Abstract

Though it is no longer an active area of research by economists, the Marshallian theory of the firm is still central to introductory pedagogy in economics. It has withstood numerous criticisms over the years—of its empirical relevance, its uni-dimensional description of the motives of firms, its "black box" treatment of the firm, and so on. In this article I put one further critique: it is, quite simply, mathematically false. When the errors in the theory are corrected, nothing of substance remains: Equating marginal revenue & marginal cost does not maximize profits, competition does not lead to price equaling marginal cost, and the welfare loss previously attributed to monopoly is due instead to profit maximizing behavior, independent of the number of firms in an industry.

1

Why economics textbooks must stop teaching the standard theory of the firm

Steve Keen
School of Economics & Finance,
University of Western Sydney
www.debunkingeconomics.com

August 28, 2007

Though it is no longer an active area of research by economists, the Marshallian theory of the firm is still central to introductory pedagogy in economics. It has withstood numerous criticisms over the years—of its empirical relevance, its uni-dimensional description of the motives of firms, its "black box" treatment of the firm, and so on. In this article I put one further critique: it is, quite simply, mathematically false. When the errors in the theory are corrected, nothing of substance remains: competition does not lead to price equaling marginal cost, equating marginal revenue & marginal cost does not maximize profits, output is independent of the number of firms in an industry, and the welfare loss the model attributes to monopoly is due instead to profit maximizing behavior.

1 The Marshallian model

The Marshallian model makes the following assumptions:

1. All firms in an industry produce an undifferentiated product, so that the only form of competition is by price;

2. The industry faces a downward sloping market demand curve, so that marginal revenue falls as market output rises;

3. Firms produce under conditions of diminishing marginal productivity, so that for the relevant range of output, marginal costs rise;

4. Firms are atomistic: they do not react to the hypothetical actions of their competitors (in contrast to the more sophisticated Cournot model of competition); and

5. Firms are rational profit-maximizers.

Given these assumptions, the model distinguishes two extreme market taxonomies: monopoly, where one firm supplies the entire market; and perfect competition, where there are numerous firms. In the former case, it is asserted that the monopoly maximizes profits by setting a price that equates its marginal revenue and marginal cost. In the latter case, though firms still act as profit-maximizers, and therefore equate their marginal revenue to their marginal cost, it is asserted that, for various interchangeable reasons—the small size of each firm relative to the market, atomism, or "price-taking behavior"—their marginal revenue equals the market price. Graphically, the demand curve for a perfectly competitive firm is drawn as a horizontal line at the market price, while the demand curve for the monopoly is the downward-sloping market demand curve.

As a result, it is alleged that the perfectly competitive industry structure results in a higher output and a lower price, and the important welfare result that marginal cost equals price. This both maximizes social welfare, and, if all industries are perfectly competitive, assures that prices reflect relative scarcity. These propositions are summarized graphically in Figure 1.

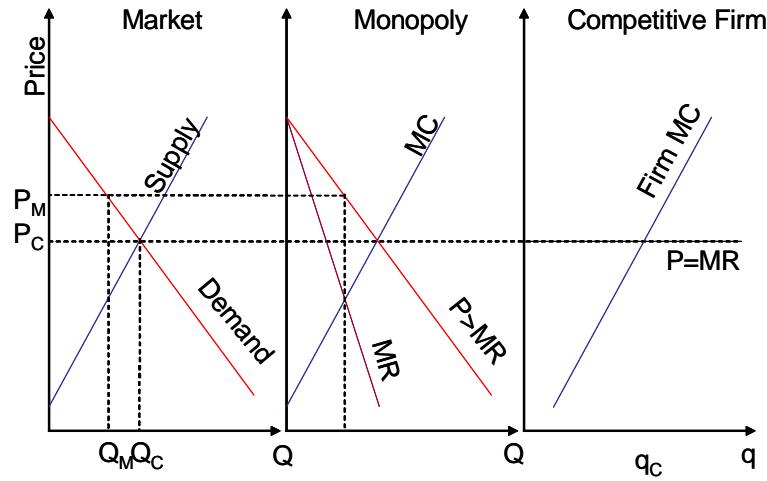Documents/economic/Papers/ProfitMax/Submissions/GermanMathEconBook/MarshallianMonopolyVsP

Figure 1: Standard Marshallian comparison of monopoly and perfect competition

Elementary calculus shows that these widely-believed assertions are false.

2 The "Horizontal Demand Curve" Fallacy

The propositions that the market demand curve slopes downwards, whereas the demand curve for a competitive firm is horizontal, can be mathematically expressed in the coupled propositions (a) that $P'(Q)\left(=\frac{dP}{dQ}\right) < 0$, while (b)

PERFECT COMPETITION, HISTORICALLY CONTEMPLATED

GEORGE J. STIGLER

[31] Let one seller dispose of q_i, the other sellers each disposing of q. Then the seller's marginal revenue is

$$\frac{d\,(p\,q_i)}{d\,q_i} = p + q_i\,\frac{dp}{dQ}\,\frac{dQ}{d\,q_i},$$

where Q is total sales, and $dQ/dq_i = 1$. Letting $Q = nq_i = nq$, and writing E for

$$\frac{dQ}{dp}\,\frac{p}{Q},$$

we obtain the expression in the text.

