Are There Any Cournot Industries?

Article *in* Japanese Economy · January 2010

DOI: 10.2753/JES1097-203X390201 · Source: RePEc

1 author:

David Flath
Ritsumeikan University

The Japanese Economy, vol. 39, no. 2, Summer 2012, pp. 3–36.

ISSN 1097–203X (print)/ISSN 1944–7256 (online)
DOI: 10.2753/JES1097-203X390201

David Flath

Are There Any Cournot Industries in Japan?

Abstract: *For each of the seventy Japanese four-digit SIC manufacturing industries, using annual data for 1961–90, I test the simple Cournot hypothesis of proportionality between industry price-cost margin and Herfindahl index against the non-nested alternative that the industry price-cost margin remains constant in the face of varying Herfindahl index, as it would under a simple product-differentiated Bertrand framework. I then test each of these against the alternative hybrid specification that nests both of them, and from the pairwise tests, compute likelihoods of each specification. The simple Cournot specification is the most likely for five of the industries, the simple Bertrand specification for thirty-five, and the hybrid specification for thirty.*

Whether firms compete by choosing quantities or by choosing prices can matter a lot in economic models of industrial organization. For instance, as shown by Shapiro (1989), strategic ploys often have completely opposite effects on economic profits depending on whether subgames attain Cournot equilibria or Bertrand equilibria. Sometimes the strategic variable matters less than it does in the strategic ploys examples. In differentiated-product industries, each firm is in effect a monopolist facing a demand that depends, in part, on the prices of substitutes or complements supplied by other firms. If the quantities supplied by other firms are predetermined, then the effect of the one firm's own choices on the other firms' market prices must enter its calculations. Otherwise they do not enter its calculations, but these effects may be small in any case.

Attempts to determine by theory alone whether quantity competition or price

David Flath is an adjunct professor of economics at the Institute of Social and Economic Research, Osaka University; e-mail: flath@iser.osaka-u.ac.jp. This research is supported by Japan Society for the Promotion of Science, Grant-in-Aid for Scientific Research (C), grant no. 22530227.

competition, or some hybrid of the two, arises as an equilibrium have not reached a definitive end. The current essay takes a different approach and offers some empirical evidence on the issue. The premise is that a wide sample of four-digit SIC Japanese manufacturing industries for which Herfindahl indexes of concentration are also available should include some that are approximately homogeneous product oligopolies. If Cournot competition is ubiquitous, then for that portion of the sample (the industries supplying homogeneous products), industry price-cost margins should vary year to year in proportion to year-to-year variation in Herfindahl indexes of concentration. If Bertrand competition is ubiquitous, annual variation in industry price-cost margins should have no relation to annual variation in Herfindahl in any of the industries, whether product differentiated or not. Cournot industries in which firms supply both homogeneous and differentiated products, might yield a hybrid result in which industry price-cost margins vary linearly but not proportionately with annual changes in Herfindahl index.

A companion study to this one (Flath 2011) estimates Cobb–Douglas production functions for seventy four-digit SIC Japanese manufacturing industries, 1961–90, and from these estimates constructs annual time series for industry price-cost margins. Here, for each industry, I estimate three separate regressions relating annual variation in the industry's price-cost margin to annual variation in its Herfindahl index of concentration. In the first regression, industry price-cost margin is proportionate to Herfindahl (as it would be for homogeneous-product Cournot industries). In the second, industry price-cost margin is unrelated to Herfindahl (as it would be for Bertrand industries whether differentiated or not). The third regression, for each industry, is one in which industry price-cost margin varies linearly but not proportionately with Herfindahl (as would be the case if one segment of the industry were in a Cournot-homogeneous-product equlibrium and another segment was not).

A non-nested test based on Vuong (1989), comparing the first two specifications for each of the seventy industries, at the 10 percent significance level, favors the homogeneous-product-Cournot specification for ten industries and the Bertrand specification for forty-four of the industries. Further comparisons of each of these specifications with the hybrid specification that nests both of them lead me to conclude that the simple Cournot specification is the most likely for five of the industries, the simple Bertrand specification is the most likely for thirty-five of them, and the hybrid specification is the most likely for thirty. It seems from this evidence that Bertrand is an adequate description of the modal industry. But four-digit SIC manufacturing industries that have some segments that are homogeneous-product Cournot industries may not be so rare. This is as much as the results here will allow. Comparisons of average Herfindahl index, average industry price-cost margin, and estimated labor coefficient, across the sets of industries for which each of the three specifications had the greatest likelihood, reveal no evident pattern.

Some notes on the previous literature may be helpful. Kreps and Scheinkman (1983) showed that if firms first compete in choosing productive capacity, followed by choices of prices, the outcome resembles the Cournot equlibrium, suggesting that the presence or absence of capacity constraints is a key determinate of whether Cournot equilibria attain. Singh and Vives (1984) posited a duopoly facing product-differentiated demand in which the firms could precommit to making price the choice variable or quantity the choice variable, and argued that if the products are substitutes, they would make quantity the choice variable. Häckner (2000) showed that this result does not generalize to the *n*-firm case. And Zanchettin (2006) showed that when demand and costs are sufficiently dissimilar (a case disallowed by the Singh and Vives [1984] assumption that if both prices are set at marginal costs, both firms sell positive outputs), even a duopolist may elect to make price its choice variable. Tremblay and Tremblay (2011) show that a duopoly in which one firm makes price its choice variable and the other makes quantity its choice variable can be a stable equilibrium. In short, theory admits Cournot, Bertrand, and hybrids in which some firms in an industry choose quanitities and others prices, all as possible equilibrium frameworks.

Empirical literature on oligopoly pricing usually assumes either Bertrand or Cournot behavior rather than leaving that for the data to determine. For example, the Berry, Levinsohn, and Pakes (1995) approach to intra-industry demand estimation presumes Bertrand pricing. Of course specifications that would allow Cournot or Bertrand to emerge from the estimation are not so easy to configure. Nevo (1998) describes the essentially unsurmountable data requirements for identifying conjectural variation parameters in product-differentiated industries. That is one motivation for this study, which eschews any attempt to estimate firm-level parameters and focuses instead on aggregate industry data.

Price-Cost Margins

The price-cost margins from the companion study to this one (Flath 2011) are constructed from estimates of Cobb–Douglas production functions for seventy industries at the four-digit SIC level. For each industry, annual observations of output are constructed by deflating value of shipments by the annual average wholesale price index for the corresponding product. The required matching of industries from the Census of Manufacturers (Ministry of International Trade and Industry, serial; and METI, www.meti.go.jp/statistics/kougyou/arc/index.html) with the product categories of the Wholesale Price Index (Bank of Japan, serial) limits the sample to a relatively small set of industries, but ones for which the output measure is accurate. The appendix describes the data sources in more detail.

In Flath (2011), I estimated an equation on the pooled annual time-series, cross-section of seventy industries at the four-digit SIC level, 1961–90. The regression equation is:

$$\ln Q_{it} = A_i + \theta_i \ln L_{it} + (1 - \theta_i)\ln e^{At}K_{it} + v_{it}, \qquad i = 1\ldots, n; t = 1,\ldots,T, \tag{1}$$

where the error term follows a first-order autoregressive (AR1) process:

$$v_{it} = \rho_i \, v_{i,t-1} + u_{it}, \qquad \text{and } u_{it} \sim (0, \sigma_i^2). \tag{2}$$

Here Q_{it} represents value of shipments by industry i in year t divided by average monthly wholesale price index for the corresponding product during the same year. The labor input is L_{it}, defined as the number of workers employed in the industry i in year t. And K_{it} is the book value of the fixed tangible assets of the industry i at the beginning of year t. This specification imposes constant returns to scale and allows for implicit deflation of book value of capital stock. Essentially, this means that the deflated capital stock series $e^{At}K_{it}$ is measured in pan-industry efficiency units. Any economy-wide technological advances or improvements in labor quality are reflected in the deflator e^{At}, leaving only industry-specific technological advances to the residual error term v_{it}.

From the estimates of these Cobb–Douglas production functions for each industry I constructed time series for the price-cost margins of each industry. For details, refer to Flath (2011). In brief, the method of construction follows the logic of Hall (1988). The labor coefficients from the Cobb–Douglas production functions measure labor's share in total cost for each industry. Price-cost margins are computed as the percentage by which value added minus total cost exceeds value of shipments (where total cost is the wage bill divided by the Cobb–Douglas labor coefficient). After dropping from the sample the four industries for which average price-cost margin was negative, the remaining average price-cost margins range from Glass Bulbs for Use in Cathode Ray Tubes at 1.2 percent to Sheet Glass at 45.4 percent. The average price-cost margin across the seventy industries is 12.56 percent, with standard deviation 8.53 percent.

The sample industries vary in concentration. The average Herfindahl indexes range from Sake at 0.005 to Pianos at 0.460. The average Herfindahl index across the seventy industries is 0.155 with standard deviation 0.124.

The object of the current study is to consider how the annual time series for industry price-cost margins interact with Herfindahl indexes of industrial concentration. The question I address is for which, if any, of the industries do price-cost margin and Herfindahl index move together as the homogeneous product Cournot model predicts?

