Replacing the Law of One Price with the Price Convergence Law

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Abstract

Agreements for the exchange of commodities typically consist of two major components. Explicit, objectively measured contractual component enforced by the state, and implicit, subjective component enforced by sellers’ reputation. It is easier to become informed about the former than about the latter. I expect prices to diverge because the market does not fully adjust for differentials due to differences in the reputational component. The compilers of price indices tend to take account only of the contractual components of exchanged commodities. Because they ignore the reputational component of exchange, I expect empirical worker to reject the laws of one price as well as that of the PPP. I formulate an alternative law: As information about a commodity improves, its price variability will decline. As the cost of information or, more specifically, of measurement falls and especially when commodity standards are formed, and as the gain from using it increases, transactors will shift attributes from the reputational component of their agreements into their contractual component. Uncertainty about the make-up of commodities will then decline, and at the same time, price compilers would do a more accurate job. Both factors will lower the observed price variability.

1. Introduction

The “law of one price” has acquired the status of a folk theorem. In recent years, however, it fared well neither empirically nor theoretically. For instance, Isard (1977), who tested the law states (p.

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1 I wish to thank Dick Startz for his comments and Maria Kozhevnikova for her assistance.
942): “In reality the law of one price is flagrantly and systematically violated by empirical data.” Rogoff (1996) surveys the literature on the law and on the purchasing power parity (PPP), and reaches the same conclusion. Taylor and Taylor (2004) discuss the narrowing of the gap between the theory and the empirical findings and the tendency toward convergence. Machesney et al (MSH, 2003) point to serious conceptual difficulties and inadequacies with the notion of one price. The literature, however, says little about conditions that make the violation of the law more or less severe.

In this paper I construct a (informal) model that derives conditions under which price variability will increase or fall. The model also implies that the law of one price is bound to be refuted. This may appear to reiterate the findings in the literature. I argue, however, that existing tests of the law of one price are flawed. They compare prices of commodities that are not truly homogenous. The flaw is the result of the failure to account for the costliness of commodity information (which is a factor distinct from those advanced by MSH).

At the heart of the problem is the multi-dimensionality of transactions in commodities and services, combined with the fact that the cost of, and the gain from measuring the level of each attribute
differ from those of others. Sellers tend to guarantee the levels of the attributes of the commodities they sell. They guarantee some of them by contract, and others by their reputation. The contractually guaranteed attributes are explicitly measured, for example, that a steak a restaurant serves is not spoiled and weighs no less than what the menu states. The attributes that are guaranteed by sellers’ reputation are only tacitly stipulated in exchange agreements, for example, how tasty the steak is or how pleasant is the service. Buyers encounter difficulties in measuring the latter attributes and outside observers encounter even greater difficulties in measuring them. Individuals therefore, are not certain as to what the real prices of commodities (and services) are.

The state has a comparative advantage in enforcing easy-to-measure attributes because these tend to be common to many commodity specimens and there are scale economies in enforcing them by the state. The tacitly guaranteed attributes tend to be unique to each specimen or brand and thus would not benefit from the scale economy of state enforcement. We expect, among other thing, that as standards

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2 Whether or not attribute levels are stipulated in contracts also depends on the reliability and probity of the legal system. The state of the legal system is taken as given in this paper.
are formed, sellers will switch attributes from the tacit component of the sale agreement to its contractual component.

As one example, consider the hedonic estimate of price change. The hedonic “builds up” commodities from their attributes. This procedure obviously requires information on the attributes. Research workers estimating the hedonic function, however, do not deem it necessary to bring up information issues. They rather assume that consumers (costlessly) know all there is to know about commodities. In their empirical work, researchers tend to overlook the difficult-to-measure, tacitly guaranteed attributes of commodities (how comfortable an automobile is) even though such attributes are pervasive. The neglect of the tacitly guaranteed commodity attributes is common to the compilation of all price indices I am familiar with. Such price indices, then, leave a great deal of fuzziness as to what is being measured. Services are usually only tacitly guaranteed because their attributes tend

3 Stigler’s (1961, p. 224) observation that “Quality has not yet been successfully specified by economists, and this elusiveness extends to all problems in which it enters” seems as valid today. I suggest that the tacitly guaranteed attributes are what give commodities their “quality.” The quality problem is addressed here as well as in Barzel (2004). Vernon (1966) also emphasizes the importance of commodity information, especially of the role of standards in reducing search cost. Thanks to Bentley MacLeod for bringing Vernon’s contribution to my attention.
to be difficult to measure. They are subject even more acutely to the problem that commodities are subject to.

Taking account of the costs of acquiring commodity information, I attempt to quantify the *extent* of our ignorance, which responds to Stigler’s statement when he says (1961, p. 214), “Price dispersion is a manifestation--and, indeed, it is a measure--of ignorance in the market.” In Section 3 I formulate a new law entitled “The price convergence law.” This law predicts that the degree our ignorance will increase or decline as the level of commodity information falls or rises.

2. The law of one price and perfect competition

The notion that the same commodities command the same prices is old. Cournot ([1838] 1927, p. 51) seems to have been the first to assert such price uniformity. Tying it to the market, he states “the market is the entire territory of which the parts are so united by the relations of unrestricted commerce that prices take the same level throughout with ease and rapidity.” Marshall ([1920] 1952, p.325), being more circumspect, says “the more nearly perfect a market is, the
stronger the tendency for the same price to be paid for the same thing at the same time in all parts of the market.”

