

THE “LAW” OF ONE PRICE: IMPLAUSIBLE, YET CONSEQUENTIAL

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I

The law of one price (hereafter LoP) is one of the most basic laws of economics and yet it is a law observed in the breach. That a given commodity can have only one price, except for the briefest of disequilibrium transitions, seems to be almost an axiom. Economists are bent on considering their subject to be empirically based, yet the most elementary of laws seems to defy empirical confirmation. Would it not be wise to simply admit that economics cannot do without some *a priori* beliefs? Why has the law been accepted? Can the law be confirmed by data? If not, why is the law still accepted? and what does this acceptance tell us about good economic method? McChesney et al. have challenged the logical validity of the law and since no logical flaw exists in their presentation (McChesney, Shugart, and Haddock 2004, pp. 706-16), clearly there must be some implicit institutional factor that the usual description of the market ignores. The provenance of the LoP extends beyond methodology—to the treatment of real exchange rates, of industrial regulation and of such contentious issues as wage discrimination by sex—and hence some synthetic treatment has to be attempted. How do we treat a phenomenon that we believe to be true yet are unable to establish empirically? It may be noted that these thoughts lead one toward an Austrian methodology. While I have sympathy with various aspects of Austrian economics, it is not my intent to plead that the LoP is proof positive of the validity of Austrian ideas, especially as I am not an “Austrian.” But the contradictions implicit in the neoclassical attitudes toward the Austrians perhaps need exposure.

Verifying the law of one price involves getting accurate data on many thousands of individual prices as well as the many forces that have affected

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them such as location, quality, etc. Of the Austrian economists, it is F.A. Hayek who worried most about our inability to collect many particular facts. Hayek first used this insight to provide the most pungent critique of centralized economic planning in the 1930s; later he used these ideas to build a sophisticated case for differentiating between the physical and the social sciences. In the physical sciences the number of elementary facts that needed to be known before acquiring a satisfactory explanation of phenomenon were few, while in the social sciences they were many. The primary facts of the social sciences were so many that they not only defied analytical manipulation by the human mind, they were so many that we simply could not hope to gather all of them (Hayek 1969, pp. 22-42).

The chief difficulty [in the social sciences] becomes one of in fact ascertaining all the data determining a particular manifestation of the phenomenon in question, a difficulty which is often insurmountable in practice and sometimes even an absolute one. (Hayek 1969, p. 27)¹

As a result, Hayek went on to say, the social sciences should not aim at making particular predictions, since, even if the theory was correct, the particular facts required for prediction could never be ascertained anyway; rather, the social sciences should only attempt to indicate general patterns that could be relied upon to develop.² Hayek was always skeptical of the trend of scientism to claim to “know” and it is in the same skeptical spirit that this note is written.³

The empirical work and its implications have been clarified by many authors and I will largely be concerned only with putting things together. In order to emphasize the extent to which this paper is based on others, I have decided to adopt an ugly expositional style: I will quote from others directly often, sometimes in the notes and sometimes in the text, reserving my comments to a minimum except for the conclusion.

The rest of section I provides some evidence for the claim that the LoP is confirmed only for a very limited class of commodities, even after disaggregating to the maximal extent we appear capable of. Section II then tries to unpack the economists’ reasons for believing in the LoP, paying attention to the processes and institutions implicit in our arguments. Section III then goes on to argue that the implicit conditions necessary for the LoP to be verified are fulfilled only for a narrow range of commodities, and one expected to get narrower with time. Hence, if economists insist on believing in LoP, which

¹Hayek returns to this theme at two points in his Nobel lecture, “The Pretence of Knowledge” (1978). I am grateful to Joseph Salerno for guidance regarding Hayek.

²In the language of mathematics, which Hayek would probably disapprove of, it is the topological, and not the metric, structure that is the provenance of the social sciences.

³Section 9 of the essay on “Complex Phenomena” is particularly poignant. Note Hayek’s approving quote of Warren Weaver in a footnote on p. 40, where Weaver questions whether increasing knowledge does not also increase ignorance. This is a theme hinted at by some earlier scholars, but which awaits a fuller development.

they probably cannot do without, then they should stop claiming that the law can be empirically verified. Section IV draws some methodological conclusions from the fact that economists do believe in the LoP.

The three examples of empirical studies below are chosen from amongst many others and deal with increasing levels of fineness in the data, from motor cars, with their many attributes combined in one physical product, to consumer goods, which still have many attributes, to identical products. Note how, in each case, there is definite evidence that economic forces do work, thus distance does increase price variation, and common currencies do diminish them, but the point is that economic forces are neither strong enough nor persistent enough to produce the LoP as an empirical phenomenon.