Herfindahl Indexes and Price-Cost Margins

The Cournot model of a homogeneous product oligopoly implies a precise relation between industry-level price-cost margin and Herfindahl index of concentration defined on shares of output. Specifically, the industry price-cost margin equals the Herfindahl index divided by elasticity of market demand. This has been well-known for many years. See, for example, Cowling and Waterson (1976) or Tirole (1988:

222–23). Let us call this relationship between price-cost margin and Herfindal index "Model 1–Cournot." The relationship follows directly from the fact that the price-cost margin of firm f in homogenous-product Cournot industry equilibrium equals its market share divided by the elasticity of market demand:

$$\frac{p_f - c_f}{p_f} = \frac{s_f}{\xi}. \tag{3}$$

Here, p_f is the firm's price, c_f its marginal cost, and s_f its market share (i.e., share of industry sales revenue $s_f = p_f q_f / \Sigma p_f q_f$). The industry price-cost margin m is, in general, a weighted average of the firms' price-cost margins, with weights equal to market shares:

$$m = \sum \frac{(p_f - c_f)q_f}{\Sigma p_f q_f} = \sum \frac{(p_f - c_f)}{p_f} \frac{p_f q_f}{\Sigma p_f q_f} = \sum \frac{(p_f - c_f)}{p_f} s_f. \tag{4}$$

So in the homogeneous-product Cournot equilibrium, industry price-cost margin equals the summation of squared market shares, or Herfindahl index, divided by elasticity of market demand:

$$m = \sum \frac{s_f^2}{\xi} = \frac{H}{\xi}. \tag{5}$$

I observe Herfindahl indexes H_{it} annually for each of the seventy industries, drawn from the Japan Fair Trade Commission data archives (JFTC 1974, 1975; JFTC, www.jftc.go.jp/ruiseki/ruisekidate.htm; Senou 1983). For each industry *i*, I regress these on the price-cost margin series m_{it} as described by:

Model 1–Cournot: $m_t = \beta_1 H_t + e1_t, \qquad t = 1,..., T,$ (6)

where $e1_t$ is a stochastic error term. In accordance with the theory I impose a zero intercept.

An alternative formulation (call it "Model 2–Bertrand") is that each firm is in effect an independent monopoly, and the industry price-cost margin is simply a weighted average of the reciprocal demand elasticities facing each firm, the weights corresponding to market shares. If the demand elasticities facing each firm are similar to one another, then the industry price-cost margin is the reciprocal of that demand elasticity and this remains true even as the market shares of firms vary in response to innovation and changing input prices. Under this framework, for each industry *i*, we have:

Model 2–Bertrand: $m_t = \beta_0 + e2_t, \qquad t = 1,..., T.$ (7)

Yet a third specification nests the two previous ones:

Model 3–Hybrid: $m_t = \beta_0 + \beta_1 H_t + e3_t, \qquad t = 1,..., T.$ (8)

It is possible to construct an example that supports the Hybrid specification.

Suppose that firms in an industry are selling both to loyal customers who either buy from their one favorite firm or not at all, and to less loyal customers who only buy from the firm with the lowest price. Each firm may have its own loyal customers. If the firms are price discriminating, charging higher prices to loyal customers, while acting as Cournot oligopolists in selling to the price-conscious customers, it can lead to Model 3. It is a kind of hybrid of Bertrand and Cournot. In particular, if the fraction λ of each firm's own sales that are to loyal customers is the same fraction for all the firms, and the firms are price discriminating as just suggested, then the price-cost margin of firm f is:

$$\frac{\lambda}{\xi_1} + \frac{(1-\lambda)s_f}{\xi}, \tag{9}$$

where ξ_1 is the demand elasticity of the loyal customers and ξ is the market demand elasticity in the Cournot segment. The industry price-cost margin is

$$m = \frac{\lambda}{\xi_1} + \frac{(1-\lambda)H}{\xi}. \tag{10}$$

This is one motivation for the Model 3.

For each of the seventy industries in the sample, I next construct specification tests for pairwise comparisons among the models, and from these statistics construct an overall likelihood for each specification for each industry.

Specification Tests

Non-nested Alternatives: 1–Cournot Versus 2–Bertrand

I estimated both the 1–Cournot and 2–Bertrand regressions for each industry using maximum likelihood, here equivalent to ordinary least squares (OLS), and also computed the value of log likelihood function for each. (Note that log likelihood = $-n/2 \ln(2\pi SSE/n) - n/2$). These results are represented in Appendix Table A1. The two alternative specifications here are non-nested. Accordingly, I draw on the work of Vuong (1989) who proposed a likelihood ratio test statistic for model selection among nonnested alternatives. The Vuong statistic is a normalization of the likelihood ratio that is asymptotically distributed as a standard normal variate under reasonable conditions. Specifically, denote the value of the log likelihood for a single observation by

$$L_i = -\frac{n}{2}\ln\left(\frac{2\pi SSE}{n} - \frac{ne_i^2}{2SSE}\right). \tag{11}$$

The value of log likelihood function for a regression specification is the sum of L_i over all observations i. The Vuong statistic for comparing two alternative nonnested specifications (1–Cournot and 2–Bertrand) is with obvious notation defined as follows:

$$\text{Vuong statistic} = \frac{L1 - L2}{\Sigma(L1_i - L2_i)^2/n} - (\Sigma(L1_i - L2_i)/n)^2)^{1/2}. \quad (12)$$

These Vuong statistics and log likelihoods of the alternate specifications are reported in Appendix Table A2. In only nineteen of the industries did the likelihood function favor Cournot over Bertrand. In only ten of these did the data clearly distinguish between the two specifications (i.e., at the 10 percent significance level), based on the Vuong statistic. The ten industries are:

Bicycles
Jute Yarn
Manmade-graphite electrodes
Ordinary steel pipes and tubes
Records
Storage batteries
Sugar
Synthetic rubber
Thermos bottles
Wheat flour

There were far more industries, forty-four in all, in which the likelihood ratio strongly favored the Bertrand specification over the Cournot one (again, at the 10 percent significance level). That leaves sixteen industries for which the Vuong test fails to distinguish between the 1–Cournot and 2–Bertrand specifications, at the 10 percent significance level.

Nested Alternatives: 3–Hybrid Versus 1–Cournot, or 2–Bertrand

The 3–Hybrid specification nests 1–Cournot and 2–Bertrand. Specification tests between Hybrid and Cournot, and between Hybrid and Bertrand, are based on the *t*-statistics for the intercept and slope coefficients in linear regression of price-cost margin on the Herfindahl index (the Hybrid specification). These estimates are reported in Appendix Table A3. The statistical test between the Cournot and Hybrid specification is the *p*-value for the null hypothesis that the intercept in the Hybrid specification is greater than zero. This *p*-value is the area under the *t*-distribution, to the right of the *t*-statistic, for estimated intercept in the Hybrid specification. It represents the likelihood that the intercept is positive and so the Hybrid specification is superior to the Cournot specification in which the intercept is zero.

Similarly, the statistical test between the Bertrand and Hybrid specification is the p-value for the null hypothesis that the slope in the Hybrid specification is greater than zero. This p-value represents the likelihood that the slope is positive and so the Hybrid specification is superior to the Bertrand specification in which the slope is zero.

The results are these. At the 10 percent significance level, the Cournot specification was better than Hybrid for only one of the industries cast iron pipes and tubes. One other industry records just missed at the 10 percent significance level. For thirty-eight of the industries, the Hybrid specification was better than Cournot, at the 10 percent significance level. For seventeen of the industries, the Bertrand specification is better than the Hybrid at the 10 percent significance level, and for fifteen of the industries the Hybrid specification is better.

Likelihoods of Each of the Three Specifications

From the three pairwise tests among the different specifications, I now construct likelihoods of each specification, using Bayes's rule. Models "1," "2," and "3" are mutually exclusive. Denote the probability that model 1 is the true one by $P(1)$. Let A = not 1, B = not 2, and C = not 3. Denote by $P(C|B) = P(1|B)$ the conditional probability of C, given B.

The pairwise comparisons among the three models are each premised on removal from consideration of one of the three models. So for example the Vuong test of likelihood of 1–Cournot versus 2–Bertrand presumes that those are the only two possibilities; the likelihood of the 3–Hybrid model is zero ($P(C) = 1$). Similarly, my interpreting one minus the p-value for the t-test that the regression intercept is positive as a likelihood of 1–Cournot versus 3–Hybrid presumes that the slope of the regression line is positive; the likelihood of the 2–Bertrand model is zero ($P(B) = 1$). And interpreting one minus the p-value for the t-test that the regression slope is positive as a likelihood of 2–Bertrand versus 3–Hybrid presumes that the intercept of the regression line is positive; the likelihood of the 1–Cournot model is zero ($P(A) = 1$). These prior presumptions cannot all be true because they are mutually contradictory. To form a single consistent set of posterior probabilities of each of the models based on all three pairwise statistical tests thus requires a modified set of prior probabilities.

I propose the following. In constructing the likelihood of 2–Bertrand based on the t-test that the regression slope is positive, use the likelihood of 1–Cournot based on the Vuong test as the prior probability of not-Bertrand $P(B)$. And in constructing the likelihood of 1–Cournot based on the t-test that the regression intercept is positive, use the likelihood of 2–Bertrand based on the Vuong test as the prior probability of not-Cournot $P(A)$. Construct the likelihood of the 3–Hybrid model as one minus the posterior likelihood of 1–Cournot and 2–Bertrand.

