Cost and Outputs:
The Taussig & Pigou Controversy Reconsidered

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May 2000

Over a century ago, economists began what became pointed scientific exchange on the topic of joint versus common costs and, by implication, price differentials versus discrimination. The reference, of course, is to Taussig's original application of the model of joint products to railway rates in which he claimed competitive price differentials based on demand elasticities exist. Pigou countered that railroads supply services that have common not joint costs, and the price differentials are the result of monopolization. Thus, the controversy began. The differing views of these two scholars were never fully reconciled, and the debate on this point has never died out completely, though it has tended to flare up in new places over the years.

The questions raised in the Taussig & Pigou exchange seem timeless. Joint v. common costs were the root of contention in rate regulation of rail, truck, and airline transportation service until rate regulation expired. Now they are the basis of debate over price differentials observed in these industries as they operate in an apparently competitive environment. Peak-load pricing of electricity confronts this cost structure issue. Production, distribution, and pricing of video products, telecommunications services, literary works, etc., bear a family resemblance to the railway rate issues debated nearly a century ago. The questions are timeless and the answers are important even if evasive. For instance, as we stand on the threshold of ribbon cutting for the information superhighway, everyone wants to know what the toll will be, what it should be, and what it might be under different regulatory scenarios.

Given the endurance of this controversy, one wonders what new contribution can be made. My effort is intended to refocus the debate, not to end it. I do not attempt to answer all questions or review all the literature concerning joint v. common costs. The approach I take is two-fold. First, the historical debate is reviewed briefly. The merit of recounting the history of scientific discourse on this topic is greater than usual because the debate has bounced across so many fields. Possibly because of this bounce the normal linear progression of science has been less effective in resolving the controversy, and a return to the beginning may yield new insight. Second, a taxonomy of the issues is offered in an attempt to refocus the debate.

"Railway Rates and Joint Costs Once More"

Taussig started all the trouble in 1891 by making the simple application of the theory of joint products to the case of railway rates. No doubt, he thought that it was trivially obvious. (It was forty years later that he began to explore some of the nuances, such as competitive equilibrium supply, that make the problem more confusing than he originally imagined.) In his first stab at the problem, Taussig noted two fundamental points: 1) the bulk of costs in providing railway service are fixed; and 2) the services provided to different shippers are heterogeneous not homogeneous across all shippers because these users are shipping different things and have different demands for shipping them.

To Taussig, the fixed costs used to service different consumers implied joint supply, and as in the joint supply model the different consumers pay different prices. These price differentials

were based on demand elasticities, but Taussig was loath to call the differentials discrimination. In Taussig's view, the price differentials would exist and would be based on demand intensities of the different buyers even when there is competition so abundant and fierce that profits are driven to zero, that is, when every dollar collected from every demander is necessary to cover the "joint cost" of supplying service. " 'Charging what the traffic would bear' " is a necessary condition of supply not an evil of monopolization.[1]

Taussig's view held sway in the literature for two decades, but then Pigou took a different look.[2] The analogy of railway services to the joint production of goods like cotton and cotton seed seemed off to him. In simple terms, cotton was a different good from cotton seed. On the other hand, shipping copper or coal from point A to point B was the same good. Pigou argued that by mistakenly calling the transport of copper and coal the production of heterogeneous services, Taussig was errantly led to conclude that they were produced as joint products. Pigou called the costs "common" and concluded that the firm only charges price differentials because of 3rd degree monopoly price discrimination.

Pigou raised the backhaul issue as a case of "true" jointness, but gave the example of short haul charges exceeding long haul charges as the ultimate example of monopoly price discrimination. Pigou's main point was that there was no patently obvious reason to claim that railway transportation service supplied to two different customers is a heterogeneous product and, hence, it was not a case of joint products. He claimed that if the market was competitive, the price differentials would be driven to zero.

Thus attacked, Taussig countered with the observation that if the price differentials were monopoly based then monopoly returns should be observed.[3] There was scant evidence that railroads were making any monopoly money. Interestingly, this point apparently spurred a young Chamberlin to devise his theory of monopolistic competition in which monopolists are driven to the point of zero profits by competitive pressures. Chamberlin's theory demonstrated that monopoly pricing power and monopoly returns are separable issues.

More importantly, Taussig went directly after the short haul-long haul example. He claimed that the issue was not one of whether a railway possessed local monopoly power in some place or another, but whether the entire structure of "rate classification" is a monopoly device. For instance, are freight rates compared to passenger tickets in the large driven by monopolization of passenger and freight transport?

Taussig reiterated his view that the large fixed plant of a railroad created jointness across all service. In fact in his view one good that is transported between points A and C going through B could quite reasonable be priced at a rate low enough to make the total charge less than the charges on another good going only between A and B. This would occur if the capacity utilization between A and C was very low and the demand for a particular product shipped between A and C was very low also. Taussig said that if an entire railway plant could be worked to the full by a single kind of traffic, there would be no application of the theory of joint costs. While such is the case in some coal and logging situations, it is not generally the case in standard railway service.

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[1] F. W. Taussig, "A Contribution to the Theory of Railway Rates," *Quarterly Journal of Economics*, 1891, 438-465. Quote at 456.

[2] A. C. Pigou, *Wealth and Welfare*, Pt. II, Ch. 8, "The Special Case of Railway Rates," (1912); republished as *The Economics of Welfare*, 1920.