First, motor cars in Europe:

This paper uses micro-level price data from the European car market to examine why there are deviations from the law of one price. The absolute law of one price is strongly rejected, but there is convergence to its relative version. Two sets of explanations are considered: (1) price-setting in segmented markets and (2) arbitrage barriers. Overall, the determinants of arbitrage costs have more explanatory power. The single most important factor is the distance between markets. Evidence for Belgium and Luxembourg suggests that a single currency lowers price differences significantly. (Lutz 2004)

Next, closely related consumer goods in the U.S.:

We use new disaggregated data on consumer prices to determine why there is variability in prices of similar goods across U.S. cities. We address questions similar to those that have arisen in the international context: is this variability purely a result of market segmentation or do sticky nominal prices play a role? We also examine how the degree of tradability of a good influences price variability. Surprisingly, we find that variability is larger for traded-goods. We attribute this finding to greater price stickiness for nontraded goods. Distance between cities accounts for a significant amount of the variation in prices between pairs of cities. But we also find that nominal price stickiness plays an even more significant role. (Haskel and Wolf 2001, pp. 545-58)

Third, narrowly defined commodities in futures markets:

The LoP is tested for narrowly defined commodities traded in futures markets in different countries during the period 1973-80. Although the LoP holds as an average tendency for most of the commodities, there are instances of large riskless arbitrage returns (before transactions costs). Deviations from the LoP tend to be commodity specific rather than due to a common external factor and they tend to be smaller the longer the maturity of the futures contract. (Protopapadakis and Stoll 1983, pp. 1431-455).

Finally, identical goods sold by multinational retailers:

We use retail transaction prices for a multinational retailer to examine the extent and permanence of violations of the law of one price (LOOP). For identical products, we find typical deviations of 20 to 50 percent, though there is muted evidence for convergence over time. Such differences might be due to differences in local costs. If so, relative prices of similar products (round versus square mirrors) should be equal across countries. In fact, relative prices vary significantly across very similar goods within a product group; indeed, the ordering of common currency prices often differs for similar products. The finding suggests that differences in local distribution costs, local taxes, and probably tariffs do not explain the price pattern, leaving strategic pricing or other factors resulting in varying markups as alternative explanations for the observed divergences. (Aalto-Setälä 2003)

No wonder that Williamson and Milner summarized the evidence by writing that “The hypothesis that arbitrage quickly equates goods prices internationally has probably been rejected more decisively by empirical evidence than any other hypothesis in the history of economics.”⁴

II

As ordinarily stated the law relies on a simple thought experiment, which will be referred to hereafter as the “snapshot.” “Imagine two prices being demanded in one market for exactly the same good—who but a fool would pay the higher price? Therefore if both sellers are to be able to sell they must charge exactly the same price. Hence, the law of one price.” However this formulation is so simple as to invite obfuscation. What exactly does it mean for the prices we will *observe* in a market? Does it mean that all prices are identical at all times? But this is verifiably false—indeed if this were true, the market would become redundant as it would no longer be the mechanism that produces efficiency by disseminating information and equalizing prices.⁵ As

⁴Wada and Warren (quoted in Hufbauer, Wada, and Warren 2002, p. 17). This slim monograph contains a clear and valuable discussion of the issues and nothing said by me affects the value of the Hufbauer et al. findings.

⁵See Meyer, Huyck, Battalio, and Saving (1992, pp. 292-316):

What causes individual suppliers to allocate goods in such a way that the aggregate allocation satisfies the law of one price? A satisfactory answer to this question must confront two related problems: Equal net prices at all allocations provide no information to suppliers about the quantity to deliver to a specific location, and strategic uncertainty makes an observed violation of the law of one price an unreliable indicator of a profit opportunity. This paper develops a simple analytical framework to formalize these two problems, reviews some solutions found in the literature, and reports laboratory evidence on how people solve them. In addressing these issues, we focus on the role historical prices play in coordinating decentralized allocation decisions.

described above, the law of one price is the name of a process and not a result. This realization has led scholars like Yoram Barzel to advocate a replacement of the current form of the law with a restatement of the LoP as a tendency (Barzel 2005). “*As information about a commodity improves, its price variability will decline.*” Such a reformulation does not necessarily make the new law more testable since the difficulties of measuring “information” and its “spread” are at least as great as those of measuring the LoP at present.