In its simplest form the law is confined to a point in space. Marshall, however, proceeds to say, “Allowance must be made for the expense of delivering the goods…” Allowing for shipping costs (inclusive of tariffs) is a crucial step in that it alerts us to the opportunity for expanding the domain of the law. Marshall’s adjustment expands the domain of the law from a point to an area. This expansion forms the basis of the purchasing power parity (PPP), where the law has received much of its empirical testing. Taylor and Taylor (2004, p.137) state “[T]he Law of One Price, [abstracting from, or ignoring transport cost] implies that a PPP exchange rate should hold between the countries concerned.” Another extension that can further expand the domain of the law is in combining two or more of its applications. For instance, the law then applies not only to the adjusted unit cost of

4 The citations from Cournot and Marshall are taken from MSH.

5 In its crudest form (Cassell), the PPP states that adjusted for the exchange rate, the price levels in different countries should be the same. In the Ballassa-Samuelson version, the indexes may diverge because of transportation costs. Marshall’s notion, which is followed here, compares individual prices, not indices.

6 Note that the PPP pertains to traded goods; these, as a rule, are easier to measure that non-traded goods and services.
commodities but also to combinations of commodity-attributes. This application of the law forms the basis of the hedonic price index. The extension applies as well to price differences across times.

MSH’s primary argument is that the transportation cost qualification is flawed, and that the law of one price “was meant to apply only to perfectly competitive markets where knowledge is perfect.” Indeed, perfect competition is a sufficient condition for the law. Under perfect competition buyers and sellers are informed at no cost of the quality of the commodities traded and of their prices. Where knowledge is costless we expect prices to converge instantaneously.

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7 Marshall’s extension of the law to an area requires that transportation too would be subject to it. Only then would the extension work. Thus, he implicitly combines two commodities each of which is subject to the law.
8 MSH point to a wide range of caveats to the law brought up by other economists. They argue that because of these, the law is not falsifiable.
9 The relationship $P=MR=MC=AC$ holds under perfect competition. The law does not hold under regular or locational monopoly or under quantity discount. To avoid MSH criticism we must assume that producers have no locational monopoly. The possible deviation from perfect competition is not germane to the question of what constitutes the same commodity, however, and therefore I abstract from it.
10 All the studies of the Law of One Price and of the PPP that I am familiar with seem to implicitly assume that commodity information is costless.
Consider the law itself. I was unable discover a formal statement of the law. It seems, however, that it says something like: “Under competition specimens of the same commodity would sell for the same price within a market area.” A law must always hold. Any price discrepancy among (quality adjusted) specimens of the same commodity would refute the law of one price.

As tests of the law seem to refute it, what might explain its refutation, and what alternative model(s) could account for the observed facts? Marshall, astutely, does not claim that price uniformity is a law; he only asserts a tendency toward it. Elaborating, he says that the tendency is very strong for commodities such as gold and government bonds that the public easily recognizes as homogeneous. He also says (p.325) that “all those things for which there is a very wide market are in universal demand, and capable of being easily and exactly described,” are subject to the tendency. He does not pursue the issue further, however. I concur with Marshall’s (and others) that the tendency towards one price is expected to be strong for homogenous commodities.

The only reasons given for why the law is refuted are that prices are subject to “transaction costs,” to “frictions” and to “border
penalties,” and that adjustments are “sluggish.” These, however, do not constitute explanations. Without a model attempting to explain the disparity from price uniformity we cannot evaluate the empirical results. Among other things, absent an alternative model, Isard’s notion that the law is “flagrantly” violated is not meaningful. We lack a yardstick to decide what constitutes a significant price discrepancy. None of the studies of the law of one price or of the PPP that I am aware of offers an alternative model that might provide such a yardstick.

I argue that commodity information is at the heart of such explanation. When information is costly, people must spend resources on search to assure them that the prices they pay would not be “too high.”\textsuperscript{11} Since collecting information takes time and effort, prices cannot adjust instantaneously and discrepancies are inevitable. There is no a priori reason, then, to believe that one price would hold under costly information. Moreover, for many commodities, the forces that might lead to convergence, whatever they are, appear to operate slowly at best. Indeed, it is all too easy to observe specimens seemingly of the

\textsuperscript{11} Stigler addresses the price dispersion issue in this fashion.
same commodity selling at different prices. It is not surprising that empirical studies claim to refute the law.

The law of one price is subject to another problem. Laws must take a form such as: “as x takes certain values, y would take corresponding values.” The “law of one price,” however, does not seem to be a law since it yields a constant. I offer an alternative, relying on commodity information, suggesting that as its cost changes, so would price discrepancies. I argue that commodity heterogeneity is bound to generate diverse prices even after accounting for quality. Moreover, as will be seen, one price emerges as a special case--a point--of the proposed law.

3. Commodity information and the Law of Price Convergence

As stated, the scope for testing the law can be expanded by accounting for the three contributors to commodities’ price differences—differences in their attributes, location or transaction time. Under competition, one could then test the law for any observed price difference between any two commodities, even if one is a rickshaw in pre-communist China and the other is a new Caddillac. One “simply”
evaluates all the factors that contribute to the difference in price, and these should add up to the actual difference.