[3] Taussig, "Railway Rates and Joint Costs Once More," *QJE*, 1913, 378-384.

Taussig also drew analogy to the peak load problem of electricity production, which Pigou had discussed in his book and admitted was a case of jointness. Taussig could see no difference between electricity capacity going to waste during the day (in those days) and railroad bed lying idle. Thus, Taussig stuck by his interpretation that the differentials between freight rates would exist even in the face of competitive pressure because they were like the price differentials on cotton and cotton seed. They were the prices of heterogeneous products produced jointly.

Little new ground was gained in the next exchange.[4] In his reply, Pigou continued to debate that competitive market equilibrium was the test and continued to assert that such an equilibrium in the case of coal and copper freight would lead to uniform rates, while the prices of cotton and cotton seed would never be equal. Taussig tried for clarification: 1) heterogeneity does not imply jointness, rather heterogeneity exists because of differing demands; 2) jointness exists because of large fixed costs that are not allocable to any particular service and because of excess capacity. Taussig fueled the controversy by appealing to the policy importance: Should the ICC regulators allow freight rate classifications or impose uniform pricing? (Taussig [1891, p. 455] detailed the misfortunes of the Germans in instituting uniform rate schedules for railways in the Alsace-Lorraine in the 1880s.)

True blood was drawn in the last exchange of 1913.[5] Pigou began by accepting the challenge to try to get to the bottom line of the policy debate. Should uniform freight rates be mandated by the ICC? Pigou admitted that there is no debate in the case where a rail line would be unprofitable without rate differentials. “In the particular ... case, in which there would not, under a system of uniform rates, be enough demand to enable *the least expensive railway that is possible to construct at all* to utilize its full capacity, I recognize that the conception of joint costs and the conception of monopoly afford equally suitable avenues of approach.” (p. 688) But if the railway can obtain operating revenues under a system of uniform rates then what? Pigou conceded that the transport of coal and copper are different goods because they have different demands, but he engaged sharply on the point that fixed plant implies jointness. He offered three arguments to the contrary:

1. Large fixed expenses are everywhere and we do not claim jointness everywhere.
2. The production of coal and copper freight transport is not the same as cotton and cotton seed production. If cotton is increased, cotton seed increases as well. The same is not true for coal and copper transport. Pigou noted that “a railway adapted to the weekly transport of x tons of copper *plus* y tons of coal can be altered into one adapted for the transport of (x+h) tons of copper *plus* y tons of coal.” (p. 691) This difference, he claimed, is the essence of the difference between common costs and joint costs that he expounded in his book.
3. Competition would drive the prices to uniformity. If price differentials existed in competition, then it would be in the interest of each seller to transfer production from the low priced to the high priced good thus driving the price differential to zero.

Under this siege, Taussig was not willing to give up. He claimed Pigou admitted to the right answer in one setting and then was unwilling to continue the analysis to its next logical stage. If price differentials are acceptable in the case where minimum profitability for the least expensive railway requires them, what about the case where excess capacity would exist if service were

[4] *QJE*, 1913, 535-539.
[5] *QJE*, 1913, 687-694.

limited to only the most profitable traffic. In other words, take the case of the existing, profitable railroad. Look at its rate classifications and limit service only to the transport of those goods with the highest prices. Taussig maintained that this would generate large excess capacity and it is socially undesirable not to use this capacity. Moreover, the only way to use the capacity is to charge shippers of other goods transport rates that are well below the highest rates paid. He gave an example of the New Haven railway system that was primarily a passenger line but moved freight when the plant was not fully utilized by passenger service. The rates charged for freight were necessarily lower to induce the freight shippers to be forthcoming. Taussig went back to Pigou's own example of excess, peak-load capacity in electricity and asked why rail service is different.

Pigou rewrote his book *Wealth and Welfare* and republished it under the title *The Economics of Welfare* in 1920. Little in his view of the railway rate controversy changed. He still maintained the joint cost-common cost dichotomy was the most important theoretical consideration and that the competitive market equilibrium was the efficiency-deciding guidepost. However, he did not offer any analysis of how a competitive equilibrium would obtain.

Taussig fired the last shot in 1933.[6] Taussig backed off his boldest statements of 1891 where he claimed that the existence of large fixed plant and multiline production implied joint cost. His view of the competitive equilibrium of such a world had led him to the conclusion that the plant (many plants of competing firms) would allocate its time among the different products, presumably so that market prices are equalized.[7] But even if the joint product model is not as universally applicable as he may have once thought it still applied in his mind to railroads. Railway plants have persistent unused capacity. Moreover, this excess capacity phenomenon is not confined to railways. Consider electricity production or in-season versus out-of-season hotel rates. The price differentials that exist in these cases can only be explained in the context of joint production. Taussig continued to see railways in the same light.

Always the empiricist, he asked the reader to consider the American experience. As railways in the U.S. matured, capacity was expanded. So if his capacity argument only applied to industries struggling to survive it should have passed out of the picture. Such was not the case. As the railways matured they added more lines, two and three abreast with numerous sidings. This all occurred in the face of growing competition from automobile transportation. With this growth did the industry have more or less excess capacity? Taussig's conclusion (understated though it was) was that growth and competition created more excess capacity and put forth greater pressure for price differentials, not less.

