MEASUREMENT COST AND THE ORGANIZATION OF MARKETS*

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PEOPLE will exchange only if they perceive what they get to be more valuable than what they give. To form such perceptions, the attributes of the traded items have to be measured. Some measurements are easy to obtain; others pose difficulties. For example, determining the weight of an orange may be a low-cost, accurate operation. Yet what is weighed is seldom what is truly valued. The skin of the orange hides its pulp, making a direct measurement of the desired attributes costly. Thus the taste and the amount of juice it contains are always a bit surprising. The grower, more knowledgeable than the consumer, may gain by making the surprise an unpleasant one. The potential errors in weighing the commodity and in assessing its attributes permit manipulations and therefore require safeguards. The costs incurred by the transactors will exceed those under joint maximization.

A sampling of activities that arise solely because these costs are positive may hint at how costly the measurement of commodity attributes is.[1] Had product information been costless, warranties would disappear since attribute levels and defects could be effortlessly identified at the time of exchange; fancy packaging (unless valued for its own sake) as well as the *Consumer Report* and the Good Housekeeping Seal would be super-

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[1] A trifling episode dramatically illustrates how costly some measurements might be. In one of Eddie Bauer's sporting goods stores, sneakers were marked down to almost a third of the regular price after a single "defect" was found: their size markings were missing. (Thanks to Dean Worcester for the information.) Presumably, the cost to Eddie Bauer of measuring the sneakers' sizes, and perhaps of convincing consumers that nothing else was faulty, was perceived as more than half the retail price. The inducement required to compensate consumers for undertaking the measurement was obviously smaller than Eddie Bauer's cost, but still very substantial.

fluous, as would professional certification and recruiting efforts; and beautiful but rotten apples would fetch the appropriate price.

Virtually no commodity offered for sale is free from the cost of measuring its attributes; the problem addressed here is pervasive. "Market signaling" and "adverse selection" are seemingly instances of the general case. In both cases, the costs of measuring the attributes of individuals are high, and the resulting errors permit people to transfer wealth to themselves at a resource cost. Costly measurement is a factor common to these and various other instances where individual and joint maximization do not coincide.

The accuracy of measurement differs fundamentally from other valuable attributes. The presence of random errors introduces the opportunity for costly transfers of wealth. Of concern here are the effects of such behavior and the market arrangements that emerge to reduce the losses from the exploitation of the inaccuracies.[2]

The Nature of Measurement Error

Consider a model adopting all but one of the Walrasian assumptions for a competitive economy; the exception is that product information is costly to obtain. Product information is defined as information on the levels of the attributes per unit of the commodity and on the actual amount contained in the nominal quantity. Measurements of these magnitudes are subject to error. The greater the variability of the measurement around the true value, the lesser the information about the commodity.[3]

Had product information been freely available, equally valued units would sell at the same price and, so long as choosing does not damage the commodity, a seller would not be harmed from allowing buyers to pick and choose. The seller then would have no incentive to constrain choice. It will be seen that when product information is costly, the seller may gain from imposing such a constraint.

The purchase of oranges when the desired good is fresh orange juice can illustrate the measurement problem. Suppose that oranges are identical in the quality of their juice, but the amount each yields varies; that the cost of squeezing oranges at the sellers' premises is prohibitive; that buyers and sellers are able to form estimates of the amount of juice any

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[2] John C. McManus, The Costs of Alternative Economic Organizations, 8 Can. J. Econ. 334 (1976), takes a rather similar approach. Steven Cheung, A Theory of Price Control, 17 J. Law & Econ. 53 (1974), it seems, was the first to introduce the notion that markets are organized to minimize dissipation.

[3] Measurement is the quantification of information, and its use will facilitate in making the model operational.

orange contains and that the cost of greater accuracy is increasing. The amount of the attribute desired by consumers (and its price) then is subject to measurement error.[4]

Suppose further that numerous sellers sell the commodity. Each sorts it to as many classes as he wishes and then posts a price, say, in dollars per pound, for each class, permitting consumers to select any item provided they pay the posted price.

A consumer's periodic demand for the desired good is downward sloping, reflecting substitution within the period and the increasing cost of storage. The selection of a seller to buy from entails a fixed cost assumed to be so large that the entire period's quantity is obtained from a single bin of a single seller. After deciding which seller to patronize, a consumer will meet the period demand from that seller's offerings.

Had the units in the bin been identical and the amount of the desired attribute they contain known, the quantity purchased by a consumer would be determined by his demand for the attribute and by the price of the commodity. Had the units been varied, but not enough to justify *any* selection effort by the buyer, the quantity purchased would depend in part on the buyer's aversion to variability. At the going price for the commodity, the *expected* price for the attribute is determined, but the quantity obtained is subject to error. For now this effect of the error is abstracted from.

The quantity purchased in a particular period depends on the cost of selection in the following way. If, for instance, a buyer plans to buy only units estimated to be at the top quarter of the distribution, it is expected that four units will be inspected for each unit selected. The total cost of a purchased unit then is the sum of the posted price and the cost of inspecting four units. If, relative to its posted price, the commodity seems a better buy, so that the buyer plans to buy units from the top one-third of the distribution, then for every unit bought only three units will be inspected.

Thus, the interaction among the buyer's demand for the attribute, the buyer's cost of measuring the commodity, the posted price, and the estimated distribution of the attribute determines the amount purchased. That amount will increase as the demand for the good rises, as the cost of selection falls, as the posted price of the commodity falls, as the average quality increases, and, most important, as the *variability* of the commod-

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[4] The assessment of how long a machine will last, the quality of a particular performance of a long-running play, and the cost of preparing a site for construction are a few additional examples of commodities that are difficult to evaluate or to measure, and thus their measurements are subject to error.

ity offered increases. The reason for the last result is that there is no added penalty for inspecting an exceptionally poor item, but there is an added gain to finding an exceptionally good one.

What are the constraints on the seller in posting his price? Buyers, it is assumed, make use of their past experience to predict the relationship between a seller's posted price and the distribution of his commodity. They will stop patronizing a seller who they determine has a high price relative to the distribution offered. This is the route by which competition from other sellers enters the model. Subsequent to a buyer's decision to buy from a particular seller, that seller faces a downward-sloping price function. To survive, however, the relationship between a seller's price and the quality of his offering cannot "exceed" that of other sellers too often.