In my notation, $P(B|C)$ is the likelihood of 1–Cournot versus 2–Bertrand based on the Vuong test, which is premised on $P(C) = 1$. Bayes's rule is:

$$P(B|C) = P(C|B)\,P(B)\,/\,P(C), \tag{13}$$

but if $P(C) = 1$, then this reduces to:

$$P(B|C) = P(B) = P(1). \tag{14}$$

Let us take the Vuong likelihood statistic as a prior probability of not-Bertrand $P(B)$ or not-Cournot $P(A)$ in interpreting the t-tests. So, for example, the t-test that the regression intercept is positive tells us the likelihood of the Cournot model, only given that the Bertrand model has zero likelihood $P(1|B)$. In Bayes's rule the unconditional posterior likelihood of 1–Cournot is:

$$P(1) = P(1|B)\,P(B). \tag{15}$$

My proposed use of the Vuong likelihood of 1–Cournot as the prior probability of not-Bertrand $P(B)$ here means that the posterior likelihood of 1–Cournot equals the likelihood of 1–Cournot versus 3–Hybrid based on t-test that the regression intercept is positive, times the likelihood of not-Bertrand based on the Vuong test. Analogously, my constructed posterior likelihood of 2–Bertrand equals the likelihood of 2–Bertrand versus 3–Hybrid based on the t-test that the regression slope is positive, times the likelihood of not-Cournot based on the Vuong test:

$$P(2) = P(2|A)\,P(A). \tag{16}$$

The likelihoods of each model, computed in the way just described, are reported in Table 1. 1–Cournot is the most likely for five of the industries, 2–Bertrand is the most likely for thirty-five of the industries, and the 3–Hybrid specification is the most likely for thirty of the industries. The five for which Cournot is the most likely are:

Cast iron pipes and tubes
Jute yarn
Records
Sugar
Thermos bottles

If we consider only the eighteen industries for which the likelihood of one specification was at least 90 percent, then there were eleven for which Bertrand was preferred, seven for which Hybrid was preferred, and none for which Cournot was preferred. Records just misses with 89 percent likelihood of Cournot. A summary of the results for all the specifications is in Table 2.

Some statistics describing the five industries for which the simple Cournot specification was the most likely are shown in Table 3. And comparable statistics for the eleven industries with likelihood of Bertrand specification greater than 90 percent and the seven with likelihood of Hybrid specification greater than 90 percent are in Tables 4 and 5. The statistics in these tables include reciprocals of

Table 1

Specification Tests

	Prob 1–Cournot vs. 2–Bertrand	Prob 2–Bertrand vs. 3–Hybrid	Prob 1–Cournot vs. 3–Hybrid	Likelihood Model 1–Cournot	Likelihood Model 2–Bertrand	Likelihood Model 3–Hybrid	Preferred specification	Likelihood of preferred specification
Industry	Vuong–Norm dist from Table A2	prob > *t* (prob β1 > 0) from Table A3	prob > *t* (prob β0 > 0) from Table A3					
Aluminum window sashes	0.00	0.88	0.00	0.00	0.88	0.12	2–Bertrand	0.88
Bearings	0.36	1.00	0.00	0.00	0.64	0.36	2–Bertrand	0.64
Beer	0.00	0.60	0.11	0.00	0.60	0.40	2–Bertrand	0.6
Bicycles	0.99	0.08	0.25	0.25	0.00	0.75	3–Hybrid	0.75
Boilers	0.59	0.37	0.42	0.25	0.15	0.60	3–Hybrid	0.6
Briquettes	0.00	0.73	0.00	0.00	0.73	0.27	2–Bertrand	0.73
Calcium carbide	0.00	0.38	0.00	0.00	0.38	0.62	3–Hybrid	0.62
Canned seafood	0.00	0.03	0.00	0.00	0.03	0.97	3–Hybrid	0.97
Cast iron pipes and tubes	0.74	0.00	0.96	0.71	0.00	0.29	1–Cournot	0.71
Caustic soda	0.00	0.58	0.08	0.00	0.58	0.42	2–Bertrand	0.58
Cellophane	0.76	0.20	0.27	0.21	0.05	0.75	3–Hybrid	0.75
Cement	0.00	0.63	0.02	0.00	0.63	0.37	2–Bertrand	0.63
Charging generators	0.25	0.92	0.06	0.02	0.69	0.30	2–Bertrand	0.69

Chemical seasoning	0.00	0.93	0.05	0.00	0.93	0.07	2–Bertrand	0.93
Coke	0.00	0.61	0.05	0.00	0.61	0.39	2–Bertrand	0.61
Cold-rolled steel plate	0.00	0.76	0.00	0.00	0.76	0.24	2–Bertrand	0.76
Combed fabrics	0.00	0.86	0.00	0.00	0.86	0.14	2–Bertrand	0.86
Cotton fabrics	0.00	0.88	0.01	0.00	0.88	0.12	2–Bertrand	0.88
Cotton yarn	0.63	0.28	0.62	0.39	0.10	0.51	3–Hybrid	0.51
Dissolving pulp	0.00	0.99	0.00	0.00	0.99	0.01	2–Bertrand	0.99
Eighteen liter cans	0.00	0.49	0.01	0.00	0.49	0.51	3–Hybrid	0.51
Electrical copper	0.63	0.22	0.65	0.41	0.08	0.51	3–Hybrid	0.51
Electrical wires and cables	0.36	0.42	0.39	0.14	0.27	0.59	3–Hybrid	0.59
Fireproof bricks	0.00	0.74	0.13	0.00	0.74	0.26	2–Bertrand	0.74
Fishing nets	0.00	1.00	0.00	0.00	1.00	0.00	2–Bertrand	1.00
Fishmeat sausage	0.11	0.93	0.01	0.00	0.83	0.17	2–Bertrand	0.83
Galvanized	0.00	0.69	0.05	0.00	0.69	0.69	2–Bertrand	0.69
Glass bulbs for use in cathode ray tubes	0.43	0.99	0.01	0.00	0.56	0.56	2–Bertrand	0.56
Glass containers for beverages	0.00	0.78	0.07	0.00	0.78	0.78	2–Bertrand	0.78
Grinding stones	0.00	0.94	0.00	0.00	0.94	0.94	2–Bertrand	0.94
Ham sausage	0.00	0.48	0.00	0.00	0.48	0.48	3–Hybrid	0.52
Jute yarn	1.00	0.04	0.70	0.70	0.00	0.00	1–Cournot	0.7
Manmade-graphite electrodes	1.00	0.07	0.31	0.31	0.00	0.00	3–Hybrid	0.69

(*continues*)

Table 1 (*continued*)

Industry	Prob 1–Cournot vs. 2–Bertrand	Prob 2–Bertrand vs. 3–Hybrid	Prob 1–Cournot vs. 3–Hybrid	Likelihood Model 1–Cournot	Likelihood Model 2–Bertrand	Likelihood Model 3–Hybrid	Preferred specification	Likelihood of preferred specification
	Vuong–Norm dist from Table A2	prob > *t* (prob β1 > 0) from Table A3	prob > *t* (prob β0 > 0) from Table A3					
Medicines	0.00	0.97	0.00	0.00	0.97	0.97	2–Bertrand	0.97
Men's shoes	0.26	0.30	0.00	0.00	0.22	0.22	3–Hybrid	0.78
Miso	0.00	0.00	0.00	0.00	0.00	0.00	3–Hybrid	1.00
Mixed feed	0.00	0.01	0.00	0.00	0.01	0.01	3–Hybrid	0.99
Ordinary steel pipes and tubes	1.00	0.13	0.49	0.49	0.00	0.00	3–Hybrid	0.51
Paints	0.00	0.68	0.00	0.00	0.68	0.68	2–Bertrand	0.68
Paper pulp	0.63	0.18	0.31	0.20	0.07	0.07	3–Hybrid	0.74
Petroleum products	0.00	0.22	0.02	0.00	0.22	0.22	3–Hybrid	0.78
Pianos	0.10	0.80	0.12	0.01	0.72	0.27	2–Bertrand	0.72
Power tillers	0.00	0.24	0.02	0.00	0.24	0.76	3–Hybrid	0.76
Printing ink	0.00	1.00	0.00	0.00	1.00	0.00	2–Bertrand	1.00
Printing machines	0.00	0.75	0.01	0.00	0.75	0.25	2–Bertrand	0.75
Pumps	0.00	0.97	0.02	0.00	0.97	0.03	2–Bertrand	0.97
Raw silk	0.59	0.31	0.32	0.19	0.13	0.68	3–Hybrid	0.68
Records	1.00	0.01	0.89	0.89	0.00	0.11	1–Cournot	0.89
Rectifiers	0.00	0.92	0.04	0.00	0.92	0.08	2–Bertrand	0.92