Figure 2: Stigler's 1957 application of the chain rule

$P'(q_i)\left(=\frac{dP}{dq_i}\right) = 0$—where $Q = \sum_{i=1}^{n} q_i$ is total industry output and q_i is the output of the ith firm.[1] It is easily shown that these two conditions are incompatible, given the assumption of atomism. This is not a new result—it was first established by George Stigler in 1957 (see Figure 2):

The key proposition in Stigler's argument that $\frac{dP}{dQ} = \frac{dP}{dq_i}$ that $\frac{dQ}{dq_i} = 1$ can be derived from the concept of atomism. Given the definition above of industry output Q as the sum of the output of n competitive firms, we can express $\frac{dQ}{dq_i}$ as:

$$\frac{dQ}{dq_i} = \frac{d}{dq_i} \sum_{i=1}^{n} q_i \tag{1}$$

The total derivative of Q with respect to q_i is the sum of the n partial derivatives $\frac{\partial q_i}{\partial q_j}$. Expanding equation (1) yields:

---

[1] There is an error in mathematical grammar here, which reflects current erroneous economic practice. This will be amended later.

4

$$\frac{dQ}{dq_i} = \sum_{j\,=\,1}^{n} \frac{\partial q_j}{\partial q_i} \qquad (2)$$

Atomism means that $\frac{\partial q_i}{\partial q_j} = 0 \ \forall \ i \neq j$, while of course $\frac{\partial q_i}{\partial q_j} = 1 \ \forall \ i = j$. Therefore:

$$\frac{dQ}{dq_i} = \frac{\partial q_i}{\partial q_i} + \sum_{j\,\neq i}^{n} \frac{\partial q_j}{\partial q_i} = 1 \qquad (3)$$

Consequently, we get the result that Stigler arrived at in 1957, that marginal revenue for the atomistic competitive firm is less than the market price:

$$\frac{d}{dq_i}\left(P \cdot q_i\right) = P + q_i \cdot \frac{dP}{dQ} \qquad (4)$$

There is nothing mathematically remarkable in this result: it is a well-known property of multivariate calculus that, if several variables additively determine a rate of change, then it doesn't matter which one of them changes—the slope of the function with respect to the change will be the same. In this sense, the function $P(Q)$ is shorthand for the multivariate function $P\left(\sum_{i=1}^{n} q_i\right) = P(q_1 + q_2 + \cdots + q_i + \cdots q_n)$, where under the assumption of atomism, changes in any given q_i don't cause changes in any q_j for $i \neq j$.

What is remarkable is that economists have persisted with a mathematical fallacy for so long. Partly this is because the reasoning behind it has been graphical or verbal in nature, and unintentional deceptions have arisen in these less precise languages: the graphical argument effectively compresses the horizontal scale but does not compress the vertical; the verbal argument—about "price-taking" behavior—describes as rational something that clearly involves irrationality. The errors that arise in these forms of argument have then become part of economic lore, and are extremely difficult to dislodge from the minds of economists. Both errors can be seen in Figure 3:

Considering the rationality argument in more detail, at the very minimum, rational behavior means acting consistently with regard to known data. The knowledge in this instance is the proposition that the relative price of the good falls as the quantity produced increases. In that case, it is rational to believe that $P(Q + \delta Q) < P(Q) \ \forall \ \delta Q > 0$, since $P'(x) < 0$.[2] However, the neoclassical "price-taking" assumption is the belief that the individual firm has no impact on the market price: this is the belief that $P(Q + \delta Q) = P(Q) \ \forall \ \delta Q$. Clearly this is an irrational belief;[3] a rational firm must believe that, if the market demand curve slopes downwards, then its output *will* have an impact on the commodity's relative price—no matter how small this impact might be. The rational belief

---

[2] I use x here as the argument to the price function, to emphasize that it does not matter what independent argument to $P\,()$ changes: the slope of the function is independent of which argument to it changes.

[3] I confirm this in a related paper. See[5]

Figure 3: Rational versus irrational belief for a competitive firm

necessarily results in a lower output level, even if the firm chooses to produce where marginal cost would equal price. Of course, it might be expected that the rational firm would instead produce where its marginal cost equals its marginal revenue, which would involve an even lower of output. It transpires, however, that the output level of a rational profit-maximizer would be lower still, because the neoclassical definition of profit-maximizing behavior is wrong.

3 True profit-maximizing behavior

If market demand and the cost function of the firm can be given mathematical forms, then the output level that maximizes the firm's profits π_i can be objectively defined. Whether or not a given market structure—or a given type of strategic interaction between firms—actually results in the profit maximizing level being the equilibrium level is irrelevant to the question of what the profit maximizing level actually is.