How finely will a seller sort his commodity? Assuming that the cost of estimation increases with the accuracy of the estimate, suppose first that this cost is the same to the seller and to his buyers and that all buyers are identical in their aversion to variability. When the variability of the commodity offered at a given price is very low, buyers will forgo selecting and will take whatever is handiest. As variability increases, a point will be reached where selection will begin.

Under the assumptions here, sellers will sort the commodity to that break-even point in variability, that is, just finely enough to dissuade buyers from any sorting. When the seller effects such sorting, each item is measured *exactly* once. On the other hand, when buyers effect the measurement, each item will be measured *at least* once; some will be measured twice or more. Thus the net price—that is, price net of the cost of measuring—at which the commodity can be offered is lowest when the seller effects the measurement. Competition will force sellers to effect the measurement.

The conclusion that the seller will be the one to measure does not depend on the level of this cost so long as this cost is the same to buyers and to the seller. Whatever that cost is, the seller will always measure just finely enough to prevent buyers from measuring regardless of how averse to variability they are. The other side of the coin is that even when buyers do not value a better-sorted product, they will gain from measuring by getting the more highly valued units selling at a given price.

Suppose now that the buyers' cost of measuring is higher than the sellers', say, because a tax on measurement by buyers is imposed or because they are constrained in some way. It immediately follows that the sellers' level of sorting will fall to the new level that would just prevent buyers from any sorting. A striking feature of this result is that when the buyers' cost of measuring is increased, the net price they pay for the commodity, or for the desired attribute, will fall.

Buyers perform their measurements in the market in two steps. In the first they estimate the distributions different sellers offer to decide from whom to buy; in the second they determine the properties of individual items. If the increase in buyers' cost applies only to the second step, then the analysis is complete. If, however, it applies to the first step also, a new problem arises.

If buyers' cost of determining what the distribution is is increased, a seller could more easily entice buyers to buy from him even when his merchandise is "overpriced." In that case, buyers must rely more heavily on their past experience or on some other proxy measure and less on assessing what they are offered on a particular shopping trip. The role of a seller's reputation, warranty, and so forth acquires, then, greater prominence. Constraining buyers' choice in that case will generate some gains but will also introduce new problems. Moreover, the imposition of such a constraint is unlikely to eliminate all measurement by buyers since buyers need to convince themselves that they do not receive worthless merchandise.

The earlier assumption that sellers' measurement cost is not higher than that of buyers seems satisfactory for single-attribute commodities. In reality, most commodities have numerous attributes whose levels vary across units. If a commodity is sorted by all its attributes, each unit may occupy a class by itself. If a commodity is not sorted so exhaustively, various buyers will find it worth their while to pick and choose by attributes that they value highly, but not ones by which the seller sorted the commodity. Whereas such sorting will generate a gain, it will be carried "too far" in comparison with the joint-maximization level.[5]

Because of the cost of measurement, the seller cannot capture the entire value of his merchandise had it been costlessly described. This was shown to be the case when the seller sorted to prevent consumers from any choosing. It is also the case when consumers engage in choosing, selecting items valued more than their price. Because of competition among consumers, however, they will be able to obtain the differential in value only by spending resources—those used on measuring the commodity and perhaps on rushing to the top of the line.

In the remainder of the paper, an attempt is made to determine whether particular market practices are designed to cope with the excess-measurement problem, and implications capable of refuting the hypotheses are derived. Some casual empirical observations are made, but no serious tests are conducted. The particular practices considered below are selected on the basis of their apparent "importance" or "interest."

[5] The buyer will sort to the point where an extra dollar's worth of sorting effort yields one dollar in value. Whereas the valued attribute is costly to produce, it is obtained by the buyer at a zero marginal charge from the seller.

An examination of some of the earlier considerations may facilitate in the derivation of hypotheses. A consumer who is convinced that he received a random selection from an optimally measured commodity will not use additional resources for measuring. This requires that trust is established, perhaps by acquiring brand names. The seller still has to select a method of selling to avoid excessive sorting. One such method is to raise the buyer's measurement cost. DeBeers's diamond "sights" seem a case in point. The approved dealers have diamonds chosen for them by DeBeers, and they are not allowed to pick and choose from different offerings.

A buyer's incentive for excessive measurement can also be lowered if he is compensated for items ultimately revealed to be of exceptionally low value, which may explain product warranties. The terms of exchange for warranted products depend on subsequent performance rather than relying entirely on measuring the commodity by the time of exchange. The arrangement, however, lowers the buyer's cost of the careless handling of the product. The severity of this problem depends on the nature of the commodity and on the contractual ability to curb abuse. Share contracts rely even more fully on subsequent performance and obviate the need for certain measurements at the time of exchange. Such contracts are expected, then, when the determination of the value of the exchanged property at the time of exchange is exceptionally costly.

The next four sections discuss product warranties, share contracts, brand names, and the suppression of information. Hypotheses are offered to explain these arrangements, and testable implications are derived. Later sections further expand the model and its applications to such diverse issues as vertical integration and futures markets.

Product Warranties

In every exchange, both the seller and the buyer will require some verification of the measurements of the exchanged goods: the seller to assure himself he is not giving up too much, the buyer to assure himself he is not receiving too little. The process of producing a commodity spans a period of time; the costs of measuring the attributes and of verifying the measurements will vary along the way and will be different for the buyer than for the seller. Which quantitites, then, will be measured, when, and by whom? The remainder of this section concerns measurement by the consumer at the time of consumption.

