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Author(s): Darren Hudson, Don Ethridge and Eduardo Segarra

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Incorrect Price Information for a Heterogeneous Commodity: A Conceptual Synthesis

Darren Hudson, Don Ethridge, and Eduardo Segarra

Theory and analysis of markets and market behavior have typically assumed that the information available to market participants is correct. Additionally, most analyses examine market behavior assuming homogeneous products. This article examines the implications of incorrect market price information, especially price differentials based on quality, first conceptually and then with evidence from prior research on cotton prices as an illustration. This evidence shows that price differences based on quality have direct implications on production and marketing processes. Incorrect price/quality information can lead to distortions in the market and market inefficiency.

Price information is important because it is needed for market efficiency. Because prices are rarely known with certainty, economic agents attempt to obtain as much (correct) information as is economically feasible. If sufficient correct information exists, and all agents use it accordingly, perfect information is approximated and market pricing efficiency is achieved. However, two general problems arise. First, most goods and commodities possess a range of quality attributes (e.g., cotton, fruits and vegetables, and livestock), thus complicating the process of price discovery. Second, if the information, especially that on variations in price due to variations in quality, is incorrect, resource misallocation can occur.

Price information has been a subject of analysis in economic literature for many years. Stigler's seminal article marked a recognition of the importance of price information in the optimizing behavior of individuals. Rothschild incorporated the role of "learning" about the distribution of prices, and Stiglitz expanded and synthesized the role of imperfect information in economic analysis. However, most of

■ *Darren Hudson is assistant professor, Department of Agricultural Economics, Mississippi State University; Don Ethridge is chairman and professor, Department of Agricultural and Applied Economics, Texas Tech University; Eduardo Segarra is professor, Department of Agricultural and Applied Economics, Texas Tech University.*

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the conceptual and empirical literature centers on the search for, the utilization of, and the optimal amount of information, assuming that the existing information is correct. For example, Allan; Adam, Garcia, and Hauser; Antonovitz and Roe; Babcock; Byerlee and Anderson; and Moffit et al. have provided evidence of the value of information to decision makers. Feuz, Fausti, and Wagner and Kreps and Wilson (among others) have provided examples of the effects of incomplete information. Although not directly related to the issue of incorrect information, this line of literature provided useful parallels in resulting effects on markets.

Armbruster and Crom recognized some of the practical problems in providing this information to markets and provided some suggestions to counter those problems. Nevertheless, the effect of incorrect price information has had little exploration (for a survey of the economics of price information literature, see Levine and Lippman). One example is Chopra and Ziemba's discussion of the effects of estimated means, variances, and covariances on the optimal portfolio choice. One limitation of this work is that it deals with a homogeneous commodity (i.e., stocks).

The issue of price information for heterogeneous commodities is not extensively treated in the literature (although much of the agricultural economics price information literature deals with heterogeneous commodities, most does not explicitly address the heterogeneity). The literature that does exist also tends to assume that the information is correct. Both Lancaster and Rosen formalized the theoretical analysis of price on the basis of quality, which might have first been introduced in its empirical form by Waugh.[1] This process, called hedonics, allows the derivation of marginal implicit prices for the attributes and/or quality of a product. With the exception of Brown et al., no real attempt has been made to adapt the hedonic approach to a market price reporting setting. These authors demonstrated the applicability of hedonic theory in providing daily market price information on the basis of quality on a marketwide scale. Although a useful analytical technique in providing marketwide information to a market, it is impractical for individual market participants to use hedonics in deriving price information for different qualities of a commodity. This is not to say that market participants do not have subjective estimates of price differences due to quality. Rather, most if not all market participants do not have the capacity to collect large samples of data from which to accurately estimate these price differences. Thus, market participants usually find it infeasible to discover prices for various qualities on their own.