Neoclassical pedagogy asserts that this maximum is given by the quantity at which the firm's marginal revenue equals its marginal cost:

$$\pi_{iMax}\left(Marshall\right): MR_i\left(q_i\right) = MC_i\left(q_i\right) \tag{5}$$

Given the definition of marginal revenue and the substitution that $\frac{d}{dq_i}P = \frac{d}{dQ}P$, this expands to:

$$P\left(Q\right) + q_i \cdot \frac{d}{dQ}P = MC_i\left(q_i\right) \tag{6}$$

6

However, the profit maximizing output level for the ith firm is a function not merely of its output, but also of the output of all other firms in the industry—regardless of whether or not the ith firm can influence their behavior, or knows what that behavior is. The true profit maximum is therefore given by the zero, not of the *partial* differential of the ith firm's profits π_i with respect to its output q_i, but by the *total differential* of its profits with respect to industry output Q: not by the value of q_i for which $\frac{\partial}{\partial q_i}(\pi_i) = 0$—which economists normally erroneously write as $\frac{d}{dq_i}(\pi_i) = 0$—but by the value of Q for which $\frac{d}{dQ}(\pi_i) = 0$. Though the individual competitive firm can't ensure that the market produces this amount, it can work out what its own output level should be, given a specified market inverse demand function $P(Q)$ and firm cost function $TC_i(q_i)$. We start by expanding $\frac{d}{dQ}(\pi_i) = 0$ in terms of P, Q, q_i and TC_i:

$$\frac{d}{dQ}\pi_i = \frac{d}{dQ}\left(P(Q)\,q_i - TC_i(q_i)\right) = 0 \tag{7}$$

This total derivative is the sum of n partial derivatives in an n-firm industry:

$$\frac{d}{dQ}\left(P(Q)\,q_i - TC_i(q_i)\right) = \sum_{j=1}^{n}\left\{\left(\frac{\partial}{\partial q_j}\left(P(Q)\cdot q_i - TC_i(q_i)\right)\right)\cdot\frac{d}{dQ}q_j\right\} \tag{8}$$

In the Marshallian case, atomism lets us set $\frac{d}{dQ}q_j = 1\;\forall\,j.$[4] Expanding the *RHS* of (8) yields:

$$\sum_{j=1}^{n}\left(P(Q)\cdot\frac{\partial}{\partial q_j}q_i + q_i\cdot\frac{\partial}{\partial q_j}P(Q) - \frac{\partial}{\partial q_j}TC_i(q_i)\right) = 0 \tag{9}$$

Under the Marshallian assumption of atomism, the first term in the summation in (9), $P(Q)\cdot\frac{\partial}{\partial q_j}q_i$, is zero where $j\neq i$, and $P(Q)$ where $j=i$. The second term is equal to $q_i\cdot\frac{\partial}{\partial q_j}P(Q)\;\forall\,j$, and $\frac{\partial}{\partial q_j}P(Q) = \frac{d}{dQ}P$, so that this yields n copies of $q_i\cdot\frac{d}{dQ}P$; the third term $\frac{\partial}{\partial q_j}TC_i(q_i)$ is zero where $j\neq i$, and equal to marginal cost $MC_i(q_i)$ where $j=i$. Equation (9) thus reduces to

$$P(Q) + n\cdot q_i\cdot\frac{d}{dQ}P = MC_i(q_i) \tag{10}$$

This is the true profit-maximization formula, and it coincides with the neoclassical formula only in the case of a monopoly, when $n=1$. It is easily shown that the (10), which I call the Keen formula, results in a substantially higher profit than the standard Marshallian formula.

---

[4] See the Appendix for the derivation of this result. I address the Cournot case in separate papers with Russell Standish [6], [7].

4 A symbolic example

Consider an industry facing a linear demand curve given by:

$$P(Q) = a - b \cdot Q \tag{11}$$

with n identical (but independently managed and non-colluding) firms facing a quadratic total cost function:

$$TC_i(q_i) = k + c \cdot q_i + \frac{1}{2} \cdot d \cdot q_i^2 \tag{12}$$

If the ith firm follows the Marshallian "profit-maximization" formula, its output level will be such that equation (13) applies:

$$a - b \cdot Q - b \cdot q_i = c + d \cdot q_i \tag{13}$$

With all firms independently following this formula, we can substitute that $q_i = q$ and $Q = n \cdot q$. This lets us derive a Marshallian prediction for the output level that will maximize the profits of the individual firm:

$$q_M = \frac{a - c}{d + b \cdot (n + 1)} \tag{14}$$

If, on the other hand, the firm follows the Keen formula, then its output level will be such that equation (10) applies:

$$a - b \cdot Q - b \cdot n \cdot q_i = c + d \cdot q_i \tag{15}$$

Making the same substitution for all firms as for (13) above, this yields the Keen prediction for the output level that will maximize the profits of the individual firm:

$$q_K = \frac{a - c}{d + 2 \cdot b \cdot n} \tag{16}$$

The profit earned by the ith firm from these two output levels can now be compared. Calling the Marshallian level of profit π_M and the Keen level π_K, the difference between the two profit levels is given by:

$$\pi_K - \pi_M = \frac{b^2 \cdot (a - c)^2 \cdot (n - 1)^2}{2 \cdot (d + 2 \cdot n \cdot b) \cdot (d + (n + 1) \cdot b)^2} \tag{17}$$

Given the conditions that must apply to give well-behaved price and cost functions,[5] this difference is positive for $n > 1$: the Keen formula results in a higher profit.