As a rule, measurement is by the seller, whether in advance or at the time of exchange. Quite often, however, measurement is automatic, or its cost is greatly reduced as the commodity is used. Therefore, substantial

savings will result if measuring is left to the buyer to be performed at the time of consumption. A prevalent arrangement for vesting in the consumer the responsibility for certain measurements is that of the guarantee. Presumably, it is too costly for the seller to determine which of his products may have defects. The consumer, on the other hand, can obtain this information cheaply at the time of consumption.[6] In the absence of a guarantee, to avoid getting stuck with a bad item, the consumer will examine several to identify the one with the fewest defects. Given the expected cost of selection by buyers, the seller must price the items he sells below the expected valuation of the best unit; otherwise he will not be able to sell any unit. The differential between the price and the valuation of the units offered for sale is effectively left in the public domain, and buyers will spend resources to acquire it. Selling a commodity with a warranty is essentially a promise to provide one *good* unit at the going price. Thus, the warranty reduces the differential in value received by consumers for given payment and reduces correspondingly the attendant resource expenditure.

The fact that some new cars have numerous defects is not necessarily a sign of poor workmanship. The consumer may simply be more efficient than the seller in providing quality control. When no guarantee is offered, however, a buyer would inspect several cars before choosing one. This excessive examination is avoided when the product is guaranteed. A seller who guarantees his product, then, can raise his price not only by an amount equal to the expected cost of repair, but by a premium representing the cost to the consumer of a prior examination.[7] Guarantees are routine for new cars, but not for used ones. The apparent reason is that a new-car seller can relatively cheaply verify the measurement supplied by the buyer, which is not the case for used cars.[8]

When a warranty is too expensive to supply, two types of arrangements can be used to reduce excess measurement. One is a higher degree of

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[6] The same consideration may explain certain return privileges. For such items as paint, tiles, and wool it may be difficult to match the items if a second purchase is needed. Since the consumer can measure his requirements most economically at the time of consumption, he is promised a refund for excess quantities of these goods he may buy originally.

[7] In his seminal "lemon" paper, George Akerlof discusses this role of warranties. See George Akerlof, The Market for "Lemons": Quality Uncertainty and the Market Mechanism, 84 Q. J. Econ. 488 (1970).

[8] The warranty is warranted only if buyers cannot easily exercise it even though they, rather than the seller, are at fault. The ability of one party or the other to abuse his position seems to correspond to Williamson's notion of "information impactedness," where "circumstances relevant to the transaction, or related set of transactions, are known to one or more parties but cannot be costlessly discerned by or displayed for others." See O. E. Williamson, Markets and Hierarchies 31 (1975).

quality control, which one would expect, for instance, with commodities designed for the tourist trade. The section on brand names continues this discussion. The other arrangement is to get the consumer to act as if his choice were random. The sale of used cars, where dealers often obliterate potential distinctions among cars, is, seemingly, a case in point. This issue is further developed in the section on the suppression of information.

SHARE CONTRACTS

Share contracts are often said to reflect the desire of the risk averse to moderate the effect of risk. Had this been their sole explanation, it would be refuted by the royalty payment to authors. The royalty contract between author and publisher stipulates that the author will receive a given share of the revenue from the sale of the book. Since the success of the book and the total revenue its sale will generate are not known when the contract is drawn, the author's income is uncertain. Had authors been paid a lump sum, their entire risk would have been shifted to publishers. Publishers are often diversified to start with, and thus paying a lump sum would increase the riskiness of their operations only moderately. The desire to reduce risk, then, would have generated the outright purchase of rights to books rather than the common royalty contract.

What else, then, could explain the sharing arrangement? In the royalty contract the share, or share structure, is set in advance, but the absolute amounts the two parties will receive are contingent on consumers' actual demand subsequent to publication. Because of the difficulty in predicting the ultimate success of the venture, the determination of the appropriate lump sum is expensive to reach. If publishers make competitive lump-sum bids, each of them will require some market research. Even the successful bidder's effort is excessive, since subsequently the information will emerge anyhow. Had publishers attempted to lower the cost by spending only a small amount on research, their bids would be subject to large errors, and the winning bidder might turn out to be a big loser.[9] By sharing, the need for market research is reduced and the error is largely limited to the sharing percentage, making the expected value of the royalty contract larger than the lump sum would have been.[10]

Share contracts are subject to incentive problems absent from lump-

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[9] Their loss is similar to the loss to speculators in Hirshleifer's model. See Jack Hirshleifer, The Private and Social Value of Information and the Reward to Inventive Activity, 61 Am. Econ. Rev. 561 (1971). In that model, speculation is with respect to price; here, it is with respect to quantity.

[10] Similarly, owners of mineral rights usually do not sell their rights but rather agree to a share of the unknown revenues.

sum contracts and in this regard are more costly. For instance, the publisher will tend to advertise less than when he does not share added revenues with the author. The lesser the information problem, the more attractive the lump-sum arrangement; thus share contracts are expected to be more common with new authors than with established ones,[11] with the first editions than with subsequent ones, and with novels than with "how-to" manuals.

The sharing arrangement, then, makes some search less profitable. Market forces dissuade publishers and authors from acquiring prior information on the value of the traded property.[12] But because such acquisition would have been wasteful, the sharing arrangement is a more efficient solution.[13]

BRAND NAMES

Since consumption yields direct measurement, it is often advantageous to let consumers do the measuring, which may explain warranties and contracts as argued above. Consumers, however, can gain by understanding the value of the good, and it is often difficult to verify their measurements. On the other hand, at the time of transaction, measurement or verification may be rather costly.[14] How can costly measurement be avoided?

Suppose one wants to buy a six-pack of beer. To determine whether the beer is cold enough, he will touch one or two bottles, but not all of them. Similarly, if he looks for a rope of certain strength, he will test just a small segment. In both examples the procedure followed is not as innocuous as it may appear. The beer seller can reduce refrigeration costs if the easiest-to-reach bottles are coolest, and the rope maker can strengthen just the exposed end of the rope. When the buyer does not engage in a

[11] The more books an author publishes, the smaller the proportionate effect of risk from variability in the royalty income from any of the books. The risk-aversion model then implies that sharing, or royalties, will become more common as the number of books an author publishes increases, which is the opposite of this paper's prediction.

[12] See Yoram Barzel, Some Fallacies in the Interpretation of Information Costs, 20 J. Law & Econ. 291 (1977).