The Controversy Resurfaces

Of course, this did not reconcile Taussig and Pigou. The peak-load issue took off on its own and the joint v. common cost discussion moved into the question of joint versus overhead costs. Finally a definition of second-best optimality conditions was recognized in the form of Ramsey pricing, which will be discussed more in a moment.[8]

The Taussig & Pigou debate was replayed starting in the late 1960s. It was initiated by Demsetz's proposition concerning the efficient private supply of public goods. Much like Taussig,

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[6] *QJE*, 1933, 337-342.

[7] For a development of the structure of cost in such settings, see M.T. Maloney and R.E. McCormick, "Intermittent Production, Cost, and the Multiproduct Firm," *Journal of Business*, April 1983, 139-154.

[8] William J. Baumol and David F. Bradford, "Optimal Departure From Marginal Cost Pricing," *American Economic Review*, June 1970, 60(3), 265-283.

Demsetz made the simple, almost trivial application of the theory of joint costs to the case of public goods.[9]

Public goods were a hot topic. Especially keen was the question of whether a competitive supply of public goods was possible. Demsetz held the view that it was, based on the analytic implications of the joint supply model. Public goods are jointly supplied to the multiple recipients. As a joint supply problem each user pays a price that is equal to his demand valuation for the amount of the good received. As more of the good is supplied, each user moves down along his demand curve. However, the relative prices paid across the various users is still determined by their relative demand intensities. So long as the users have heterogeneous demands, the prices that they pay will differ. The private production of public goods then depends on the ability of firms to collect differential prices from heterogeneous consumers.

This set off a storm. Thompson had written just prior to the publication of Demsetz's paper that competitive supply of public goods would not be efficient.[10] They engaged debate with point-counterpoint in the *Journal of Law & Economics* where Demsetz also took on an attack by Ekelund and Hulett who used the Taussig & Pigou controversy to try to win their point.[11] The Demsetz-Thompson debate is interesting because it revolved around the question of competitive equilibrium which is where the Taussig & Pigou debate was headed but never reached.[12]

Ramsey pricing as a solution to the natural monopoly problem was highlighted at this same time. On the assumption that a natural monopoly must stand on its own without subsidy, Baumol and Bradford (1970) showed that consumer surplus is maximized if prices are set among heterogeneous demanders according to their demand elasticites. The Ramsey rule is to set the ratio of price-cost margins equal to the ratio of the inverse demand elasticities.[13] The idea is to minimize the dead weight loss by allocating the difference between price and marginal cost across the demanders, placing a larger burden on the less elastic groups. Ramsey pricing was ultimately adopted by the Interstate Commerce Commission in the 1980s as the ideal policy for railway rates but eschewed because it is not practicable in a regulatory framework.[14]

On one level, the Ramsey pricing theorem vindicates Taussig and damns Pigou: Optimal prices (under the assumption of self sufficiency) require price differentials among heterogeneous demanders. Because of this, it is odd that Baumol and Bradford do not cite Taussig or the Taussig and Pigou debate on this point. They have a section that sketches the evolution of the Ramsey pricing theorem. They start with several scholars who simply note an efficiency in prices that vary directly with demand elasticities. These examples are all in reference to railroads. Why Taussig is not listed here might be explained by the fact that the other contributors pre-dated and possibly pre-empted Taussig's contribution. However, the kicker is that they reference Pigou's (1928) discussion of the Ramsey theorem, where he uses the analysis approvingly in the context

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[9] Harold Demsetz, "The Private Production of Public Goods," *Journal of Law and Economics*, October 1970, 8(2), 293-306.

[10] Earl A. Thompson, "The Perfectly Competitive Production of Collective Goods," *Review of Economics and Statistics*, 50, 1968, p. 1, and reply, *REStat*, 51, 1969, p. 479.

[11] Robert B. Ekelund and Joe R. Hulett, "Joint Supply, the Taussig-Pigou Controversy, and the Competitive Provision of Public Goods," *Journal of Law & Economics*, 16(2), October 1973, pp. 369-388; "Joint Supply and Price Discrimination," Harold Demsetz, same issue, pp. 389-406; "The Private Production of Public Goods: A Comment," Earl A. Thompson, same issue, pp. 407-412; "Reply to Professor Thompson," Harold Demsetz, same issue, pp. 413-416.

[12] Borcherding summed up the debate and offered insights into the competitive equilibration process that are useful for the discussion here and are discussed in detail later. See Thomas E. Borcherding, "Competition, Exclusion, and the Optimal Supply of Public Goods," *Journal of Law & Economics*, April 1978, 22(1), 111-132.

[13] Price-cost margins are used here to mean the difference between price and marginal cost divided by price.

[14] See *Consolidated Rail Corporation v. U.S. and ICC*, 812 F.2d 1444 (3rd Cir. 1987) at 1454 and 1455.

of public finance, without remarking on the fact that Pigou had explicitly eschewed the same idea when applied to railroads.

Most likely, Baumol and Bradford just wanted to dodge the Taussig and Pigou debate because it was (and is) too confusing. The reason that the Taussig and Pigou debate went on so long is not so much due to the difficulty of defining optimal prices as the practice of rate setting in either a free market or a regulatory setting. Market equilibrium is the kernel of the Taussig and Pigou debate.