---

[5] $b > 0, c \in \mathbb{R}, d > 0$.

5 A numerical example

Consider the above symbolic example with the parameter values $a = 1000, b = 1/1000, c = -1, d = 3/1000, k = 10000$, and $n = 200$. The two formulae yield substantially different predictions for the output level that will maximize profits: $4,907$ units per firm for the Marshallian formula versus $2,484$ units for the Keen. The per firm profit predictions are even more disparate: $50,193$ for the Marshallian formula, versus $1,233,177$ for the Keen. Whatever else the Marshallian formula does, it certainly does not maximize profits!

6 Instrumentally rational profit-maximizing

Experience has led me to expect that neoclassical economists reading this would have at least the three following reactions: (a) that somehow the analysis above has introduced collusive rather than competitive behavior; (b), that in practice, and without collusion, competitive firms would be unable to work out the higher profit level of output; and that (c) in any case, the Cournot approach to competition reaches the same results as the Marshallian. The third objection is a separate issue which I address elsewhere ([6]); the other two are irrelevant to the issue of what is, in fact, the correct profit-maximizing formula.

These propositions can nonetheless also be shown to be false hopes, by considering a completely independent way of working out what profit-maximizing firms might do. Consider a computer simulation of a market inhabited by what I term *instrumentally rational profit-maximizers*. These are firms whose sole behavior is to alter production in search of higher profit: if an output change caused an increase in profit on the previous iteration, it repeats the change on the next; if it caused a fall in profit, then the firm reverses direction. Their behavior provides independent confirmation that (a) the Keen formula locates the profit-maximizing output level for the firm, and (b) rational profit-maximizers can locate this amount by a simple process of trial and error.

The program shown in Figure 6 implements the simplest possible algorithm of this concept, in the programming language within the mathematics program Mathcad:

Documents/economic/Papers/ProfitMax/Submissions/GermanMathEconBook/RationalFirmsProgram.em

$$\text{Sim}_l := \begin{vmatrix} Q_0 \leftarrow \text{round}\big(\text{runif}\big(n, q_K, q_M\big)\big) \\[6pt] P_0 \leftarrow p\left(\sum Q_0\right) \\[6pt] dq \leftarrow \text{sign}\,(\text{rnorm}(n, 0, 1)) \\[6pt] \text{for } i \in 0.. \, 5000 \\[4pt] \quad \begin{vmatrix} Q_{i+1} \leftarrow Q_i + dq \\[6pt] P_{i+1} \leftarrow p\left(\sum Q_{i+1}\right) \\[6pt] \text{for } j \in 0.. \, n-1 \\[4pt] \quad \begin{vmatrix} dq_j \leftarrow dq_j \quad \text{if } \left[P_{i+1}\cdot\big(Q_{i+1}\big)_j - tc\big[\big(Q_{i+1}\big)_j\big]\right] - \left[P_i\cdot\big(Q_i\big)_j - tc\big[\big(Q_i\big)_j\big]\right] > 0 \\[6pt] dq_j \leftarrow -dq_j \quad \text{otherwise} \end{vmatrix} \end{vmatrix} \\[6pt] Q \end{vmatrix}$$

<center>Rational Firms Simulation Program</center>
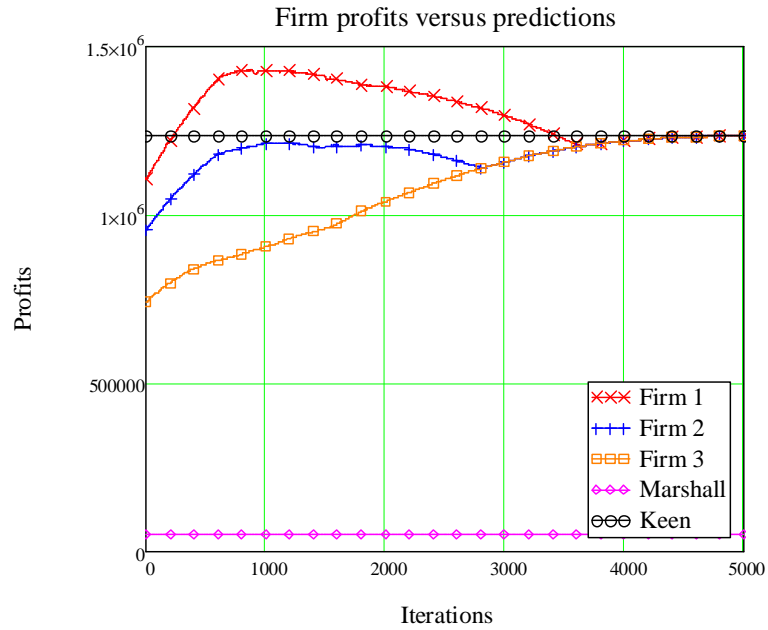
Going through the program line by line:

1. The 200 firms are randomly allocated an initial output level lying between the Keen and the Marshallian predictions.

2. An initial market price is calculated, based on the initial aggregate output level

3. The 200 firms are randomly assigned to either increase or decrease their output by one unit on the first iteration

4. For 5000 iterations:

5. The revised output level for each firm is calculated

6. A revised market price is calculated, based on the new aggregate output level

7. For each of the 200 firms:

8. The firm works out whether profit has risen or fallen as a result of the last output change; if it has risen, it continues to change output in the same direction.

9. Otherwise it reverses the direction of its change in output

10. The program then returns an array containing the output level for each firm at each iteration.

Figure 6 shows the output levels of three randomly chosen firms. Though the strategy is extremely simple, complex individual behaviors result because of the impact on each firm of the behavior of all other firms; nonetheless, all firms converge to the Keen output level over the 5000 iterations of the program.
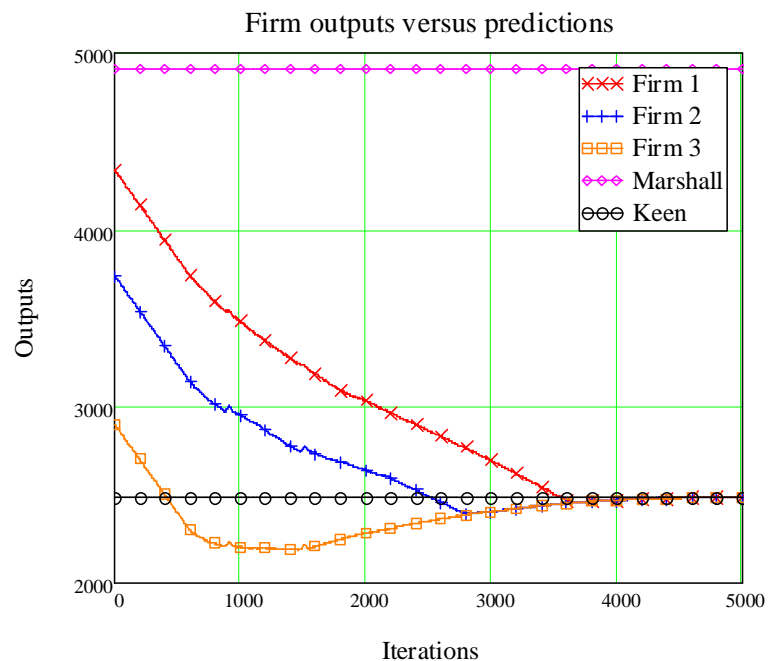
Rational Firms Output Levels in a 200 firm industry

The profit results in Figure 6 show the same impact of complex interactions with other firms, but of course converge to the Keen prediction.

Documents/economic/Papers/ProfitMax/Submissions/GermanMathEconBook/RationalFirmsProfits.emf

Firm profits versus predictions

Rational Firms profits in a 200 firm industry

The plots of aggregate output and market price in Figures 6 and 6 respectively show how starkly different the two predictions are: the Marshallian prediction is that a industry inhabited by profit-maximizing firms—who neither collude, nor interact strategically—will produce an output level of $990,196$ units that will result in a market price of \$9.80; the Keen prediction is that the aggregate output of the firms will be $501,241$ units, resulting in a market price of \$498.76.

Documents/economic/Papers/ProfitMax/Submissions/GermanMathEconBook/RationalMarketOutput.en
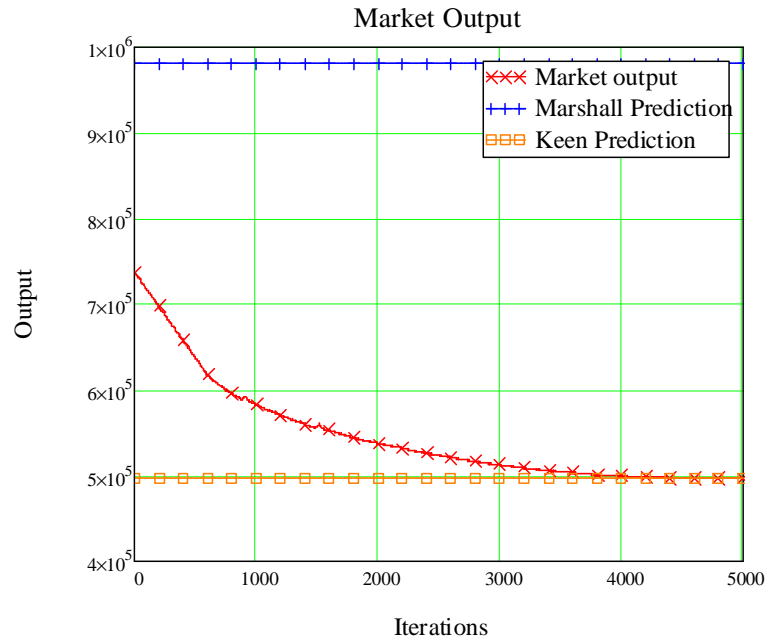
Market Output