So the proposition must be that “When equilibrium is reached, i.e., the quantity demanded equals the quantity supplied at a stated price, then all transactions must be at the stated price.” Something like the above is believed, at least by implication, by the many economists who have attempted to provide empirical verification of the law. For such a definition of the law to retain practical content, we must slip in an implicit assumption—that equilibrium is rapidly attained. Otherwise, the disequilibria that are being eliminated will have an influence on the “equilibrium” and our definitions will become very much more complicated in having to take the path to equilibria into account. We need to be observing the data at time periods longer than the time to convergence, a requirement that seems to demand different observation periods for each group of commodities. Unfortunately, most of the careful empirical work that has been done suggests rates of convergence that are not particularly fast—as is usual in this murky area, there is a silver lining in that large price differences do induce more rapid convergence.

Using a panel of 51 prices from 48 cities in the United States, we provide an upper bound estimate of the rate of convergence to purchasing power parity. We find convergence rates substantially higher than typically found in cross-country data. We investigate some potentially serious biases induced by i.i.d. measurement errors in the data, and find our estimates to be robust to these potential biases. We also present evidence that convergence occurs faster for larger price differences. Finally, we find that rates of convergence are slower for cities farther apart. However, our estimates suggest that distance alone can only account for a small portion of the much slower convergence rates across national borders. (Parsley and Wei 1996, pp. 1211–236)

In summary, the casual statement of the law of one price requires greed to produce arbitrage and speedy movements of prices so that all observations of the market are actually observations of equilibrium values. What does this mean for empirical confirmation of the law—if our price data are disequilibrium values, we should have nothing to say about the LoP; if our price data are equilibrium values, then we appear to have falsified the law—but the practice of economists tells us that we refuse to disbelieve the law. More convoluted rationalizations are possible—with some mixture of greedy and altruistic individuals in the market and with varieties of speeds of convergence to equilibrium—but this seems to invite seven degrees of chaos.

The law may be plausible at the individual level, simply because we economists all believe in greed as a motive force. But we need to move from

individual to market for the law to hold and unless we assume that all individuals are identical, this is not a direct inference. Once again the simplicity of our original picture misleads. For the arbitrage to work individuals not only have to be greedy, they also have to be knowledgeable, a point implicitly avoided when we “presented” the individual in our snapshot with the same good but at two prices. Are all individuals always greedy and knowledgeable? What if not? Suppose the greedy ones do not know and the knowing ones are not greedy?

The assumptions that individuals are both greedy and knowledgeable have not always been palatable. As early as 1819 Edward Copleston pointed out how crucial the arbitrage assumptions were for Classical economics, while John Stuart Mill famously denied consumer rationality. And the question becomes more complex if market movements are one way to “know”—this invites speculation by all and sundry, especially by “noise” traders. This is an area that has been explored by George Akerlof and Janet Yellen and by Larry Summers and his coauthors; we have a variety of models each of which shows that small deviations from perfect rationality can have first order consequences (Akerlof and Yellen 1985a, pp. 823-838 and 1985b, pp. 708-20; Shleifer and Summers 1990, pp. 4, 19-33).

Going back to the “snapshot.” Suppose I know of a difference of a dollar a bag for basmati rice between two stores. The cheaper bags cost five dollars each and 10,000 of them are available. To profit by arbitrage, I would need to have \$50,000 to pay for the cheaper bags and then I would have to be able to sell the 10,000 bags to realize my full profit. If I sold only 5,000 of the rice bags at the higher price, not only would I make less direct profits but I would also be saddled with inventory and depreciation. Let us take the easier option and just assume that the bags will be sold at six dollars if they can be bought. So even if I am greedy and knowing I still need the \$50,000 to effect the arbitrage. If I do not have it at hand, I would either need to save up the capital or borrow it. But saving up takes time, and the arbitrage opportunity may well disappear while I am engaging in thrift. Alternatively, I can try to borrow the money, but from whom? Why will someone lend me money without knowing what my proposed business plan is? And if I tell them about the arbitrage, why should they loan me money instead of engaging in the arbitrage themselves? Buying and selling to live off the difference in prices is not so simple as it seems.

So the law can be expected to work only in specialized markets with standardized goods and large traders—such as the wholesalers of the rice market in a less developed country (LDC).⁶ In other words, the law is true for those commodities for which accepted standard amounts can be defined, and which have prosperous traders who are habituated in transacting large sums of both money and quantities of goods. This needs homogeneous commodities in

⁶Martin Ravillion doubts the profit calculating capacity of the Arothdars (large rice traders) of the Dhaka rice market in his study of the Bangladesh famine of 1974.

high demand—a condition true and only true for the traditionally designated staples or the precious metals.