I hypothesize that information costs generate a fourth source of price differences. Individuals cannot costlessly determine whether observed price differences among specimens of a commodity are equalizing, or whether they are genuine. As a result of this uncertainty, they do not instantly eliminate genuine price differences. Moreover, prices may differ because of search cost to determine what the actual prices are. I predict, then, that even after adjusting for differences in make-up, location and time of transaction, commodities prices would not be uniform. I therefore expect the law of one price to be refuted. In the remainder of the paper I focus on the make-up of commodities and abstract from the differences in time and in place.

I formulate a new law designated “The price convergence law” which states that:

As information about a commodity improves, its price variability will decline.

Price variability, a measure of our ignorance, is the consequence of errors in individuals’ assessment of what the make-up of a commodity is which results in genuine price disparities. The new law
implies that such ignorance, and with it, price variability would decline as commodity information improves; when it becomes cheaper or more profitable to collect. Since the levels of information about different commodities (and services) differ, the level of ignorance across commodities also differs. Thus the law of one price is summarily refuted for some commodities while the data tend to support it for others. Among the latter are commodities that can be transacted anonymously without inspection since the information about them must be very good. By my hypothesis, the law of one price constitutes a point on the function where information cost is zero as zero variance, i.e., one price would prevail then.

As argued below, a fall in the cost, or an increase in the value of information will tend to transfer attributes to the contractual component of commodities. As a result of the improved information, we expect the variability in the non-contractual component to fall, even not holding constant the levels of these commodity attributes.

To this point it was taken for granted that the meaning of what constitutes the “same commodities” is clear. The above discussion implies that this is not so. I consider two commodities to be the same if all their specifications, or attribute levels, whether delineated
contractually or by reputation, match each other. It should be recognized, however, that as an economic, i.e. behavioral concept, when information costs are positive, homogeneity does not require specimens of a commodity to be identical. It only requires that ex ante, given the price, individuals are indifferent as to which specimens they give or receive. Subject to this caveat, I proceed to explore the sameness notion.

4. **Sellers’ guarantees of commodity information**

Individuals stand to gain from discovering genuine low prices as well avoid paying high ones to get, or avoid, what they use and for speculation. How do they discover the make-up of commodities; how do they gain from price disparities; and how do their actions affect price variability? Section 9, concerned with price-adjustment forces, discusses information that buyers collect for speculation. In this section I focus on users’ information; primarily information that sellers provide.

As a rule, buyers (re)discover the make-up of commodities as they use them. But they want assurance not being short-changed before committing to buy. They often acquire the information by inspection. Sellers, however, usually already possess the information, and can
transmit it to buyers. Sellers, though, must convince buyers that they provide true information. Buyers will trust them if they demonstrate that they stand to lose if the information they provide is wrong. Sellers transmit information in the process of making promises, and guarantee the information by making the promises credible.

Sellers make explicit promises on the levels of the attributes that are contractually guaranteed. They make implicit, tacit promises on the levels of other attributes that they guarantee by their reputations or brand names. (For some attributes they may choose to make no promises, letting caveat emptor govern their sale. Buyers can ascertain the levels of the latter attributes by inspection). I now enquire into the factors that govern the division of attributes among the two guarantee forms.

Commodity information can be classified into information about the attributes that are common to all the specimens of a commodity and to information about idiosyncratic attributes of the individual specimens. The information about the common attributes as well as

12 People do not automatically possess either type information. Rather, they acquire it, at some cost, through their own and others’ experience.
their delineation are public goods in that once obtained for one specimen, they can be applied at no added cost to all others.

The tacit component of agreements (as well as that subject to caveat emptor) covers attributes that are not subject to standards and are not, or at least, not known to be common to all items. Information about these attributes is, as a rule, a private good. Every transactor must spend resources to learn about them, sometimes separately for each specimen.

On a per specimen basis, the attributes that are common to all specimens can, as a rule, be measured cheaply. Thus they are suitable to be placed in the contractual component of agreements, especially when they are subject to standards.\(^\text{13}\) Sellers make explicit, contractual promises (appliances specifications; labels on cans) for easy to measure attributes. The contractual component of commodity sale agreements tends to be publicized. These, then, tend to be publicly known, and can be priced reasonably cheaply in the market. The cost of acquiring information on these public goods, while still positive, is likely to be less than the cost of generating it.\(^\text{14}\)

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\(^\text{13}\) I discuss standards in Barzel 2004.
\(^\text{14}\) The literature, however, tends to views information on public goods as “common knowledge.” It would not be “common,” however, unless
The idiosyncratic attributes tend to be expensive to measure and sellers find it economical to guarantee them by reputation. As it is difficult to obtain objective information about the make-up of the non-standardized components of commodities, buyers do not become fully informed about their contents. They also find it difficult to price these attributes, and still more difficult to price the attributes or commodities sold under caveat emptor. Outside observers find it difficult to price tacit promises, and exceedingly difficult to price caveat emptor attributes. This problem is especially acute for the attributes subject to caveat emptor since these are not part of any agreement. The extent to which the exchange of commodities and services is governed by contract, then, determines how solid is the information about their prices. When discussing below buyers’ attempt to resell just purchased commodities, I elaborate on the nature of their costs in ascertaining commodities’ make-up.

[Sellers guarantee the easier-to-measure attributes (for example, that a steak a restaurant serves is not spoiled and weighs no less than what the menu states) in the contractual component of their agreements.