Rolled and wire-drawn copper products	0.00	0.48	0.30	0.00	0.48	0.52	3–Hybrid	0.52
Sake	0.00	0.00	0.00	0.00	0.00	1.00	3–Hybrid	1.00
Sanitary ware	0.36	1.00	0.00	0.00	0.64	0.36	2–Bertrand	0.64
Sheet glass	0.00	1.00	0.00	0.00	1.00	0.00	2–Bertrand	1.00
Soy	0.00	0.06	0.00	0.00	0.06	0.94	3–Hybrid	0.94
Spinning machines	0.28	0.99	0.01	0.00	0.71	0.28	2–Bertrand	0.71
Storage batteries	1.00	0.02	0.30	0.30	0.00	0.70	3–Hybrid	0.70
Sugar	1.00	0.09	0.67	0.67	0.00	0.33	1–Cournot	0.67
Synthetic fibers	0.00	0.12	0.08	0.00	0.12	0.88	3–Hybrid	0.88
Synthetic rubber	1.00	0.00	0.00	0.00	0.00	1.00	3–Hybrid	1.00
Thermos bottles	1.00	0.08	0.77	0.77	0.00	0.23	1–Cournot	0.77
Tile	0.00	0.00	0.00	0.00	0.00	1.00	3–Hybrid	1.00
Tires and tubes for motor vehicles	0.00	1.00	0.00	0.00	1.00	0.00	2–Bertrand	1.00
Tractors	0.00	0.23	0.02	0.00	0.23	0.77	3–Hybrid	0.77
Valve cocks	0.00	0.16	0.01	0.00	0.16	0.84	3–Hybrid	0.84
Vegetable oil	0.00	0.72	0.05	0.00	0.72	0.28	2–Bertrand	0.72
Vinyl chloride resin	0.00	0.63	0.02	0.00	0.63	0.37	2–Bertrand	0.63
Weaving machines	0.00	0.92	0.00	0.00	0.92	0.08	2–Bertrand	0.92
Wheat flour	1.00	0.15	0.48	0.48	0.00	0.52	3–Hybrid	0.52
Worsted yarn	0.00	0.68	0.00	0.00	0.68	0.32	2–Bertrand	0.68
Zinc	0.56	0.20	0.73	0.41	0.09	0.50	3–Hybrid	0.50
Mean	0.25	0.51	0.16	0.11	0.45	0.44		0.76
Standard deviation	0.37	0.37	0.25	0.22	0.37	0.30		0.16

Table 2

Results of Specification Tests

	Numbers of industries in each category at 10 percent statistical significance			
	1–Cournot vs. 2–Bertrand	1–Cournot vs. 3–Hybrid	2–Bertrand vs. 3–Hybrid	
Test statistics	Vuong	*p*-value for Hybrid intercept > 0	*p*-value for Hybrid slope > 0	Likelihoods
Preferred specification				
1–Cournot	10	1		0
2–Bertand	44		17	11
3–Hybrid		38	15	7
Indeterminate	16	31	38	52

	Numbers of industries in each category; most likely specification, regardless of statistical significance			
	1–Cournot vs. 2–Bertrand	1–Cournot vs. 3–Hybrid	2–Bertrand vs. 3–Hybrid	
Test statistics	Vuong	*p*-value for Hybrid intercept > 0	*p*-value for Hybrid slope > 0	Likelihoods
1–Cournot	19	8		5
2–Bertand	51		35	35
3–Hybrid		62	15	30

Table 3

Five Industries for Which Cournot Specification Was the Most Likely

Industry	Likelihood Model 1–Cournot	Likelihood Model 2–Bertrand	Likelihood Model 3–Hybrid	Implied elasticity of demand ($1/\beta_1$)	Avg. Herfindahl (H)	Avg. Price-Cost Margin (m), %	Estimated labor elasticity θ
Records	0.89	0.00	0.11	0.4	0.101	25.6	0.53
Thermos bottles	0.77	0.00	0.23	1.6	0.250	15.0	0.51
Cast iron pipes and tubes	0.71	0.00	0.29	1.4	0.383	26.8	0.59
Jute yarn	0.70	0.00	0.30	3.0	0.396	12.7	0.77
Sugar	0.67	0.00	0.33	0.8	0.065	7.9	0.66
Mean				1.7	0.274	15.6	0.63
Standard deviation				0.9	0.154	8.0	0.11

Table 4

Eleven Industries for Which Likelihood of Bertrand Specification Was at Least 90 Percent

Industry	Likelihood Model 1–Cournot	Likelihood Model 2–Bertrand	Likelihood Model 3–Hybrid	Implied elasticity of demand ($1/\beta_0$)	Avg. Herfindahl (H)	Avg. price-cost margin (m), %	Estimated labor elasticity (θ)
Fishing nets	0.00	1.00	0.00	10.0	0.050	10.0	0.66
Printing ink	0.00	1.00	0.00	12.5	0.137	7.6	0.65
Sheet glass	0.00	1.00	0.00	2.2	0.388	45.4	0.49
Tires and tubes for motor vehicles	0.00	1.00	0.00	6.7	0.288	14.7	0.53
Dissolving pulp	0.00	0.99	0.01	11.1	0.299	8.6	0.67
Pumps	0.00	0.97	0.03	50.0	0.077	1.5	0.42
Medicines	0.00	0.97	0.03	3.3	0.025	30.1	0.33
Grinding stones	0.00	0.94	0.06	7.1	0.069	14.2	0.59
Chemical seasoning	0.00	0.93	0.07	11.1	0.352	9.3	0.49
Rectifiers	0.00	0.92	0.08	25.0	0.111	3.7	0.51
Weaving machines	0.00	0.92	0.08	5.0	0.133	19.6	0.78
Mean				13.1	0.175	15.0	0.56
Standard deviation				13.7	0.131	12.8	0.13

Table 5

Seven Industries for Which Likelihood of Hybrid Specification Was at Least 90 Percent

Industry	Likelihood Model 1–Cournot	Likelihood Model 2–Bertrand	Likelihood Model 3–Hybrid	Implied ξ/λ	Implied $\xi/(1-\lambda)$	Avg. Herfindahl (H)	Avg. price-cost margin (m), %	Estimated labor elasticity (θ)
Synthetic rubber	0.00	0.00	1.00	5.9	1.3	0.322	34.0	0.5
Miso	0.00	0.00	1.00	5.3	0.2	0.017	26.9	0.74
Sake	0.00	0.00	1.00	5.9	0.2	0.005	20.0	0.69
Tile	0.00	0.00	1.00	10.0	1.3	0.090	17.0	0.65
Mixed feed	0.00	0.01	0.99	14.3	12.5	0.107	8.1	0.53
Canned seafood	0.00	0.03	0.97	14.3	3.7	0.060	9.0	0.66
Soy	0.00	0.06	0.94	5.0	2.4	0.074	23.2	0.71
Mean				8.7	3.1	0.096	19.7	0.64
Standard deviation				4.2	4.3	0.106	9.4	0.09

estimated coefficients for preferred specifications, average Herfindahl index, average price-cost margin, and elasticity of output with respect to labor from the estimated Cobb–Douglas production functions. None of the differences in average among the Cournot, Bertrand, and Hybrid groups, for Herfindahl, price-cost margin, and labor elasticity, are statistically significant, based on a *t*-test. The reciprocals of estimated coefficients for the Cournot and Bertrand specifications represent implied elasticities of market demand. This elasticity of demand ranges from 0.4 to 3.0 for the five putative Cournot industries and from 2.2 to 50.0 for the eleven Bertrand industries. The Bertrand industries generally face more elastic demand than the Cournot industries. The reciprocals of intercept and slope for the Hybrid industries represent weighted elasticities of demand, the weights being the reciprocals of fraction of sales to loyal customers and others. Because we cannot infer these weights the estimates are not easy to characterize.

Conclusion

The homogeneous-product Cournot model is a good starting point for thinking about many topics in industrial organization. The reasons are many. The model is simple yet elegant, in that it represents the unique Nash solution to a well-defined game. It can be manipulated easily and comports with common-sense notions of the way prices, profits, and market shares might respond to mergers, technological advance, entry, and exit. But as industrial organization specialists turn toward econometric analysis, the simple Cournot model is a lot less useful. For example, the Berry, Levinsohn, and Pakes (BLP) approach to intra-industry demand estimation presumes Bertrand pricing. With the wide application of the BLP technique over the past few years, the presumption seems to have settled in that the typical industry actually is best regarded as one in which price-setting firms face differentiated demand. The simple, homogeneous product Cournot model, so useful for algebraic explorations, is not in fact empirically apt. Or is it? If the simple Cournot model did represent an actual industry very well, how would we know that? And how rare are such industries? In fact, are there any such industries? This study has taken a modest step toward answering these questions. And the answer is that four-digit SIC manufacturing industries that have some segments that are homogeneous-product Cournot industries may not be so rare. Ones that are wholly homogeneous Cournot industries probably are rare.

This study explored a panel data set matching establishment-based production statistics from Japan's *Census of Manufacturers* with wholesale price indexes from the Bank of Japan (BOJ), and Herfindahl indexes from the JFTC. The data include annual observations over the period 1961–90 for seventy industries at the four-digit SIC level. I estimated Cobb–Douglas production functions and used these to construct annual time series for price-cost margins in each industry.

