Two-Sided Uncertainty in a Sequential Auction

A Model of Farmer-Intermediary Coffee Trade in Rural Guatemala

Final Draft

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Abstract

This paper develops a model of trade between intermediaries and farmers in which there are three important sources of uncertainty: (1) the seller cannot accurately assess quality, (2) the buyer cannot accurately assess quality (3) coffee quality is only weakly increasing in inputs. This matches the coffee trade between farmers and intermediaries observed in the western highlands of Guatemala. The model suggests that the key to improving the profit margins of farmers is to increase the accuracy of assessment of their coffee and enable them to wait longer to sell. Meanwhile, the clearest path to improving quality is to educate intermediaries on quality appraisal. To confirm the model of quality appraisals used in the paper, I then examine quality ratings paired with descriptions. Hedonic pricing regressions suggest that attributes of the coffee capture around half of quality variation while only one fifth of price variation. I argue that this is an indication of early instability in the specialty coffee market.

Introduction

It is a common complaint within the coffee community that the producers are not paid fairly for their work. Indeed, growing coffee is backbreaking work nearly year round. In most locations farmers pick cherries by hand one-by-one, a process that is so intensive that producing countries often have school breaks during the harvesting months to allow children to help their families pick the coffee. Despite all of this work, a coffee farmer makes on average only 12% of the sale price in groceries or only 3% of the cost of a cup of coffee sold in a shop (Fischer, 2014). Ignoring many complexities in the question of fair labor rates, it seems to be a small percentage given that their labor is by far the largest input into any coffee that is consumed.[1]

Coffee is not the unique target of these complaints though; sweatshops for clothing and technology manufacturing draw similar criticisms for exploitation of labor. What is unique to the coffee market is the response that has taken place. The consumer response to sweatshops was to refuse to buy their goods in favor of US made clothing. Clearly, this is not possible for coffee as it can only be grown in Southern countries. The natural response then has to be a way of verifying that the coffee was traded at a "fair price," and so entered Fair Trade certification.

Fair Trade is one idea of how to ease the poverty of farmers by establishing a price floor on coffee and then labeling coffee that has been bought this way. The issue with fair trade is that it is expensive to be certified and is thus only practical for larger producers – either individuals or co-operatives. Moreover, Fair Trade represents only 3% of total coffee trade, so it clearly is not a large-scale solution. Disintermediation then came along as another tool to combat low prices and specialty coffee purveyors began branding "direct trade." This is unique to specialty coffee though and once again it is only profitable for large producers or co-operatives as farm visits, DHL-shipped samples, and phone calls are expensive. These two methods have trapped together the idea between profitability and high quality coffee though. When specialty coffee is bought and traded, it often commands above market rates because the buyers are consuming not only the coffee but also the feeling of having made a morally conscionable choice. What is also clear though, is that the higher prices are eluding small producers, as only large producers can take advantage of these new tools.

What then for the small producer? This is the fundamental question the remainder of the paper will address: is there a way, without upending the entire system of trade, in which a small producer can begin to take advantage of the market gains associated with the increased concern with quality?

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[1] Consider that the four points of direct transformation in coffee are the growing, milling, roasting and brewing. Growing is a year-round activity, milling is often performed by the farmer and takes a few days, roasting takes twenty minutes, and brewing takes five minutes.

Roadmap

The next section will begin to detail that system of trade and the status quo. The paper will then move to present a model that captures the key interaction between the small producer and the intermediary. It will then explore the important levers of change in outcome for the farmers. The paper will finish by recommending how to implement a system that would take advantage of the lessons learned. There will then be an extension addressing the relevance and accuracy of the definition and modeling of quality within the coffee market.

Methodology

There are two elements of research that underpin the observations reported. This paper is not intended to report all of the findings of this research but will frequently reference interviews to justify decisions in the model.

Field Work

In June and July 2014, I, along with another student, conducted individual interviews with members all along the specialty coffee supply-chain to understand its structure in Guatemala. We worked, in some cases with a translator, to interview roughly 20 small producers, 10 medium producers, two large producers, three coyotes (local intermediaries), three exporters and six roasters (based in the US). The interviews ranged from 15 minutes to three hours depending on time constraints and the loquaciousness of the subjects. The interviews were guided by a set of questions, though we quickly broke from the script to delve into subjects that the subjects found most interesting. The goal of the interviews was to understand the barriers small producers face in accessing the specialty coffee market, understanding perceptions of quality and information asymmetry along the chain.

We picked subjects based on their availability. We chose from a list of contact information of Cup of Excellence winners from our contacts at the National Association of Coffee Growers (Anacafe.) We hypothesized that small producers surrounding these farms were likely to be producing coffee of a similar quality level. We progressed through supply chains as much as was possible by asking each interviewee for more contacts. An important shortcoming is that we were only able to meet with three coyotes and none of them was the same coyotes that are buying from the small producers that we were able to talk to in the western highlands. Intermediaries vary dramatically in intention and so the competitiveness of these coyotes will be hard to assess[2].

[2] The closest we came to one of the famed coyotes was with an owner of a taqueria who had a series of three rapid-fire emergencies, which prevented us from talking to him. This led us to believe that he was either lying to avoid talking to us; or he was telling the truth in which case his life lived up to every expectation we had about a coyotes day to day life. In either case, it does suggest distinctive set of characters.

In Spring 2015, towards the end of the harvest, we returned to collect coffee samples for the purpose of comparing quality. We bought samples of parchment coffee from 12 smallholding producers in Huehuetenango, on the same mountain in which interviews were held in the summer. We also collected samples from neighboring producers who were producing Cup of Excellence quality coffee. We evaluated the samples for the quality of their parchment, and had them cupped by Anacafe following SCAA 2003 protocol.

Survey

During June 2014, a large-scale survey of smallholding producers throughout Guatemala was also undertaken. Teams of Guatemalan field researchers from University del Valle went out with local Field Technicians from Anacafe. They conducted a long interview following a questionnaire designed by Ted Fischer and Bart Victor. The teams conducted a well-randomized survey that covered 333 farmers distributed in all coffee growing regions. Their survey is loosely categorized in economic anthropology and the results will be used in a forthcoming paper and book covering how the producers interact with the global market to tie into their aspirations for a better future. This survey was preceded by a small-scale non-randomized survey that can be read about in Fischer and Victor (2014).

Background on Coffee

Coffee is of extreme importance throughout the world and represents the seventh most widely traded agricultural export in the world. Coffee plants are productive around four years after planting. There are two main types of coffee: Robusta and Arabica; Robusta is the lower quality type and it used mainly for instant coffees. Beneath this large distinction, there are many different varietals of coffee each with different flavor profiles and often-different growing requirements and associated productivity.

Coffee is perennial and is harvested yearly (in most countries) in the form of coffee cherries. The beans are picked and then processed for the first time to remove the cherry. This can happen in several ways, but in Latin America it is mostly done through wet milling. Wet processing works to remove the flesh from the bean by fermenting it in water and running it through machines that agitate the bean to separate the skin. After removing the mucus membrane it is dried and then it is called “parchment coffee” and the weight will have reduced by about eight times. This parchment coffee is then sold until it eventually reaches the exporter who takes care of dry processing- the step to remove the parchment and leave “green coffee.” Dry processing also separates the coffee into different quality levels by removing damaged beans and, depending on the technical capacity, may sort based on color. The exporter then sells to the consuming country where it is roasted and then sold to coffee shops or grocery stores.

The rest of this section will discuss the history and current status of coffee pricing, then the current supply chain structure, the status of growers, and will finish by summarizing the salient characteristics of the coffee market for the purpose of this study.

A Brief History of Coffee Trade

In recent history, the bulk of coffee trade has been conducted through the C-price (the futures contract on New York Commodity Exchange which is a contract for a container of quality, washed Arabica green beans delivered to a licensed warehouse in the US or Europe). In this way, coffee has traditionally been a commodity crop in which quality played little role. This meant that the farmers' goal was simply to produce acceptable coffee at the cheapest price possible. Over time, this adjusted to include price differentials to compensate for quality. This differential however was assessed only by country of origin. For instance, the 2013 price of Brazilian coffee is discounted by 9 cents per pound, meaning it is worse than the average coffee while Columbian coffee receives a 10-14 point premium (Thurston 2013; Fischer and Victor 2014). Currently the coffee market is going through a transition, which is allowing quality to take the forefront and creating independence from the C price. This trend towards favoring specialty coffee has pushed some producers to increase the capital devoted to production to produce a higher quality of coffee that is then sourced by smaller exporters or roasters.

Today, the highest quality of coffee is often sold at auctions, such as the Cup of Excellence. These coffees command very high prices. One farmer we spoke to has created an online auction at which he sold an eight-pound lot to Korean buyers for $500 per pound. Meanwhile, the current C price in March 2015 is $1.42 a pound (which itself has fallen from around $2.20/pound fall of last year.) Coffee prices fluctuate so wildly because coffee is a boom-bust crop; it takes around four years for coffee plants to become productive from the time that they are first planted. Consequently, when coffee prices go up, farmers tend to convert land to coffee production. After four years, when the plants are productive, there is a sudden surge in supply that drops prices and causes many to switch production away from coffee. It is important to note though that coffee plants can be left unattended for one or two years with low upkeep costs and then returned to full productivity easily. Moreover, it is susceptible to several diseases and drought, which causes occasional shortages.

The market supply chain is complex; the general path that coffee flows is from the farmer to a cooperative or coyote. At this point in the process the coffee is then usually aggregated which can destroy its value, since single origin coffee receives higher prices. The coffee is then sold to a major exporter, then to an importer who sells it to a roaster before it is finally sold to coffee shops or groceries. The numerous middlemen each take a substantial cut for their services. (Gilbert, 2006)

The Current System

In terms of the individual farmers' organization, the bulk of coffee producers work on their own or with their family (Valkila, 2009). Indeed, there are over 50,000 producers of coffee in Guatemala; most with plots under five hectares (Fischer and Victor, 2014). The producers tend to be relatively poor. A study of producers in Nicaragua, Mexico and Guatemala showed that 67% of producers had experienced between three and eight months of extreme food scarcity each year (Beuchelt and Zeller, 2011) indicating the severity of the issue of low wages for the farmers. One contributing factor to the low prices received by farmers is that the producers are largely market blind. They have very little information about the consumers they are selling to or the conditions of demand around the world. This gives them no bargaining power as they essentially receive a take-it-or-leave-it offer (Thurston, 2013). The difficulty of transportation causes them to not have the ability to shop around for different prices and the bulk of farmers sell the coffee cherries unprocessed. This means that they only have a few days between the time that they are picked and they need to be sold. Additionally, most cooperatives looking to sell the fully processed beans are only able to sell to a few exporters, as there is an oligopoly over major coffee exports (Tedeschi and Carlson, 2013). In Guatemala, around 30 exporters sell 85% of the coffee[3]. One may wonder why farmers or cooperatives have not yet invested in capabilities to change the conditions and take charge of more steps in the value chain. They are generally unable to do this because of a lack of a developed credit market. Rates are either too high, or come with conditions that are deemed unsuitable (Thurston, 2013). This corners producers into a system of which they have no control in the market.

Indeed, Ponte (2002) examined how the deregulation (with the lapse of the International Coffee Agreement (ICA)) affected the value chain of coffee. He finds that the deregulation of the coffee industry shifted market control into the hands of the exporters and supermarkets. This has caused the value added in the consuming countries to increase dramatically while the price paid to growers and the value added in producing countries have both dropped substantially.

A last important characteristic of the coffee market is that is grown only in specific regions. Coffee is grown only in regions that are generally considered to be part of the global South. Meanwhile the consumer market is nearly global, though the recent shifts to high quality "specialty" coffee are concentrated mainly in wealthy countries (specifically the US, Australia, Scandinavia, South Korea and Japan).

In summary then, we can look at the coffee market as having a four main special characteristics: asymmetric information, an undeveloped credit market, an oligopoly of exporters and production that can only take place in a subset of countries. The main

[3] Moreover, the exporters operate under a powerful union: http://www.adecgt.com

change seems to be a switch to a market producing higher quality, more specific coffee in which farmers engage in monopolistic competition.

The Three Uncertainties of Quality

To answer the question of how to allow farmers to retain more value, I am primarily interested in the seemingly most attainable steps of achieving change: dissemination of information that is already existent. It is worth noting up front that one large vein along which farmers are uninformed is in respect to their understanding of the market. This means they cannot shop around and cannot skip intermediaries as a step. Indeed, in our large survey from the summer, 70% of farmers selling to coyotes claimed to have little to no understanding of the market. This is undoubtedly a source of information asymmetry that could have big impacts but it is outside the scope of this paper to address it. Though I will refer to quality as a clear concept in the main body of the paper, the extension on defining quality supports its importance as a general concept but not its supremacy as a perfect indicator of price.

Farmer's Knowledge of Quality

The first important variable is a farmer's understanding of his or her own coffee quality. With the market's shift from strict commodity grading to a differentiated product, farmers are now expected to know more about coffee than before. For them to sell their coffee properly they need to be able to evaluate coffee quality in order to appraise its value, whether for the sake of negotiating or for knowing when to accept an offer and when to reject it. A first obvious problem is that, of farmers selling to coyotes, only 21% claimed to know the C-price (and this portion were not quizzed on this claim.) Given that so few knew the price of commodity grade coffee, we should be skeptical that they know the difference in their own quality.

The difficulty in assessment is two-fold. First, the correct way to measure coffee quality involves wet milling, dry milling, sample roasting and cupping the coffee. Clearly, no farmer is able to do all of these steps on his or her own. That said, it would be possible to get a weaker sense of the quality just by drinking coffee with a less precise method of roasting, brewing and tasting which could be done on a farm. It will not be precise but will improve upon the current system. The second issue though is defining quality in the first place. The Specialty Coffee Association of America (SCAA) precisely defines quality, but cupping at that level requires Q-certification, which, from our interviews, could take five years to become professional. Once again, this is unrealistic. What is realistic is some way of tasting successful coffees and generally giving farmers a better understanding of what the market values. All of this seems possible to allow farmers to better estimate their own quality.