Rational market output in a 200 firm industry

As is evident from the simulation, the behavior of instrumentally rational profit maximizers drives the market towards the Keen predictions over time. At the final iteration on this simulation run, aggregate output was $501,091$ units and the market price was $\$498.91$. This occurs without any recourse to calculus, either within the program or in the behavior of the firms, and thus provides independent, "orthogonal" verification that the Keen profit-maximization formula is correct and the Marshallian formula is wrong.

Documents/economic/Papers/ProfitMax/Submissions/GermanMathEconBook/RationalMarketPrice.emf
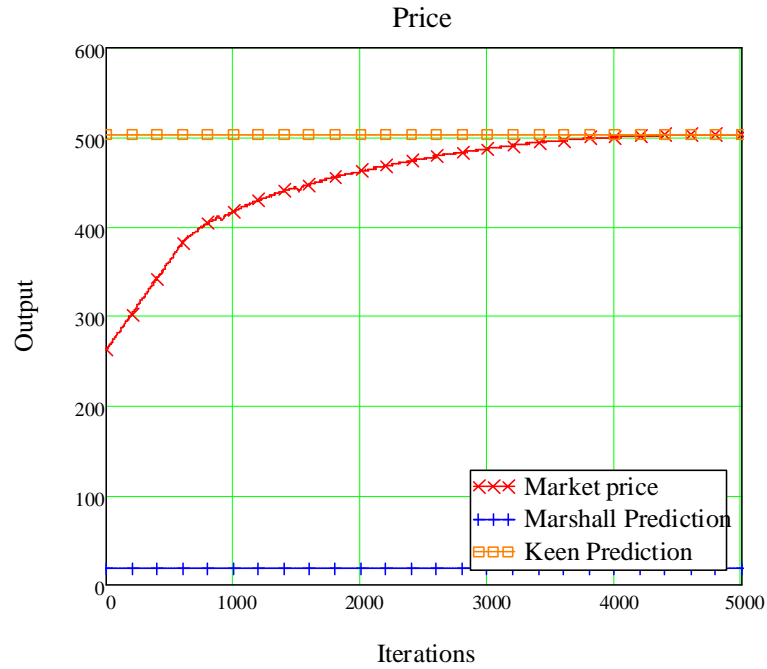
Rational market price in a 200 firm industry

7 "Perfect competition" equals Monopoly

The removal of the mathematical fallacy of the horizontal demand curve under "'perfect competition" reduces the Marshallian analysis of the firm to no more than the proposition that, if a profit-maximizing level of output exists, a rational profit-maximizing firm will locate it. As a result, simplistic supply and demand analysis is false: given the assumptions of the Marshallian model, all industry structures will produce the so-called "monopoly" level of output at which aggregate market-level marginal revenue equals aggregate market-level marginal cost. Before this can be shown, however, another unacknowledged fallacy in standard neoclassical pedagogy must be revealed.

The standard graphical exposition of Marshallian theory draws a common "Supply" curve to represent both the marginal cost curve of a monopoly and the sum of the marginal cost curves of a "competitive" industry. In fact a single curve can be drawn for these two market structures only under three restrictive conditions: (a) the monopoly is created by taking over, and continuing to operate, all the plants of all the competitive firms;[6] (b) identical *but necessarily constant* marginal costs; and (c) differing marginal costs which happen to be a function of the number of firms in the industry, and coincide when aggregated.

---

[6] This is a trivial condition, and would result in no change in behavior—as shown above, the competitive firms produce the same aggregate level as a monopoly.

14

If this is not done, then cost functions like the one used above predict dramatically higher marginal costs for a monopoly than for a competitive industry at the same aggregate level of output—a result that is both counter-intuitive and counter-empirical. The table below shows the impact this has using my numerical example—the marginal cost of the 200-firm industry is shown as merely 6 per unit output, versus one hundred times that for a 1-firm industry at 40% of the 200-firm output level. This has nothing to do with the comparative efficiency of the two market structures, but is simply an artefact of using incomparable cost functions (note however that the Keen formula still correctly predicts the outcome of profit-maximizing behavior, whereas the Marshallian formula is wildly inaccurate).

