

Tariffs, environmental change, and the Maine lobster industry: A case study

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Abstract

This paper examines economic and other developments affecting the Maine lobster industry over the past decade and one-half. Special emphasis is given to the effect of recent tariffs imposed by China and the European Economic Union, in addition to what has mostly been (so far) favorable climate change. Specific questions raised and answered pertain to the year-by-year behavior of large swings in price, quantity and revenue. Supply and demand analysis is used to analyze and explain how these swings have occurred in response to external factors such as warming waters, rising and falling consumer income, and a growing reliance upon exports which has been recently challenged. The focus then turns to the impact of recent developments on lobster fishermen and lobster dealers, two important components of the industry supply chain. The first is perceived to operate in what is interpreted here to be a near perfect competition sub-industry. Both domestic and international developments such as dramatically increased Maine harvests due to conservation and climate change and expanding markets for American Lobster are considered. Lobster dealers, too, are subsequently analyzed using the same framework applied to a global trade situation, in which their pricing power has recently been effectively destroyed by restrictions and increased competition from abroad (mostly Canada). The important question addressed and partially answered is whether they, and lobster fishermen, should continue operating their business at a loss, a staple of Managerial Economics, though some alternative suggestions from other business curriculum subjects are noted at the end.

Keywords: Lobster, Tariffs, Trade War, Managerial Economics, Climate Change

BACKGROUND

American Lobster, a species technically known as *Homarus*, inhabits waters in the United States and Canada. Harvesting by lobster fishermen occurs year-round, though strong but differing seasonal patterns occur in the two countries. Within the U.S., the harvest historically spanned several states along the Atlantic Ocean with coastline and inland sources of supply. More recently, climate change and little regulation in some locations have led to an exhaustion of supply in many states. In contrast, the Maine lobster population exhibited rapid growth. Favorable climate there, reduced numbers of predators (mostly cod) and conservation measures including controlled feeding of lobster have resulted in a population explosion. Today, most *Homarus* production in the U.S. (83%¹) occurs in specific coastal areas in Maine.

Domestic demand for live lobster in the U.S. historically exhibited a seasonal pattern, too, with live lobster often marketed in the same region in which it was caught. But improvements in lobster transportation and storage have opened new markets, resulting in rising domestic and international sales over the past decade. Lobster has become the most important commercial fishing industry, and a major source of income, employment, and exports for the state. The Department of Maine Marine Resources (DMR) reports that lobster landings reached a record 132 million pounds in 2016, with a boat value of \$540 million and revenue to lobster fishermen of over \$554 million (revenue to fishermen includes a bonus subsequently paid from lobster co-ops to harvesters).

The industry supply chain encompasses several stages, beginning with the large number of mostly small fishing vessels dropping lobster cages with bait into cold deepwater and periodically retrieving the catch. Licenses to catch lobster are tightly controlled by Maine Fishing Authorities, with 6000 licenses current. While lobster fishing is the most important link in the supply chain, other components add to total value. After the harvest reaches harbor, other stages in the complicated chain include dealers who purchase lobster from fishermen, storage facilities, processing facilities, local, national and international transportation networks, and wholesale buyers and retailers including supermarkets and restaurants.² An estimate of the value of the chain beyond lobster fishermen is one billion dollars, responsible for employment of about 4000 additional jobs.³ The combined output value of about one and one-half billion dollars and employment of around 10,000 persons attests to the importance of this industry to the state economy. Additional multiplier effects such as that between lobster fishing and tourism could add more to the totals.

Rebounding prices paid to fisherman the past few years suggests the increased size of lobster harvests has been accompanied by a similar growth in demand. Much of that growth has come from three countries, Canada, Europe and China. Recent adverse developments on both the domestic and international front, however, have threatened the economic livelihood the industry

¹ Calculated from U.S. Department of Commerce, NOAA, NMFS data by weight, 2016.