Coyote's Knowledge of Quality

Coyotes face a similar predicament except they have perhaps a slightly harder task but are also better at it. It is harder because farmers know their effort level, which provides some signal, but the coyote comes in blind. They buy the coffee unprocessed so cupping is still out of the question. Instead, they judge quality by color and humidity, which most farmers believe to be important to their assessment and price offer. Indeed 72% of farmers said that fruit quality was important to coyotes. Coyotes, however, will ultimately turn around and sell to an exporter (or a larger coyote) who will almost certainly cup the coffee to remove any confusion on quality and then pay based on this final rating. For this reason, they will pay based on quality, as higher quality will certainly net them higher prices at resale.

Though I am certainly not a trained coyote, I, along with two other amateurs, attempted to rate the quality of the parchment based on the coyotes' specification of a "clean, white parchment." The relationship between our ratings and the cupping score was non-existent. Even though there are clear differences in the appearance of parchment, it is not clear that it relates well to quality from our small experiment.

The Relationship between Inputs and Quality

A last major problem is that it is unclear how to produce great quality. Moreover, those that may know would be unlikely to share their knowledge with competitors while public institutions are mostly interested in solving the rust problem[4] and have placed quality as secondary to yield. This means that, as it stands, farmers each have their own techniques and have little clue how to increase quality. They all recognize high variability from year to year even with the same techniques. This would imply that it may be weather related but generally it seems likely that new varietals or techniques can and will be bred to reduce this variability. Indeed, the largest of quality farmers seem to maintain consistency through a high level of attention implying that it is possible to devote enough resources to be confident of the quality of coffee.

In our sample of 12 farmers coffee (all from a 5km radius of one another) we find that the average cupping score was 69, with a standard deviation of 21 points. The results did not seem to be normally distributed with some scoring around 85, some around 75 and a few below 50. There was no clear relationship between a producer's processing technique or size and their cupping score.

[4] Coffee Rust is a fungal infection of plants, which has been spreading throughout coffee producing countries. It renders plants inactive for the year and will often invade a farmers' entire crop.

Literature Review

Due to the specificity of the topic, there are few similar papers from which to build so the review will instead shape the main ideas piece-wise. It will first cover information asymmetry in bargaining, then current thoughts on upgrading the share of income for small-producers in the value chain for coffee and finally look at hedonic pricing of wine. Finally, an important section that reviews the conditions of small farmers was covered expansively in the earlier "Background on Coffee" section.

The classical beginning point to information asymmetry is Akerlof (1970) in the discussion of the market for lemons in automobiles. In this case, there is uncertainty on the buyer's side that eventually collapses the market for high quality used cars. He finishes by discussing the need for uninterested institutions to fix the lack of trust and re-engage the market. Stiglitz (1975) discusses the economic implications of adding in screening to the system. Screening allows businesses to differentiate quality of goods into different levels, but is costly to institute. Looking at productivity of workers in the labor market, Stiglitz shows that instituting screening will benefit the high skill workers and harm the low-skill workers. With redistribution, however, it represents a potential pareto improvement. Depending on the cost of screening, however, there exist equilibria in which no screening is better for all parties. This suggests that we should consider if it is even worthwhile for coyotes to screen or if paying an average quality price would be beneficial. Samuelson (1984) takes on bargaining under asymmetric information. They demonstrate that when the buyer is relatively more uninformed than a seller, then a "first and final offer" is the most desirable bargaining situation. Interestingly, this is exactly the model used in the coffee trade though the seller is modeled to be relatively less informed. Metzger (1988) deals with the imposition of minimum quality standards. The finding is that one can consider minimum quality standards to be important if an only if they raise the quantity of the good supplied. This is because with underproduction of quality, expectation of quality is lower than desirable which discourages quality production. It is hard to imagine how a quality floor could be added, but we can think of distinctions in the altitude as a first effort at approximating quality distinctions. These papers highlight that some current market features are already explained by information asymmetry. The structure of offers, the choice of some coyotes to make consistent offers, and the division of coffee on an observable grade are all market adjustments expected in the case of information asymmetry.

Turning now to the current prescriptions for bettering the condition of small farmers, it is important to note that most of these papers are neither entirely empirical nor model-based. Generally they consist of case studies of specific interventions or theoretical, common-sense driven explanations of impacts. Fromm and Dubon (2006) look at the opportunities created by the de-commodification of coffee. Their definition of small producer leaves the mean production at 32,500 pounds of coffee a year (an order of

magnitude bigger than the farmers this paper will tend to consider small). Surveying the relationship between total sales and different investments they find that investment in R&D, contracts, length of investment, trust, the availability of information, and functional upgrading all improve the amount of coffee sold. The only insignificant factors are process upgrading and investment in marketing. They also note that the biggest investments have been made in post harvest humidity management. It is worth noting that the utility of these results is open to question as production size is a bizarre outcome variable because it is fundamentally regressing investment on the wealth of the farmers. Fritter and Kaplinsky (2001) study the effect of which part in the value chain is gaining from the increased differentiation of coffee. They note that though the variance of export prices has increased over recent history, the variance of farmer prices seems steady or perhaps slightly decreasing. Moreover, the share of money kept by farms has remained constant while the post-farm value added has dropped and been absorbed by the consuming countries. They attribute this to the weak, fragmented power in producing countries as compared to the importing side, where the importers, roaster and retailers each have strong, oligopolistic power. Pietribelli (2006) covers the spectrum of upgrading in global value chains. He emphasizes of the importance of clustering to the success of farmers and identifies the following conditions as key to strong clustering: (1) Trust (2) Leader firms (3) Knowledge intermediaries (4) Solutions to collective action problems (CAP). We can see that Guatemala is disadvantaged partly by these: (1) There is a large, albeit justified, lack of trust. (2) The problem with having leaders in the market is that it is segmented by size and prior research has suggested that the leader firms may not end up helping smaller farmers as they react to fundamentally different incentive systems. Thus even though leader firms are making progress that is transferable, small farmers cannot currently capture the value of this upgrading. (3) Anacafe is the only organization that may be qualified as a "knowledge intermediary" but it does not disseminate the information efficiently to small producers[5]. (4) There is so little collective action among independent farmers that the idea of CAPs does not necessarily make sense. Thus, coffee farming in Guatemala is not conducive to clustering, though it may be important for success in development.

Rosen (1974) lays out a conceptual explanation of hedonic pricing. He claims that "a class of differentiated products is completely described by a vector of objectively measured characteristics." (34) He notes that the method does fail to distinguish between demand-driven and supply-driven price differences, which are impossible to disentangle. The general model also assumes divisibility in production, meaning that any characteristic can be added independently. This is unlikely to be the case in coffee or many agricultural goods, so we should expect most price differentials are demand-

[5] We received one of Anacafe's guides to coffee growing. It reported that it was part of a 1,000 copy run. There are over 50,000 producers in Guatemala and we are not farmers.

driven. Studies have been undertaken in many markets for housing or labor but the most relevant papers deal with wine. One exception to this is Wilson and Wilson's (2014) study of price and quality within the coffee market. They look at data from the Cup of Excellence and examine the effect of rating and ranking on prices. They find that having a high ranking in a country is the best for a higher price. Though this paper looks at quality and prices within coffee it fails to look into component ratings and sensory observation and only deals with the very highest end of specialty coffee present in the top 20 farms in each country, which is a unique and difficult to generalize market. This paper will most heavily draw from Combric, Lecocq and Visser (1997) analysis of hedonic pricing and quality ratings as it relates to the market for Bordeaux wine. Wine and coffee share many similarities, especially as it relates to dissolved-solid content and the importance of provenance to wine ratings. They look at easily observable characteristics like region and variety as well as sensory characteristics like "finish" and "flatness." Using a stepwise procedure to select important regressors, they find an R-square value of 66% of price variation explained by their selected factors. Similarly they find 66% for the assigned jury grade. They find that most sensory characteristics are unimportant to consumers, which explains their absence in the pricing regression but not the grading regression. This paper differs importantly in that it tackles coffee instead of wine, but also takes a different look at sensory characteristics. Whereas they limit regressors to what are considered component ratings in coffee rating (dry fragrance, wet aroma, etc), I extend the set out further to specific identifier words that are closer to the fringes of objectivity.

The Model

The model has F farmers and C total coyotes. Each producer chooses to use labor in accordance to their best-expected outcome, which is simulated in their mind. All farmers are homogenous and so they each make the same decisions when presented the same options. Each simulation in their mind is conducted as follows:

(1) The farmer picks a labor level and produces the resulting quality
(2) The farmer forms a perception about the quality
(3) Intermediaries then come one by one making an offer based on discounting their assessment of the quality by an amount they expect to maximize their profit
(4) The producer accepts if this offer is higher than they expect any other offer to be

They will simulate this a large number of times for each labor choice and then choose to produce with the labor that yielded the highest average profit level. As all farmers are homogenous they make the same choices, but will have different outcomes based on the variation added in the production, assessment and negotiation portions.

1. Production

We assume that the level of production is constant and each farmer produces one unit of coffee each year. This is reasonable as farmers have set plots of land and though productivity of plants can vary, most farmers have similar yields. Moreover producing more coffee would happen through increasing inputs, which would raise the price in this model through the quality channel. We also assume that there is only one input (L) that is used. In reality, there are several inputs including fertilizers, saplings, fungicides or pesticides. Labor is also used very intensively throughout the year, in both applying various chemicals, planting and pruning coffee shrubs and shade trees and trimming the weeds. I model all of these inputs as one because they are each explanations of increased quality and are substitutable to some extent to that end. Moreover, since the marginal effect of these different inputs on quality is not well understood, any differentiation in the model would be manufactured, so we will only consider one input. It is then assumed that the quality of the coffee is generally weakly correlated with the amount of input L. Quality is also assessed at a 0-100 point scale. I model quality as:

$$q = 100 * \frac{L - c}{L} + \varepsilon$$

where c is an arbitrary constant (set to 50 to allow for greater variation in optimal input choice.) As we have said that $q \in [0, 100] \rightarrow L > c$. ε is an error term modeled as

$$\varepsilon \sim N(0, \frac{100 - \hat{q}}{k})$$

where $\hat{q}$ is the quality level before the shock, and k is a constant ($k > 0$) that will be increased to represent a better understanding of the relationship between inputs and quality.

Important Features

(1) This is asymptotic at 100. (If q > 100 we will cap it to 100 and below 0 we will set it to 0.) This reflects the true quality scale used by cuppers.

(2) This choice of error means that variance is a decreasing function of L. This is likely accurate as greater certainty comes with more effort since we can observe consistently successful farmers that devote huge resources to experimentation and careful monitoring of quality.

2. Pricing

The pricing function must obey three important features of the market:

1. *Price must always be increasing in quality*
2. *The majority of the action must take place in a small region of the upper range of scoring*. In real coffee, anything above 80 is considered specialty, but just about every coffee that is cupped is rated above 60 and below 95. This means a coffee rated at 50 probably would not sell.
3. *Quality and price are non-linear*. The key idea is that if a coyote mixes 80 and 60. The average quality may become 70 but the price is not half way P(70) ≠P(80) + P(60) in the action range. [6]

With these constraints in mind, price is represented as:

$$P(q) = \begin{cases} \dfrac{800}{1 + 100 * e^{-.08q}} & if\ q > 50 \\ 0 & otherwise \end{cases}$$

To visualize this:

[6] It is also important that, at some point the graph becomes concave and has an upper bound as otherwise the results will become unstable.

3. Players' Knowledge

Producers

Now that the quality is set, the producer will look at the quality and evaluate it. Their evaluation is not perfect though and will consist of:

$$q_f = q + \varepsilon_f$$

where $\varepsilon_f \sim N(b, a_f)$ with b, $a_f \geq 0$

In this case, b is the producer bias. Our interviewing indicated most farmers view their quality to be above average, which would suggest they are apt to overstate their quality in negotiation. a_f is the farmer's knowledge level. We should note that in this case a high value is low knowledge as it represents the variance of their judgment. The farmers' low awareness of their quality level is clear as they generally will speak only on the color of the cherry, which can only reliably distinguish between mistake level coffee and commodity level or higher.

Coyotes

Similarly, the quality assessment of coyotes is given by:

$$q_{c_i} = q + \varepsilon_{c_i}$$

where $\varepsilon_{c_i} \sim N(0, a_{c_i})$ with $a_{c_i} \geq 0$, i is an index of each coyote

$$a_{c_i} \sim N(a_c, 1)$$

All ideas are the same as for farmers except they have no bias in their actual assessment of the quality. In addition, since there are multiple coyotes involved, we will let their individual knowledge levels vary slightly to allow for slight heterogeneity. This will also allow us to see whether coyotes are better or worse off depending on their estimation of quality. This is also realistic as no farmer has any training but some coyotes are smarter than others from experience at seeing thousands of different coffees.

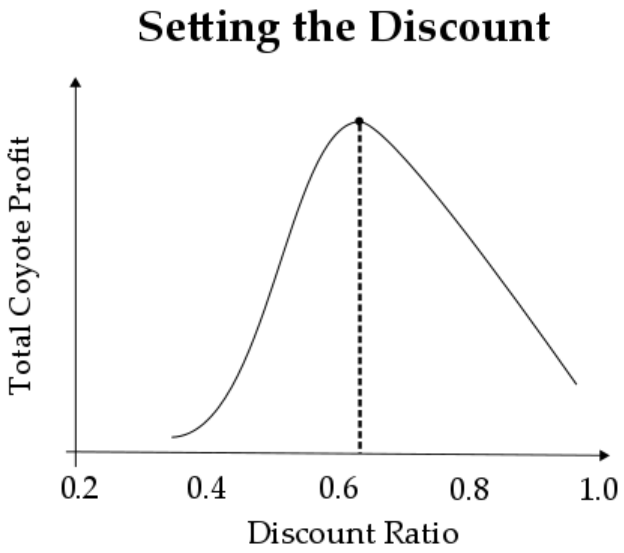
Farmers' Choice

Farmers choose what quality to aim to produce based on maximizing their expectation of profit, which is given by:

$$\max_{L \epsilon \mathbf{N}} \left(\boldsymbol{E}(P(q(L))) - w \cdot L \right)$$

4. Coyote Discount and Number of Visit Setting

Before coyotes choose what offers to make they must decide what percentage of the true value they are willing to offer. Clearly there is a tradeoff: if they choose to offer a very low price then they will almost never win, but when they do, they will make huge profits. If they set a high price, they will win more frequently but will make smaller profits each time. So to choose what to offer they imagine an even distribution of coyotes with each pricing strategy and see which one is most profitable. They then set their discount to that level. This will obviously depend though on the number of coyotes that are expected to visit the farm, which creates a feedback loop as they set their preference with a fixed number of visits. The model therefore burns in over five iterations as the best discount is set for the number of visits which then sets a new best discount. In most cases, it becomes reasonably stable after just a few runs. To visualize the decision that the coyotes must make we can see:



We can see that in this example they would choose to set their discount to marginally above .6. However this choice will feed back into the expected profitability, which will in turn incentivize a change in the number of visitors and change the optimal decision. Therefore, we will need to perform several iterations.