To counter this problem, some commodity markets are provided information on prices of different qualities. This information is intended to assist market participants in the price discovery process and to more closely equalize information sets of buyers and sellers (Armbruster and Crom). However, what if the information provided to the market is incorrect? The term *incorrect* is distinguished in this context from random measurement error. Rather, the term is used to describe systematic error that is not predictable (e.g., error arising from unknown sample bias, inadequate sampling, or improper estimation procedures). On the surface, this resembles a definition of risk/uncertainty. However, in the context of price information, the distinction is that the errors are not known. That is, yield uncertainty is not knowing what yields will be *ex ante*. The "incorrectness" of the price information in the context of this article arises from unpredictable errors that are unknown to participants *ex ante* or *ex post*.

The implications of incorrect general (aggregate or average) price information

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are readily understood (see, e.g., Bressler and King; Leavitt, Hawkins, and Veeman; Tomek). However, the implications of incorrect price information for a heterogeneous commodity are not. The objective of this article is to merge the concepts of differentiated products and price information to examine the role of incorrect price information on the market for a heterogeneous commodity. It should be noted that what follows is not an attempt to derive an empirical test for market efficiency. Rather, it is a conceptual discussion of the role of price/quality information in the marketplace for heterogeneous commodities. Evidence from published studies is then used in conjunction with the conceptual discussion to make inferences about market efficiency and performance.

A Conceptual Model: The Case of the Cotton Market

Many markets are provided, either privately or publicly, with price information. The justifications for this provision are clear and well documented (Armbruster and Crom). One main objective is the equalization of information sets. A second reason is price discovery. That is, for diverse and geographically disbursed markets, it might be relatively expensive to individual market participants to gather the necessary information to form effective expectations about prices. Thus, external parties step in to act as a collector and distributor of that information.

One major source of that information has traditionally been the federal government. Through the Agricultural Marketing Service (AMS), the USDA provides information to many agricultural commodity markets. Information is generally collected by regional or local representatives of AMS, published, and disseminated to market participants. Currently, at least to some degree, this activity has been taken up by trade associations, universities, and private industry (the trend is more prevalent in some commodities than in others). The information provided by AMS ranges from simple reporting of average prices and volumes for relatively homogeneous commodities to complex sets of tables of premiums and discounts for highly heterogenous commodities.

The cotton market is an example of a market for a heterogeneous commodity that is provided price information on various qualities. Cotton is a commodity that contains a diverse and complex set of quality attributes. The uniqueness of cotton is that it has a large number of measured attributes. Official grading standards recognize eight attributes: fiber length, fiber length uniformity, fiber strength, micronaire, color, trash, preparation, and extraneous matter (USDA 1993). The USDA designates over 800,000 combinations of these quality attributes, each potentially having a different market price. In reality, the subset of quality combinations that are actually traded is smaller. The 800,000 represents all the possible combinations that officially exist and is stated to illustrate the complexity of the price/quality interface in cotton. Cotton classification and trading has evolved greatly over time. In the early part of the twentieth century, all cotton was hand graded by a classer, and trading was based on physical inspection of samples by merchants sent by producers. As quality classification became more precise (more attributes examined), trading on the basis of printed grade reports became more common. Presently, all cotton in the United States is classed (graded) using high volume instrument (HVI) grading (USDA 1993), and the marketing system relies heavily on these

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quality measurements for the trading of cotton. In fact, much of the cotton traded in the United States today is done on the basis of grade reports over a computer.

The textile processing of cotton is sensitive to the combinations of quality attributes being used. That is, processors of cotton (textile mills) must have knowledge about the quality of cotton being used to manage textile machinery operations and quality of the products. Different qualities of cotton are substituted for one another to some degree, depending on the difference in price between those qualities, and still maintain the quality of the end product. The deciding factor in these substitution decisions is whether the price difference between qualities of cotton equals the change in processing efficiency. From the producer perspective, different varieties and cultural practices produce different qualities. Although producer decisions tend to be more discrete, some variability exists in production practices that can occur within the year that affect quality, and interyear production practices can be modified greatly, depending on the price/quality relationship. Decisions on which varieties to plant or on cultural practices are largely driven by yield potential and price differences between qualities.