[13] Hashimoto hypothesizes that the Japanese wage-bonus payment is a sharing arrangement induced by the cost of evaluating a worker's contribution. He finds that the evidence conforms with this hypothesis. See Masanori Hashimoto, Bonus Payments, on-the-Job Training and Lifetime Employment in Japan, 87 J. Pol. Econ. 1086 (1979).

[14] Various contests and calls for bids are subject to a time limit. Presumably, the caller would wish to have all the materials assembled by a given time. The restriction imposed, however, is on the time marked on the posting, since this seems a much cheaper validation method.

more comprehensive test, he is implicitly trusting the integrity of the
seller. But convincing others of one's integrity is a costly activity.

If the buyer is to buy without measuring every item, he has to be
persuaded to rely on the seller's assertion of the prior measurement. In
some instances, the seller will try to convince the buyer that his purchase
will actually be "representative" of the lot; in others that the good is quite
uniform and would not vary significantly from sample to sample. Uni-
formity is the subject of the remainder of this section; suppression of
information is the subject of the next section.

A canner known to change the quality of peas (e.g., size, tenderness,
sweetness) from one season to another will induce buyers to conduct a
fresh, costly test every season. If, on the other hand, the canner is known
to maintain tight quality control, much less testing is required. The can-
ner's reputation, or brand name, serves here to guarantee that the product
is, and will remain, uniformly good.[15]

The canner incurs costs in establishing reputation,[16] both in controlling
quality to assure uniformity and in the maintenance of uniformity when
external pressures would call for a change,[17] as any change endangers the
canner's reputation, reducing the value of his brand name. Even a higher
quality offered at the old price will cause problems by reinducing costly
sorting. Thus, it is expected that when the seller's reputation is used to
back the product, quality will fluctuate less than when the consumer is to
measure it.

Product uniformity lowers the cost of measurement to the consumer. It
is probable that to provide continuing uniformity, extensive measurement
is required by the seller. However, a seller of established reputation can
choose to measure at the cheapest point in the production process rather
than at the time of exchange, as would be necessary if the buyer were to
insist on verification of the measurement.[18]

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[15] In an article on the growing and canning of peas, Susan Sheehan gives a detailed
description of the extraordinary effort by Green Giant to guarantee product uniformity at all
grades. See Susan Sheehan, Peas, The New Yorker, September 17, 1973, at 103.

[16] If it is easier to convince a consumer of the uniformity of a widely distributed product
than of each of several narrowly distributed ones, horizontal integration is advantageous.

[17] This point was contributed by Levis Kochin. The pursuit of constant quality by Mars, a
candy maker, is detailed in an article in Business Week (August 14, 1978, at 291). "One
source of that mystique is Mars' fanaticism about the quality and freshness of its products.
. . ." "While other manufacturers were . . . reducing the quality of their candy because of
the price of sugar and cocoa . . . Mars [did not]." "[Mars] was the first candy manufacturer
to date its products and to guarantee to take back and credit merchandise still on the shelf
in four months."

[18] Brand name also involves "standards." Had the most desired characteristics of peas
been easy to measure, the label of each can could have stated their amounts. A shopper then

When a buyer receives a bad unwarranted item, his money is lost. Thus, to gain the buyer's patronage the seller must persuade him that he himself will suffer a substantial loss if his product is found deficient. By backing the quality of the item with a brand name, a bad item sold under that name will tarnish the entire brand. The more likely the consumer is to encounter the brand in the future, the more severe the penalty he can impose on the seller and thus the less he has to worry about being cheated.[19] It is expected that the more difficult it is to measure commodities at time of exchange or to warrant them, the more extensive would be the brand under which they are sold. It is also expected, paradoxically, that a seller committed to compensate the buyer for defective products will sell relatively more defective units than a seller who makes no such commitment.

THE SUPPRESSION OF INFORMATION

The provision of uniform commodities would some of the time be too costly. A commodity may be defined as heterogenous if, when allowed, its consumers will spend resources on choosing among equally priced units. Thus, patrons line up for preferred seats in a single-price movie theater; produce and meat in a grocery store are routinely subject to selection; and prospective employers spend resources in recruiting among equally paid, but diverse, workers. As already noted, the competition for the high-valued items is a costly activity; spared of the added cost, a consumer would have offered more for the item.[20]

How much is a buyer who is not permitted to inspect and to choose willing to pay for a commodity? This depends on his guess of the quality of the unit handed to him, which, in turn, depends on how much he trusts the seller. He expects to be given an item from the low-quality end from a mistrusted seller. Suppose, however, that the seller is able to persuade the buyer that he is offering a random or a "representative" selection.

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could choose his exact preference and uniformity would lose value. A consumer seeking uniformity would simply buy units having the same specifications. Thus the capability to measure implies the existence of "standards." These appear to be a substitute for brand name, and the usage of the two will be negatively correlated. It is expected that the fewer the dimensions of a commodity amenable to standardized measurement, the greater the emphasis on the brand name. Even for commodities that can be cheaply measured, however, brand name helps to assure that the measurements are correct.

[19] Klein and Leffler discuss the nature of brand names and particularly the "last-period" problem. Benjamin Klein & Keith Leffler, The Role of Market Forces in Assuring Contractual Performance, 89 J. Pol. Econ. 615 (1981).

[20] Precisely the same reasoning led to the conclusion that consumers will pay a premium (apart from those for risk reduction and for saving on the expected cost of repair) for commodities sold with warranties.

The buyer will have to submit to the choice effected by the seller, but the resource expense of duplicate sorting is bypassed. Thus, abstracting from risk aversion, he will be willing to bid up to his expected valuation.

Operating within the framework of competitive markets, it is argued that information on the quality of goods that inspection would have generated is deliberately suppressed.[21] On occasion, sellers may even offer buyers "a pig in a poke." There is no difficulty in opening the poke to inspect the pig. When trust can be created cheaply enough, trusting consumers will offer a higher average price for the entire batch when inspection is not allowed, and this arrangement will prevail. In some cases inspection might damage the commodity. In other cases, however, the arrangement is deliberately contrived at a cost of resources.