The number of visits that a coyotes will make depends on their expectation of profits from a single sale, the cost of visiting a farm and what they would like their average profit of a visit to be. Written out more formally:

$$V = \max\left\{v \in \mathbf{N} \middle| \frac{E(\pi)}{v} - c > D\right\}$$

where V is the number of visits, E(π) is the expectation of profits from a successful purchase, c is the cost of the visit and D is the coyote's desired average profit from a visit. The logic here is that they will expect to win about once every V visits since they all have similar strategies.

D is not zero though because the qualifying factor of being a coyote is owning a truck. There are alternatives out there that may be profitable and so entry occurs at a possibly non-zero value.

Winner's Curse

It is worth noting that the winner's curse is present in this arrangement. Their expected profit is assuming they are equally likely to win every plot on which they bid. In reality, they are most likely to win when they overestimate the quality. They would never know that before a given purchase though. Moreover, we will expect them to be profitable (above 0) even with the winner's curse, so we will ignore it.

Are Coyotes Competitive?

Notice that the model described suggests that coyotes are competitive despite some large barrier to entry. It seem that the idea of a cartel of coyotes is possible given the market's relationship to drug trafficking. This question was difficult to unearth. Generally, the sentiment of farmers in the western highlands was that coyotes were not bad people. The coyotes I did talk to, who were in much less remote areas, suggested that they felt like they were very competitive with other coyotes and had to always offer higher prices to win. For this reason, I think the assumption that they behave generally competitively barring the entry cost being high is reasonable. This means they can make non-zero profits but that they will all be similarly profitable and their profit level is constrained by the possibility of new entrants.

5. Negotiation

V coyotes will visit the farm one by one and make an offer. The farmer knows that there will be V visits in total in the year. The coyote offers:

$$p_{c_i} = d * P\left(q_{c_i}\right)$$

where d is the discount they apply which was set above.

Coyotes will only visit farms with coffee so as soon as they do sell the coffee, no more coyotes visit and waste resources.

6. Accepting

A farmer knows to expect V visits in a year, which is simply informed by their previous experience. Their only other information is their quality perception and a sense of their own poor judgment from past experiences. They thus accept offers when an offer represents a greater value than their expectation for the highest remaining offer. Meaning they would sell if:

$$p_{c_j} > E(\max\left(_{i=j+1}^{V}\{p_{c_i}\}\right))$$

Note that we take the maximum of an empty set to be zero, so the farmer must sell on the last offer.

As farmers are not aware of the coyote's error levels, they must rely on their own; thus, they expect that:

$E\left(\max\left(_{i=j}^{V}\{p_{c_i}\}\right)\right) = \mathrm{E}(\max\left(_{i=j}^{V}\{P(q_i)\}\right))$ where $q_i \sim N(q+b, a_f)$ (the same distribution as their assessment of their own coffee)

We also add in that farmers are risk averse and have a very short time preference. They will look to sell their coffee quickly and so there is a premium given to both time and certainty which will be jointly captured as r which will be a non-negative constant, meaning that their final decision making dynamic is given by

$$p_{c_j} + r > \mathrm{E}(\max\left(_{i=j}^{V}\{P(q_i)\}\right)$$

They then sell the coffee and we keep track of each coyote's purchases as well as the number of visits. Coyotes will mix coffee and so their average quality gives the price per sample that they receive. This is because in our sample of coffee, the result of mixing coffees of different quality was a cup score in between the two component coffees (though it also signaled the presence of defects.)

Model Implications

Establishing Base Levels

The survey does not contain price information and nowhere near enough relevant variables to try to estimate variables for this model. It remains entirely hypothetical though the next section shows that it can replicate the price dispersion observed in our interviews. We are not interested in proving that this model is the best explanation as

that would simply not be possible. We are most interested instead in predictions this model would imply from changing model parameters. There is a substantial amount of interaction between each variable so we must worry about picking static levels for variables that are close enough to reality to mean that the extrapolations based on modifying individual variables, one-by-one, are economically significant. Here is a table that summarizes all the variables we will manipulate along with their name in the above model and the base level from which we will manipulate them.

Table 1: Variables and Base Levels

Variable	Name in Model	Base Level	Notes
Farmer Knowledge	a_f	10	Variance on Estimate of Quality
Coyote Knowledge	a_c	5	Variance on Estimate of Quality
Collective Farming Knowledge	k	3	Factor dividing the variance of quality given a level of inputs
Desired Profit	D	10	Amount of profit desired per farm visit
Cost of Visit	c	10	Cost to visit a farm and make an offer
Risk/Time Premium	r	10	Discount accepted for a present offer over expectation of future offer
Producer Bias	b	2	Points of quality they believe their coffee is above average
Cost of Inputs	w	2	Wage rate of extra input

What Explains the Current State of the Market?

One interesting question is first whether this vision of the market is accurate. We have only two variables with which to try to pin down the number of inputs. With this information, it will be impossible to establish baseline values for the variables. We can however check that this is a realistic version of the market by imagining that two of the variables drop to zero simultaneously. This will allow us to see the level of confusion that would be necessary to cause the current market dispersion if we imagine that only one group is currently driving the variation.

We can look at a sample of 11 farmers all producing similar amounts and living within a 20-minute walk of each other, we can see that the average of the previous year was 795 and the year before was 940. We can expect this will vary with the C-Price (the international price). More importantly the standard deviation in offers to farmers was 138 in year one and in year two 224. We can consider the average of 181.

We must also consider how the variation we observe compares to the C-Price variance. We find that in 2012 the weekly standard deviation of the C-Price was 20% of

the price whereas it was only 4% during the harvesting season where the farmers we spoke to were located. We should expect that part of that variation transfers to the farmers but that there is a lag and they are shielded from it in some respects.

Meanwhile the observed standard deviation as a percentage of mean was 17% for the most recent year and 24% for the year before. The differences in prices that they quoted suggest they sold early in the season in January, this suggests that they did not spread out the selling too much. Moreover, as they all work in the same region and at the same altitude, they almost certainly sold their coffee at similar times.

When we eliminate all three of the uncertainties of the market in the model, we find that the price dispersion is still 14%. Allowing the relationship between quality to vary changes it to 23% (which is the same level as when everything is free). Meanwhile liberating coyotes to make mistakes pushes it to 20% while letting only farmers' judgment vary drops it to only 14%.

This suggests that it is not simply that farmers cannot assess the quality of their goods but it also suggests there is a surprising level of natural variation in the model outside of the normal shocks applied to judgment. These originate largely through setting the number of coyote visits and discount rate and likely reflect a real source of variation in the market as imperfect knowledge causes too many visits in some areas and too few in others.

Effects of Changing Parameters

We have established the base levels in the section above. This section will deal with moving a single variable along a series of reasonable values to estimate the impact of that change on each key variable in the model: coffee quality, farmer profit, coyote profit, total profits per sale, and variance of farmer profit. The bottom right graph will also give the discount factor that was in force for the run as this is a huge cause for variation in all outcome variables and the mechanism for estimating it is imperfect so it is worth seeing how variation in its determination will affect other variables. The section will end with a discussion of the source of this large variation.

This section will only explicitly address changes in the three levels of uncertainty. Appendix A contains the graphs of results of varying the levels of the five other variables contained in Table 1. The results of those changes are largely intuitive and will be discussed in the concluding section.

Note that all the graphs have the same scale to give a sense of the strength of trends. This makes some sense, but it is worth considering that we expect different variables to have varying degrees of impact so a weak trend may yet be important.

1. Coyote Knowledge

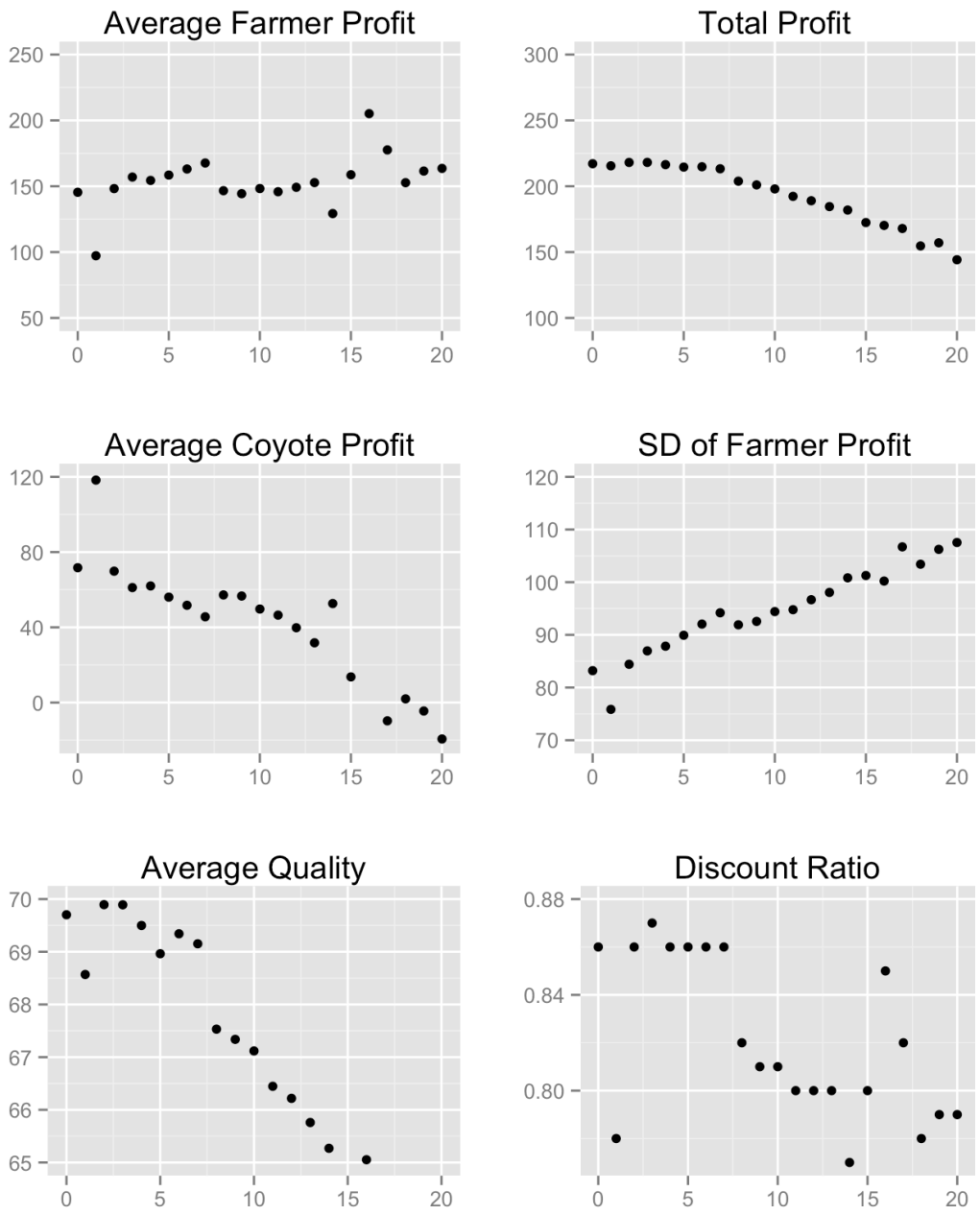
These graphs highlight that as coyote knowledge decreases: quality decreases, coyotes make less money per sale, farmers make marginally more per sale resulting in a

total effect of less profit per sale due to the decrease in quality. Farmers choose lower average quality production because there is a very good chance that the coyote will overestimate the quality dramatically and so quality is not as important since it simply changes the base at which they start estimating. For this reason, there really is decreased incentive to invest more in quality, as the quality signal is lost in the noise.

Clearly, a second effect is that the income of the farmer becomes highly variable. The increase in variance for farmers is very significant. It is worth keeping in mind that welfare is generally decreasing in risk meaning that increased variance should be considered a bad outcome for farmers The higher variance comes directly from the higher variance in offers received.

An important lesson from this set of runs, which will reappear, is that this is not always a zero-sum game in which either the farmer or the coyote are guaranteed to take in the same amount of money. In this case, it changes quality incentives but another mechanism is wasted resources in visiting farms.