Industry price-cost margins in only 7 percent of the industries varied with temporal changes in Herfindahl index as the simple Cournot model would predict. Far more of the industries, 50 percent of them, exhibited stable price-cost margins as industrial concentration fluctuated, as the product-differentiated Bertrand model might predict. The remaining industries were a hybrid of Cournot and Bertrand. From this sample, the modal Japanese manufacturing industry is a product-differentiated Bertrand industry in which the seven or so major firms each face a demand with elasticity of ten or greater.

References

Bank of Japan. Serial. *Nihon ginkou toukeikyoku* [Price Indexes Annual]. 1970–2002. Available at www.boj.or.jp/en/type/stat/dlong/index.htm.

Berry, Steven; James Levinsohn; and Ariel Pakes. 1995. "Automobile Prices in Market Equilibrium." *Econometrica* 63, no. 4 (July): 841–90.

Cowling, Keith, and Michael Waterson. 1976. "Price-Cost Margins and Market Structure." *Economica* 43 (August): 267–74.

Flath, David. 2011. "Industrial Concentration, Price-Cost Margins, and Innovation." *Japan and the World Economy* 23: 129–39.

Häckner, Jonas. 2000. "A Note on Price and Quantity Competition in Differentiated Oligopolies." *Journal of Economic Theory* 93: 233–39.

Hall, Robert E. 1988. "The Relation Between Price and Marginal Cost in U.S. Industry." *Journal of Political Economy* 96, no. 5 (October): 921–47.

Japan Fair Trade Commission (JFTC), Executive Office, ed. 1974. *Dokusen kin konkai shiryou shū IV* [Antitrust Meeting Data Set]. Tokyo: Japanese Government Printing Office.

———. 1975. *Shūyou sangyou ni okeru ruiseki seisan shucchūdo to haafindaaru shisū no suii (shouwa 35 nen– 47 nen)* [Cumulative Concentration and Herfindahl Index Measures of Industrial Concentration in Major Industries, 1960–1972]. Tokyo: Fair Trade Institute. Available at www.jftc.go.jp/ruiseki/ruisekidate.htm.

Kreps, David M., and Jose A. Scheinkman. 1983. "Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes." *Bell Journal of Economics* 14, no. 2 (Autumn): 326–37.

Ministry of International Trade and Industry. Serial. *Kougyou toukei hyou* [Census of Manufacturers: Report by Industries]. Available at www.meti.go.jp/statistics/kougyou/arc/index.html.

Nevo, Aviv. 1998. "Identification of the Oligopoly Solution Concept in a Differentiated-Products Industry." *Economics Letters* 59: 391–95.

Senou, Akira. 1983. *Gendai nihon no sangyou shucchū* [Industrial Concentration in Contemporary Japan]. Tokyo: Nihon keizai shinbunsha.

Shapiro, Carl. 1989. "Theories of Oligopoly Behavior." In *Handbook of Industrial Organization,* ed. R. Schmalensee and R.D. Willig, vol. 1, ch. 6, 329–414. Amsterdam: North Holland.

Singh, Nirvikar, and Xavier Vives. 1984. "Price and Quantity Competition in a Differentiated Duopoly." *Rand Journal of Economics* 15, no. 4 (Winter): 546–54.

Tirole, Jean. 1988. *The Theory of Industrial Organization.* Cambridge: MIT Press.

Tremblay, Carol Horton, and Victor J. Tremblay. 2011. "The Cournot-Bertrand Model and the Degree of Product Differentiation." *Economics Letters* 111, no. 3: 233–35.

Vuong, Quang H. 1989. "Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses." *Econometrica* 57, no. 2 (March): 307–33.

Zanchettin, Piercarlo. 2006. "Differentiated Duopoly with Asymmetric Costs." *Journal of Economics and Management Strategy* 15, no. 4 (Winter): 999–1015.

Appendix: Data Sources

I have constructed a panel data set by merging 1961–90 calendar-year observations from three different sources for the intersecting subset of four-digit SIC industries, of which there were seventy.

From Japan's *Census of Manufacturers: Report by Industries,* listed in the references under the author definition the Ministry of Economy, Trade, and Industry (METI), we draw value-added, value of shipments, employment, wages, and book value of fixed tangible assets. The book value of tangible assets is observed for establishments employing ten or more. All other items are for establishments employing four or more. The book value of tangible assets is observed at the beginning of the calendar year. These data and continuation of like data through 2002 are available for downloading from the Web site of METI, www.meti.go.jp/statistics/kougyou/arc/index.html.

From two published sources and a Web site we compile observations of Herfindahl index of industrial concentration of production. The two published sources are JFTC (1975) and Senou (1983). These data are collected by the JFTC in fulfillment of its charge under the antimonopoly law. The two sources comprise overlapping time series, respectively: (1960–72) and (1971–80). The series are continued (1975–2002) in data posted on the Web site of the JFTC from which I was able to extend my data through 1990, www.jftc.go.jp/ruiseki/ruisekidate.htm,

The FTC observations on Herfindahl indexes, both from the published sources and the Web site, represent the summation of squared shares of industry production for nearly 500 industries. These data are, in principle, shares of physical units produced, not shares of revenues. But apparently for many of the industries a production index is used in lieu of physical units.

Finally, I collect the monthly observations of wholesale price index series for each commodity, from the BOJ for 1962–90. Monthly data from 1985 on are available in electronic format from the Web site of the BOJ, www.boj.or.jp/en/type/stat/dlong/index.htm.

Earlier data were drawn from the BOJ serial *Price Indexes Annual*. From these sources, I converted linked series to common 1980 base-year units and calculated calendar-year averages for each.

The three sets of data correspond to imperfectly matched industries. I was able to identify an overlapping subset of seventy four-digit industries with observations from all three sources (corresponding to the four-digit SIC level in the *Census of Manufacturers*). In the current study I dropped the four of these for which average price-cost margin was negative, leaving seventy industries in all. This is a relatively small subset of any of the three sources. For example there are about 450 industries for which the JFTC reports Herfindahl indexes and more than 1,000 commodities for which the BOJ tracks wholesale price indexes. And Japan's *Census of Manufacturers* identifies around 700 four-digit SIC industries.

Appendix Table A1

Regression Analysis of Average Industry Price-Cost Margin (Cournot Versus Bertrand)

	Model 1–Cournot: $m_t = \beta_1 H_t + e1_t$, $t = 1,\ldots, T$					Model 2–Bertrand: $m_t = \beta_0 + e2_t$, $t = 1,\ldots, T$					
Industry	Error DF	β_1	S.E.	*t*-value	prob > |*t*|	R^2	β_0	S.E.	*t*-value	prob > |*t*|	R^2
Aluminum window sashes	23	0.40	0.05	7.9	0.00	0.73	0.07	0.01	10.5	0.00	0.83
Bearings	29	0.10	0.08	1.3	0.21	0.05	0.02	0.02	1.5	0.14	0.07
Beer	29	0.15	0.02	9.3	0.00	0.75	0.06	0.01	9.6	0.00	0.76
Bicycles	23	1.75	0.11	15.5	0.00	0.91	0.11	0.01	14.9	0.00	0.91
Boilers	23	0.16	0.07	2.2	0.04	0.18	0.04	0.02	2.2	0.04	0.18
Briquettes	13	1.81	0.13	13.8	0.00	0.94	0.15	0.01	20.6	0.00	0.97
Calcium carbide	19	0.30	0.06	5.1	0.00	0.58	0.10	0.01	7.4	0.00	0.74
Canned seafood	23	1.26	0.12	10.8	0.00	0.84	0.09	0.00	21.8	0.00	0.95
Cast iron pipes and tubes	13	0.70	0.03	23.0	0.00	0.98	0.27	0.01	18.5	0.00	0.96
Caustic soda	29	3.75	0.25	14.8	0.00	0.88	0.18	0.01	15.4	0.00	0.89
Cellophane	13	0.28	0.05	5.3	0.00	0.68	0.06	0.01	5.1	0.00	0.67
Cement	29	3.19	0.15	21.6	0.00	0.94	0.28	0.01	23.4	0.00	0.95
Charging generators	19	0.09	0.02	3.7	0.00	0.42	0.03	0.01	3.9	0.00	0.44
Chemical seasoning	13	0.26	0.08	3.0	0.01	0.42	0.09	0.03	3.2	0.01	0.44
Coke	23	0.23	0.05	4.9	0.00	0.51	0.04	0.01	5.5	0.00	0.57

(*continues*)

Appendix Table A1 (*continued*)