This may explain why apples are often sold in opaque bags filled in advance by the seller. The consumer spends less time per apple on inspection than when choosing them individually. He obviously will not buy the bag unless he believes that on average he gets a better buy; thus the seller's "fairness" becomes a factor in his decision. It is predicted that sellers catering to transient trade will sell a smaller fraction of their apples by the bag and will sort them into more uniform grouping than will sellers whose credentials are well established.[22]

The advantage of suppressing information may explain some of the practices associated with the selection of physicians by patients. As a rule, a physician has an immense edge over a patient in measuring the service delivered because of the complexity of medical problems and because of the great variability in outcome of a given treatment, even for a single person at different times. Since the patient's cost of measuring the service is much higher than the physician's, resources can be saved if physicians rather than patients engage in measuring. But how can patients be stopped from spending resources trying to identify the best buys? One way is to enhance even further the asymmetry in information between physician and patient.

Sellers of medical services, through the AMA, ADA, etc., spend a large amount of resources to persuade buyers to choose among physicians as if the choice were random.[23] Various measures taken by the AMA lower still further the return to measurement by patients. A high uniformity of skill among physicians is attained through the control of training, of qual-

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[21] This parallels the argument that with the royalty-payment scheme, authors and publishers will abstain from collecting duplicate information on the value of a manuscript.

[22] The hypothesis could be tested by comparing the behavior of shopkeepers in resort areas during the tourist season with that during the off-season.

[23] The assumption of competition through free entry does not hold in this case. As will be shown presently, however, in at least one dimension the restriction on entry may prove to be efficient.

ifying examinations, and of admission to medical schools (where, e.g., large fellowships are less readily available than in other graduate programs). Not surprisingly, then, medical school graduates seem more uniform in ability than those in other professions.[24] Moreover, the gap between the training of nurses and physicians is so wide that only seldom would patients compare the services of the two.

Comparison among physicians also is discouraged. Physicians are constrained from criticizing one another, and until recently were not allowed to advertise and were severely restricted with respect to office signs, yellow-page entries, and the like. Additionally, price information is kept in low profile. Thus, a patient can compare physicians only by expedients such as word of mouth.

If the preceding hypothesis is correct, the following observations are implied: (1) The AMA would resist moves to make comparisons easier. (2) The easier it is for patients to measure a medical service, the looser will be its control by the AMA. (3) Income variability among doctors would be less than in other professions that require a comparable amount of training, such as law. Casual observations on the first two implications are in conformity with the hypothesis. The tenacious fight of the AMA against prepaid medical insurance is consistent with the first implication. The question as to whether to join such an insurance group itself requires comparison, and when a compensation schedule is provided, price comparison becomes easier.

With respect to the second implication, consider the distinction between acute and chronic medical problems. A person afflicted with a chronic problem gains experience which in time increases his ability to measure the service he receives. To that extent, he has a comparative advantage over someone with an acute problem. From this it is predicted that the treatment of chronic problems will be less tightly controlled by the AMA. This seems to be borne out by the fact that chiropractors, whose specialty is treating predominantly chronic ailments, are allowed to compete with physicians.

Vertical Integration

When production is specialized, the product will change hands before reaching the ultimate consumer. In this section, some of the problems associated with measuring the product in its intermediate stages are analyzed.[25] Home production is an extreme form of vertical integration.

[24] Medical societies also deny membership, and the right to practice, to physicians who prove ''incompetent.''

[25] Cohen's discussion of the firm is based, in part, on the difficulties in measurement. L. R. Cohen, The Firm: A Revised Definition, 46 S. Econ. J. 580 (1979).

Since all stages of production are carried out by a single person, the motive for excess measurement is absent but the advantages of specialization are lost. What role does the vertically integrated firm play regarding the problem of measurement?

Consider a production process requiring several workers. A firm employing these workers will incur the costs of contracting with them and policing their activities. These costs would be avoided if the process were divided among firms, each consisting of one worker who would buy the intermediate good from the one preceding him on the production line. He may also buy other needed materials and buy, or rent, the space and equipment he uses. These factors, combined with his own work, would enhance the value of the intermediate good which he subsequently would sell to the next man on the line.[26] If production is so organized, the problem of "shirking" disappears.[27]

At most points, however, the value of the intermediate product may be difficult to assess, and therefore its sale may be accompanied by excess sorting. Thus, costs are incurred also in the exchange among such firms. Sometimes the relationship between input and output is well understood. The change in input may then serve as a satisfactory proxy for the change in output value.[28] As will now be shown, the use of input as a proxy for output does not by itself necessitate exchange within a firm, though it is a condition for this form of organization.

Would separate one-worker firms be formed in a production process spanning the tasks of several workers where output is easily measured at the end points but not at others? If the first step is organized as a separate one-worker firm, its output has to be sold to the firm performing the next task. As asserted, it is more costly to evaluate that output directly than to

[26] During the 1860s, several major industries in Birmingham were composed of numerous one-man firms. See G. C. Allen, The Industrial Development of Birmingham and the Black Country, 1860–1927 (1929; reprinted ed. 1966).

[27] Jensen and Meckling analyze the problem of borrowing and of the associated policing when the amount of capital required for the efficient firm size diverges from what the entrepreneur can supply. For their analysis to hold, firm size has to be independent of what they call "agency cost." This would be the case if optimal firm size were an exogenous "technological" datum. It is suggested here that this size is itself economically determined. See M. C. Jensen & W. H. Meckling, Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure, 3 J. Fin. Econ. 305 (1976).