Given the complexity of the potential qualities available in the market, price information on the quality differentials (called premiums and discounts) is thus relevant. However, those differentials are not directly observable in the market because individual qualities are not traded. That is, cotton is a composite commodity so that cotton fiber strength, for example, is not traded individually from the cotton itself. The only observable price is the price for a pound of cotton, not the price of the strength embodied within it. Because of the complexity, it is not feasible for individuals to derive the quality differentials themselves. Thus, they rely on the information provided to them.

Two sources of price differential information that is generally available to market participants exist. One is the Daily Spot Cotton Quotations (DSCQ), which is published daily by the Agricultural Marketing Service, USDA. The DSCQ contains a base price for a base quality and the quality differentials (premiums and discounts) from that price for each of seven designated marketing regions (USDA, daily issues). The DSCQ is the official government estimate of premiums and discounts. The other source of price differential information is the loan schedule of the Commodity Credit Corporation (CCC). However, the CCC loan schedule is based on an average of the DSCQ quality differentials for the first seven months of the marketing year, averaged with the previous year's loan schedule (USDA 1994). Thus, the CCC loan schedule differentials resemble the DSCQ differentials.

These differentials are used in many ways in market activity. For example, the DSCQ is used in the settlement of prices of cotton delivered against futures contracts as well as for general information and expectations about differences in prices of different qualities of cotton on a daily basis. The CCC loan schedule differentials are often used in forward contracts between producers and merchants, in allocating proceeds from marketing pools, and in determining the value of cotton going into the loan program. Thus, these sources of price differential information have proliferated the market so as to be assumed by many participants to be an accurate reflection of market price differences. If the information on the quality differentials is correct (i.e., consistent with the quality differentials in the real market), market participants can make effective decisions on the trade-offs between qualities. If not, market participants are likely making incorrect decisions, leading to resource mis-

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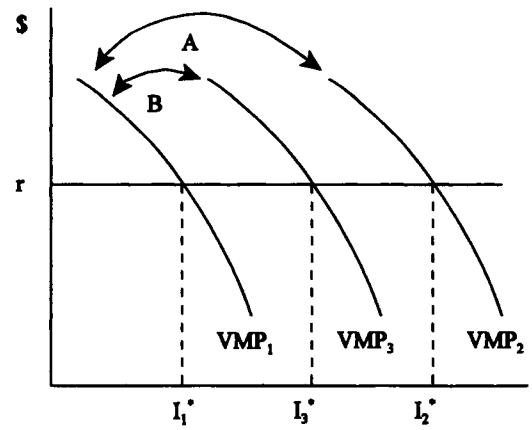
Figure 1. Effects of incorrect price information on input usage decisions



allocation and market inefficiencies. It would be naive to assume that market participants use the DSCQ or CCC loan schedule as the only source of price information. However, given that the DSCQ is the only official source of price information, it is reasonable to assume that market participants use it as a large part of their information set so that any errors in the DSCQ distort, or at least complicate, their information set. It is also reasonable to assume that market participants will "learn" about mistakes in information. However, the market is dynamic, and if mistakes are unpredictable, "learning" is more complicated. Additionally, mistakes in premiums and discounts would be more difficult to learn because the actual premiums and discount are not directly observable by individuals *ex post*.

Conceptual Effects of Incorrect Price Information

The price of cotton is a function of both the total quantity of cotton and the quality attributes embodied within the cotton.[2] Assuming for simplicity that the quantity of cotton is a function of an aggregate variable input, I, the standard first-order condition for profit maximization under perfect competition is that the value of the marginal product (VMP) of I (VMP_I) is equal to the price of $I(r)$. However, cotton is not a homogeneous commodity, so that quality has an effect on price. Thus, the effect of quality is to alter the optimal usage of I. An example of an input that has a direct effect on quality is ginning. Producers make decisions about how many lint cleanings to put their cotton through on the basis of information on price differentials (Misra et al.) Other examples of inputs are the amount and timing of chemicals and water.