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it could be acquired without *any* effort. Even looking up a definition in a dictionary consumes resources.
The attributes that are difficult to measure and verify (how tasty the steak is or how pleasant the service) are guaranteed by reputation.]

Buyers seemingly are aware that commodities sold by sellers with different brand names that appear to be the same may, in fact, differ. Since buyers do not eliminate all genuine price differences, sellers of each of the similarly appearing commodities have some discretion in their pricing. Moreover, beyond a certain point, the gain from eliminating price differences are unlikely to decline with the passage of time. Price differences among similarly appearing commodities may persist then. The difficulty of acquiring information about transaction attributes that are either guaranteed by brand name or are subject to caveat emptor, then, is at the heart of the problem both of the validity of the law of one price and of testing it.

The previous discussion of commodity information applies even more forcefully to services. As a rule, services are consumed as they are produced. Thus, they cannot be sold on a caveat emptor basis. Moreover, it is usually difficult to contractually specify their
attributes. Thus most services are guaranteed by reputation rather than by contract. For instance, patrons cannot inspect a play to decide whether to buy a ticket, nor is the play’s quality likely to be guaranteed. They base their decision on the reputation of the theater-company combined with information on past performance. Outsiders have scant basis by which to evaluate the service. More generally, the compiler of price indices that cover services has little firm information to determine changes in the their real price.

How do services fare under the two laws? Consider the educational services that private colleges provide. The observation that tuition, which is a function of cost, varies significantly across colleges, even ones that appear similar to each other, seems to refute the law of one price. The price convergence law could be tested if we could identify situations where measuring colleges’ output becomes cheaper. For instance, suppose that surveys of starting salaries of college

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15 Electricity is also sold essentially while it is produced. However, measuring its attributes is relatively easy, and thus it is easy to contractually guarantee it.
16 Some of the transaction attributes such as the appearance of certain actors as well as seat assignment may be contractually guaranteed.
17 Theater (and other) tickets are subject to speculation (scalping). Speculators purchase tickets when they expect prices to increase. Their predictions, however, seem not to depend on the actual quality of the particular performances.
graduates became available. The prediction here is that tuition variability will decline after the appearance of such surveys.\textsuperscript{18}

5. Reputational (brand name) guarantee of commodity attributes

I stated earlier that contracts govern only a subset of the attributes of agreements and that reputation enforces some of the other attributes. Sellers’ reputation plays a role in most, if not all non caveat emptor transactions. The shares of reputational and of contractual guarantees in commodities’ sale agreements differ across commodities, and are not constant. As a commodity becomes more uniform, we expect the share of its contractual component to become larger, and its price variability to become smaller.

As the notion of multiple enforcement forms for individual commodities may not be familiar,\textsuperscript{19} I illustrate it with several examples. I commence with government bonds.

\textsuperscript{18} Not all services are as difficult to measure. The existence of the outsourcing of services implies that the transactors are able to spell out in sufficient detail the attributes of the services. Moreover, when service is provided by phone, its recording allows third parties to evaluate it.

\textsuperscript{19} Baker, et al (1994) and Levin (2003) develop models where both contracts and reputation are used in individual transactions. However, they focus on employer-employee relationships and not on commodity
United States 30-Year Government Bonds. These are surely one of the most standardized commodities in existence, and the contractual component of their sale agreements dominates their transactions. The role of bond dealers’ and of exchanges’ brand names is modest. Dealers provide subsidiary services such as ascertaining buyers’ credit, orderly title delivery and guaranteeing authenticity. The fee buyers pay for such services—the buy-sell differential—is small. Buyers are likely to be well informed as to the attributes of these bonds. The low cost of information, however, comes at the expense of variety; for instance, the treasury issues bonds neither of 31-year duration nor of $11,000 denomination.

In general, buyers incur costs not only in determining commodities’ make-up, but also in discovering their prices. In the case of these bonds, such costs also seem low. Therefore, we expect these bonds to trade for virtually the same price in the various financial centers in United States and abroad. If true, such observations would

\^20 Marshall notes the strong tendency for price uniformity of government bonds.
fail to refute to the law of one price. Indeed, the prices of these bonds seem to display neither “sluggishness” nor “border penalty.”

Agricultural Futures. Transactors’ perception of the uniformity of contracts for futures commodities does not fall far behind that of widely held financial instruments. Specimens of the commodities backing the contracts, however, are not born equal; rather, the futures exchanges expend resources to assure their uniformity by setting and enforcing detailed standards for each commodity.21 These commodities are exchanged strictly by standards, dispensing with the use of producers’ brand names. Buyers and sellers of futures contracts seem to view them as homogenous, and thus may operate anonymously toward each other.22 Because none of the attributes of these commodities are guaranteed by brand name, traders in futures respond to, and eliminate price disparities very quickly. Not surprisingly, textbooks routinely use futures commodities markets to illustrate perfect competition.

The actual trading in the commodities per se, however, entails a major penalty in that their make-up is “suboptimal.” Futures contracts

21 Because setting standards and ensuring uniformity of futures commodities is costly, I expect that, controlling for dollar volume, the buy-sell differential for futures will exceed that for government bonds.