[28] Alchian and Demsetz state, ". . . Suppose a farmer produces wheat . . . with subtle and difficult quality variations determined by how the farmer grew the wheat. A vertical integration could allow a purchaser to control the farmer's behavior in order to more economically estimate productivity." A. A. Alchian & H. Demsetz, Production, Information Costs, and Economic Organization, 62 Am. Econ. Rev. 785 (1972). This statement comes close to the basic argument here. Alchian and Demsetz, however, do not make the crucial distinction between random and biased errors.

measure the value of the products entering the first step plus its additional inputs. Thus, to determine the value of the product it receives, the second firm will have to monitor the inputs of the first firm. So long as the transition to the third-step output can be measured cheaply, however, there is no clear advantage in integrating the first two steps.[29]

When inputs have to be measured at two successive junctures, a rationale for an integrated firm emerges. If the second firm is also a one-worker enterprise whose output is difficult to measure, the firm performing the third step will have to monitor not only the inputs in the second step but also the value of the product entering the first step and the inputs within the step. Thus, the inputs of the first firm have to be monitored by both the second and the third firm. Although the second firm could provide the third with its own evaluation of the first firm's inputs, it stands to gain from overstating the case. The third firm, then, would need to verify the figures in some way. The problem is obviously compounded as the number of steps increases. If a separate organization performs this function for all steps, the conservation of information is clear: There is no longer a need for each firm to monitor the inputs in all prior steps. It is hypothesized that this is a function of the "firm."[30]

In view of this explanation, the notion of residual payments so commonly associated with the firm obtains an entirely different interpretation. When output is easily measured directly, the contribution of a worker can be assessed by his output, and there is a strong incentive for him to become self-employed. At other times, output can be measured by inputs more cheaply than by measuring it directly. If output is measured by inputs, remuneration of inputs cannot be based on output. Employees of a firm are paid by inputs rather than by output not because of lack of "entrepreneurship," but rather because their input is measured more eco-

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[29] Indeed, airlines employ engineers to inspect the airplanes assigned to them while they are being built by Boeing. Similarly, in other equipment contracts and in construction it is not uncommon that the buyer retains the right to inspect the production process.

[30] Coase pointed out two forces favoring organizing production by the firm rather than by the market. One is the cost of "discovering what the relevant prices are"; the other is "the costs of negotiating and concluding a separate contract for each exchange transaction which takes place on a market." R. H. Coase, The Nature of the Firm, reprinted in Readings in Price Theory 336 (1952). Suggested here is another force—the cost of measuring intermediate outputs which, it is argued, favors production within a firm. The motive for vertical integration suggested here resembles that offered by Klein et al. See Benjamin Klein, Robert G. Crawford, & Armen A. Alchian, Vertical Integration, Appropriable Rents, and the Competitive Contracting Process, 21 J. Law & Econ. 297 (1978). Their argument, however, hinges on small numbers; at the extreme, one buyer facing one seller. There is no restriction here on the number of either buyers or sellers. In Williamson's view also, small numbers are a necessary condition, since vertical integration "harmonizes interests" and reduces the hazard of cheating between firms (see Williamson, *supra* note 8, at 82).

nomically than their output; otherwise they would have become self-employed. Having employees bear the risk in output value through direct ownership has no desirable incentive effect and thus is of little purpose. When tasks are performed by employed workers, "shirking" becomes a problem and the entrepreneur is remunerated for his monitoring of inputs, which implies that he has to assume the risk of price and other fluctuations.[31]

Distinct firms will form and trade with each other at junctures where output can be readily measured, but where output is difficult to measure the different steps will be performed within the firm. Between the time that a commodity such as canned salmon leaves the manufacturer and the time it reaches the consumer, its physical properties and its value will have changed only slightly. Other goods such as produce and bread may change a great deal. The ownership of a commodity may not change at all between production and consumption, as is the case with home-grown vegetables, or it may change several times. It is predicted that ownership will change more frequently the less the commodity is subject to change. Thus, canned salmon is expected to change ownership more times than fresh salmon, powdered milk more than fresh milk, cookies more than fresh bread, and so on. A comparison, admittedly casual, of cookies and bread is in conformity with the prediction. Grocers buy the cookies they sell, but only rent shelf space to bakeries for bread sold through them.[32]

ERRORS OF PROXY MEASUREMENT

Often, the units by which a commodity is exchanged differ from those for which it is desired. For example, tires are measured by ply, size, and tread, whereas they are valued for strength, road-holding ability, and longevity; oranges are sold by weight, which includes the seldom-wanted skin. In this section, some of the problems that arise from the use of proxies are discussed.

Consider the tastiness of apples. Suppose that taste is extremely costly to measure and that it is correlated with color, which can be measured by the naked eye.[33] Color, then, is used as a measure of taste, and the market price of apples becomes a function of their color—the redder are Red

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[31] This argument strongly parallels that of Alchian and Demsetz, *supra* note 28. Their "team production" output can be measured cheaply, but because of scale economies the output of a team member cannot. Team members, then, have to be policed and are remunerated according to their inputs.

[32] Coor's beer, which is more difficult to keep fresh because it has no preservatives, is supposedly monitored by that brewery more vigorously than do other breweries.

[33] John Umbect says (personal communication) that in Tangier, tangerines offered for sale are displayed on a branch with a leaf or two. The apparent reason is that a leaf is a better visual indicator of freshness than is the fruit itself.

Delicious apples, the higher is their price. Thus, an orchardist will op-
timize with respect to color.

When the proxy measure can be manipulated, here, too, people will
redistribute income at the expense of resources. Suppose that a chemical
fertilizer can enhance apples without affecting their taste. Abstracting
from the asesthetic value of apples, if the consumer cannot discern
whether the chemical has been used and obtaining that information is too
costly, the orchardist will then apply the chemical.[34]

Since consumers ultimately value apples for their taste and not their
color, had it been possible effortlessly to stop the use of the fertilizer, the
cost of the extra reddening would have been avoided without incurring
any other loss.[35] The use of the proxy seems wasteful—the apples are
made "excessively" pretty. The proxy, however, is presumably used
because the alternative of not using it is still more costly.

The use of the chemical will affect the relationship between color and
value. Assuming diminishing marginal valuation, R_0 in Figure 1 is the
original relationship between the two attributes. The application of a
given amount of the fertilizer will shift the curve to the right to R_1. Apples
of any given color are now valued less. Still, the redder an apple is, the
tastier and more valuable it is. The shift in the curve, however, is not
likely to be uniform. Rather, the redder the apples are to start with, the
smaller is the shift. This is due to two factors, each of which is sufficient
for the argument here. First, the originally redder apples are likely to gain
less in value from a given increase in color. Second, a given dose of the
fertilizer is expected to affect them less noticeably.