Coyote Knowledge



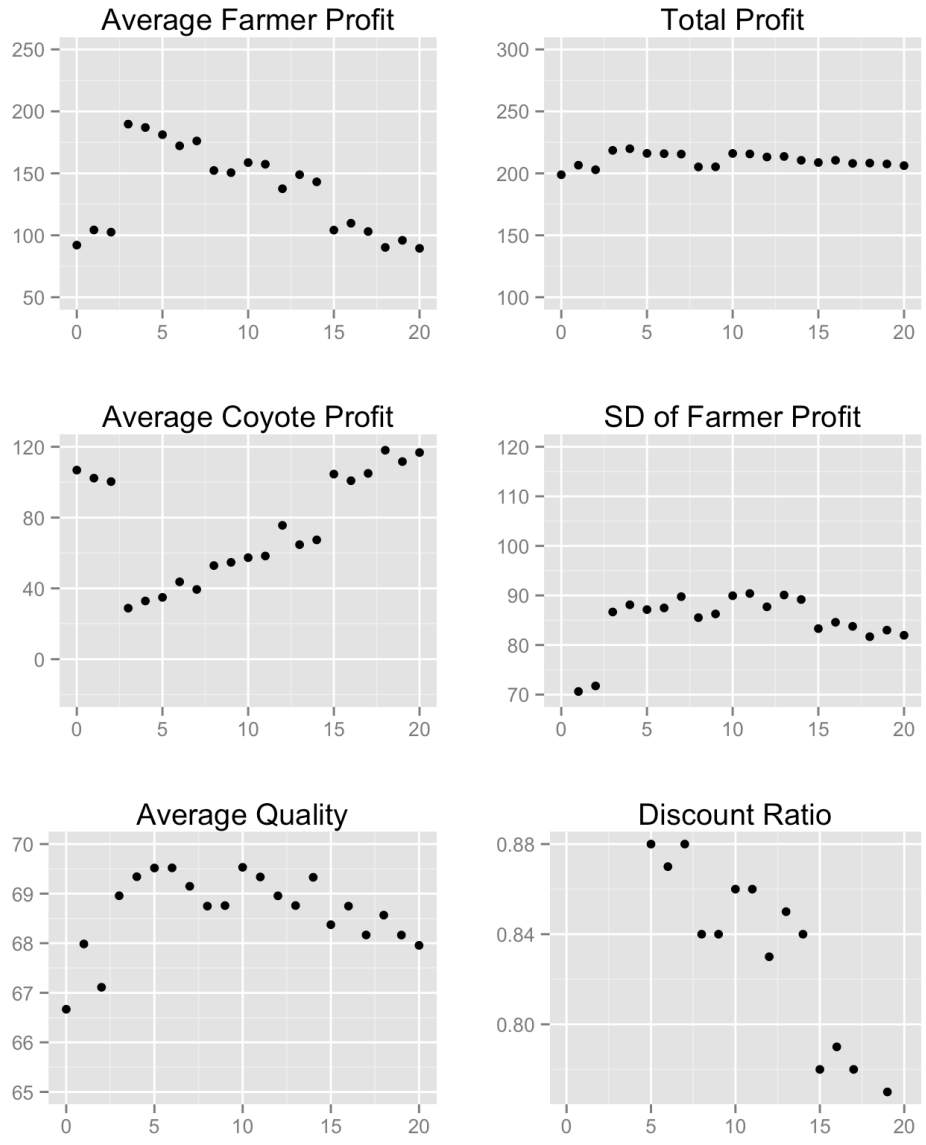
Note: Zero represents perfect knowledge while 20 would mean nearly no ability to distinguish quality ratings.

2. Farmer Knowledge

The next question naturally is what is the response to farmers becoming better informed in the quality of coffee. This increases their profitability dramatically as they are much less likely to accept a bad offer or hold out for an offer that will never come because of dramatic overestimation. In this case, it seems to be a zero-sum game in which their benefit comes directly at the cost of coyotes who become less profitable the better informed the farmers become. The change in profitability operates through adjustments in the discount rate as coyotes realize that the farmers are likely to be dramatically inaccurate in their estimation and either accept low offers or reject high offers.

The first three data points are on a different trend because the discount ratio is unsolvable at this level as it becomes cyclic where such a high natural discount level incentivizes some coyotes to offer very low prices which may be more profitable. With such a great margin, more coyotes enter and thus bid up the discount. This is a cycle that has no natural solution within the model. Intuition indicates that it is likely that the discount would stay high though to avoid the introduction of competition.

Farmer Knowledge



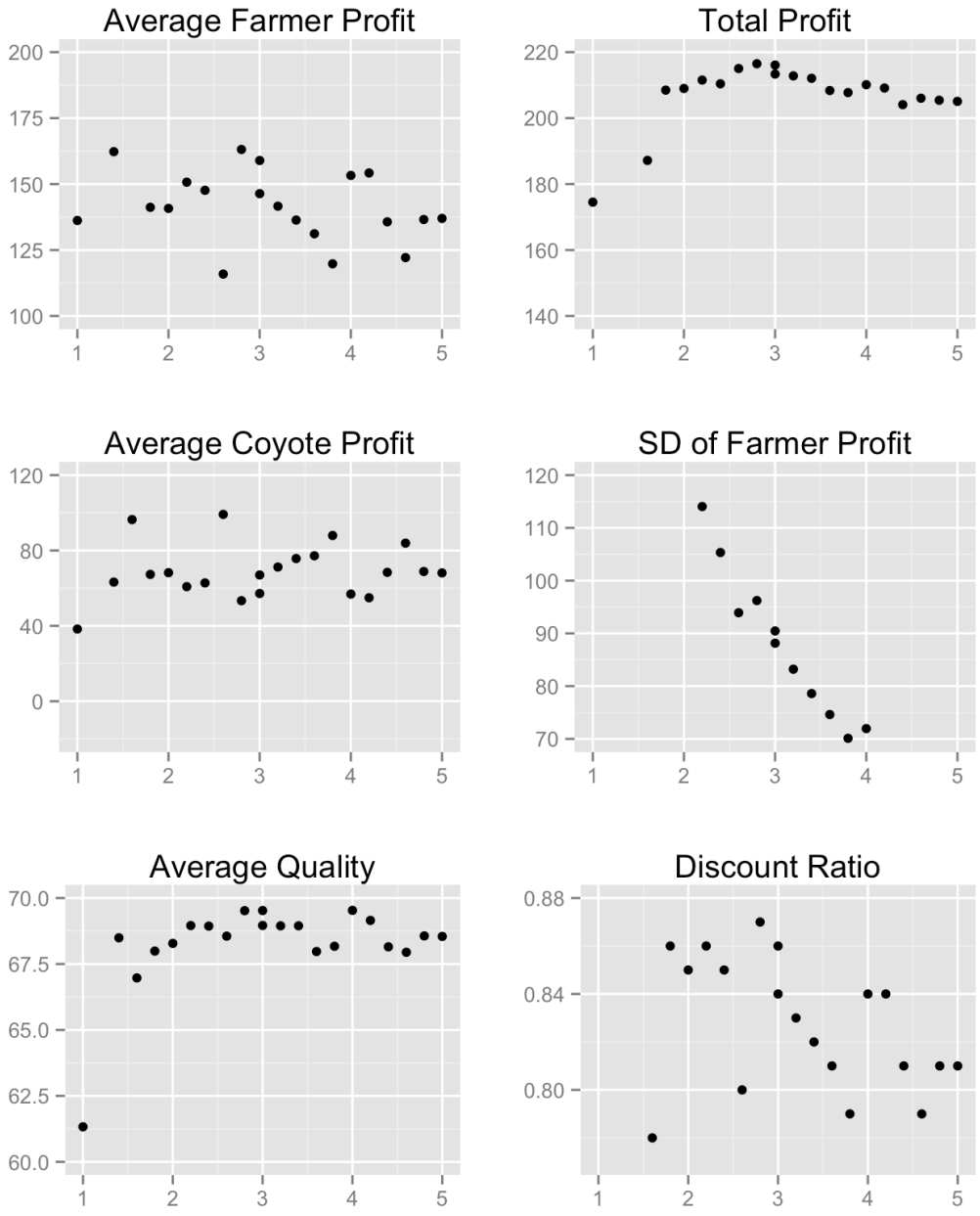
Note: Zero represents perfect knowledge while 20 would mean nearly no ability to distinguish quality ratings.

3. Collective Farming Knowledge

These results indicate that better farming knowledge will not have a large impact on average profitability or distribution of the profit but will, understandably, decrease the variance of farmer profit. This is, however, an important component of farmer welfare as price volatility is a huge issue for farmers. Notice that the relationship between collective farmer knowledge and farmer profit variance is an inverse relation because of its implementation in the model as a divisor of variation, which means that

there are higher changes at small values early on. The discount ratio is currently unstable under two as the optimal strategy may not be solvable at that level, as described before. This suggests that there are large gains to achieving at least a minimal grasp on the relationship to have strategic stability, which is important for quality choices.

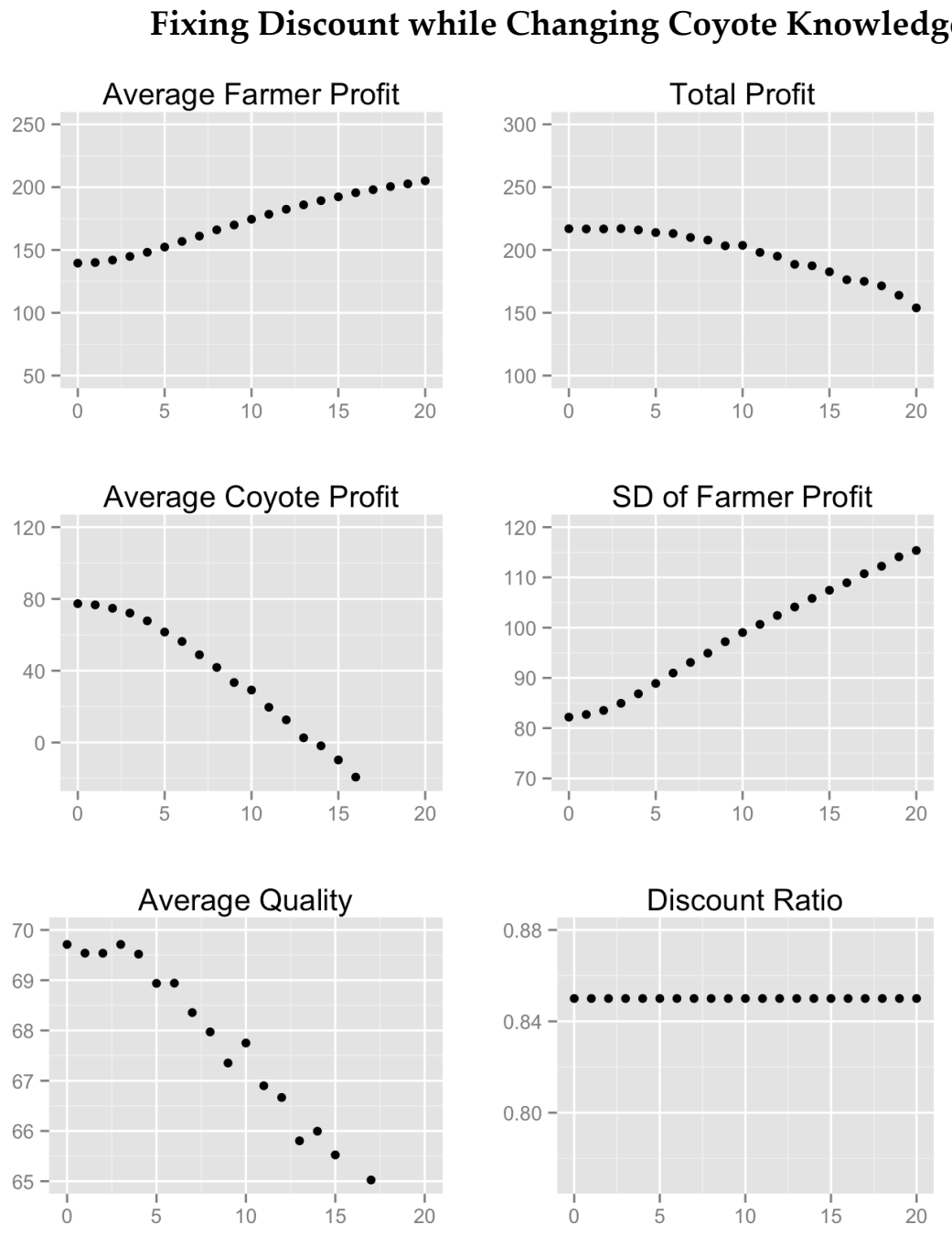
Strength of Relationship between Inputs and Quality



Note: As this is a divisor of variance, a larger value implies more certainty in the relationship between quality.

A Thought on Discount Factors

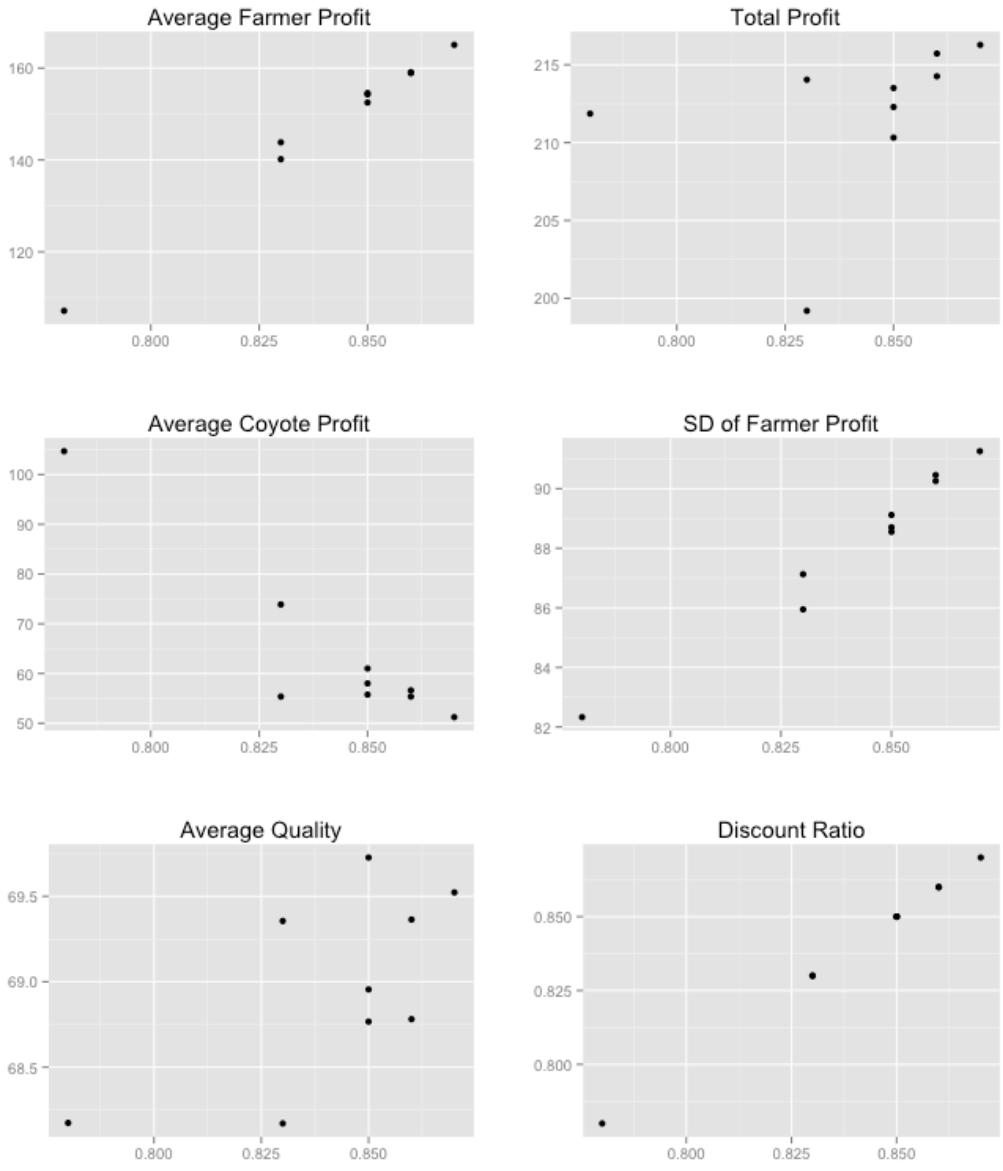
First, it is worth showing that the variability from trends in the graphs is largely due to the estimation of discount factors. To show that, here is a run looking at coyote knowledge where I have fixed the discount factor to .85 for each run:



Clearly, everything except for the average quality looks to be defined by some fixed relationship. However, this fails to take into consideration that coyotes discount to be profit maximizing and so changes in the choices of farmers will change their discount. Without accounting for this, we can see that coyote's become unprofitable very quickly which is an unrealistic outcome. This causes the noise in the graphs though. In all cases, changes in discounts serve mainly to dampen or exacerbate the impact of changes and not to change the direction.