22 The exchanges, however, guarantee that the commodities meet the standards and that the transactors are credit worthy.
do not stipulate the levels of (valuable) attributes of these commodities when the cost of measuring and verifying their levels exceeds their net value. Suppliers, who are anonymous to their buyers, do not gain from providing such attributes. We expect these suppliers to “undersupply” them. The levels of these attributes tend to be “too low,” then. Indeed, these commodities are sometimes designated as “garbage grades.” Whereas most transactors in agricultural futures choose to trade in contracts, which are essentially financial instruments, they seldom take delivery of the commodities.

*Brand-name (reputational) commodities.* Most specimens of commodities carrying within a brand are quite uniform.²³ Buyers have to collect information about the make-up of each such commodity just once. This allows, among other things, purchasing the commodity without inspection, even sight unseen. Each brand-name commodity,

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²³ Even commodities such as canned goods are not strictly uniform. For instance, they have some caveat emptor attributes such as varying dates of manufacture. As a rule, however, these do not seem significant. More significant are differences in the level of retail services accompanying purchases. These vary across sellers in attributes such as location, proximity to other sellers’ commodities, levels of inventories, availability of different sizes, materials and colors and return privileges.
however, is produced by a single producer and is distinct from similar commodities produced by other brand-name producers.\textsuperscript{24}

As measurement costs decline, and as standards for attributes of a brand name commodity are established, we expect the contractual component in the sale agreement of the commodity to increase and the role of the brand name to decline. As one example, consider the agreement between patient and physicians. As medical instruments and tests have become more common, we expect the contractual component in the agreement to have expanded, and the role of physician’s reputation to have declined (and patients ties with individual providers to have become weaker). Given the expanded contractual component, we also expect litigation regarding medical services to have increased.

Brand names assure buyers that the quality of branded commodities \textit{exceeds} that indicated by the contractually guaranteed attributes. Each brand name conveys its own quality level, rather than that of the class of such commodities. The differences across brands is most evident when comparing similar commodities such as Chardonnays wines of given vintage, but of different brands. The

\textsuperscript{24} Future markets for brand name commodities are unlikely to emerge because the exclusive producer who produces a brand could transfer to himself some of the gains from trading in his commodity.
attributes of these commodities that are guaranteed by contract often differ only modestly, yet they significantly differ in price and presumably in quality.

An implication that is the consequence of the variability of the portion of attributes guaranteed by each of the guaranteeing forms of different commodities is as follows. The smaller the contractual guarantee component (and the smaller the standardized part), the more resources individuals are expected to spend choosing among the different specimens. Thus, per dollar expenditures, they are expected to spend more resources on choosing among different brands of Chardonnays wines than of bond issued by different governments. Moreover, the range of prices of different brands of Chardonnays exceed $5-$40. It seems, then, that over 80% of the value of the higher priced brand is guaranteed by reputation. For completeness of the illustrations I now turn to caveat emptor commodities.

Caveat emptor commodities. Buyers may inspect commodities and commodity attributes sold “as is” before agreeing to buy them. The more significant the “as is” component, the less likely are buyers to make purchases sight unseen. Caveat emptor commodities include, among others, most used automobiles, and (some of the attributes of)
fruit stand produce are sold under caveat emptor. To decide what to acquire, car buyers test-drive cars, and the produce buyers scan or taste the specimens. As the contractual of commodities with significant caveat emptor attributes constitutes only a small part of these transactions, among other things, we do not expect the hedonic for them to be at all satisfactory.

6. New standards and price dispersion

Commodity standards are informative. When a seller states that his commodity meets a standard, he implicitly guarantees the level of the standardized attribute in the specimens of the commodity. This lowers buyers’ cost of acquiring commodity information. As new standards are introduced, we expect transactors to shift attributes from the brand-name enforced component of their agreements into the component enforced by contract.\textsuperscript{25} As commodity standards are adopted, we expect competition for the standardized attributes to intensify, and the scope of sellers’ price discretion to decline. In conformity with my proposed law, I predict that as new commodity standards are set both by the state and privately. Even when set privately, when they are stipulated in contracts, the state will enforce them along with other contract stipulations.
standards are introduced, the price variability of the commodity will decline, bringing it closer to “one price.”

Consider fresh milk. Milk used to be sold with no reference to its fat content. The reason seemingly being that relative to its value, the milk-fat content was too costly to measure. I assert that sellers guaranteed the level of milk-fat in their milk by their reputation, and that each supplied the milk-fat level best suited for his particular clientele, and priced the milk correspondingly.

Since buyers were not fully informed about the level of the fat in the milk they purchased, they were not going to entirely eliminate genuine price discrepancies. When the cost of measuring milk-fat fell, producers chose to explicitly account for it by providing it at several standardized levels such as 0%, 1%, 2% and 3.2%. In connection with the law of one price, I hypothesize that the variance of a hedonic regression for milk with the level of milk-fat as one of the regressors would be less than the earlier era hedonic regression variance where the level of milk-fat was not explicitly stated, and thus not controlled. One might contend as self evident that the residual variability of the prices of milk where fat is controlled would be lower than that of the undifferentiated milk sold earlier. This is probably true. Prior to the fall
in the cost of measuring milk-fat, however, it would have been tempting to declare the law of one price refuted even if the variability might have been due to difficult-to-adjust-for differences in fat content.

I also hypothesize, as the price convergence law implies, that the variability around the regression line would have fallen after the new standardized milk-fat levels were introduced even not controlling for the fat content of milk. The reason is that the general uncertainty about the make-up of milk has been reduced.

