2 3 4 5 TLB # ____ Country ______

	ROAST COLOR	AROMA DRY CRUST BREAK	DEFECTS # x i x 4 = SCORE	CLEAN CUP	SWEET	ACIDITY	MOUTH FEEL	FLAVOR	AFTER-TASTE	BALANCE	OVERALL	TOTAL (+36)
1. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
2. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
3. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
4. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
5. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
6. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
7. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
8. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
9. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M L	0 4 6 7 8 H M L	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	
10. ______ SAMPLE			__ x __ x 4 =	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8 H M	0 4 6 7 8 H M	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	0 4 6 7 8	

Appendix 3.2. SCAA Coffee Taster's Flavor Wheel.



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