This graph shows what happens when burning in for different starting values. This is a cause of some variation in the data but it seems relatively small in scale. This shows some expected results of what a different discount factor will cause. Average farmer profits go up while coyote profits go down but it does not seem to effect total profit. This graph also displays some other noise in the model, as with identical discount factors, further variation can still exist.

Effect of Different Discount Ratio with Other Parameters Constant



Policy Implications

Farmers

This model has some straightforward suggestions on the best way for farmers to be more profitable with the current system still in place. The model suggests that arming producers with information is the best way to give them better outcomes while educating coyotes may hurt the farmers' bottom lines. Indeed, it suggests that while

maintaining the uncertainty present in the market, the best outcome for negotiation is for a farmer to accurately estimate the value of his or her own coffee and trade with no risk aversion or bias. The risk aversion and time preference error are solvable with better access to credit to bridge the gaps for money which would allow for farmers to make more money by waiting for better offers. Better credit is often a suggestion for improving the farmers' condition, but this is a different mechanism for its effectiveness than is generally assumed; usually the discussion would focus on their ability to invest in resources to improve quality. In this paper, however, we have assumed farmers have enough money to choose any level of inputs they want. For this reason, the benefit is actually in being able to wait for better offers.

A second way to help farmers would be to change the variability of their outcomes each year. Indeed many farmers are confused and frustrated that despite producing coffee identically every year they receive different prices. A large part of this is variance in the C-price, but the uncertainties of quality play a large role as well. The model suggests that the way to guarantee prices that are more consistent is simple: narrow any source of uncertainty. This means that educating farmers or coyotes will both have a large impact in reducing the variability of their incomes. The biggest change will come from improving the knowledge of the relationship between inputs and outputs. The government should look to study this topic and distribute findings to small farmers.

Taken together, this suggests that instead of potentially market-distorting fair trade prices, businesses and NGOs looking to ensure higher quality of living for all farmers should offer training to farmers on recognition of quality, offer credit or savings accounts, or study and distribute findings for making quality more predictable. One may object that this means that in the long run, more people will switch to farming to erode profits – but the amount of land that produces this quality of coffee is all already being harvested and so farmers have monopoly like conditions which would actually allow them to continuously earn economic profits.

Roasters

If the goal of the specialty market is to incentivize higher quality, then they may find a way to do this without continuously offering higher prices. The solution they would push for though would be different and opposing than the strategies suggested above for farmers. They should push to educate coyotes to recognize high quality coffee perfectly. Giving offers only based on quality is good business for the coyotes and ensures that the coffee making it back will be of the highest quality as all farmers are striving to produce high quality coffee. Most other routes will not have dramatic impact on quality though the remedy suggested for farmers of improving their knowledge would have a marginally positive effect as well. Anacafe and other national coffee

associations would be wise to promote this as well because quality premiums are currently assessed at a national level.

Conclusion

This paper has first looked to summarize the conditions of coffee trade in Guatemala. It then built a model to simulate coffee trade built on two sided information gaps as neither the seller nor the buyer know true product quality. It has then looked to estimate the impact of changes in knowledge levels on quality. The estimation conveys an underlying tension in which roasters should be most interested in training coyotes though this is likely to harm the farmer's bottom line. Meanwhile farmers are best served by learning to evaluate their coffee well and then trading based on an accurate assessment. This suggests that producers' organizations, like Anacafe, should invest heavily into quality recognition training in addition to agricultural research examining determinants of coffee quality.

Limitations

It must be noted that some farmers do not believe that quality premiums exist in the first place. This paper assumes that they are already being paid as if they exist and they are generally conscious of this. If that is not true then this paper is not meaningful until they are instituted and farmers behave under this expectation. Instead, this model may have a different explanation embedded. It may be that the larger expected variance that the paper predicts and the winner's curse have caused coyotes to shy away from heavy premiums and instead offer a premium based on general region to avoid uncertainty.

Excusing this assumption, the remaining limitations deal with a lack of a data set against which to test the model's accuracy. I have attempted to verify the general principals and concepts of values in interviews and other data sets but this model is founded on many assumptions and lacks rigor.

Recommendations for future studies

Many additional opportunities for study exist within the coffee market, which has many unique and interesting characteristics. Many surveys can be run to better understand the relationship between perceptions of quality and profitability. Running games with the farmers that test their negotiating techniques as well as their understanding of quality and comparing this to the price that they receive would be a particularly interesting study. Essentially, it would look to understand if the market causes specific tastes in coffee to flow from the consuming country to the producing country, as farmers that do well must have similar tastes.

On another note, the coffee market's "de-commodification" is a unique aspect, which may soon replicate in other agricultural markets. Understanding the path it has taken, the causes for the change, and the implications for market structure would be complementary to the work in this paper.

Extension:

What it Quality?

At this point, a key question of the discussed solutions is what does quality really entail. I have referred to it in this paper as a clear concept that is well understood by at least some players in the market; but since it is such an important concept, it merits closer investigation. Indeed, in order to think about how to explain it to farmers, we would need to first understand what it means and if it is a stable concept over time.

Moreover, for the model above to be accurate, we must show that quality is a fuzzy concept – even for experts. Thus by looking at attributes' relationship to coffee, we can verify whether quality is an easily captured phenomenon and look at the variance of quality ratings within the specialty market. This section will address the variability in quality perception to suggest that the above model's view of quality as very fuzzy is an accurate notion.

A Rigorous Description of Quality

To answer this question, I have scraped two websites that offer coffee reviews. The first is CoffeeReviews.com; it offers reviews of already roasted coffee from many different roasters. I was able to compile 3731 reviews from this site. The quality I am referring to in my paper though is obviously different from their quality though as this is already roasted coffee whereas I refer to green coffee. For this reason, I also scraped reviews from SweetMarias.com, which is a retailer of green coffee. From this source, I have 1970 observations. They provide description of coffee as well as proper SCAA-form cupping score. Both of these sites have archived reviews starting roughly around 2000, which gives a significant history to investigate in the space of specialty coffee.

The key feature I will make most use of is each dataset's point rating and description. They do, however, include the producing country, the year of recording, a component rating and suggested or actual roast level. The primary goal was to see if, by looking at descriptors of the coffee, one could predict its rating. It seems that this was moderately possible, with an ability to account for around 50% of the variation in ratings on both sites.

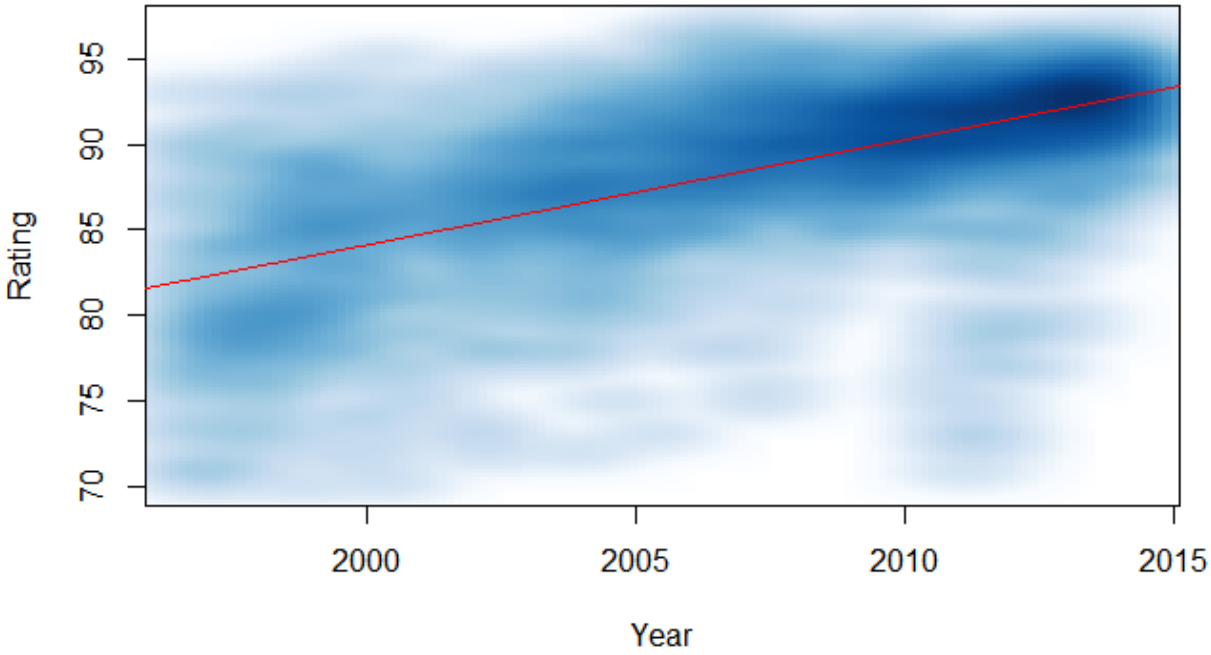
As a first step to understanding this phenomenon, we can look to see if a set of common descriptor words affects the score. To achieve this, I selected the most frequently used words (all stemmed at six characters) that described some feature of coffee. I generated word counts and then eliminated common words (eg. "and") and words that do not relate to a specific descriptor of coffee (eg. "grow", "taste", "special"). The list is given here:

Common Descriptive Words

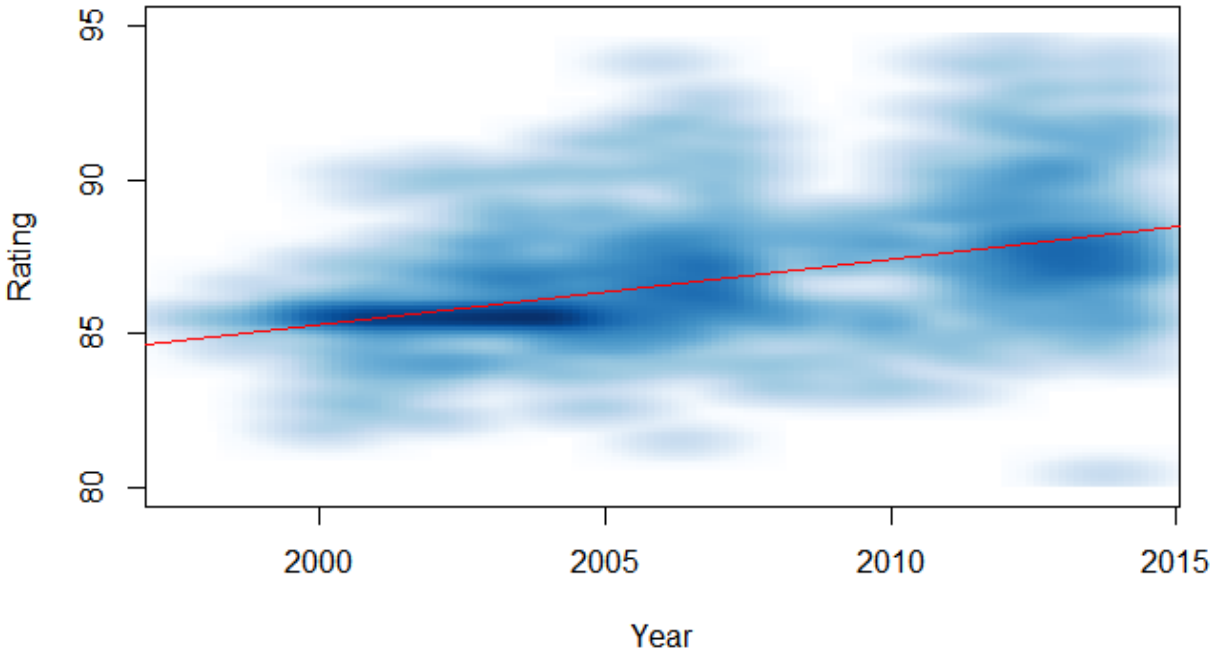
Stemmed Word	Total Instances	Stemmed Word	Total Instances	Stemmed Word	Total Instances	Stemmed Word	Total Instances
fruit	3819	**syrupy**	1005	**wood**	439	**spicy**	244
chocol	3775	**cherry**	963	**berry**	431	**grape**	240
espres	2461	**honey**	914	**raisin**	421	**grapef**	232
bright	2285	**orange**	752	**apple**	418	**wine**	217
organi	2259	**crisp**	700	**aprico**	373	**blackb**	214
floral	1969	**cocoa**	682	**vanill**	346	**walnut**	205
variet	1714	**nut**	675	**peach**	332	**tobacc**	197
pungen	1480	**tart**	615	**molass**	297	**hazeln**	173
citrus	1126	**silky**	609	**cinnam**	292	**bluebe**	169
bitter	1108	**spice**	534	**exotic**	269	**passio**	169
carame	1074	**cedar**	511	**curran**	257	**banana**	158
dried	1005	**lemon**	496	**herbal**	252	**brandy**	156

Both CoffeeReviews and SweetMaria's have tended to give higher ratings over time (which can be seen below). I will assume for the sake of this exercise that this is not because the average coffee has gotten any better and thus the changing mean will be controlled for and then ignored.