7. Commodity uniformity and standards

Costly information would not have posed a serious problem were commodities uniform; the information collected for one specimen of a commodity would have characterized them all. Under commodity uniformity, then, individuals could easily become familiar with the commodities in their baskets, and no significant violations of the law of one price would have been expected. Commodities, however, are not uniform. Had they been uniform, among other things, guarantees would have been superfluous.  

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26 Sellers are probably better able than are buyers in recognizing differences. However, they too incur costs in collecting information, and thus are not fully informed either.
Commodities’ heterogeneity is partly inherent and partly a matter of choice. The non-inherent component depends on how they are produced, sorted and handled, on the quality control governing their production and on standards. The choice of the degree of uniformity of a commodity is intertwined with the guarantee of its attributes as well as with its price variability. For most commodities achieving full uniformity is prohibitively expensive. Standardizing is a means for enhancing uniformity, but a commodity cannot be fully standardized if its specimens are not uniform. Whereas attribute standards facilitate comparing commodities and adjusting their valuations for observed differences, standards may be applied only to the components that the specimens share.

Guaranteeing the particular levels of the non-standardized attributes of every specimen is expensive. Therefore, non-uniform low-valued attributes are unlikely to be guaranteed. Conceivably, the seller

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27 The sheer existence, and the public use of Consumer Report’s ratings imply that buyers are not perfectly informed. If the Consumer Report’s findings of “best buys” (i.e., of superior commodities that sell for a lower price than those of similar commodities) are valid, then they refute the law of one price. Indeed, the existence of “best buys” is inconsistent with perfect competition. “Best buys” may be present, however, when commodity information is costly. “Price Grabber” on the web points to the lowest price for the “same commodity.” It similarly refutes the law.
of a non-uniform commodity could contractually guarantee the mean value of attributes rather than guaranteeing the attribute levels of each specimen. This may work for bulk buyers, but not for final consumers because it is too expensive for final consumers to demonstrate in court that the specimens they bought came from a population with a mean lower than the seller claimed.

The seller can guarantee the mean levels of such attributes by his reputation. With the passage of time, buyers’ estimates of the mean values become more accurate. If they conclude that the specimens a seller has been delivering come from a population with lower means than he claims, they can punish him by ceasing to deal with him.

8. The hedonic approach

Several brand-name commodities have been the subjects of hedonic studies. The basic assumptions of the hedonic are that commodities are made of additive attributes and that the attributes are competitively sold. To evaluate the attribute prices, the hedonic regresses the levels of a commodity’s attributes on its price. As a rule, the attributes actually used are stipulated in contracts. The attributes guaranteed by brand names, however, are seldom included as regressors. Students of the hedonic are aware of omitting valued
attributes from their regressions. For Instance, Ohta and Griliches (1976), in studying American automobiles, recognize that their regressors do not fully capture the difference between luxury and non-luxury cars. They respond by introducing brand dummies for the luxury cars. After accounting for the effects of other variables in the regression, they find (p. 347) that for the period 1960-1971, luxury cars sold at a premium of about 35% over other American cars.

What does the 35% represent; in what ways does a Cadillac differ from a Chevrolet, and why don’t the regressors capture the differences? Carmakers, it seems, had been “touching” and “tweaking” their luxury cars more vigorously than they did to their non-luxury ones. For instance, before the introduction of disk brakes, the luxury cars manufacturers seemingly used to tweak the drum brakes for more secure breaking. Similarly, before the introduction of fuel injection and of electronic controls of the fuel flow to the engine, they seemingly used to tweak the carburetion system to perform better. The producers used their brand names to guarantee these attributes and to set the prices of the luxury automobiles to presumably capture the value of such procedures as well as of the Klein Leffler premiums. The 35%, then, is least partly equalizing.
But for comparison, the luxury dummy is an unsatisfactory measure of quality differences over time. A change in the premium from one year to the next reflects a combination of a price change and a quantity change. The dummy coefficient allows no breakdown between the two.

Suppose that a better understanding of breaking performance would have allowed the enhancement of the effect of the tweaking on breaks’ quality. For the sake of the illustration, suppose also that the nominal prices of the luxury cars would have remained unchanged (i.e., that the price elasticity for the breaking improvement is minus one). Given the increased value due to the improvement in quality, the real prices would have fallen proportionately to the increase in value. Even though the real price of the luxury cars would have fallen, the quality premium coefficient in the hedonic regression would have remained the same. It is seen that the quality premium

Returning to the specific examples, disc brakes and fuel injection technologies were eventually developed. Some of these were incorporated in the luxury cars and included in the sale contract. The new technologies made tweaking the old ones superfluous. Since the tweaking was guaranteed by brand names, their role was diminished.
As applied, the hedonic is likely to account for the new technologies, especially after they became standard equipment. However, it is unlikely to account for the diminished value of the brand-name guaranteed attributes. This point is general; it applies whenever a contracted attribute replaces one guaranteed by brand name.

This flaw in the application of the hedonic seems to emanate from not inquiring into the role of the brand name or reputation in the make-up of commodities. This paper offers no solution to this particular problem. However, it offers a prediction for another aspect of the problem. The new options were introduced contractually, probably subject to standards. I predict that subsequent to their introduction, the price variability among models was reduced.