Most recently, the same questions have been posed in different clothes. Airline deregulation has brought with it an amazing array of prices. Most observers are willing to sweep the price differences between first class and coach fares under the rug by saying that there are obvious cost differences between the two services that explain the pricing structure. However, the price differences among coach cabin travelers do not suggest any obvious cost differences. Why do airlines allow passengers to fly at low fares with no advanced purchase if they have proof they are going to a funeral? Is there a cost explanation? Is it Pigovian price discrimination? If it is price discrimination, why does competition not expunge it?[15]

Consider the case of scheduled prices at hotels—not just rate differentials in resort hotels across the seasons. There are nontrivial price differentials everyday at the local Holiday Inn. Old people pay less; government employees pay less; people traveling from long distances pay more. Some researchers try to resolve the paradox of ubiquitous price differentials by searching for hidden costs.[16] No doubt, many costs are hidden from the view of the casual observer. However, as Taussig pointed out, the bulk of the costs are not. The bulk of the cost of a hotel room is obvious. It is the cost of the hotel itself.

A Taxonomy of Costs and Outputs

The Taussig & Pigou controversy ended but was never settled because the fundamental point of conflict was never battled head on. Pigou focused the debate on the characterization of common costs as joint costs. However, the real issue hinges on the realization of a competitive equilibrium. Let's review the issues from this perspective.

The essential characteristic of joint costs is that there is some degree of fixed proportions in production. In the extreme, each production unit yields one unit of beef and one unit of hides (or cotton and cotton seed oil, wool and mutton, chicken and eggs, etc.). The buyers of the goods are obviously different or, at least, the ultimate consumption demand for the two products is different. Everyone agrees that in this state of the world, competition yields price differentials between the two goods. In the perfectly fixed proportion case the production possibilities frontier between the two goods is concave and rectangular. The output mix is technologically constant. Price in each market adjusts to clear the market in that good. Competition generates the equilibrium where the revenue summed across the two markets equals the cost of the unified production unit.

The price differential will exist even if the goods are not produced under the conditions of strictly fixed proportions. That is, price differentials will result in a competitive market even

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[15] See Severin Borenstein and Nancy L. Rose, "Competition and Price Dispersion in the U.S. Airline Industry" *Journal of Political Economy*, 102(4), August 1994, pages 653-83, who make the point that airline pricing seems to be characterized by discriminatory prices that are somehow sustained in a competitive environment.

[16] John R. Lott, Jr. and Russell D. Roberts, "A Guide to the Pitfalls of Identifying Price Discrimination," *Economic Inquiry*, January 1991, 29(1), 14-23.

when the production technology offers a tradeoff between the joint products, so long as the tradeoff is not perfectly elastic. For instance, cattle can be bred and raised to produce marginally more beef and less hide, or sheep raised to yield more wool and less mutton, but this will not result in the price of wool being independent of the price of mutton. In the partial substitution case, the production possibilities frontier is concave but downward sloping. Nonetheless the price ratio between the two goods, driven by the relative demand intensities, determines the output mix between the two. Profit maximization for competitive firms requires that they produce at the point on the production frontier where its slope is equal to the price ratio between the two goods.

The competitive equilibrium in this world is identical to the fixed proportions case. Competition drives both prices down by increasing output in the two goods to the point where revenues summed across the two goods equals the cost of production at the optimal point on the frontier.

Notice that in the variable proportions case, competition cannot unify prices. If the elasticity of substitution in production between the two goods is less than infinity for each competitor, an interior solution will develop.[17] Each competitor will produce some of both goods as its profit maximizing choice; it is never in the interest of a competitor to produce only the higher priced good.

Contrast the case of joint costs to the purest form of common costs. Pigou claimed that railways and, by extension, hotels and airplanes have common not joint costs in providing service to different customers. For the common cost case to be interesting these customers must be heterogeneous demanders. Say there are two groups. If we refine Pigou's argument, it says that the essential characteristic of the production of these kinds of goods is that service to the two demanders is *perfectly* substitutable in production.[18] Each production unit can be allocated to either demand group. In technical terms, the production possibilities frontier is linear with slope of -1. In this case of common costs, competition drives the prices to equality. If the market prices are different between the two groups, a single profit maximizing competitor devotes supply completely to the higher priced market. Thus, Pigou's point is that even with large, nonallocable fixed costs necessary to produce either or both of the two goods, the competitive firm will adopt the profit maximizing strategy of devoting its entire output to the higher priced good when a price differential exists.

The problem with this analysis of common costs is that it does not directly engage Taussig's argument that production is characterized by excess capacity. Clearly, Pigou is envisioning a competitive equilibrium in which there is no idle capacity. The competitive firm may produce different goods using the same fixed plant. For instance, a powdered soap mill may make blue soap and white soap, but all soap is sold for the same price net of any separable, allocable cost differentials. With sufficient competition, the same should hold for railway service. Lott and Roberts hold the similar view of air passenger service where they argue competition is pervasive so price differentials must be driven by cost. If a competitive firm can freely shift supply between demanders, the firm will maximize profits by selling only to the higher priced group. Competition will thereby equalize price between the two groups.

Taussig saw something else happening. In his view, competition is driven by the margin of large fixed costs which generate what he called excess capacity. It is not that capacity is ultimately left idle. But rather that the fixed costs create a capacity *bundle*. It is not possible to serv-

[17] Assuming that both goods are brought to market.