The VMP relationship demonstrates the importance of price information. The marginal impact of quality on price (premium or discount) is not observable in the market but must be derived from the aggregate price of cotton, usually not by market participants. Thus, market participants rely on price information to make input decisions.

Consider the situation depicted in figure 1. With no quality impact on price (i.e.,

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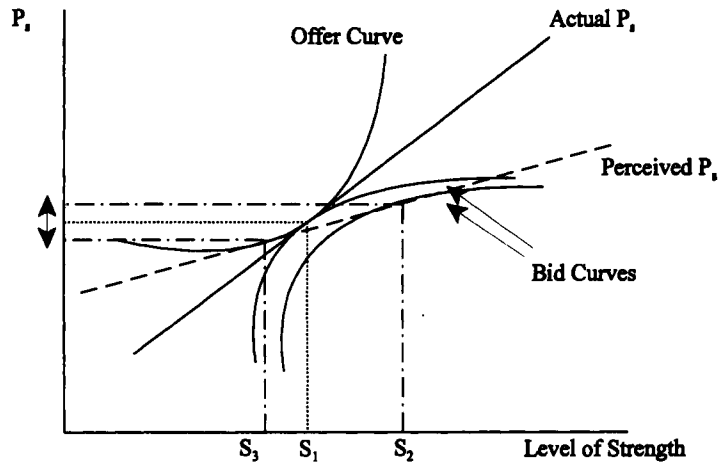
Figure 2. Bid and offer curves for strength and the implications of incorrect price information: one-factor case



no premiums or discounts), the producer would observe a VMP of VMP_1, resulting in an optimal input usage of I_1^*. However, if a total premium of size "A" was available in the market and the producer had the information to realize it, the resulting VMP would be VMP_2. This would induce the producer to increase the level of input usage from I_1^* to I_2^*. However, suppose that the information available to the producer through the DSCQ or the CCC loan schedule showed only a premium of size "B" to be available in the market (when "A" was the actual premium available in the market). The result is a lower perceived VMP of the input (VMP_3), which induces the producer to use a lower than optimal amount of the input (the scenario also works in reverse in the situation in which a discount is present in the market). The implication of this situation is that incorrect price differential information leads to nonoptimal input usage and thus nonoptimal output levels.

Information on price differentials is important to the textile industry as well. Textile mills likely have some idea of the use value of cotton in production of their end products. However, they depend on existing price information for an estimate of market value. Textile mills purchase cotton with specific sets of quality attributes (or ranges of quality attributes) to produce specific end products. Mills can alter the combinations of the qualities to produce that product on the basis of the availability and prices of different qualities of cotton. This trade-off between different qualities on the basis of price depends on information about the differentials in price on the basis of quality. If the information they possess or use is reliable, they can effectively make these trade-offs to maximize profit. However, if the information is incorrect, as above, mills will make incorrect input decisions and thus not minimize the costs of production. If they do not minimize costs, the consumers of textiles do not get the product at the lowest possible price.

This relationship can be further explained by using Rosen's framework. In figure 2, the producer of cotton has an indifference curve in production (offer curve), and the textile manufacturer has an indifference curve in consumption (bid curve) of a specific quality attribute of cotton (strength in the figure). Using Rosen's assump-