Firms	Input	q	Q	P	MC	Av. profit	Agg. Profit
200	Sim	2485	496901	503	6	1233177	246635468
200	Keen	2484	496774	503	6	1233177	246635484
200	Marshall	4907	981373	19	14	50193	10038651
20	Sim	23279	465586	534	69	11641174	232823488
20	Keen	23279	465581	534	69	11641174	232823488
20	Marshall	41708	834167	166	124	4338963	86779253
1	Sim	200200	200200	800	600	100190100	100190100
1	Keen	200200	200200	800	600	100190100	100190100
1	Marshall	200200	200200	800	600	100190100	100190100

To make valid comparisons, either condition (b) or (c) above must apply. Taking (b) first, since marginal cost is derived from marginal product, the identity of the aggregate marginal cost curves imposes the condition that marginal products are identical for all scales of inputs. Identical marginal products in turn means that the production functions can only differ by a constant. Taking labor as the variable input, this constant can be set to zero (since with zero units of labor, output will also be zero). Therefore identical marginal costs commutes into the condition that the aggregate output of the two industry structures must be the same for all levels of input. It is easily shown that this is possible only if marginal costs are constant and identical.

Using f for the production function of n firms in one industry structure, g for the production function of m firms in another, x for the per-firm labor input in the n-firm industry and y for the per-firm input in the m-firm industry, the condition is:

$$n \cdot f(x) = m \cdot g(y) \tag{18}$$

where $n \cdot x = m \cdot y$. Subsituting $\dfrac{n \cdot x}{m} = y$ into (18) and differentiating with respect to n yields:

$$f(x) = \frac{x}{m} \cdot g'\left(\frac{n \cdot x}{m}\right) \tag{19}$$

This gives us a second expression for f. Equating these two definitions and rearranging yields:

15

$$g\left(\frac{n \cdot x}{m}\right) = \frac{x}{m} \cdot g'\left(\frac{n \cdot x}{m}\right) \tag{20}$$

Substituting back $y = \dfrac{n \cdot x}{m}$ and rearranging yields an expression involving the differential of the log of g:

$$\frac{g'(y)}{g(y)} = \frac{1}{y} \tag{21}$$

Integrating both sides yields $\ln(g(y)) = \ln(y) + c$. Thus g is a constant returns production function $g(y) = C \cdot y$. From $y = \dfrac{n \cdot x}{m}$, it follows that f is the same constant returns production function $f(x) = \dfrac{m}{n} \cdot C \cdot \dfrac{nx}{m} = C \cdot x$. Thus if marginal costs are to be identical across any scale of industry and output, they must be constant and identical.

Condition (c) allows marginal costs to differ at different scales of output, but requires that they aggregate to the same level. In this case, costs at each level of output must be a function of the number of firms in the industry.[7] Not only is this extremely implausible, it also negates the very valid concept of economies of scale (see [8, p. 288; discussed in [4, p. 114]] for an excellent explanation of a real-world instance of this in the natural gas industry). However, to enable the comparison of outputs across a range of industry structures, it is imposed here. In the example above with a fixed number of firms, I used a firm marginal cost function of the form:

$$MC_i(q_i) = c + d \cdot q_i \tag{22}$$

To generalize this to enable the comparison of firms' behavior across a range of industry structures, we need an amended marginal cost function $mc_i(q_i, n)$ so that so that the marginal cost of producing q units where there are m firms in the industry equals the cost of producing Q units, where $Q = m \cdot q$. The firm level total cost function has to be:

$$tc_i(q, n) = k + c \cdot q + \frac{1}{2} \cdot d \cdot n \cdot q^2 \tag{23}$$

Figure 7 shows the outcome of simulations with this comparable cost equation, for between 1 and 100 firms. The simulations generally converge to the Keen prediction, which is that output will be where industry-level marginal cost equals industry-level marginal revenue, regardless of the number of firms in the industry.

---

[7] However, without this condition, the standard rising-marginal-cost curve that economists use actually assumes that the marginal costs of competitive firms will be substantially *lower* than those of a monopoly.

Market outcome and model predictions
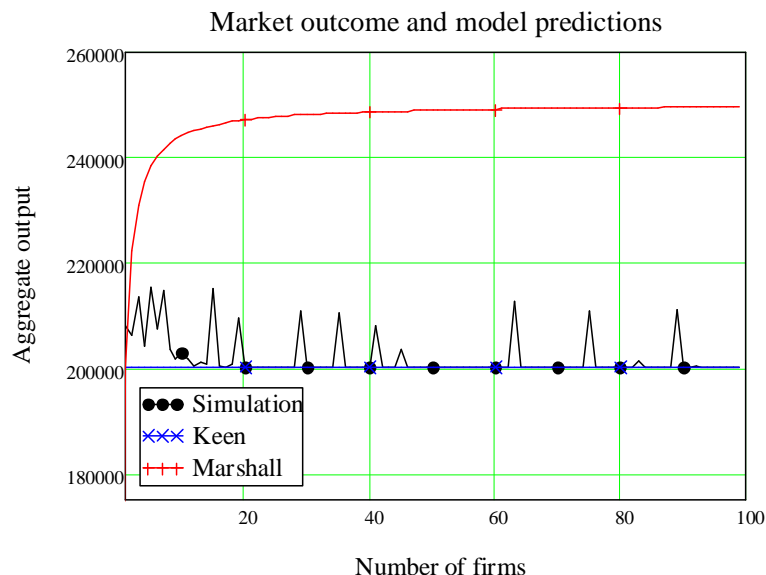
As a result, price exceeds marginal cost in all industry structures: competitive, profit-maximizing behavior does not cause output to converge to the level at which price equals marginal cost as the number of firms in an industry rises. This is due, not to collusion, but almost its opposite: rational, self-interested profit-maximizing, without regard to what other firms might or might not do. As a result, price exceeds marginal cost in a competitive industry under Marshallian conditions. The consequent welfare loss, which Marshallian analysis has called "the deadweight welfare loss from monopoly", is actually "the deadweight welfare loss from profit-maximizing behavior".