Thus R_1 is steeper than R_0. Given the cost and the error of measuring
redness, the steeper relationship constitutes a reduction in the informa-
tional value of the color of apples. This is a force constraining the applica-
tion of fertilizer, but it also guarantees that some amount will be used. To
see this, assume momentarily that the relationships between redness and
value and between redness and the amount of fertilizer are both linear.
This means that R_0 and R_1 are parallel straight lines. If the return from the
application of one unit of the chemical is positive, then a reapplication will
yield the same return. Eventually, however, consumers would cease to
employ color as a measure of taste. At this point, the return from its use in
any amount will drop to zero. But as the use of the fertilizer is discon-

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[34] A grower using the fertilizer need not be aware that his behavior is dissipating. He is
informed by the market-price structure that consumers value redness, and that is what he is
providing.

[35] Spence's "signal" is also a measurable attribute which is correlated with the "true"
one and subject to manipulation. See M. Spence, Job Market Signaling, 87 Q. J. Econ. 355
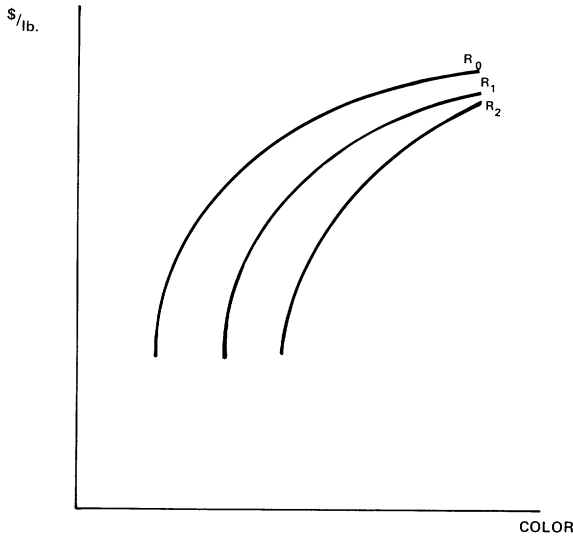(1973).

$/lb.

FIGURE 1

tinued, the relationship between color and value will be restored, return-ing us to the starting point of the cycle.[36]

When returns are diminishing, however, the dilemma disappears. In Figure 1, R_2 represents the effect of a second dose of the fertilizer. The return is lower because the effect on color is less than that of the first dose, and also because an extra unit of color increases revenue less than it did before, as R_2 is steeper than R_1. As more fertilizer is used, a point will be reached at which the return from an extra dose is equal to its cost.

If the simplifying assumptions—that the fertilizer does not affect taste and that color is valued only as a proxy for taste—are relaxed, the analy-sis grows more complicated but the logic remains the same. To the extent that taste would be improved by the use of the fertilizer, dissipation is decreased. If taste is affected adversely, but the correlation between taste and color remains positive, dissipation will exceed the cost of the fer-tilizer. If taste is affected more than color, too little of the chemical will be used; indeed, it will not be used at all if it does not alter color even though it improves the taste.

Now, relaxing the second assumption, suppose that the color of apples is valued for its own merit. In this case, the fertilizer will be applied apart from its effect on taste, and it will be used beyond the point that would

[36] Rothschild and Stiglitz present another "no-equilibrium" result. Their setting is com-petitive insurance markets. See Michael Rothschild & Joseph Stiglitz, Equilibrium in Com-petitive Insurance Markets, 90 Q. J. Econ. 629 (1976).

have been dictated if color were merely a proxy for taste. The rest of the analysis remains unchanged.

The color of apples can undoubtedly be affected in other ways, such as the choice of harvest time, of storage temperature, and so on. Each of these methods will be used (and the information content of color function "degraded") to a point where the return equals the cost. The general principle is that maximization occurs with respect to whatever measures consumers use to determine market values. Presumably, the measures in actual use combine a high correlation with the desired ones while possessing high resistance to degradation.

Activities directed toward the market measures will, in general, be off the mark in terms of their effect on the "true" measures. Nevertheless, a grower who applies less of the fertilizer will find his revenue declining more than his cost since, given the assumptions here, he is unable to convince consumers that his less colorful apples are as tasty. This is an instance where the "bad" drives the "good" out of the market. Similarly, a consumer cannot gain by buying apples that are not as red as his own preferences dictate, since the price structure of applies of different shades of red is itself determined by consumers' valuation.

It is tempting to think that if a grocer would mark a bin of apples "ugly but tasty," and if the apples indeed proved flavorful, he could overcome the problem of the spurious measure.[37] The difficulty in convincing buyers that what looks unattractive may nevertheless be good is illustrated by the owner who spends resources to "beautify" the house he plans to sell in a way he did not feel was worthwhile when he was living there. Buyers are well aware of this common practice, but its survival demonstrates that the skin-deep treatment does affect their decisions. In the case of apples, the greatest benefits accrue to those growers able to convince consumers that they avoid the fertilizer while in fact using it. It is difficult to allay consumers' suspicions, since for each type of apple the redder it is the better it tastes.

Still, suppose that to a particular grower the cost of convincing consumers that no fertilizer was used is low enough.[38] It is predicted that on average the grower's apples will look less attractive, or rather, less red, than those grown with the fertilizer; that for given redness, the unfer-

[37] Safeway stores seem to harp on this theme when advertising their "Scotch Buy" brand as "It ain't fancy but it sure is good!" This brand, however, is backed by Safeway's own brand name. Two other examples (supplied by Marion Impola) of attempts to dispel mistrust are a seller's sign by his Kiwi fruit, "Ugly, but interesting," and Smucker's ad, "With a name like Smucker's, it's got to be good."

[38] If a growers' association can police its members more cheaply than consumers can police a grower, the association is expected to prohibit the use of the fertilizer. This restrictive practice actually promotes efficiency.

tilized apples will be more expensive; and that the unfertilized apples of a given taste will be cheaper, an implication that is easy to verify subjectively but not objectively.

Given the last implication, the unfertilized apples should drive the other apples out of the market. However, the cost of upholding the no-fertilizer claim will vary among consumers. It is expected, then, that both types of apples will continue to be provided. It seems plausible that the farther consumers are from the grower, the higher the cost of creating "trust." The notion that better Washington apples or California oranges will be shipped to the East Coast then applies to the better-looking, but not to the better-tasting, fruit.