CoffeeReviews- Ratings Over Time



SweetMaria's- Ratings Over Time



With this trend controlled for, we can turn to what factors lead to better scores. This is an interesting question as it can give an idea of whether there are tangible

characteristics in the coffee that are sought after. The model used is a simple OLS regression following:

$$q = \alpha + \varepsilon \cdot t + \beta\vec{x} + \mu$$

where q is the score assigned, α is an intercept estimate, t is the year of production and $\vec{x}$ is a vector of 1's and 0's representing whether each of the listed 48 descriptors is mentioned in a review, and μ is the error term.

After a first run of the model, all factors not significant at 10% are deleted and the model is rerun, at that point, any descriptor insignificant at 5% is discarded so that any remaining descriptor is necessarily significant at 5%. The estimate for year is omitted in the table but included in the R-squared estimate.

Explaining Sweet Maria's Ratings

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
passionfruit	1.66	0.22	7.6	6.68E-14	***
currant	1.12	0.17	6.6	6.98E-11	***
grapefruit	0.89	0.23	3.9	1.21E-04	***
citrus	0.79	0.10	7.9	5.21E-15	***
peach	0.76	0.12	6.3	3.55E-10	***
exotic	0.65	0.17	3.8	1.35E-04	***
berry	0.55	0.09	6.3	4.55E-10	***
floral	0.49	0.08	5.9	3.64E-09	***
grape	0.47	0.13	3.5	4.08E-04	***
lemon	0.47	0.14	3.4	6.46E-04	***
honey	0.46	0.10	4.7	3.20E-06	***
wine	0.33	0.11	3.0	2.41E-03	**
cherry	0.32	0.09	3.5	4.44E-04	***
espresso	-0.31	0.09	-3.6	2.85E-04	***
nut	-0.31	0.08	-3.8	1.64E-04	***
spice	0.20	0.08	2.5	0.01	*

*Note: Estimates are interpreted as the average quality-rating premium associated with being described by the word. They are sorted by magnitude. Significance is assigned where *** is less than 0.001, ** is less than 0.01 and * is less than 0.05.*

Adjusted R-Squared = 52%

Explaining CoffeeReviews' Ratings

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
herbal	-2.13	0.92	-2.29	0.02	*
currant	1.37	0.28	4.76	1.9E-06	***
wine	1.35	0.23	5.87	4.5E-09	***
cherry	1.20	0.20	5.79	7.2E-09	***
espresso	1.14	0.17	6.64	3.3E-11	***
bitter	-1.11	0.21	-5.27	1.4E-07	***
floral	1.07	0.13	7.96	2.2E-15	***
exotic	1.00	0.40	2.45	0.013	*
wood	-0.98	0.19	-4.97	6.6E-07	***
banana	0.94	0.45	2.07	0.03	*
caramel	-0.83	0.23	-3.53	0.0004	***
berry	0.81	0.17	4.70	2.6E-06	***
lemon	0.77	0.20	3.80	0.0001	***
honey	0.71	0.19	3.63	0.0002	***
orange	0.67	0.18	3.63	0.0002	***
cocoa	0.59	0.19	3.11	0.001	**
citrus	0.56	0.17	3.17	0.001	**
fruity	0.54	0.12	4.33	1.5E-05	***
nut	-0.39	0.15	-2.47	0.013	*
bright	0.38	0.18	2.1	0.035	*
chocolate	0.33	0.12	2.67	0.007	**
variety	0.26	0.13	1.97	0.048	*

*Note: Estimates are interpreted as the average quality-rating premium associated with being described by the word. They are sorted by magnitude. Significance is assigned where *** is less than 0.001, ** is less than 0.01 and * is less than 0.05.*

Adjusted R-Square = 48%

At this point, we can note that these lists are relatively similar. They agree at least on the direction of most ratings. The only noticeable exception is "espresso" which CoffeeReviews tended to view as a positive trait whereas Sweet Marias tended to view it as a negative. Apart from this, it is clear that fruit descriptors are always positive traits whereas "nutty" or "caramel" are viewed as negative traits. This gives the impression that sweeter, fruitier coffees are more valuable.

Price and Descriptors?

One standard assumption in trade is that if two similar goods have different prices, then the higher priced good has a higher level of quality. In this way, the quality

rating is assigned by consumers' willingness to pay. For this reason, we can turn to see if there are descriptors that tend to receive higher prices.

CoffeeReviews began including prices in their coffee in the last five years. The included price is given in dollars per bag with bags of different size. For this reason, I have standardized the price to USD per oz. There are 942 observations that include price. I have also discarded outliers, which consist of a handful of unrealistically expensive coffees. Looking at the same set of factors:

$$\log(p) = \alpha + \varepsilon \cdot t + \beta\vec{x} + \mu$$

Note that this regression uses the log of price, and so the estimates can be interpreted as percentage variation from the mean price.

Explaining CoffeeReviews' Price

Descriptor	Estimate of Effect	Std. Error	T-Value	P-Value	Sig.
herbal	-38.6%	0.14	-2.8	0.01	**
peach	9.2%	0.03	3.3	1.13E-03	**
variety	8.7%	0.01	6.5	1.40E-10	***
wood	-7.1%	0.02	-3.1	2.20E-03	**
grape	7.0%	0.02	3.1	2.07E-03	**
bitter	-6.6%	0.03	-2.6	0.01	*
berry	5.9%	0.02	3.6	2.85E-04	***
tart	4.4%	0.02	2.9	4.05E-03	**
cedar	-3.9%	0.02	-2.2	0.03	*
floral	3.5%	0.01	2.6	0.01	**
syrupy	3.1%	0.01	2.4	0.02	*

*Note: Estimates represent the percentage increase in price associated with the word being present in the description. The table is sorted by magnitude of estimate. Significance is assigned where *** is less than 0.001, ** is less than 0.01 and * is less than 0.05.*

Adjusted R-Squared = 17%

It is clear that price has less to do with the descriptors than the quality ratings. Otherwise, these do tend to match with quality ratings in direction and magnitude. Since these do seem to be related, we can turn to comparing price and quality.

Earlier I presented the graph of quality and price so here I will stay instead to which elements of quality are driving higher price. CoffeeReviews composes its ratings of five factors: acidity, body, flavor, aroma, and aftertaste. They are each equally weighted in the rating. By regressing these five components on price, we find that acidity is most highly valued with body and flavor coming soon after. This makes intuitive sense, as this is likely the order of the most noticeable difference in coffees to an average consumer. In this way, it seems that consumers pay for coffee in the way that they actually enjoy it.

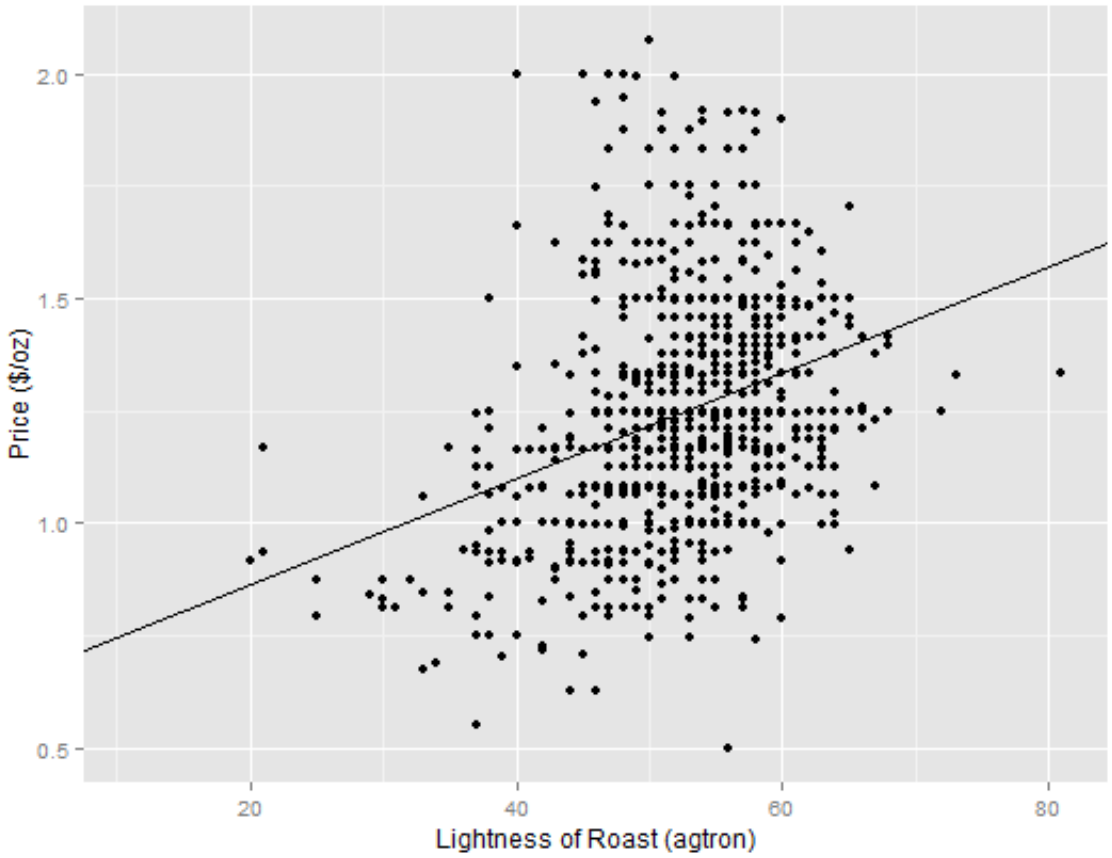
Explaining Price with Individual Factors

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
acidity	6.0%	0.012	4.87	1.35E-06	***
body	4.2%	0.014	2.99	0.003	**
flavor	4.2%	0.013	3.15	0.002	**
aftertaste	1.6%	0.011	1.51	0.132	
aroma	1.2%	0.012	1.01	0.314	

*Note: The estimate is interpreted as the percent price increase for receiving one point higher rating (of 10). Significance is assigned where *** is less than 0.001, ** is less than 0.01 and * is less than 0.05.*

Adjusted R-Squared: 16%

If descriptors are not a great predictor of price, then what about roast level? Perhaps the roasters create more value than the producers. We can see that the roast level explains a similar amount of variation in the price with 15% of the variation in the price explained by the lightness of the roast. The agtron measures the darkness of the roast with higher ratings meaning it is a lighter roast level.



With a few different approaches to explaining the difference in price, we can turn to a regression model that includes all of them. This yields the suggestion that the best predictor of price is actually its rating, and "variety" which is used to suggest that there is more specificity behind its sourcing.

Total Explanation of Price

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
rating	2.4%	0.003	7.58	8.31E-14	***
"variety"	6.5%	0.012	5.28	1.65E-07	***
"berry"	3.6%	0.015	2.43	0.015	*
"herbal"	-29.4%	0.125	-2.35	0.019	*
"peach"	5.5%	0.026	2.14	0.032	*
"grape"	4.0%	0.021	1.93	0.054	.
agtron2	0.2%	0.001	1.76	0.078	.
"wood"	-3.7%	0.022	-1.68	0.094	.
year	0.80%	0.001	1.516	0.129	
"tart"	2.1%	0.014	1.49	0.136	
agtron1	0.3%	0.002	1.32	0.187	
"cedar"	-2.1%	0.016	-1.26	0.207	
"floral"	1.0%	0.012	0.82	0.414	
"syrupy"	0.6%	0.012	0.52	0.605	
"bitter"	-0.9%	0.024	-0.38	0.704	

*Note: The estimate is interpreted as the percent price increase for receiving one higher input. Factors in quotations are descriptors represented by a dummy variable whereas others have non-binary levels. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

Adjusted R-Squared: 23%

This implies that there is a broad amount of redundancy in these descriptors. This is poor predictive power, which suggests that the market must be functioning mainly on some other front. In this case, it seems that marketing is likely a factor that is very important but not measured by the "objective" tasting of coffee, which is blind. This is best hinted at by the presence of "variety" as very important for price but not for rating. The blind portion of the sampling would not have led them to a varietal and so that is an indication of the marketing of the coffee.

Does one roast bad coffee dark or is dark roast coffee bad?

One question related to this becomes, is it the green coffee or the roast level that cause darker roasted coffees to have worse ratings. Obviously there may be an endogeneity problem wherein roast level is viewed as a substitute for the inherent quality level of the coffee. Thus when a bad coffee comes in, it is routed to be roasted more darkly meaning that the quality differential comes from the coffee and not the roasting choices. We can test this in Sweet Maria's dataset as they give suggestions as to how to dark to roast the coffee but in cupping they roast all the coffees the same amount of time meaning ratings are independent of roast level. They give five suggested roast levels, in increasing order of darkness they are: city, city+, full city, full city+, and Vienna. The difficulty is that they frequently list ranges and with only five possible levels, there is much overlap. Thus, I look only for dummy variables to see if a specific level is mentioned. To further confound the issue though, clearly city and full city will both be picked up. For this reason, I look at the interaction term between city and full city as that set will be the differential between city ratings and full city ratings. There is no group omitted for this reason, many coffees will have multiple entries and so multicollinearity is not a concern. Looking at these values, we get:

$$q = \alpha + \varepsilon \cdot t + \beta_1 \cdot c + \beta_2 \cdot p + \beta_3 \cdot c \cdot f + \beta_4 \cdot p \cdot d + \beta_5 \cdot v + \mu$$

where c is a dummy for city, p: city+, f: Full City, d: Full City+, v: Vienna

Ratings and Suggested Roast Level

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
City	0.56	0.11	4.88	1.2E-06	***
City+	0.67	0.50	1.34	0.18	
Vienna	-0.32	0.13	-2.40	0.02	*
City+ x Full City+	-0.37	0.11	-3.20	1.4E-03	**
City x Full City	-0.16	0.13	-1.25	0.21	

*Note: The estimate can be interpreted as the rating differential for having one or several levels suggested. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

This implies premiums as follows:

Roast Level	Estimate
City+	0.67
City	0.56
Full City	0.39
Full City+	0.30
Vienna	-0.32

The ratings go from lightest to darkest as City, City+, Full City, Full City+ then Vienna. This means that higher quality coffees are more frequently assigned to lighter roast profiles which is implies that the difference noted in the CoffeeReviews data related to the higher ratings for lighter coffee may still be a function of the raw coffee quality and not the roasters decision.