In a similar vein, consider what a hedonic regression for Chardonnays might show. The label descriptions of each brand of Chardonnay list some of their attributes. The hedonic regressors might be the alcohol content, bottle size and vintage and perhaps the regional origin of the grapes. These are the contractually guaranteed attributes. My guess is that the wineries guarantee by their brand names other

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28 As applied, the hedonic model takes no account of the cost of information. It is not surprising that practitioners ignore the effect of the different guaranteeing modes.
attributes that are important, but difficult to measure. The hedonic, if applied, would most likely fail to capture these. I do not expect, then, that the regression would satisfactorily explain the difference between a $5 and a $40 bottle of Chardonnays. This, by itself, is not part of the problem here; the problem arises when the guarantee of an attribute shifts from brand name to contract.

Suppose that a blood pressure reducing constituent of the wine is identifies, and that producers incorporate the information about its level on the labels. The prediction here is that because information on the chemical reduces uncertainty as to what the make-up of the wine is, that even not controlling for its level, the price variability of these wines will decline.

As a related problem, consider two supermarket chains selling the same brand of wine. They guarantee by their brand names the levels of services such as the average checkout speed or quality of storage. More generally, the retail margin reflects, in part, the level of retail services. These may differ across sellers. The hedonic is likely to miss the difference in service levels and empirical workers testing the law of one price may conclude that the remaining price differential refuted the
law.\textsuperscript{29} Turning to the model here, suppose that supermarkets start making specific promises such as that customers would not have to spend more than a given amount of time checking out their purchases. The model predicts that even not holding that time constant, the dispersion in wine prices across the stores will fall.

As potential source of evidence that non-contractual attributes are usually present and are important, consider sellers’ reaction to price control. It is well known that the quality of the controlled commodities deteriorated significantly under price control. I assert that controllers tend to control the explicit contractual attributes, but not the brand name ones. If the assertion is correct, which I think it is, then the quality deterioration must be the result of lowering the level of the latter attributes. The early 70’s price control of gasoline exemplifies such occurrence. An important part of the gasoline transaction is the service stations provide. Whereas the controller controlled the (reasonably) well-specified attributes of the gasoline, he did not control the level of services. During the shortage era, the quality of service deteriorated drastically. The non-contractual attributes, then, constituted a

\textsuperscript{29} In comparing price variability of similar commodities across stores, Eckard (2004) fails to bring up the possibility that prices might differ because different stores offer different levels of services.
significant component of the gasoline transaction, which, in my view, exemplifies well the general case.

9. Price adjustment forces

What are the forces that may induce price convergence, and how much of the discrepancies will they eliminate? Contracts tend to be publicized, so buyers’ cost of acquiring information about contract attributes tends to be low. That cost also depends on the buyers’ scale. The larger it is, the lower his unit cost of discovering the levels of the common attributes of the commodity, as well as the prices that different sellers charge. Scale is a function of a buyer’s (properly discounted) cumulative purchases. The gain to a person from becoming better informed of the attributes of a commodity and their distribution across specimens is larger the larger is the total volume of the good he purchases.

Buyers buy goods for their own consumption, for production, and for speculation. I start with purchases by final consumers. Consumers typically purchase small quantities of individual commodities, rendering their net gain from search low. Sellers can reduce buyers’ cost by supplying the information. By credibly promising “satisfaction guaranteed or your money back,” sellers lower consumers’ costly
search. The promise may sound trite, but it substitutes for search. Customers do not fear wasting their money when buying from reputable sellers as such sellers are expected to make good on their promises. The guarantee does not cost sellers much as long as their commodities conform to what is promised. Price convergence is primarily via competition among sellers. The degree of convergence, discussed below, depends on commodities’ make-up.

The scale of producers who purchase commodities for their own use tends to exceed that of final consumers, and that may make some search worthwhile. A producer who identifies a genuine price discrepancy among input specimens gains by using the input revealed to cost less than its substitutes; the larger is the producer’s (eventual) scale, the larger the gain. Individual producers, however, seldom purchase the bulk of the commodities that constitute their inputs, and thus will not, as a rule, engage in extensive search.

Speculators attempt to “buy cheap and sell dear.” A major cost of their operations is that of reselling. Under perfect competition selling cost is zero. A buyer, then, can turn around and instantly resell a
commodity at the price paid for it. In reality, a speculator incurs costs in determining that true price dispersions indeed exist and in convincing of that those he transacts with. His would-be buyers too incur costs of figuring out whether or not the commodities they are offered are good buys. In order to gain from discovering discrepancies, the expected discrepancies must exceed such costs (per unit sold). The easier reselling is, the larger is speculators’ gain from a given level of reselling. That ease depends, in part, on the organization of the exchange transaction. The exchange may be enforced partly by contract, where some of the attributes are subject to standards, partly by long-term relations or reputation, and partly by inspection, i.e. “as is.”

A buyer of a commodity backed by reputation incurs the (often-modest) cost of ascertaining the seller’s reputation. The reputation, however, does not automatically accompany the commodity. For exchange that requires inspection, the original buyer as well as subsequent ones must engage in inspection to avoid getting stuck with low value merchandise. Speculative buying, then, is unlikely to be profitable when the reputational component in commodities’ guarantees

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30 Price adjustment under perfect competition is costless, leaving no room for speculators.
is large. On the other hand, the larger the portion of the exchange that is enforced by contract, especially if standardized, the more profitable is the speculation.\textsuperscript{31}

As already argued, the more information is available, the larger are commodities’ contractual components. As long as commodity information is costly and the non-contractual component in agreements is positive, uncertainty about prices will persist, and we do not expect the law of one price to hold.