	Model 1–Cournot: $m_t = \beta_1 H_t + e1_t, \quad t = 1,\ldots, T$						Model 2–Bertrand: $m_t = \beta_0 + e2_t, \quad t = 1,\ldots, T$				
Industry	Error DF	β_1	S.E.	*t*-value	prob > |*t*|	R^2	β_0	S.E.	*t*-value	prob > |*t*|	R^2
Cold-rolled steel plate	29	0.29	0.04	7.8	0.00	0.68	0.06	0.01	9.9	0.00	0.77
Combed fabrics	19	10.05	0.85	11.9	0.00	0.88	0.13	0.00	27.3	0.00	0.98
Cotton fabrics	29	12.06	0.79	15.2	0.00	0.89	0.08	0.00	16.5	0.00	0.90
Cotton yarn	29	0.93	0.27	3.4	0.00	0.28	0.03	0.01	3.3	0.00	0.28
Dissolving pulp	19	0.25	0.08	3.2	0.00	0.36	0.09	0.02	3.9	0.00	0.45
Eighteen liter cans	23	3.82	0.15	25.3	0.00	0.97	0.16	0.01	29.7	0.00	0.97
Electrical copper	29	0.49	0.06	8.0	0.00	0.69	0.09	0.01	8.0	0.00	0.69
Electrical wires and cables	19	0.81	0.09	8.8	0.00	0.80	0.06	0.01	8.9	0.00	0.80
Fireproof brooks	19	1.85	0.19	9.8	0.00	0.84	0.09	0.01	10.1	0.00	0.84
Fishing nets	23	1.81	0.21	8.5	0.00	0.76	0.10	0.01	13.4	0.00	0.89
Fishmeat sausage	13	0.40	0.08	5.1	0.00	0.67	0.06	0.01	6.4	0.00	0.76
Galvanized	29	0.34	0.09	4.0	0.00	0.35	0.06	0.01	4.5	0.00	0.41
Glass bulbs for use in cathode ray tubes	13	0.01	0.08	0.1	0.92	0.00	0.01	0.04	0.3	0.74	0.01
Glass containers for beverages	23	1.11	0.08	14.8	0.00	0.90	0.19	0.01	15.4	0.00	0.91
Grinding stones	27	1.99	0.16	12.6	0.00	0.85	0.14	0.01	15.5	0.00	0.90
Ham sausage	19	1.18	0.08	15.7	0.00	0.93	0.09	0.00	28.4	0.00	0.98
Jute yarn	9	0.33	0.05	6.3	0.00	0.81	0.13	0.03	4.9	0.00	0.73

Manmade-graphite electrodes	23	1.20	0.08	14.9	0.00	0.91	0.22	0.02	14.2	0.00	0.90
Medicines	27	10.85	0.80	13.6	0.00	0.87	0.30	0.01	38.5	0.00	0.98
Men's shoes	9	3.45	0.29	12.0	0.00	0.94	0.13	0.01	19.0	0.00	0.98
Miso	23	14.89	0.57	26.1	0.00	0.97	0.27	0.01	48.3	0.00	0.99
Mixed feed	19	0.50	0.08	6.6	0.00	0.69	0.08	0.00	28.9	0.00	0.98
Ordinary steel pipes and tubes	29	0.83	0.08	11.1	0.00	0.81	0.11	0.01	10.8	0.00	0.80
Paints	23	3.56	0.18	19.5	0.00	0.94	0.21	0.01	24.7	0.00	0.96
Paper pulp	29	1.57	0.16	10.1	0.00	0.78	0.11	0.01	9.9	0.00	0.77
Petroleum products	29	1.29	0.07	18.2	0.00	0.92	0.09	0.00	19.5	0.00	0.93
Pianos	27	0.15	0.04	3.6	0.00	0.33	0.07	0.02	3.8	0.00	0.35
Power tillers	19	1.01	0.05	19.9	0.00	0.95	0.15	0.01	22.1	0.00	0.96
Printing ink	29	0.53	0.04	12.8	0.00	0.85	0.08	0.00	16.3	0.00	0.90
Printing machines	13	1.07	0.11	9.3	0.00	0.87	0.13	0.01	12.4	0.00	0.92
Pumps	23	0.15	0.14	1.0	0.31	0.04	0.02	0.01	1.4	0.16	0.08
Raw silk	19	1.73	0.17	10.0	0.00	0.84	0.05	0.01	10.0	0.00	0.84
Records	9	2.57	0.23	11.0	0.00	0.93	0.26	0.03	8.3	0.00	0.88
Rectifiers	13	0.29	0.15	1.9	0.07	0.22	0.04	0.02	2.3	0.04	0.29
Rolled and wire-drawn copper products	19	0.88	0.22	3.9	0.00	0.45	0.04	0.01	4.0	0.00	0.46
Sake	29	34.90	1.92	18.2	0.00	0.92	0.20	0.00	52.5	0.00	0.99
Sanitary ware	23	0.14	0.06	2.3	0.03	0.19	0.08	0.02	3.3	0.00	0.32
Sheet glass	29	1.16	0.04	28.6	0.00	0.97	0.45	0.01	38.4	0.00	0.98

(*continues*)

Appendix Table A1 (*continued*)

	Model 1–Cournot: $m_t = \beta_1 H_t + e1_t$, $t = 1,\ldots, T$						Model 2–Bertrand: $m_t = \beta_0 + e2_t$, $t = 1,\ldots, T$				
Industry	Error DF	β_1	S.E.	*t*-value	prob > |*t*|	R^2	β_0	S.E.	*t*-value	prob > |*t*|	R^2
Soy	29	2.99	0.13	23.0	0.00	0.95	0.23	0.00	48.8	0.00	0.99
Spinning machines	13	0.01	0.07	0.1	0.92	0.00	0.02	0.02	0.8	0.42	0.05
Storage batteries	29	0.73	0.03	22.1	0.00	0.94	0.16	0.01	20.4	0.00	0.93
Sugar	19	1.23	0.13	9.3	0.00	0.82	0.08	0.01	8.8	0.00	0.80
Synthetic fibers	12	1.85	0.18	10.4	0.00	0.90	0.26	0.02	10.8	0.00	0.91
Synthetic rubber	13	1.43	0.08	19.1	0.00	0.97	0.34	0.02	18.2	0.00	0.96
Thermos bottles	19	0.61	0.09	6.9	0.00	0.72	0.15	0.02	6.6	0.00	0.69
Tile	23	1.58	0.13	11.9	0.00	0.86	0.17	0.01	14.0	0.00	0.89
Tires and tubes for motor vehicles	29	0.50	0.04	11.6	0.00	0.82	0.15	0.01	12.5	0.00	0.84
Tractors	19	0.46	0.05	9.5	0.00	0.83	0.14	0.01	10.8	0.00	0.86
Valve cocks	9	4.24	0.29	14.6	0.00	0.96	0.16	0.01	19.3	0.00	0.98
Vegetable oil	13	1.49	0.27	5.5	0.00	0.70	0.15	0.02	6.4	0.00	0.76
Vinyl chloride resin	13	1.28	0.15	8.4	0.00	0.85	0.08	0.01	10.2	0.00	0.89
Weaving machines	19	1.31	0.27	4.9	0.00	0.56	0.20	0.03	6.2	0.00	0.67
Wheat flour	29	0.99	0.03	29.8	0.00	0.97	0.15	0.00	29.2	0.00	0.97
Worsted yarn	29	2.16	0.19	11.5	0.00	0.82	0.08	0.01	13.2	0.00	0.86
Zinc	23	0.30	0.07	4.2	0.00	0.43	0.05	0.01	4.1	0.00	0.42
Mean		2.26	0.18	10.86		0.71	0.13	0.01	14.27		0.97
Standard deviation		4.82	0.27	7.13		0.27	0.09	0.01	11.65		0.69

Appendix Table A2

Vuong Statistic for Test Between Model 1–Cournot and Model 2–Bertrand

Industry	Log likelihood Model 1– Cournot	Log likelihood-Model 2– Bertrand	Likelihood ratio: Cournot vs. Bertrand	S.D. likelihood ratio for indvidual obs.	Vuong	Norm dist	N	Favored model	Implied elasticity– Cournot	Implied elasticity– Bertrand
Wheat flour	66.6	66.1	0.6	0.0	7,003.0	1.00	30	Cournot	1.0	6.9
Storage batteries	54.3	52.0	2.3	0.0	1,555.0	1.00	30	Cournot	1.4	6.2
Jute yarn	13.2	11.3	1.9	0.0	1,297.0	1.00	10	Cournot	3.0	7.8
Records	12.2	9.6	2.5	0.0	956.8	1.00	10	Cournot	0.4	3.9
Ordinary steel pipes and tubes	46.0	45.3	0.7	0.0	469.7	1.00	30	Cournot	1.2	9.4
Synthetic rubber	18.5	17.9	0.6	0.0	174.8	1.00	14	Cournot	0.7	2.9
Manmade-graphite electrodes	29.5	28.5	1.0	0.0	162.2	1.00	24	Cournot	0.8	4.6
Thermos bottles	18.5	17.7	0.8	0.0	116.3	1.00	20	Cournot	1.6	6.6
Sugar	37.3	36.4	0.9	0.3	2.9	1.00	20	Cournot	0.8	12.7
Bicycles	47.3	46.4	0.8	0.3	2.5	0.99	24	Cournot	0.6	9.2
Cellophane	24.4	24.2	0.2	0.3	0.7	0.76	14	Cournot	3.5	16.3
Cast iron pipes and tubes	24.4	21.5	3.0	4.7	0.6	0.74	14	Cournot	1.4	3.7
Speed changers	37.2	35.1	2.1	4.8	0.4	0.67	24	Cournot	–2.0	–32.6

(*continues*)

Appendix Table A2 (*continued*)