This does not throw out roaster quality as an important factor. Obviously given that there are suggested roast levels we should imagine that hitting alternate levels would imply lower ratings. Taken together this is meant to show that coffee quality is related to suggested roast level.

Are these just code words for countries?

A next natural question is whether these words are just encoding information about the origin country or if there is actually a difference in ratings attributable to qualities in the coffee that changes from farm to farm. Because coffee is produced in many countries, I have grouped them into continents. Central and South America, Africa, and the Southeast Asia are the three areas I lumped coffees into. Ones that are not from a region are considered blends and will be the baseline from which the estimates will differ. The first question, similar to before is how much variation can we explain with region of origin.

$$\mathrm{q} = \alpha + \varepsilon \cdot t + \beta \cdot \vec{y} + \mu$$

where $\vec{y}$ is a vector of dummy variables of which each coffee should only have at most one with blends being the omitted group.

Explaining Ratings with Premiums

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
africa	2.33	0.17	14.0	<2E-16	***
pacific	0.68	0.19	3.6	0.000319	***
americas	1.54	0.15	10.6	<2E-16	***

*Note: The estimate can be interpreted as the premium of the region over coffee blends. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

Adjusted R-Squared = 43%

This confirms the common sense in coffee that African coffees are the highest quality, followed by American coffees while Asian coffees are still lagging behind.

To see if the value of specific countries has changed over time we can throw in an interaction term. We will also time shift so that the estimates are at 2013.

$$\mathrm{q} = \alpha + \varepsilon \cdot (t - 2013) + \beta \cdot \vec{y} + \delta \cdot (t - 2013) \cdot \vec{y} + \mu$$

Changes in Region Premiums over Time

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
(Intercept)	91.03	0.18	506.8	2.00E-16	***
year	0.59	0.02	33.1	2.00E-16	***
africa	1.52	0.22	6.8	8.75E-12	***
pacific	-0.24	0.28	-0.9	3.85E-01	
americas	0.57	0.21	2.7	6.54E-03	**
year x africa	-0.18	0.04	-4.1	3.72E-05	***
year x pacific	-0.18	0.05	-3.6	3.51E-04	***
year x americas	-0.18	0.03	-5.7	1.01E-08	***

*Note: The estimate can be interpreted as the rating increase in the year 2013, the interaction terms capture the average change in premium per year. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

Adjusted R-Squared: 44%

This is particularly interesting because all of the coffees have been losing their premium at the same rate. The omitted set here entails blends; this implies that blends have been catching up in quality to other coffees.

A last question about country is whether this is redundant with descriptors. If we insert regions into our earlier model with descriptors and date we find that R-Squared jumps from 47% to 49%. Almost all descriptors maintain importance too, which suggests that though there is significant overlap, they are not interchangeable.

Has "quality" changed?

A next important question is even if we have trouble defining quality, have preferences within the industry changed? This would be important, as it would suggest that trying to hit current standards is not possible as they are ever changing. To investigate this, I used the original list and added interaction terms between all of the descriptors and the year to see if the premiums or discounts assigned based these qualities has changed. The table lists only interaction terms for statistically significant estimates. This is imposing a linear relationship over time, which is unlikely, thus we should consider the sign and significance more than the magnitude. They are computed following this model:

$$q = \alpha + \varepsilon \cdot t + \beta\vec{x} + \delta \cdot t \cdot \vec{x} + \mu$$

As in previous examples all insignificant factors are eliminated. In this case, however, the eliminated factors are those that are not significant for the interaction term (δ). As can be seen, this model still includes standalone terms for the year and each factor.

Changes in SweetMarias' Descriptor Premiums over Time

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
year x bright	0.065	0.019	3.438	6.03E-04	***
year x cherry	0.066	0.024	2.779	0.006	**
year x berry	0.067	0.024	2.811	0.005	**
year x cocoa	-0.076	0.035	-2.185	0.029	*
year x nut	-0.091	0.022	-4.214	2.66E-05	***
year x bitter	-0.091	0.021	-4.379	1.28E-05	***
year x blackberry	-0.165	0.043	-3.811	1.44E-04	***

*Note: The estimate can be interpreted as the average change in premium per year. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

Adjusted R-Squared: **36%**

Changes in CoffeeReviews' Descriptor Premiums over Time

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
year x hazelnut	0.63	0.21	2.98	2.86E-03	**
year x dried	0.23	0.05	4.96	7.24E-07	***
year x tobacco	0.23	0.08	2.99	2.77E-03	**
year x cherry	-0.18	0.07	-2.41	0.02	*
year x honey	-0.18	0.08	-2.38	0.02	*
year x syrupy	-0.16	0.07	-2.37	0.02	*
year x orange	-0.16	0.06	-2.74	6.18E-03	**
year x lemon	-0.16	0.07	-2.26	0.02	*
year x cedar	-0.15	0.06	-2.52	0.01	*
year x chocolate	-0.15	0.03	-4.90	9.92E-07	***
year x silky	-0.14	0.07	-2.02	0.04	*
year x wine	-0.14	0.05	-2.67	7.55E-03	**
year x bitter	-0.13	0.04	-3.07	2.14E-03	**
year x floral	-0.11	0.03	-3.53	4.18E-04	***
year x variety	0.08	0.03	2.45	0.01	*

*Note: The estimate can be interpreted as the average change in premium per year. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

Adjusted R-Squared: **47%**

We see that many descriptors have had changes in value over time. It is worth noting however, that adding an interaction term has not substantially improved the total performance of the model. Though there may be some change, it is not enough to suggest that farmers cannot chase quality standards successfully.

In terms of roasting style though, we can look at the relationship between roast level and rating over time. Here, the relationship seems more substantial as lighter roasts of coffee have become more valued over time. This change in quality definition is unimportant to farmers. Note that agtron ratings are very well correlated so the large standard error is likely attributable to partial-collinearity.

Changes in Roasting Preferences over Time

Descriptor	Estimate	Std. Error	T-Value	P-Value	Sig.
year	0.84	0.06	14.268	<2e-16	***
agtron1	6.90	4.75	1.45	0.147	
agtron2	7.93	3.21	2.47	0.014	*
year x agtron1	-3.4E-03	2.4E-03	-1.44	0.15	
year x agtron2	-3.9E-03	1.6E-03	-2.45	0.01	*

*Note: The estimate can be interpreted as the rating increase for being one point lighter roast. Significance is assigned where *** is less than 0.001, ** is less than 0.01, * is less than 0.05, "." is less than .1.*

Adjusted R-Squared: **51%**

What is quality then?

This section has undermined the idea of quality as being particularly well defined. Certainly we have seen that farmers are paid on quality and that quality does lead to higher prices but it is not clear that one could communicate this information back to farmers. Never having tasted their coffee, we cannot expect that telling them to make their coffee taste "fruitier" would contain any actionable information. This should not cause us to throw out the idea that quality is important in the market, only that it does not seem worthwhile to invest heavily in specific quality. Therefore, it may be that there are cheaper ways of adding value at the source by adding marketable information.

Moreover, this section has highlighted a difference in the relationship between quality and price. It seems the best quality definition would be one that mapped on to the price at which coffee sells to the end consumer. The fact that these regressions show that quality and price vary differently with attributes is indicative of a need for a better definition and conception of quality that varies in accordance to consumer willingness to pay.

Limitations

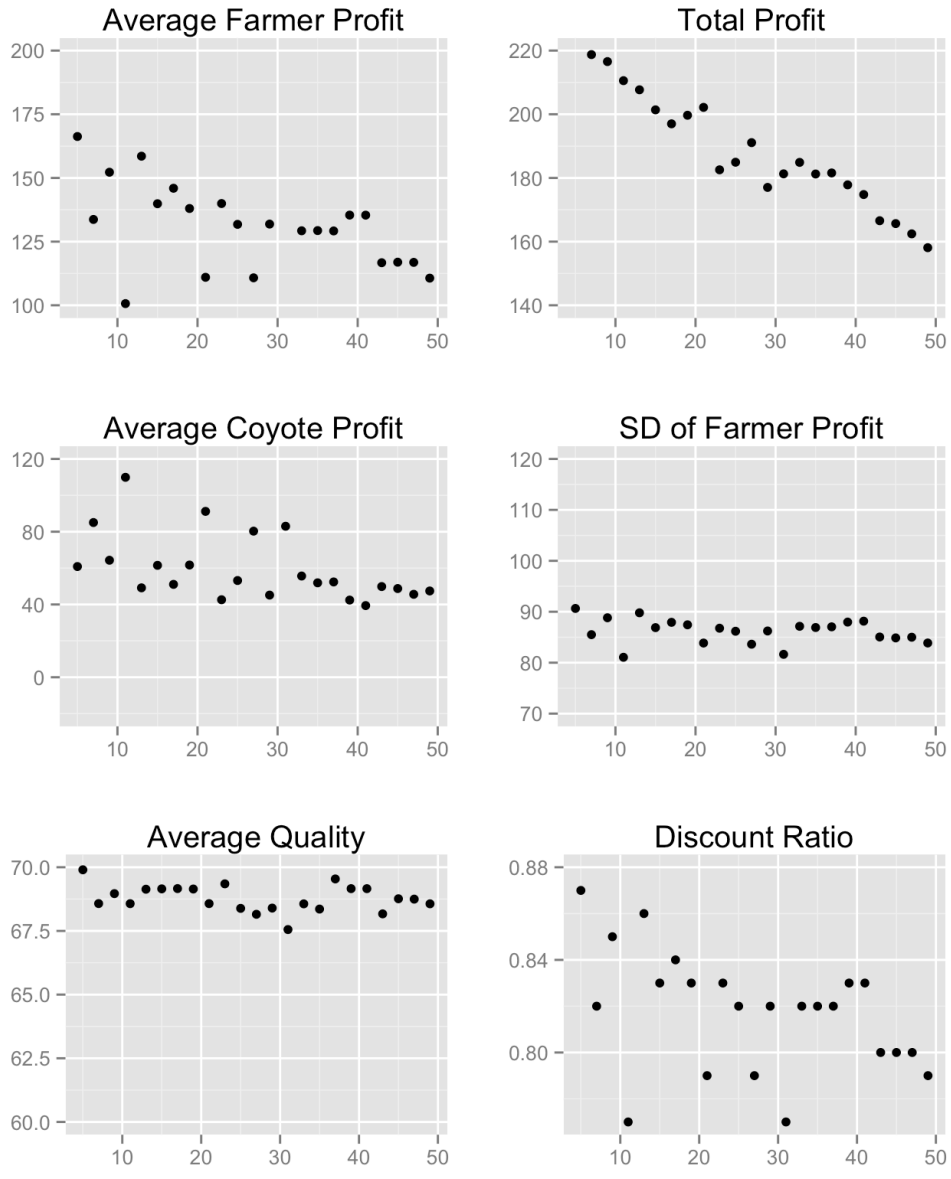
A first note is that we cannot tell if coffees sold better or worse when their value was out of line with their price and so equating price as indicative of quality is less than ideal. My personal experience in buying coffee suggests though that this should not be a big factor though and the fact that they are sold (often by major companies) suggests they are likely bought since these businesses aim to sell all coffee within two weeks of roasting.

Appendix A: More Model Results

This section shows the results of varying levels of five other key variables. The results are largely expected and self-explanatory.

i. Change of Cost of Visit

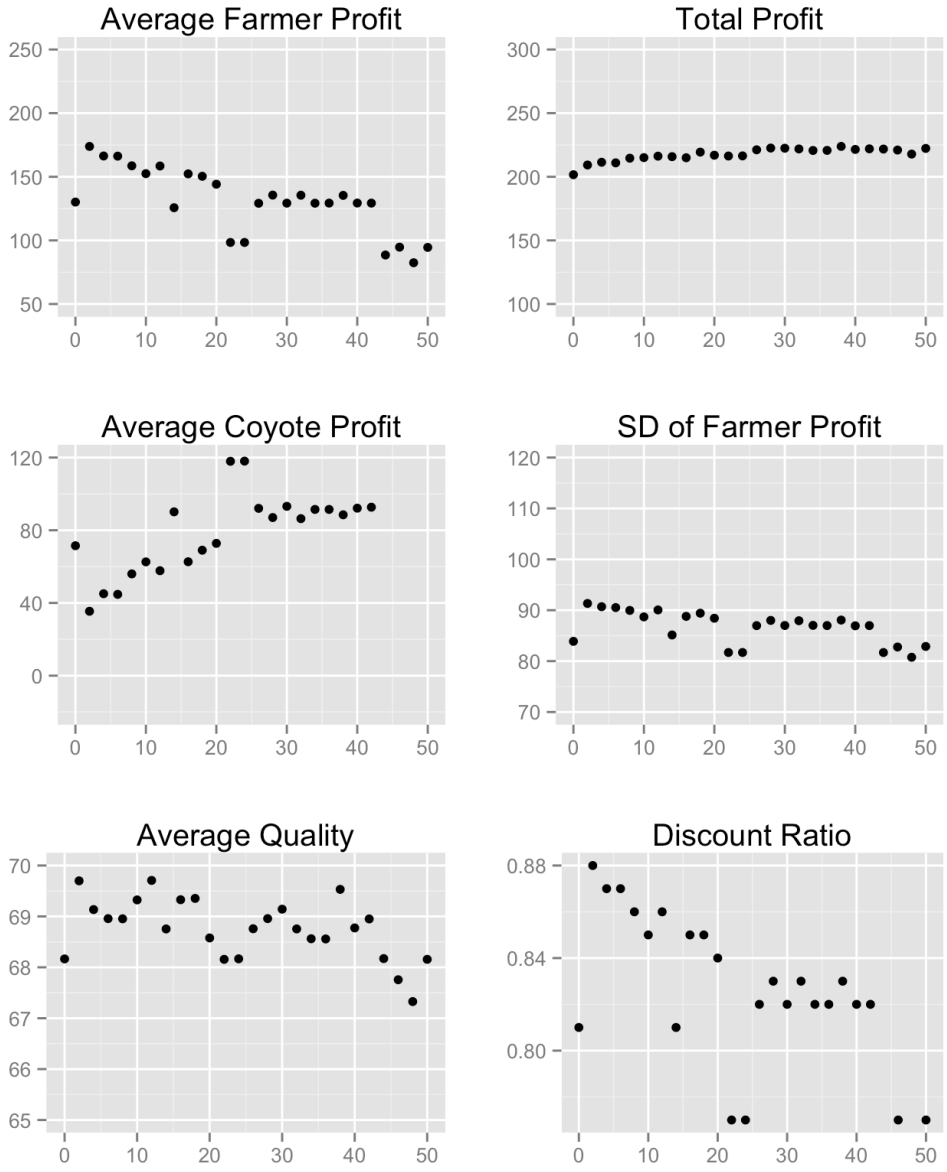
Farmers are offered lower prices since we have conditioned that coyotes would like to attempt to keep similar levels of profitability and thus farmers bear the cost. They are somewhat sheltered as the number of visits decreases thus increasing the expected profitability of a single visit.