Even in a given market, the law requires some care in statement if it is to be plausible. As soon as we feel the pinch of specifying the details of the process by which arbitrage is to take effect we see the need for institutions (to specify legal standards and to provide credit for example) and to value heterogeneity (markets work because individuals such as wholesalers are different in their greed and their knowledge, and they use these differences to spread benefits to all who transact in the market).

When used to analyze price differences in separated markets, the law has been challenged by McChesney et al. They correctly point out that every separated supplier is a local monopoly. Once we work out the logic of local monopolies, it is no longer true that the law holds. But this is not so much a logical defect of the traditional law as a reminder that the traditional snapshot implicitly assumes that there is full competition at every location. In other words, there is the implicit institutional requirement that there be at least two, and preferably several, suppliers at every point in space. Once we add this institutional requirement, the arguments of McChesney et al., being based on the effects of local monopoly, fail.

III

The following conditions are needed for the LoP to be plausible:

- A. Multiple sellers at one spot to ensure competition at each location.
- B. Standardized, bulk sale commodities with specialized traders, for which ready credit is available.⁷
- C. Rapid attainment of equilibrium.

Is it likely that conditions A, B, and C above will be fulfilled in the modern world? Everyday experience suggests not.

First, even if all commodities were goods, the sheer volume of goods makes the collection, compilation, storage, and transmission of data so costly that we will never get individual data, only indexes and aggregates. This lands us into all the intractable problems first encountered by input-output analysis. What can be tested with the data we gather is some index of goods that we think second order homogeneous—cheese. But now we are back to the sorts of problems faced by aggregation, even in the Leontief model. These prevent constant coefficients because of input and output mix changes, (typically induced by price changes), technological change, and violations of constant returns to scale (CRS) (Green 1964). Here the price index can change because tastes cause

⁷This really covers several conditions, but as they are met by trade in wholesale goods like staples, I think it best to provide a single condition.

more French cheese to be consumed, thus raising the “cheese” price in the U.S. autonomously; because French cheese prices have risen, this leads to substitution away from French cheese in the U.S., and U.S. cheese prices rise by a lesser amount, *ceteris paribus*. In either case, LoP appears violated. But perhaps most importantly for the empirical case, modern goods are seldom identical and are demand induced, being tailor made for particular groups of customers. Hence the product can have sharp price gradients as we move in and out of customer types.⁸

Second, the trend of modern consumerism is toward more personalized products, which not only increases the number of goods to be considered but also makes price discrimination more likely. By separating the explicit and measurable component of a commodity from the implicit and reputational components, Barzel has provided an extensive and persuasive argument to support this point.

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 workers to reject the laws of one price as well as that of the PPP. . . . 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. [Barzel notes that this depends upon “the reliability and probity of the legal system.”] 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 things, that as standards are formed, sellers will switch attributes from the

⁸It would be nice to find a specific example, but I have not found one yet in the literature.

tacit component of the sale agreement to its contractual component.
(Barzel 2000, abstract)

Third, all modern economies are moving away from mass produced manufactured goods and toward services. Since services contribute about 70 percent of GDP in economies as disparate as Bangladesh and the United States, it is the applicability of the law to services that should dictate the empirical importance of the law. But services are notoriously known to be both personalized and subject to price discrimination, making both conditions A and B unlikely. The literature on this point is large and uncontested, so I will only provide some representative quotes. In differentiating the service economy T.P. Hill wrote in 1987 that “because economic theory is dominated by the goods paradigm, price discrimination tends to be treated as a special case” (Hill, as quoted in Quibria 1989, p. 14), whereas for services such price discrimination is more like the norm. This is illustrated with examples from health, education, transport, hotels, and restaurants—no wonder that “anyone who has worked or set up house in more than one country knows that as far as services are concerned, standardization is a joke” (Jones typescript, p. 3).

Fourth, fluctuating transport costs, caused partly by unpredictable shifts of oil prices as well as by technological developments, when combined with the crudity of our statistical tools, make it impossible for us to discriminate between hypotheses of instantaneous and lagged price equilibrium. In 1994 J.M. Roberts produced the interesting result that, once we allow for small errors, the data do not allow us to distinguish between models of complete price flexibility *versus* incomplete ones. Even the fastest claims for price convergence have a half-life of four months—and this is within a country and for a restricted set of goods (Ratfai 2006). Since we have no predictions about disequilibrium price differentials (except perhaps that greater differentials attract faster convergence), once we allow for open borders and the differential speed of many markets, what hope is there that the data will represent equilibrium values?