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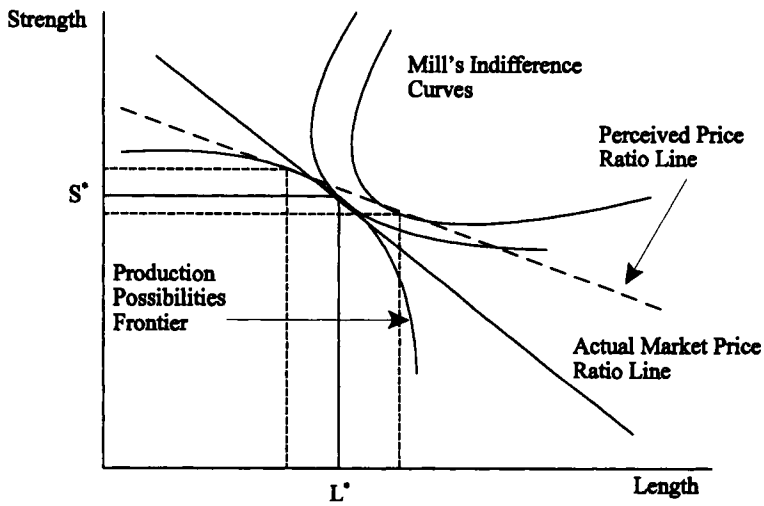
Figure 3. Effects of incorrect price information on the input allocation process: two-factor case



tions, including perfect information of both parties, these two curves are tangent at some point that lies on the hedonic price function for strength, yielding an optimal price and quantity of strength (S_1) in the market. If the perceived hedonic price function (premiums and discounts) for strength is different because of incorrect price information from the DSCQ or CCC loan schedule (the dashed line in figure 2), the result is a movement to a new set of bid and/or offer curves and a disequilibrium in the market for strength. That is, in this example the perceived price generates a situation in which producers are willing to produce less strength (S_3) than mills want to purchase (S_2) at the reported price of strength.

Rosen's single-attribute case can be extended to a two-attribute case to highlight the implications of incorrect information on quality trade-offs. Figure 3 shows the situation in which the producer and the mill are producing and using fiber strength and length (any pair of attributes could be used in this analysis). Along the actual market price ratio line (the contract curve), the mill and producer come together (the production possibilities frontier and the indifference curve are tangent) where there is an optimal amount of S^* and L^* produced and consumed. If information were perfect, this would be the optimal result. However, if the price information on quality differentials showed a different price ratio than the market (e.g., the dashed contract curve in figure 3), producers would offer more strength and less length than optimal. In contrast, mills would attempt to purchase less strength and more length than the market would provide.

Thus, the result of the incorrect price information on quality is a market disequilibrium for quality. This is not a general disequilibrium in the total quantity of cotton because the market will find prices of cotton to balance consumption with availability to clear the supply. However, the result is a disequilibrium in terms of the qualities produced/sold. Thus, the exchange process is inefficient and the market inefficient; the extent of the inefficiency depends on the size of the discrepancy

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between actual market price differentials and the reported price differentials as well as what proportion of the market participants' information set is made up of this erroneous information.

Evidence of Effects of Incorrect Information

The marginal implicit prices of cotton have been examined at national and regional levels at the consumer (mill) pricing point (Chen, Ethridge, and Fletcher) and at the regional market level on a daily basis at the producer pricing point (Brown et al.). These studies used a hedonic framework to derive the marginal implicit prices and attribute premiums and discounts for the individual quality attributes of cotton on the basis of large samples of primary market transactions data. The Daily Price Estimation System (DPES), which has examined these marginal implicit prices in the Southwest region (Texas and Oklahoma) on a daily basis since 1988 (Brown et al.), constitutes a reliable, analytically rigorous (Brown and Ethridge) set of measures of cotton market price premiums and discounts available at the producer level. The existence of this daily set of estimates allows the accuracy of the official price information provided by the government to be examined.

Hudson, Ethridge, and Brown examined the accuracy of the daily price information provided to producers in the Southwest region by the DSCQ by using the results of the DPES from two standpoints: the magnitude of the premiums and discounts and the movement of those premiums and discounts through time. They found that the DSCQ premiums and discounts did not effectively represent the producer market in terms of the level of premiums and discounts or the movement of the market premiums and discounts through time. What might be more important is the finding that the errors in the DSCQ were not consistent. That is, no systematic pattern to the errors was found, thus making it difficult for market participants to learn the magnitudes of the errors and correct for them. Thus, market participants were receiving incorrect information on the level of premiums and discounts and their day-to-day movement.[3] This is somewhat different than the inability to interpret information because of "noise," alluded to by Antonovitz and Roe. To those market participants who realize that the information is incorrect, the price reports act as "garbled" messages. To those that do not know it is incorrect, they might be accepting the misinformation as fact.