Note: This represents increasing the cost of visiting a farm whether or not a purchase is made.

ii. Desired Profit Level

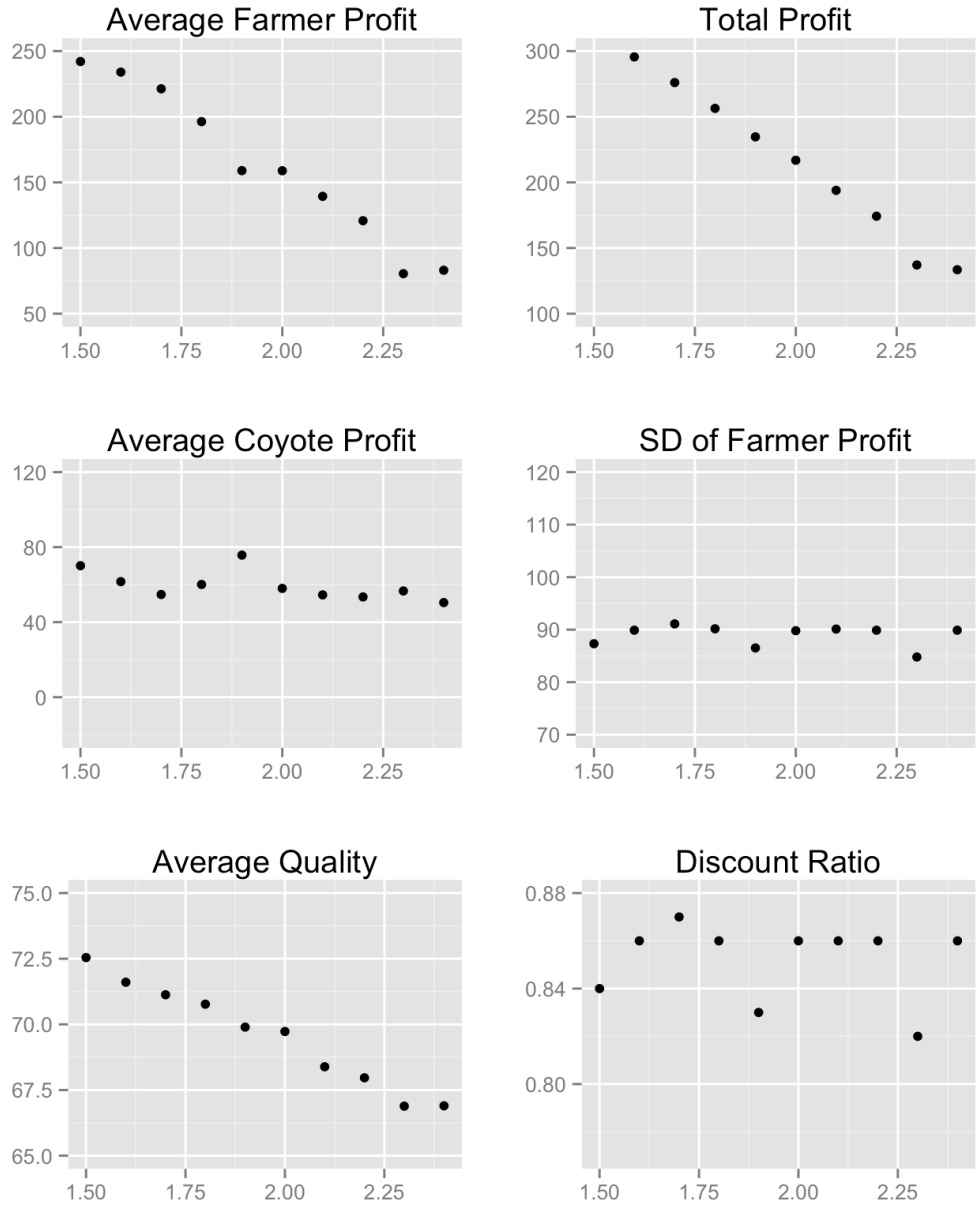
Similarly, here we find that if the coyotes require a higher profit level to enter then the net effect is that they take a greater share of profit relative to the farmers. The reason it increases total profit is that this results in less visits meaning less wasted resources from rejected offers.



Note: This represents the profit margin that the coyotes hope to make in each purchase. It's clear that they fail to meet this because of the winner's curse.

iii. Change in Cost of Inputs

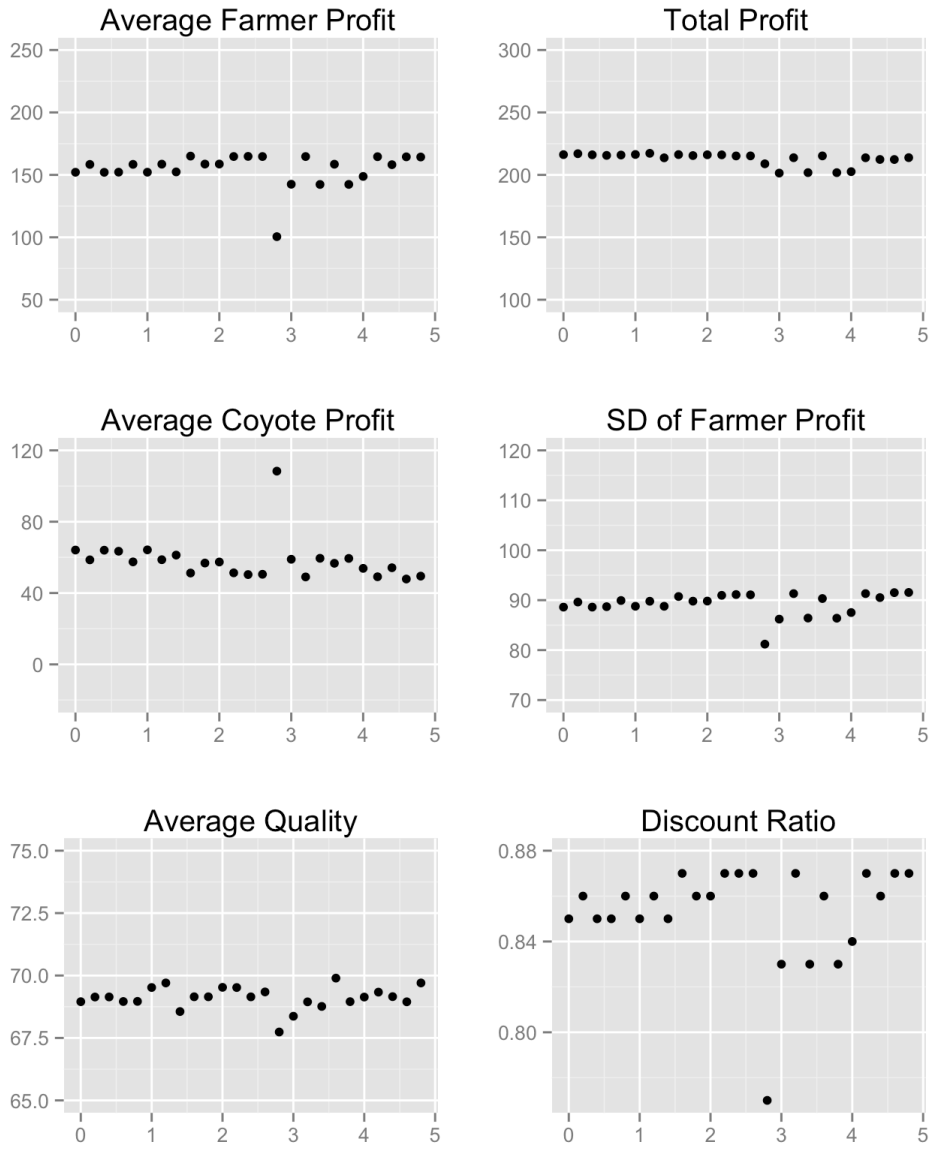
This is an expectable outcome. It shows farmers are much less profitable as the cost of inputs rises. Likewise, because of the increase in cost, they choose to produce lower quality coffee.



Note: Rising cost of inputs mean producing high quality coffee is more difficult.

iv. Producer Bias

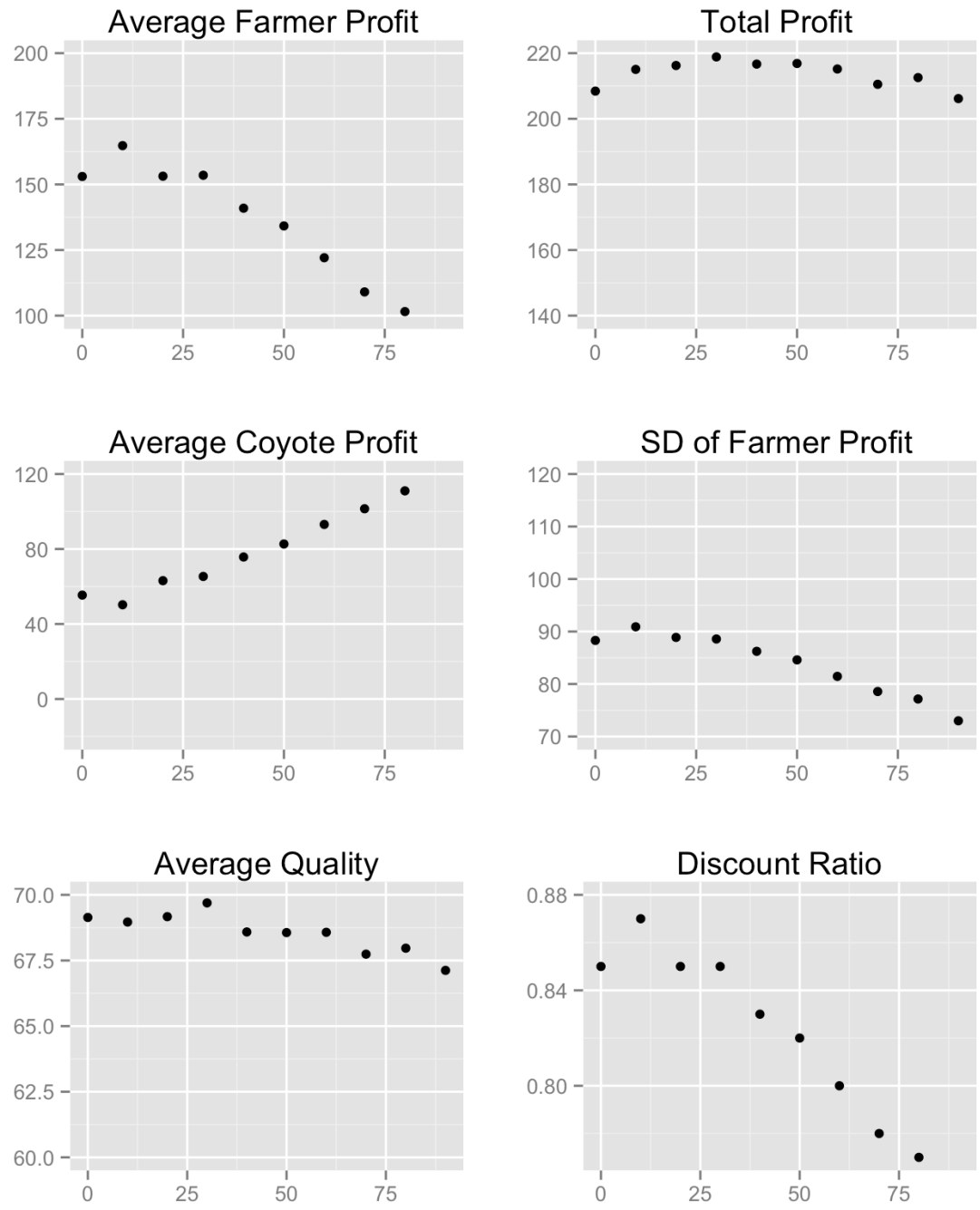
There is very little effect to producer bias. It seems that they may face slightly more variability in profits because of higher bias, as they are more likely to wait for the last offer. Likewise, it seems they actually are more profitable, this is almost certainly because in this range of values their bias actually serves to offset their risk discount thus returning them to a fair estimate.



Note: These represent the quality points by which farmers are overvaluing their coffee on average.

v. Risk Preference

Risk aversion is very costly for farmers because greater risk aversion leads directly to decreased profits though it does also decrease the variability in profits. As coyotes realize that farmers are discounting their true value, the coyotes adjust their discount factor downwards and thus take more of the surplus.



Note: This is the amount of a lower offer that farmers are willing to accept to stop waiting.

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