FUTURES MARKETS[39]

The impersonality that characterizes markets in received models does not appear to hold for most actual markets, where the identity or brand name of transactors is essential to functioning. In "futures" markets, however, the trustworthiness of the parties is inconsequential, since apart from the enforcement role of the exchange there is no continuing relationship. The exchange certifies that the traded commodities meet the required specifications and that payment is forthcoming. Thus, the buyer need not worry about receiving defective merchandise and the seller does not have to spend resources to collect his pay. However, far from the accepted view, it appears that such impersonality is attained at high cost.

Suppose that the rate at which a good will deteriorate can be controlled. If the present price decreases as expected deterioration increases, the seller will spend resources to retard that process. Suppose, however, that measurement of the expected deterioration at the time the exchange is agreed upon is so costly that it will not be performed. Now, if the exchange is strictly by specifications, as in the futures trade, the prevention of deterioration will not occur since it will not be remunerated. On the other hand, in the spot market, where sellers operate under a brand name, deterioration will be controlled because a positive return is expected.[40]

This distinction may explain an otherwise puzzling phenomenon: Farm products traded in futures markets tend to be characterized as of "low-quality" or "garbage" grade.[41] How can such a term apply to a commod-

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[39] An earlier analysis of these markets by Acheson and McManus is not unlike the one presented here. See K. Acheson & J. McManus, The Costs of Transacting in Futures Markets (August 1979) (unpublished paper, Carleton Univ.).

[40] Lindsay draws a similar distinction between government output that is evaluated strictly by specification, and private output, in which unspecified margins are (somehow) adhered to. See Cotton M. Lindsay, A Theory of Government Enterprise, 84 J. Pol. Econ. 1061 (1976).

[41] The costliness of measuring the protein content of wheat and the resulting allocation of

ity that meets all stipulated specifications? The answer may well be that other *non*stipulated attributes will be underproduced when the commodities are destined for futures markets. The levels of the valuable qualities could have been increased at a lower cost than their valuation except for the cost of measurement—which has prevented such action. For this reason, producers are not expected to plan to produce for the futures markets. Only when the commodity is found unsuitable for regular customers would they divert it toward the futures market.

Since commodities sold in futures markets are also sold in spot markets, two testable implications are suggested. First, the price in the spot market is predicted to be higher than that in the futures market for what appears, in terms of specifications, to be the same commodity. Second, specifications are expected to be more comprehensive in futures markets than in spot markets. Since brand name is already established in the spot market, some direct measurements can be dispensed with.

Uncertainty and Dissipating Behavior

Diminishing marginal utility of income implies that the more income varies around a given mean the less it is valued. The presumption that in reality the marginal utility of income is indeed diminishing is the basis for the accepted explanation of insurance, product warranties, and sharing arrangements that are said to reduce the uncertainty facing the individual. It was suggested, however, that warranties and sharing arrangements may be explained by a quite different force: the cost of getting reliable information about a good. This argument is now more generally related to the problem of uncertainty.

Some uncertainty is truly and entirely random; in most situations, however, opportunities abound for the human hand to affect the odds. A person facing an uncertain situation has reason to fear that if the odds are tampered with, they will not be in his favor. A used-car buyer who suspects that the salesman will attempt to saddle him with a worse-than-average car will take some countermeasures. Both the odds tampering by the seller and the protective steps by the buyer consume resources. The buyer, then, would pay a premium independent of any "risk aversion" to convert the uncertain situation into a certain one.

The risk-aversion model predicts that risk will be shifted toward the party for whom risk is less costly. The prediction here is that whoever is in a position to affect the odds will tend to assume the risk, though the two are not mutually exclusive. The payment of royalties rather than a lump

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high-protein wheat to regular channels and low-protein wheat through impersonal channels is described by Carl L. Alsberg, Protein Content: A Neglected Factor in Wheat Grades, in 2 Wheat Studies of the Food Research Institute 163–76 (1926).

sum to an author, and particularly to a novice, tends to support the latter hypothesis.

The offering of warranties or of some other means to reduce uncertainty is itself costly. It is predicted that the more easily tampering can be detected and the larger the subsequent loss, the less frequently will a warranty be offered. Indeed, people are expected to expose themselves deliberately to detection to reduce the buyer's fear of being cheated.[42] It is predicted, though most tentatively, that well-established law firms will set fixed fees or fixed hourly charges rather than contingent fees more often than will less prestigious law firms. The highly reputable law firm having more of a reputation to protect is expected to monitor its members to provide clients with satisfactory service. To attract business, law firms of lesser reputation in effect offer insurance when they base their fees contingent on good performance.

CONCLUDING REMARKS

The problems and costs of measurement pervade and significantly affect all economic transactions. Errors of measurement are too costly to eliminate entirely. The value of equally priced items will differ, then, and people will spend resources to acquire the difference. Such resource expenditure is wasteful, and it is hypothesized that exchange parties will form such contracts and engage in such activities that reduce this kind of resource use. The customer's random selection from an already optimally sorted commodity will avoid the excessive expense. Thus, for example, it is expected that some readily obtainable information will be suppressed to preempt opportunities for excessive measurement.

Because inputs are sometimes the best available proxies for measuring output, vertical integration in the form of organizing output within firms can conserve some measurement costs. Measurement losses also can be lowered by other expedients such as share contracts and warranties. "Trust," "brand name," "repeat purchases," and the like also lower the need for costly measurements, though they are too costly to produce.

The fragments of evidence presented are only illustrative and should not be construed as a test of the model. Even the hypotheses offered are rather tentative; more thorough knowledge of the details of market organization are needed to make firmer predictions. They help to demonstrate, however, that the concept of "measurement" is operational and that the model based on it is capable of generating testable implications.

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[42] The owner of a race track has less incentive to tamper with the results of a horse race when betting is on a parimutuel basis, which may explain the prevalence of that arrangement. In general, it seems that organizers of games of chance are rewarded not on the basis of their risk but of gross income. Sellers of insurance, on the contrary, subject themselves to substantial risk.