The CCC loan schedule is adjusted using the DSCQ (USDA 1994), so that any errors in the DSCQ lead to errors in the CCC loan schedule. Given the evidence regarding errors in the DSCQ cited above, Carr and Ethridge simulated a CCC loan schedule for Texas and Oklahoma using market (DPES) premiums and discounts rather than the DSCQ to make annual adjustments to the CCC loan schedule. That is, the CCC loan schedule for the current year is formed by averaging the previous year's loan schedule with the average of the first seven months of the previous marketing year's daily DSCQ premiums and discounts. In Carr and Ethridge's simulation, the seven-month DPES averages were used in place of the DSCQ averages to make the annual revisions. After five years, the CCC loan schedule would have looked substantially different, especially at the lower end of the quality spectrum. Thus, errors in the premiums and discounts of the DSCQ are affecting both of the primary sources of price information to producers (and other market participants) in that market region.

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Although no predictable pattern was found in the daily DSCQ errors, DPES results for a succession of years (Hoelscher, Hudson, and Ethridge; Hudson, Brown, and Ethridge; Hudson and Ethridge; Floeck, Hudson, and Ethridge) show that the annual averages persistently underestimated the quality premiums and overestimated the discounts (and overestimated producer base price) in the Southwest market. This suggests that, for example, farmers who base decisions on the DSCQ (or CCC loan) differentials are likely to be producing less of both the higher and the lower end of the quality attributes than the market wants and, by extension, more of the midrange qualities of the attributes than the market wants.

Evidence of more concrete direct effects of the errors in price information on decisions is available in a study by Misra et al. They examined the optimal number of lint cleanings for stripper-harvested cotton given three sources of price information: market (DPES), DSCQ, and the CCC loan schedule premiums and discounts. This study accounted for the effects of lint loss and ginning on final quality and then used the three different estimates of prices and premiums and discounts to examine net revenue to the producer. Six different varieties at three different harvest dates (a total of eighteen scenarios) were examined. In contrast to long-standing industry practice, one lint cleaning was found to be optimal using market (DPES) premiums and discounts regardless of the cotton variety or harvest date. When the DSCQ or CCC loan schedule premiums and discounts were used instead of market premiums and discounts, two or more lint cleanings were optimal in more than half the cases analyzed. Increasing the number of lint cleanings reduced producer net revenue by an average of $4.50 per bale of cotton. In addition, it "overcleans" cotton (damages the fiber) from the textile mill's perspective.

Other situations can be described to support the conclusions from the conceptual analysis, but they are individual, undocumented circumstances that constitute *prima facie* evidence. However, the published research is sufficient to demonstrate that the official price reporting is misleading in the Southwest region cotton markets. Objective evidence of the actual market price and differential structures in the other regions is yet to be developed.

Conclusions

This article highlights the importance of quality to the exchange process through the price of a commodity and the importance of markets having accurate price information on the basis of those qualities. Cotton is the commodity used to address this topic, both conceptually and empirically, both because it is very heterogeneous and because the market depends heavily on external (reported) price information.

This article develops the conceptual framework showing how incorrect price information on quality differentials results in suboptimal production decisions, from raw materials to finished goods. The evidence of errors in reported price information in the cotton market is presented, as is one empirical example of the extent of economic losses from it (in ginning cotton). The intent is to emphasize that although availability of market information is a necessary condition for efficient operation of competitive markets, one of the sufficient conditions is that it be accurate.