[18] Pigou confuses this somewhat in the quote (1913, p. 691) cited above. However, this seems to be the point he was driving at.

ice a single rail or air travel passenger. Either the firm runs a whole train or plane that has the capacity to serve many travelers, or the firm serves none. Taussig's view of the joint-products model was very similar to Demsetz's application of this model to the case of public goods. Taussig's vision was a train that can carry a lot of people produced by using the idle road bed built primarily to haul freight. Demsetz's case is the production of a movie that, once made, can be sold to many and varied customers. Pigou's simple characterization of common versus joint costs does not capture this notion of bundled or lumpy production units.

Characteristics of the Market with Bundled Production

Table 1 outlines this view of the Taussig & Pigou controversy. There are four classes of costs and outputs. Both the joint cost and common cost models are well developed; it is their application that is in question. Demsetz applied the joint cost model to public goods; Taussig applied it to what I call *bundled goods*.

Bundled goods are goods that meet two conditions: There are significant economies of scale characterizing production, and market demand is small relative to the minimum average cost level of production. Consider the case of air passenger service. Production is characterized by the economies of scale of air transport. There are many types of airplanes that can be employed to provide passenger service between Chicago and Atlanta. However, there is one airplane that achieves minimum average cost per passenger mile on the trip. Other airplanes are too big or too small—their average cost is higher over this distance.

At the same time, demand is relatively small compared to this average cost menu. One characterization of the extent of demand is the number of passengers across all classes seeking service at a price equal to minimum average cost. This demand level divided by the quantity associated with minimum average cost gives a number which is the equivalent of the number of firms the industry will support in a perfectly competitive, zero-profits equilibrium.

Arguably, neither public goods nor bundled goods follow the strict characterization of joint costs and are just as reasonably portrayed as having common costs. Nonetheless, the implications of the joint cost model in terms of pricing seem appropriately applied to both public and bundled goods.

An observation about the market for a bundled good such as air passenger service between Chicago and Atlanta, which also seems to characterize the problem envisioned by Pigou, is that the number of firms is not an integer value at the zero-profits point along the market demand curve. In other words, the idea that production comes in bundled units suggests that there is never the exact level of productive capacity that will satisfy both market demand and quell the competitive attraction for profits. The Atlanta-Chicago air passenger demand is too large for two air carriers—*and* too small for three. When three carriers serve the market, an excess of capacity exists, which is the kernel of Taussig's idea.

In both the public goods and bundled goods applications of the joint cost model, consumers with heterogeneous demands pay different prices. One confusing aspect of applying the joint cost model to public goods is that a public good is not obviously differentiable between the demanders. Hides are hides, and beef, beef. However, a movie is a movie whether consumed by a cinema aficionado or a couch potato. Even so, the public goods model does not fail on this point. Different consumers of a public good who have different demands optimally pay different "Lin-

dahl-tax" prices. This is true in the standard textbook treatment of national defense. It is equally true in Demsetz's application of the theory of joint cost to privately produced public goods.[19]

Taussig argued that the same type of price differentials occur in the application of the joint cost model to bundled goods. Consumers with different demands pay different prices. Rail service to coal and copper shippers is different because these shippers have different demands. Pigou finally conceded to Taussig that shippers were different because they had different demands. However, he was unwilling to concede that they *optimally* pay different prices.

Public goods and bundled goods are similar. The production of a unit of a public good is in a sense a bundle. It can be sold to many demanders (an infinite number in principle, though only a finite number have a positive marginal valuation for the last unit of the good). In the same way, goods that are necessarily produced in bundled units have the same marketing characteristic as privately produced public goods. Production of the package may require that the many people to whom the capacity may be sold all pay according to their relative demand intensities for their share of the bundle. Production comes in lumps of service and to defray the cost of these lumps, competition forces firms to charge different prices to different customers based on their intensity of demand. It is in this world of capacity bundles that Taussig saw a competitive equilibrium defined by zero profits at the competitive entry margin and characterized by price differentials among demanders of different intensities.

Market Adjustment with Bundled Production

The confusing part of the puzzle comes from the dynamics of the competitive equilibrium. It is hard to envision how a privately produced public good can be distributed by the competitive market in a way that the price differentials among the demanders can be enforced. Ultimately, the debate over Demsetz's proposition about the efficient private supply of public goods foundered on this issue—the nature of the competitive adjustment process that can achieve differential prices among consumers receiving the same good. Borcherding claims that the equilibrium is not likely to be efficient because of the standard problems associated with free riding. While the fixed-proportions joint-products model fits the public goods model in principle, it is in practice that the difficulty comes into play.

Consider Demsetz's example of movies. We see movie producers distributing their products in a way that seems to differentiate among buyers. The price for first run, theater release is higher than the price for later showings. HBO gets the movie next, presumably for a price that is higher than the video stores. Ultimately the movie is released to public on cassettes discounted to Wal-Mart prices. Buyers with more intense demands as proxied by the immediacy of their interest in viewing the movie pay a higher price. Of course, whether this schedule of prices is in fact efficient is an open question. Borcherding argues that the proxies used to differentiate demanders are imperfect. The firm is generally not able to collect the full value of its product and the supply of the privately produced public good is likely suboptimal.