Industry	Log likelihood Model 1–Cournot	Log likelihood-Model 2–Bertrand	Likelihood ratio: Cournot vs. Bertrand	S.D. likelihood ratio for indvidual obs.	Vuong	Norm dist	*N*	Favored model	Implied elasticity–Cournot	Implied elasticity–Bertrand
Electrical copper	42.3	42.0	0.2	0.7	0.3	0.63	30	Cournot	2.1	11.4
Cotton yarn	46.9	46.7	0.1	0.4	0.3	0.63	30	Cournot	1.1	31.7
Paper pulp	42.9	42.6	0.3	1.0	0.3	0.63	30	Cournot	0.6	9.3
Raw silk	47.2	47.2	0.0	0.1	0.2	0.59	20	Cournot	0.6	19.1
Boilers	22.4	22.4	0.0	0.2	0.2	0.59	24	Cournot	6.4	22.7
Zinc	32.7	32.5	0.2	1.2	0.2	0.56	24	Cournot	3.3	18.7
Glass bulbs for use in cathode ray tubes	8.4	8.5	–0.1	0.3	–0.2	0.43	14	Bertrand	119.5	81.3
Sanitary ware	15.6	17.6	–2.0	5.7	–0.4	0.36	24	Bertrand	7.3	12.6
Electrical wires and cables	41.0	41.0	0.0	0.1	–0.4	0.36	20	Bertrand	1.2	15.8
Bearings	30.5	30.8	–0.3	0.9	–0.4	0.36	30	Bertrand	10.0	40.7
Spinning machines	17.8	18.1	–0.4	0.6	–0.6	0.28	14	Bertrand	127.1	65.1
Men's shoes	19.9	24.3	–4.4	7.0	–0.6	0.26	10	Bertrand	0.3	7.4
Charging generators	40.2	40.5	–0.3	0.5	–0.7	0.25	20	Bertrand	11.6	35.2
Fishmeat sausage	24.7	26.9	–2.2	1.8	–1.2	0.11	14	Bertrand	2.5	16.0

Pianos	24.5	24.9	–0.4	0.3	–1.3	0.10	28	Bertrand	6.6	13.8
Briquettes	25.8	31.1	–5.3	1.4	–3.9	0.00	14	Bertrand	0.6	6.7
Tile	30.8	34.1	–3.4	0.8	–4.0	0.00	24	Bertrand	0.6	5.9
Dissolving pulp	17.0	18.5	–1.5	0.4	–4.2	0.00	20	Bertrand	3.9	11.6
Power tillers	39.8	41.8	–2.0	0.5	–4.3	0.00	20	Bertrand	1.0	6.6
Paints	37.9	43.4	–5.4	1.2	–4.4	0.00	24	Bertrand	0.3	4.9
Petroleum products	67.8	69.6	–1.9	0.4	–4.7	0.00	30	Bertrand	0.8	11.6
Worsted yarn	55.2	58.7	–3.5	0.7	–4.8	0.00	30	Bertrand	0.5	12.0
Printing machines	22.6	26.2	–3.7	0.7	–4.9	0.00	14	Bertrand	0.9	7.8
Medicines	22.5	50.0	–27.4	5.3	–5.2	0.00	28	Bertrand	0.1	3.3
Grinding stones	40.5	45.6	–5.1	0.8	–6.5	0.00	28	Bertrand	0.5	7.1
Combed fabrics	33.9	49.6	–15.7	2.3	–6.8	0.00	20	Bertrand	0.1	7.9
Tires and tubes for motor vehicles	38.4	40.3	–1.9	0.3	–6.9	0.00	30	Bertrand	2.0	6.8
Sheet glass	31.4	40.1	–8.6	1.2	–7.2	0.00	30	Bertrand	0.9	2.2
Aluminum window sashes	43.2	48.6	–5.4	0.7	–7.4	0.00	24	Bertrand	2.5	14.3
Cold-rolled steel plate	56.5	61.6	–5.1	0.6	–7.9	0.00	30	Bertrand	3.4	17.5
Ham sausage	46.7	58.1	–11.4	1.4	–8.3	0.00	20	Bertrand	0.8	11.6
Soy	45.4	67.4	–22.0	2.4	–9.2	0.00	30	Bertrand	0.3	4.3
Beer	57.7	58.5	–0.8	0.1	–9.4	0.00	30	Bertrand	6.5	16.3
Mixed feed	33.6	59.8	–26.2	2.6	–10.2	0.00	20	Bertrand	2.0	12.4

(*continues*)

Appendix Table A2 (*continued*)

Industry	Log likelihood Model 1–Cournot	Log likelihood-Model 2–Bertrand	Likelihood ratio: Cournot vs. Bertrand	S.D. likelihood ratio for indvidual obs.	Vuong	Norm dist	*N*	Favored model	Implied elasticity–Cournot	Implied elasticity–Bertrand
Weaving machines	8.4	11.3	–2.8	0.1	–19.6	0.00	20	Bertrand	0.8	5.1
Chemical seasoning	11.3	11.6	–0.3	0.0	–23.8	0.00	14	Bertrand	3.9	10.7
Tractors	26.8	28.9	–2.1	0.0	–43.7	0.00	20	Bertrand	2.2	7.1
Synthetic fibers	13.3	13.7	–0.4	0.0	–67.8	0.00	13	Bertrand	0.5	3.8
Vegetable oil	13.0	14.5	–1.5	0.0	–164.1	0.00	14	Bertrand	0.7	6.6
Cement	37.8	40.2	–2.4	0.0	–280.6	0.00	30	Bertrand	0.3	3.6
Galvanized	37.0	38.3	–1.3	0.0	–323.4	0.00	30	Bertrand	2.9	17.9
Caustic soda	40.1	41.1	–1.0	0.0	–354.7	0.00	30	Bertrand	0.3	5.7
Glass containers for beverages	32.4	33.4	–0.9	0.0	–560.1	0.00	24	Bertrand	0.9	5.2
Calcium carbide	23.3	28.2	–4.9	0.0	–926.8	0.00	20	Bertrand	3.3	10.0
Pumps	36.7	37.2	–0.5	0.0	–1,244.9	0.00	24	Bertrand	6.9	65.0
Rolled and wire-drawn copper products	36.8	36.9	–0.2	0.0	–1,431.9	0.00	20	Bertrand	1.1	28.5
Rectifiers	19.5	20.1	–0.6	0.0	–2,265.3	0.00	14	Bertrand	3.5	27.4
Fishing nets	37.0	45.9	–9.0	0.0	–4,154.4	0.00	24	Bertrand	0.6	10.0
Fireproof bricks	35.7	36.1	–0.5	0.0	–4,398.6	0.00	20	Bertrand	0.5	10.9
Sake	43.3	74.0	–30.7	0.0	–5,724.5	0.00	30	Bertrand	0.0	5.0

Coke	46.1	47.7	–1.5	0.0	–7,726.4	0.00	24	Bertrand	4.3	26.4
Miso	38.4	52.8	–14.4	0.0	–8,843.3	0.00	24	Bertrand	0.1	3.7
Eighteen liter cans	50.0	53.7	–3.7	0.0	–15,174.3	0.00	24	Bertrand	0.3	6.3
Cotton fabrics	64.2	66.3	–2.1	0.0	–17,755.8	0.00	30	Bertrand	0.1	12.3
Printing ink	61.6	68.1	–6.5	0.0	–18,806.5	0.00	30	Bertrand	1.9	13.2
Canned seafood	44.7	60.0	–15.3	0.0	–23,406.9	0.00	24	Bertrand	0.8	11.1
Vinyl chloride resin	27.8	30.1	–2.3	0.0	–28,406.3	0.00	14	Bertrand	0.8	12.6
Valve cocks	20.0	22.7	–2.7	0.0	–40,565.7	0.00	10	Bertrand	0.2	6.2
Mean			–3.68	0.72	–2,443.61	0.25			5.45	13.94
Standard deviation			6.87	1.38	7,375.52	0.37			20.50	14.44

Notes: Model 1–Cournot: $m_t = \beta_1 H_t + e1_t$, $t = 1,..., T$; Model 2–Bertrand: $m_t = \beta_0 + e2_t$, $t = 1,..., T$.