Individuals’ cost of obtaining commodity information goes down with standardization. The greater the degree of commodities’ standardization, the easier is the discovery of their make-up. Standards, as a rule, apply only to a subset of a commodity’s attributes, and, in addition, the levels of some of the attributes may exceed the standard. Commodities, then, may be subject to standards, but are not, as a rule, fully standardized.

Speculators’ scope for profiting from their discoveries tends to get larger as the standardized component in a commodity gets larger.

\textsuperscript{31} It is more difficult to exchange the non-standardized contractual component of an agreement than to exchange standardized contractual component because it is more difficult to ascertain what the former is than what is the latter.
and as the volume of trade gets larger; the latter is often the consequence of the former. The return from discovery, then, is larger for such commodities than for more idiosyncratic ones. Thus, the more standardized commodities are, the faster we expect their price discrepancies to be eliminated.

This relationship receives a quantum break when the cost of information goes to zero. As commodity information becomes costless, the contractual component would constitute the entire agreement. The contractual specifications would be complete, and the transactors could be anonymous to each other. In that case we expect the resale “penalty” to vanish. Anonymous transactors expect only what is contractually stipulated; what is not fully stipulated is unlikely to be delivered. But under costless information the contract will include all attributes. Thus efficiency will prevail.

The limiting case of costless information has a major counterpart in reality. Transactors erect institutions that reduce the cost of commodity information. For instance, in futures markets, as well as in various financial markets, except for the role of the exchanges’ brand name, agreements are entirely contractual. Commodities traded in these markets are likely to conform well to the law of one price. This
apparent support for the law is “tainted,” however, as it ensues from the preconditions created to accommodate it. Moreover, these preconditions are not consistent with perfect competition. In any case, where the cost of commodity information is significant, the law is likely to be refuted.

10. Standard, international trade and the purchasing power parity

Many of the tests of the law of one price have been in attempt to determine if the PPP, an application of the law, can be maintained. These tests uniformly reject the law. Engel and Rogers (2001) test the law as well as its hold across federal states and reject the latter hypothesis as well. Some authors conclude that prices are “sluggish,” and that borders impede price convergence, but offer no explanation for the sluggishness, for what makes prices more or less sluggish, or why, except for tariffs, the existence of international borders matters.

This paper claims that price dispersion is bound to occur as a result of the costliness of acquiring commodity information. The dispersion will decline as the cost of the information falls and as the gain from collecting it increases.\textsuperscript{32} Standards tend to be formed as

\textsuperscript{32} The level of the rule of law, abstracted from in this paper, is another factor affecting price dispersion. The higher the level of the rule of law
product information becomes cheaper. Taking account of standards offers an explanation for the role of borders. As a rule, each state forms its own standards. In the absence of international treaties that unify standards, brand-name guarantees will substitute for the contractual ones. Price dispersion across countries is expected to be greater than within countries because the standards adopted by individual countries are not enforceable across them. As countries more fully recognize each other’s standards, we expect the price dispersion across their borders to decline, reducing the “border penalty.”

As it evolved in the last half-century, Europe provides attractive grounds for testing the above propositions. First, most countries introduced many new standards during that time-span and thus we predict that for given commodities, the within-country dispersion declined with time. However, we do not expect the rate of that decline to be uniform; rather, the faster the introduction of standards, the greater

in a country, the higher the level of standard formation and of contracting. This is because the role of contracts would then be stronger and enforcement would less heavily rely on long-term relations. The higher that level, the lower the expected price discrepancies. Where the rule of law is weak, given their observed characteristics, commodities backed to a greater extent by brand names would also appear “expensive.”
the expected rate of convergence. Second, as the European Union continues to unify the member countries’ standards, we expect prices across states to converge. Third, we expect that the more recent is the admission of a country to the union, the faster is the rate of convergence of its post admission prices to that of the rest of EU.

11. Conclusions

Sellers’ guarantees consist of two parts. One is explicit and objective and enforced by state-backed contracts. The other is implicit and often subjective and enforced by reputation or brand name. Information about the make-up of the explicit component is relatively easy to come by, and of the implicit component is relatively difficult to come by. Individuals, then, tend to be well informed about the former, but not about the latter and thus are able to accurately estimate the value of the former, but not of that of the latter.

The compilers of price indices usually take account of the objectively measured components of commodities, but (tend to) overlook the subjective components. Therefore, I expect prices as compiled in price indices to diverge. This should hold even if we adjust for quality differences because people are not sure what the appropriate adjustments are. The first would lead one to reject the laws of one price
as well as that of the PPP even when real prices do not diverge. The second would lead one to reject these laws even when we control for quality.

I formulate an alternative law, which I call “the price convergence law.” The law states that: *As information about a commodity improves, its price variability will decline.* The rationale behind this law is that as the cost of measurement falls, and as the gain from using information increases, transactors will shift attributes from the reputational component of their agreements into their contractual component. Such a shift would be enhanced when the lowering of information cost leads to the formation of commodity standards. Given such shifts, the price compilers would do a more accurate job, and at the same time, uncertainty about the make-up of commodities will decline, both resulting in lower observed price variability in the market.

**References**