Even so, the conclusion is that the market equilibrium adjustment process is more important than the definitions of cost or outputs. In the traditional case of joint products, the competitive adjustment process and equilibrium is easy to envision. Separation of production between the

[19] Coase's lighthouse example of a privately provided public good is a case in point. See Ronald Coase, "The Lighthouse in Economics," *Journal of Law & Economics*, October 1974, 357. However, Borcherding argues as discussed later in the text that the efficient equilibrium envisioned by Demsetz and Coase will not generally prevail.

demanders that are served by the production unit is natural. Beef demanders are not satisfied by chewing on hides. Consumers of cotton shirts cannot pour cotton seed oil on their heads with equal effect. Because the markets used in the standard joint products analysis are naturally separable, the market equilibrium is well defined.

Public goods are just the opposite. If the competitive private supplier of public goods depends on consumers to self select themselves into high intensity versus low intensity groups, the wait will be long and the winter hard. Only by guile and shrewdness can the seller force demanders to reveal their true preferences. Only by compelling this revelation can the competitive firm cover the costs of the production of the good at its optimal level.

Bundled goods are nearly identical in this sense to public goods. The financing of the production of the bundle requires that buyers with intense demands pay more than buyers with lower valuations. Taussig's view was that in order to run a train, a schedule of rates has to be charged. Shippers of different products necessarily pay different prices according to their demand intensities or else the train will not cover costs.

The fundamental point of contention between Taussig and Pigou was that Pigou questioned why competition would not direct itself at supplying the high priced shippers. What restricts a competitor from trying to sell exclusively to the buyers who are being charged a relatively high price by other firms? Pigou imagined that with sufficient competition, price across all consumers would be driven to equality.

Taussig agreed that in certain limiting cases this would be true. He said, coal that is carried on a railway solely devoted to coal transport will pay a different rate than coal transported over a line servicing many users. However, the extent to which the shippers that pay the highest price are protected by competition depends on the profitability that might derive from marketing a similar bundle that is solely directed at the highest priced consumers.

Let's consider the most familiar examples in simple terms. A airplane on the trip from Atlanta to Chicago costs $45,000 to operate and carries 150 people. The average cost is $300 per person. First class travelers pay $750, regular coach, $675, tourist class, $250, and some special fares are as low as $200. Obviously, some people on the plane pay more than the average cost per seat. Ignore the first class travelers because presumably they are receiving extra services. Let's concentrate on the price differences between regular coach and tourist class fares. These seats have exactly the characteristic of supply that so puzzled Pigou in his criticism of Taussig. Tourist class seats can be freely turned into regular coach. Why in competition does the price of regular coach not get driven down to $300 (and the price of tourist class up to that level)? Why does not one of the competing airlines convert all of its seats to regular coach at a fare of, say, $500 and steal away all of the regular coach traffic? Taussig's answer is that if they did they would not fill the plane.

Alternatively, consider what happens when the demand by the relatively inelastic but separable demanders becomes large relative to the size of minimum efficient production. In this world, price competition works to price protect the relatively inelastic demand group. If the intense demanders can be served by a firm devoted exclusively to their demands, such will be done. The example that Taussig used was the dedicated coal railway. The modern example is the case of business travelers along the northeast corridor. Business air travel is sufficiently large along this route that firms find it profitable to specialize in this service. Because there are a large number of business travelers, so large that an entire production bundle can be filled by them, they are not discriminated against. However, when the number of business travelers is smaller than the size of

the production bundle, they pay a price that is based on their demand elasticity relative to the demand elasticity of the less intense travelers.

In the mid 1990s there were three carriers serving the Chicago O'Hare-Atlanta route. Surveys indicated that between 80 and 90 percent of all domestic air travelers at that time flew on some sort of discounted ticket.[20] This means that if all three carriers were flying planes at the same time from Atlanta to Chicago, there would only be 90 full-fare customers at most. In fact, at any given time of the day there are, no doubt, substantially fewer. There are not enough people willing to pay full fare to fill a plane and yet these customers demand a seat. The competitive equilibrium gives them a seat and sells off the remaining, excess capacity to other travelers, charging whatever fare the traffic will bear.[21] The competitive equilibrium also causes there to be three carriers serving this market instead of two. Two carriers make excess profits. Three carriers do not (or at least not as much).

While a general solution to the competitive entry problem is unknown, there are conditions that set the boundaries of the market adjustment process generated by lumpiness in productive capacity relative to demand.

1) *Excess profits will attract entry but will not necessarily induce entry.*

A single-price market equilibrium that generates excess profits for the existing firms will attract the attention of potential entrants. Whether these potential rivals actually enter the industry depends on whether they can find a way to cover costs.

2) *Entry will **not** occur if under the most favorable circumstances of cartel behavior and pricing an additional firm will cause all firms to suffer losses.*

The most favorable conditions of cartel behavior from the potential entrant's perspective is that it will get cut into the game. If the potential rival begins production, its best hope is that it will not face sanctions from the other firms and that it will be allowed to capture a full $1/n^{th}$ share of the market. Moreover, the best-case scenario is one in which the cartel behaves like a multiplant monopolist in determining price and sharing output. From the pricing perspective, the most favorable circumstance is that the cartel can price discriminate on many margins. If, under these most favorable circumstances, entry will cause losses, then entry will not occur.

Beyond this, entry may not occur even when perfect cartel behavior and pricing could generate profits for all simply because perfect cartel behavior is too costly to achieve. To the extent that the market is hard to organize and cartel behavior is hard to police, a potential entrant cannot reasonably expect that its entry will occasion a reduction in these cartel inefficiencies and a move toward perfect monopolization.