One trend that is likely to enhance the importance of commodity quality in the

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future is the "industrialization" of the agricultural sector. That is, a greater number of end products are being produced to fit specific markets. As these consumer demands back upstream in the market channel, processors will begin demanding consistency (or specific qualities) of raw material inputs to match production needs (e.g., cotton fiber characteristics produced for producing different textile products). As this process evolves, raw product heterogeneity will likely become more important. Thus, knowledge of the values of attributes embodied within commodities, especially those such as cotton, will likely become increasingly important as the marketing system attempts to provide a wider array of raw materials for more heterogeneous end products.

Changes in farm policy through the Federal Agricultural Improvement and Reform (FAIR) Act are also relevant. New planting flexibility afforded producers enhances the need for information. Accurate and timely market price and price differential information will become more important in making planting and production decisions. This information will also be important in making effective marketing decisions without government protection.

Acknowledgements

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Endnotes

[1] It seems that some earlier works might have employed the same technique (e.g., Taylor), but Waugh is the most widely recognized for the early use of the emprical approach. Griliches, Ladd and Martin, Ladd and Suvannant, and others also used it extensively on a wide range of goods.

[2] The following discussion is based on a derivation found in the Technical Appendix and the related figures. Readers are referred to the appendix for explicit treatment of the relationships.

[3] Discussion with market participants suggests that merchants are aware of the lack of reliability of the DSCQ in reflecting the market, although they do not know the "correct" premiums and discounts; farmers appear to be less aware of the unreliability of the DSCQ.

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Technical Appendix

To simplify, all markets (input and output) are assumed, as per Rosen, to be purely competitive, except that the good (cotton) is not homogeneous.

Consider the price of cotton (P_c) to be determined as

$$P_c = f(Q_c, TR, C, L, M, S) \tag{1}$$

where Q_c is the total quantity of cotton, TR is the distribution of trash content of cotton, C is the distribution of color of cotton, L is the length distribution of the cotton fibers, M is the micronaire distribution of cotton, and S is the distribution of strength of cotton fibers. Thus, both quantity and quality affect the price.

The quantity of cotton produced is some function of an aggregate bundle of production inputs, I, which can affect both the quantity and quality of the product:

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$$Q_c = g(I) \tag{2}$$

Taking equations (1) and (2), a profit function for the producer is defined as

$$\pi = P_c Q_c - rI - F \tag{3}$$

where r is the price of the aggregate input bundle and F is the fixed cost. Taking the partial derivative of π with respect to the aggregate input results in

$$\frac{\partial \pi}{\partial I} = P_c \frac{\partial Q_c}{\partial I} + Q_c \frac{\partial P_c}{\partial I} + Q_c \frac{\partial P_c}{\partial TR} \cdot \frac{\partial TR}{\partial I} + Q_c \frac{\partial P_c}{\partial C} \cdot \frac{\partial C}{\partial I} + Q_c \frac{\partial P_c}{\partial L} \cdot \frac{\partial L}{\partial I} + Q_c \frac{\partial P_c}{\partial M} \cdot \frac{\partial M}{\partial I} + Q_c \frac{\partial P_c}{\partial S} \cdot \frac{\partial S}{\partial I} = r \tag{4}$$

which reduces to

$$VMP_I(1 + \eta_d^{-1}) + Q_c \left[\frac{\partial P_c}{\partial TR} \cdot \frac{\partial TR}{\partial I} + \frac{\partial P_c}{\partial C} \cdot \frac{\partial C}{\partial I} + \frac{\partial P_c}{\partial L} \cdot \frac{\partial L}{\partial I} + \frac{\partial P_c}{\partial M} \cdot \frac{\partial M}{\partial I} + \frac{\partial P_c}{\partial S} \cdot \frac{\partial S}{\partial I} \right] = r \tag{5}$$

where VMP_I is the value of the marginal product of input bundle I and η_d^{-1} is the price flexibility of demand for cotton in the aggregate. In the case of perfect competition with a homogeneous output, $\eta_d^{-1} = 0$, and the partial derivatives of price with respect to the different quality attributes equals zero, so that $r = VMP_I$. Because cotton is not homogeneous, the impact of quality (TR, C, L, M, and/or S) is to alter the optimal input usage of the input I.

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