Appendix Table A3

Regression Analysis of Average Industry Price-Cost Margin

	Intercept β_0						Slope β_1					
Industry	Error DF	β_0	S.E.	*t*-value	prob > |*t*|	prob > *t*	β_1	S.E.	*t*-value	prob > |*t*|	prob > *t*	R^2
Aluminum	22	0.1	0.03	3.84	0.00	0.00	–0.19	0.16	–1.20	0.24	0.88	0.06
Bearings	28	1.08	0.19	5.52	0.00	0.00	–5.02	0.93	–5.41	0.00	1.00	0.51
Beer	28	0.08	0.06	1.28	0.21	0.11	–0.04	0.15	–0.26	0.79	0.60	0.00
Bicycles	22	0.04	0.05	0.69	0.50	0.25	1.19	0.82	1.45	0.16	0.08	0.09
Boilers	22	0.02	0.08	0.21	0.83	0.42	0.10	0.29	0.34	0.74	0.37	0.01
Briquettes	12	0.18	0.05	3.82	0.00	0.00	–0.37	0.58	–0.65	0.53	0.73	0.03
Calcium carbide	18	0.09	0.03	3.41	0.00	0.00	0.03	0.09	0.32	0.75	0.38	0.01
Canned seafood	22	0.07	0.01	8.43	0.00	0.00	0.27	0.13	2.02	0.06	0.03	0.16
Cast iron pipes and tubes	12	–0.33	0.17	–1.90	0.08	0.96	1.56	0.45	3.45	0.00	0.00	0.50
Caustic soda	28	0.21	0.15	1.42	0.17	0.08	–0.67	3.13	–0.21	0.83	0.58	0.00
Cellophane	12	0.03	0.04	0.62	0.55	0.27	0.17	0.19	0.88	0.39	0.20	0.06
Cement	28	0.32	0.15	2.23	0.03	0.02	–0.55	1.69	–0.33	0.75	0.63	0.00
Charging generators	18	0.24	0.14	1.68	0.11	0.06	–0.67	0.45	–1.48	0.16	0.92	0.11
Chemical seasoning	12	0.99	0.56	1.75	0.11	0.05	–2.54	1.60	–1.59	0.14	0.93	0.17
Coke	22	0.04	0.03	1.76	0.09	0.05	–0.05	0.16	–0.28	0.79	0.61	0.00

Cold-rolled steel plate	28	0.07	0.02	3.49	0.00	0.00	–0.08	0.11	–0.72	0.48	0.76	0.02
Combed fabrics	18	0.15	0.02	8.62	0.00	0.00	–1.56	1.40	–1.11	0.28	0.86	0.06
Cotton fabrics	28	0.16	0.07	2.44	0.02	0.01	–12.27	10.02	–1.23	0.23	0.88	0.05
Cotton yarn	28	–0.04	0.11	–0.32	0.75	0.62	1.97	3.28	0.60	0.55	0.28	0.01
Dissolving pulp	18	0.35	0.11	3.08	0.01	0.00	–0.89	0.38	–2.36	0.03	0.99	0.24
Eighteen liter cans	22	0.16	0.06	2.82	0.01	0.01	0.02	1.35	0.02	0.99	0.49	0.00
Electrical copper	28	–0.08	0.22	–0.38	0.71	0.65	0.95	1.22	0.78	0.44	0.22	0.02
Electrical wires and cables	18	0.04	0.13	0.28	0.78	0.39	0.34	1.68	0.20	0.84	0.42	0.00
Fireproof bricks	18	0.21	0.18	1.17	0.26	0.13	–2.42	3.66	–0.66	0.52	0.74	0.02
Fishing nets	22	0.22	0.03	8.57	0.00	0.00	–2.44	0.51	–4.82	0.00	1.00	0.51
Fishmeat sausage	12	0.14	0.05	2.78	0.02	0.01	–0.54	0.34	–1.57	0.14	0.93	0.17
Galvanized	28	0.08	0.05	1.67	0.11	0.05	–0.15	0.31	–0.49	0.63	0.69	0.01
Glass bulbs for use in cathode ray tubes	12	0.77	0.29	2.64	0.02	0.01	–1.64	0.63	–2.61	0.02	0.99	0.36
Glass containers for beverages	22	0.39	0.25	1.55	0.14	0.07	–1.16	1.46	–0.79	0.44	0.78	0.03
Grinding stones	26	0.24	0.06	3.90	0.00	0.00	–1.42	0.88	–1.61	0.12	0.94	0.09

(*continues*)

Appendix Table A3 (*continued*)

Industry	Error DF	β_0	S.E.	*t*-value	prob > |*t*|	prob > *t*	β_1	S.E.	*t*-value	prob > |*t*|	prob > *t*	R^2
		Intercept β_0					Slope β_1					
Ham sausage	18	0.09	0.01	6.17	0.00	0.00	0.01	0.19	0.04	0.97	0.48	0.00
Jute yarn	8	–0.05	0.09	–0.54	0.60	0.70	0.44	0.22	2.04	0.08	0.04	0.34
Manmade-graphite electrodes	22	0.06	0.11	0.51	0.62	0.31	0.90	0.60	1.49	0.15	0.07	0.09
Medicines	26	0.35	0.03	13.67	0.00	0.00	–1.95	0.98	–1.99	0.06	0.97	0.13
Men's shoes	8	0.12	0.03	3.47	0.01	0.00	0.47	0.88	0.53	0.61	0.30	0.03
Miso	22	0.19	0.02	11.34	0.00	0.00	4.53	0.94	4.82	0.00	0.00	0.51
Mixed feed	18	0.07	0.00	18.24	0.00	0.00	0.08	0.03	2.75	0.01	0.01	0.30
Ordinary steel pipes and tubes	28	0.00	0.09	0.01	0.99	0.49	0.82	0.72	1.14	0.26	0.13	0.04
Paints	22	0.24	0.07	3.60	0.00	0.00	–0.55	1.15	–0.48	0.64	0.68	0.01
Paper pulp	28	0.04	0.07	0.51	0.61	0.31	1.02	1.08	0.95	0.35	0.18	0.03
Petroleum products	28	0.06	0.03	2.11	0.04	0.02	0.35	0.45	0.79	0.44	0.22	0.02
Pianos	26	0.25	0.21	1.20	0.24	0.12	–0.38	0.44	–0.85	0.40	0.80	0.03
Power tillers	18	0.11	0.05	2.16	0.04	0.02	0.25	0.35	0.72	0.48	0.24	0.03
Printing ink	28	0.17	0.03	5.54	0.00	0.00	–0.72	0.23	–3.16	0.00	1.00	0.26
Printing machines	12	0.17	0.06	3.01	0.01	0.01	–0.33	0.47	–0.70	0.50	0.75	0.04

Pumps	22	0.12	0.05	2.20	0.04	0.02	–1.33	0.68	–1.95	0.06	0.97	0.15
Raw silk	18	0.02	0.05	0.47	0.65	0.32	0.91	1.76	0.52	0.61	0.31	0.01
Records	8	–0.23	0.17	–1.35	0.21	0.89	4.82	1.68	2.87	0.02	0.01	0.51
Rectifiers	12	0.17	0.09	1.85	0.09	0.04	–1.22	0.83	–1.48	0.17	0.92	0.15
Rolled and wire-drawn copper products	18	0.03	0.06	0.54	0.59	0.30	0.08	1.49	0.05	0.96	0.48	0.00
Sake	28	0.17	0.01	15.73	0.00	0.00	5.47	1.97	2.77	0.01	0.00	0.22
Sanitary ware	22	0.53	0.09	5.90	0.00	0.00	–1.01	0.20	–5.10	0.00	1.00	0.54
Sheet glass	28	0.88	0.14	6.12	0.00	0.00	–1.10	0.37	–2.97	0.01	1.00	0.24
Soy	28	0.20	0.02	10.21	0.00	0.00	0.41	0.26	1.59	0.12	0.06	0.08
Spinning machines	12	0.15	0.05	3.03	0.01	0.01	–0.55	0.19	–2.85	0.01	0.99	0.4
Storage batteries	28	0.03	0.06	0.53	0.60	0.30	0.59	0.27	2.23	0.03	0.02	0.15
Sugar	18	–0.04	0.09	–0.44	0.66	0.67	1.81	1.32	1.37	0.19	0.09	0.09
Synthetic fibers	11	0.15	0.10	1.54	0.15	0.08	0.83	0.68	1.22	0.25	0.12	0.12
Synthetic rubber	12	0.17	0.04	4.66	0.00	0.00	0.76	0.15	4.98	0.00	0.00	0.67
Thermos bottles	18	–0.17	0.22	–0.76	0.46	0.77	1.27	0.88	1.45	0.17	0.08	0.10
Tile	22	0.10	0.02	6.22	0.00	0.00	0.76	0.15	4.89	0.00	0.00	0.52

(*continues*)

Appendix Table A3 (*continued*)

		Intercept β_0					Slope β_1					
Industry	Error DF	β_0	S.E.	*t*-value	prob > |*t*|	prob > *t*	β_1	S.E.	*t*-value	prob > |*t*|	prob > *t*	R^2
Tires and tubes for motor vehicles	28	0.79	0.20	3.85	0.00	0.00	–2.23	0.71	–3.14	0.00	1.00	0.26
Tractors	18	0.11	0.05	2.20	0.04	0.02	0.12	0.16	0.75	0.46	0.23	0.03
Valve cocks	8	0.12	0.04	2.75	0.02	0.01	1.19	1.13	1.06	0.32	0.16	0.12
Vegetable oil	12	0.23	0.12	1.81	0.09	0.05	–0.77	1.27	–0.61	0.55	0.72	0.03
Vinyl chloride resin	12	0.09	0.04	2.22	0.05	0.02	–0.25	0.70	–0.35	0.73	0.63	0.01
Weaving machines	18	0.37	0.13	2.96	0.01	0.00	–1.34	0.93	–1.45	0.16	0.92	0.11
Wheat flour	28	0.01	0.13	0.05	0.96	0.48	0.94	0.91	1.04	0.31	0.15	0.04
Worsted yarn	28	0.10	0.04	2.78	0.01	0.00	–0.46	0.96	–0.48	0.63	0.68	0.01
Zinc	22	–0.1	0.22	–0.63	0.54	0.73	1.05	1.20	0.87	0.39	0.20	0.03

Notes: Model 3–Hybrid: $m_t = \beta_0 + \beta_1 H_t + e3_t$, $t = 1,\ldots, T$.