In any case, the interesting point of the conditions of entry posited above is that competition generates a result in which price discrimination is the outcome. Lumpy production bundles mean that with n firms even single-price competition will not driven profits to zero. With n+1 firms, the excess capacity generated by the extra production bundle will lead to price discrimination to

[20] This comes from a 1994 survey by *Traveler's Weekly*, a trade publication that surveys travelers concerning the type of ticket that they purchase. In 1994, there were three carriers serving the Atlanta-Chicago O'Hare route, Delta, United, and American.

[21] American Airlines Decision Technologies is a research subsidiary of American Airlines that works to refine the algorithm for solving this pricing/allocation problem.

clear the market as well as cover costs. With n+1 firms, price competition or collusion may occur, but in either case, price discrimination will characterize the pricing structure. Under collusion, price discrimination will enhance profits; under competition, price discrimination is the only way to break even.

Consider an example similar to the airline case. Holiday Inn operates a hotel in the Atlanta metro area that has around 1000 rooms. Most of these rooms are identical. Even so, Holiday Inn sells the rooms at different rates. They have about 10 separate rate classifications. We are all familiar with some of these—government, corporate, senior citizen, etc. When you call for a reservation and ask for a special rate, Holiday Inn must decide whether to allocate a room to you at that rate or not. They decide to do so based on among other things the length of your stay and their forecast of being able to sell the room at a higher price. The rate structure is conditioned on the total number of hotel rooms in an area and the total demand by full-fare customers. Competition does not drive these price differentials away because production capacity comes in big bundles.

Of course, to say that production comes in big bundles—bundles that are larger than the sum of the demand by full-fare customers across the entire market—is not to say why a given seller eschews the option of cutting its full-fare price a little in an effort to gain all of the full-fare customers. It is not sufficient to say that they will because if they do not they will go broke. Some sort of game theory strategy must be ascribed to the market participants.

It is at this point that our understanding of market equilibria fails us as it did Taussig and Pigou 80 years ago. If the single-price, zero-profits-equilibrium number of production bundles is a non-integer, the supply of the whole unit that covers this equilibrium will cause a single competitive price to fall to the point where losses are endured by all firms. Markets of this sort are often said to have an empty core. [22] If entry occurs, the only way to cover costs is by means of price discrimination, but how firms behave to achieve a stable, price discriminating market equilibrium is not well defined. Numerous possibilities come to mind with all of the well-known shortcomings of the theories of oligopoly. The firms can act like Cournot competitors, or they can act in cartel fashion, or possibly they compete against one another in terms of price even to the point of ruin.

Why does one of the airline competitors on the Chicago-Atlanta route not cut price to the regular coach customer? One possible strategy that will produce the result that they do not is that all participants assume that all other rivals will match their low price. In this case cutting full-fare prices will not gain all the full-fare customers. However, such an assumption about market dynamics does not describe how prices are determined in the first place.

It is interesting to return at this point to the Demsetz-Thompson debate. These scholars offered two different interpretations of the equilibrating process in the case of public goods where the suppliers had full information about the demand schedules they face. Thompson concluded that with a type of Cournot adjustment mechanism there would be an over supply of the public good. Demsetz, on the other hand, concluded that the efficient supply would obtain. Borcherding in a lucid and succinct characterization of both models concludes that Thompson's oversupply conclusion hinges on a strained application of the Cournot adjustment process. Alternatively,

[22] Sjostrom argues that the market for oceanic shipping has an empty core. To solve this problem, the firms form a cartel to prevent entry and allocate output. His characterization of the cost and production structure in oceanic shipping is one of bundled production units. See William Sjostrom, "Collusion in Ocean Shipping: A Test of Monopoly and Empty Core Models," *Journal of Political Economy*, 97(5), 1989, pp. 1160-1179.

Demsetz's efficiency conclusion grossly glosses over the problems of contracting inherent in all public good situations. Even so, the sustainable conclusion to be reached from both models is that the marginal buyer will not be offered a price cut on the marginal purchase even though the marginal cost of supply is zero because to do so will force default. In other words, a competitive entry equilibrium with price differentials based on demand intensities unfolds.[23]

A key ingredient in the competitive equilibrium expounded by Demsetz and Thompson is that each seller knows perfectly the demand schedule of each buyer. In practice this may generally be a problem. However, in the airline case, the relatively inelastic demand of the business traveler is separable and readily apparent to the supplier. The business traveler has a demand characterized by immediacy that implies intensity and that separates him from other travelers—he cannot book in advance. Airlines can sell tickets to elastic demanders in advance at lower fares, hold some seats available for the inelastic demanders of spur-of-the-moment service. In doing so airlines can still hold out the threat to meet any price cutting by their rivals. Hence, the airline that lowers its regular coach fare cannot hope to get *all* of the inelastic travelers if it expects its rivals to meet the low price.

Informational asymmetries can be used to extend the application of a model of competitive price discrimination. The hotel example is a case in point. Hotels offer discount rates to large parties and groups. These groups demand large facilities, which causes the bundle of production (1000 room facilities), but these groups are also relatively elastic demanders. Corporate conferences and professional meetings can be booked far in advance. The organizers can cheaply shop among competing suppliers, even interregionally. On the other hand, the last-minute traveler who pulls up at the Holiday Inn does not know whether there are rooms at the Ramada down the road or what their price might be. Moreover, cutting the price to a lone wayfarer even though excess rooms are available will not likely generate additional business. The knowledge of the price cut cannot be cheaply announced to other loners, nor are their numbers particularly sensitive to such an influence.