Will increasing information processing capacities bring an end to persistent price differentials? This far from obvious. Looking at price behavior of suppliers on the Internet, it appears to be in the interest of sellers to acquire one degree of information beyond that acquired by consumers—hence there will always be some room for the sellers to manipulate consumers and violate the LoP in the process (Ellison and Ellison 2004, abstract).

We examine the competition between a group of Internet retailers that operate in an environment where a price search engine plays a dominant role. We show that for some products in this environment, the easy price search makes demand tremendously price-sensitive. Retailers, though, engage in obfuscation—practices that frustrate consumer search or make it less damaging to firms—resulting in much less price sensitivity on some other products. We discuss several models of obfuscation and examine its effects on demand and markups empirically. Observed markups are adequate to allow efficient online retailers to survive.

The conclusion then is that even if the law of one price is true, we have no way of verifying it except for a small class of goods. The “theory-data gap”—between the specifications which allow the theory to apply and the conditions under which the relevant data can be collected in the real world—is much too large, and shows no signs of becoming smaller.

IV

The literature is quite aware of most of the problems mentioned above, but does not appear to face up to the methodological conundrum they pose. Otherwise it is hard to explain the considerable investment in trying to extend PPP and, by extension the LoP, to consumer goods (Ghironi and Melitz 2005, p. 865n).⁹ If the arguments of Section III are valid, it allows the following conclusions to be drawn:

First, since the law has been accepted till now, it tells us that economists *have* accepted *a priori* laws.

Second, that some laws may never be “testable” as general propositions, and so economists may have to continually accept *a priori* laws.

Third, that these laws, when we spell out the reasons for their acceptance, require institutions and heterogeneity. Accepting and incorporating institutions and heterogeneity makes life simpler and more true. Occam’s Razor is worthwhile only if other things are equal, but they are surely not over here.¹⁰

Fourth, insofar as data are used, they are almost always aggregated—how many studies of one inch wood nails are there? Therefore the neoclassical reluctance to consider aggregate laws in their own right may be false modesty.¹¹

Fifth, whether there is much point in the theoretical and empirical refinements addressed to theories of the real exchange rate, given the heavy burden

⁹Charles Engel of Wisconsin provides a very helpful set of Notes for understanding PPP on his website.

¹⁰Graddy:

In this article, I report the results of a study of the prices paid by individual buyers at the Fulton fish market in New York City. In principle, this is a highly competitive market in which there should be no predictable price differences across customers who are equally costly to service. The results indicate that different buyers pay different prices for fish of identical quality. For example, Asian buyers pay 7% less for whiting than do white buyers, a result which is inconsistent with the model of perfect competition. (1995, pp. 75)

¹¹Nails may obey the LoP but only because we have used our common sense to aggregate them leaving out screws and nuts. When the aggregates are of richer micros we may have no *a priori* idea of their behavior—hence the Lucas type of new macro is misplaced precision.

placed upon the law in such theories. The problems of getting reliable results with aggregated data even extends to demand function estimation.¹²

Finally, the failure of the LoP shows us that the stability we require for our subject to be meaningful is obtained by assuming away "secondary" effects. Akerlof and Yellen have forcefully argued that such effects are made "secondary" largely by assumption, but, except for some attention paid to this question in finance, no one seems to have followed up this issue with care.¹³

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¹²Anglin:

This paper shows that the method of estimating of demand functions may contain an erroneous, implicit assumption when aggregated data are used. This assumption, revealed by the choice of regressors, yields estimates of own price elasticity and other coefficients that are inconsistent. It can also cause heteroscedasticity in the second stage of two-stage least squares estimation where none would otherwise exist. (1990, pp. 125-43)

¹³Once we allow "small" changes in the specification of models, many variants of standard models can be made to "fit the data."

This paper examines how proportional transaction costs, short-sale constraints, and margin requirements affect inferences based on asset return data about intertemporal marginal rates of substitution (IMRSs). It is shown that small transaction costs can greatly reduce the required variability of IMRSs. This suggests that the low variability of many parametric, aggregate consumption based IMRSs need not be inconsistent with asset return data. Euler inequalities for a transaction cost economy with power utility are tested using aggregate consumption data and returns on stocks and short maturity U.S. Treasury bills. In the majority of cases there is little evidence against power utility specifications with low risk-aversion parameters. The results are obtained with transaction costs on stocks as small as .5% of price, and are in sharp contrast to the strong rejection of the analogous Euler equalities for a frictionless economy. (Luttmer 1996, pp. 1439-67)

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