8 Concluding Remarks

One neoclassical reaction to my argument—which has been put to me frequently since I developed this analysis while writing *Debunking Economics* [3]—is that the proposition that $\frac{dP}{dq_i} = 0$ while $\frac{dP}{dQ} < 0$ is merely an assumption, and since theories can't be tested by their assumptions, my critique is irrelevant. This is not the place for a full discussion of methodology (see instead chapter 7 of [3], "There is madness in their method"), but assumptions that breach the laws of mathematics *do* matter—and cannot be allowed. A sound theory cannot have two (or more) mutually inconsistent assumptions, and the proposition that $\frac{dP}{dq_i} = 0$ while $\frac{dP}{dQ} < 0$ is inconsistent with the assumption of atomistic behavior.

They can be reconciled in the alternative Cournot-Nash model of competition, since in that model, a firm chooses its output level, not in isolation, but with a view to the hypothetical reactions of other firms. In this context, the

17

arguments to $P(Q)$ are not independent, and therefore the critique developed in this paper does not apply. However, the Cournot-Nash analysis of "perfect competition" has other problems. Some of these are well-known—see the literature on the Iterated Prisoners' Dilemma—and others have been recently discovered (see [6] and [7]).

Taken together, these dilemmas mean that, while game theory remains an amusing distraction for academic economists, it has limited relevance to the actual real-world process of competition. It is high time that economists abandoned the *a priori* approaches of both Marshall and Cournot, and instead looked closely at the empirical data on industry structure and competition—see for example [1] and [2]. We need theories that explain the real, empirical phenomena. Such theories may not reach the same neat welfare conclusions of which economists are so enamoured, but they will at least describe the economy in which we live.

9   Appendix: Value of $\frac{d}{dQ}q_j = 1$

Assume that $\frac{d}{dQ}q_i = \varepsilon \; \forall \; j$ and $\frac{\partial}{\partial q_j}q_i = \theta$. Then

$$\frac{d}{dQ}q_i = \frac{\partial}{\partial Q}q_i + \sum_{j \neq 1}^{n}\left(\frac{\partial}{\partial q_j}q_i \cdot \frac{d}{dQ}q_j\right) \tag{24}$$

$$= 1 + \sum_{j=1}^{n}(\theta \cdot \varepsilon)$$

$$= 1 + (n-1) \cdot \theta \cdot \varepsilon$$

Solving for ε we find that

$$\varepsilon = \frac{1}{1 - (n-1) \cdot \theta} \tag{25}$$

In the Marshallian case where $\frac{\partial}{\partial q_j}q_i = 0$, the value of ε collapses to 1. We explore the general case in our critique of the Cournot-Nash analysis of competition [6], [7].

References

[1] Alan Blinder, E. Canetti, D. Lebow, and J. Rudd (1998). *Asking About Prices: a New Approach to Understanding Price Stickiness*, New York: Russell Sage Foundation.

[2] Paul Downward and Fred Lee (2001). Post Keynesian pricing theory reconfirmed? A critical review of Asking About Prices. *Journal of Post Keynesian Economics* 23 : 465-483.

[3] Steve Keen (2001). *Debunking Economics: the naked emperor of the social sciences*, Pluto Press & Zed Books, Sydney & London.

[4] Steve Keen (2004). "Deregulator: Judgment Day for Microeconomics", *Utilities Policy*, 12: 109 –125.

[5] Steve Keen and Russell Standish (2005). Irrationality in the neoclassical definition of rationality, *American Journal of Applied Sciences* (Sp.Issue): 61-68.

[6] Steve Keen and Russell Standish (2006). Profit maximization, industry structure, and competition: A critique of neoclassical theory. *Physica A* 370: 81–85

[7] Steve Keen and Russell Standish (2006). Debunking the theory of the firm—a chronology, *American Review of Political Economy* (http://www.arpejournal.com), (forthcoming).

[8] P.G. Rosput, (1993). "The limits to deregulation of entry and expansion of the US gas pipeline industry", *Utilities Policy*, 1: 287-294.

[9] George J. Stigler (1957), Perfect competition, historically contemplated. *Journal of Political Economy* 65: 1-17.