The ability to price discriminate determines the competitive adjustment. If demand is indistinguishable, then there is no possibility of price discrimination. Given the bundled nature of production, the market equilibrium may be characterized by existing firms enjoying positive profits at a single priced equilibrium. Price is equal to marginal cost, but not sufficiently large to support another firm. Brand named products may be the best example of this phenomenon. Brand names involve a sunk cost that generates a U-shaped average cost when coupled with increasing marginal cost of production. Producers of the brand name cannot distinguish among buyers based on the intensity of their needs for a brand name. A single price results—some people eat at McDonald's out of fear of the local diner down the street, others merely for variety between the two. Both types of McDonald's patrons pay the same price. McDonald's and other brand named producers enjoy positive profits when demand causes price to exceed cost but is still insufficient to support another brand name entrant. When firms can separate demand and when a game theory equilibrium is possible, price discrimination is a way that the positive profits that would exist in the case of single pricing can be exploited by competitive entry.

[23] Reconsider the case of movies. A movie producer could, after completing a film, distribute it to all buyers at the discount video cassette price of $10. Similarly, book publishers could distribute literary works initially in both paper and hardback. However, they do not because the cost of the project cannot be recovered.

Conclusions

Taussig and Pigou engaged in a debate concerning the cause of price discrimination. Taussig claimed that price discrimination is competitively driven. Pigou claimed that it can only result from monopolization and that sufficiently rivalrous competition will expunge it. The arenas in which this debate is replayed are almost too numerous to mention—industries like transportation, communications, entertainment, hotels, and restaurants all have pricing practices that look suspiciously like price discrimination. Indeed, almost every industry has such practices. Some researchers tell us to keep looking for hidden cost differences to explain the obvious price differentials. Not only does this approach seem unscientific, it has proved futile.

What I have attempted in this paper is a reexamination of the Taussig & Pigou controversy in a way that highlights the essence of their exchange and offers an explanation of the competitive pricing anomalies that we see around us. I argue that Taussig envisioned a market characterized by production that comes in bundled units. These bundles create discontinuities in the market. One too few bundle causes excess profits to be earned by all market participants. One additional bundle creates excess capacity that can only be exploited by means of price discrimination. The paradoxical result is that price discrimination becomes the engine of competition. Competitive entry in response to excess profits creates excess capacity that calls forth price discrimination.

Taussig's depiction of this type of market is not without its own shortcomings. We do not have a well formed model of the behavior of the firms engaging in bundled production with excess capacity. Possibly the market is dynamically unstable—firms bounce between ruinous competition and perfect cartel behavior. Empty core models characterize the problem but offer little insight to the process. On the other hand, Taussig's perception was that price discrimination would develop. Casual empiricism suggests that in markets characterized by apparent price discrimination, the competition may be unstable but it is rarely ruinous. The prediction of Taussig's argument is that excess capacity will generate price discrimination at the competitive margin, and that is what we observe.

A final word on efficiency is in order. There is nothing in the analysis set forth here that assesses the efficiency of competitively driven price discrimination. In practice, efficiency is not an absolute precept. The relative merits of different regimes must be investigated. Arguably in some stylized and static sense, Pigou was correct in asserting that a regulatorily mandated single price structure is more efficient than a system of scheduled prices based on demand elasticities. More recently, Ramsey pricing has been accepted as the benchmark for efficient pricing for zero-profit rate making, but disregarded because it is not feasible in regulatory practice. Even so, whatever the theoretical optimal, a problem of regulation is that it stifles initiative. The benefit of competition even if it generates discriminatory price differentials that are not precisely optimal is that it encourages innovation. The magnitude of this benefit is, however, hard to measure.

* Helpful comments by Don Gordon, Tom Borcherding, John Chant, and Steve Easton are gratefully acknowledged. Matt Lindsay and Bobby McCormick have been especially patient in helping me work through the issues addressed in this paper.

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Table 1: Taxonomy of Costs and Outputs

Category	*Conditions of Consumption*	*Conditions of Production*	*Market Equilibrium*
Joint Costs	Heterogeneous Goods	Fixed Proportions: Each Production Unit yields Consumption Units for each Heterogeneous Consumer Group	Competition: Price Differentials based on Demand Elasticities
Public Goods	Homogeneous Good	Nonrivalrous Consumption: Each Production Unit Allocable to all Consumers	Government Supply: Differentials in Tax Prices when Consumers are Heterogeneous (usual ?); Competition: Price Differentials among Heterogeneous Consumers based on Demand Elasticities (sustainable ?)
Common Costs	Homogeneous Good; Heterogeneous Consumer Groups	Variable Proportions in Number and Allocation of each Production Unit	Competition: Price Uniformity; Monopoly: Price Discrimination among Separable Consumer Groups
Bundled Goods	Homogeneous Good in Multi-Unit Production Bundle; Heterogeneous Consumers	Variable Proportions but Nonrivalrous Consumption when Bundle has Excess Capacity	Competition: Price of Bundle = Cost; Cost Sharing within Bundle based on Demand Elasticities of Separable Groups