² For more specifics, see M. Donihue and A. Tselikis, "The economic impact of the lobster distribution supply chain in Maine," *Maine Fisherman's Forum*, March 2, 2018.

³ Statistics from an industry study by Professor Michael Donihue. A recent article (Size and value of Maine lobster haul fell sharply in 2017," by Penelope Overton, *Portland Press Herald*, March 2, 2018) summarizes the methodology used in this analysis: "\$1 billion... is based on a financial analysis of 20 cooperating lobster wholesalers of different sizes that showed they pumped \$244 million into the Maine economy and supported 1,300 jobs. Then Donihue used that sample to predict the economic value of Maine's 200-dealer network."

provides. Preliminary data for 2017 indicate a 16% decline in the harvest, with the value of the statewide catch commensurately lower, at about \$434 million. Some have attributed the decline to temporary causes: “a season shortened by a late spring molt and bad winter weather,⁴ but not all believe the decline is only temporary.

The growth and even sustainability of export demand, too, has been seriously challenged by retaliatory tariffs imposed by China on U.S. lobster. A Wall Street Journal Editorial (“Trump boils Maine lobstermen,” June 26, 2018), states: “post-molt lobsters Maine harvests from July through November... sell for several dollars less (than hard shell from Canada) a pound. In the price-sensitive Chinese market, that has given the U.S. industry a competitive advantage over its Canadian counterparts. After the U.S. announced on June 15 plans to impose a 25% tariff ... (on) Chinese goods, Beijing retaliated with a new 25% tariff on American seafood ... on top of the 10% to 15% tariffs China already imposes on U.S. Canadian lobster. Meanwhile, on July 1, China’s tariff on Canadian lobster will drop to 7%.” The European Economic Union (EEU) reduction of tariffs on Canadian lobster this past year also harmed U.S. exports. Feedback of both events in the form of oversupply and falling lobster prices have hit the domestic market.

These developments add to traditional sources of industry uncertainty. As with much agricultural output, year-to-year production variation occurs in response to natural causes. In any year, the timing of demand does not have a good match with that of supply. Large quantities of hard-shell lobster (the pricier variety) are harvested in both the early and latter months of the year. During the intervening months, growing lobsters shed their shells, and a dramatically reduced harvest is dominated by lower-priced new or soft-shell lobster. To offset both seasonal and year-to-year supply and demand imbalances, lobster can be stored live, but there is a storage cost and a quantity loss, known as shrinkage, occurs, as not all lobster survive (shrinkage is higher than the natural death rate, but improved storage methods have lowered it to 4% recently.) The date and price at which stored lobster will be sold is often unknown.⁵

In any season or year not all the catch can be legally harvested, as lobster too young or small or females with eggs must be returned to the sea. The proportion of the catch in this category varies. Cage loss (snapped lines) and cage deterioration result in a continual replacement expense, and bait cost is considerable, especially more so recently since bait prices have increased. Other important operating costs include fuel, the cost of hired personnel, and maintenance and other costs of the vessel, all of which have been rising. Fixed costs must be paid, and consist of spending on vessel modification, equipment upgrades, and licenses (fees have been raised).

Lobster fishermen usually sell their catch to dealers after returning to harbor. They lack pricing power, and what they are offered depends upon momentary supply and demand. The price received by lobster fishermen (known as the ‘ex-vessel’ or ‘boat’) price, exhibits frequent ups and downs making financial and other planning difficult. Boat price is separated from the price charged to the ultimate consumer by several stages of distribution that create varying margins at different points in time. Pricing power exists in varying degrees at other stages in the distribution system. Numerous examples of very high restaurant prices, for example, have been cited at times

⁴Comments of DMR Commissioner Patrick Keliher reported by Penelope Overton, Staff Writer, in “Size and value of Maine lobster haul fell sharply in 2017,” Portland Press Herald, March 2, 2018.

⁵Futures markets in other industries are used to reduce price uncertainty for harvesters. But a Newsweek article a decade ago noted: “lobster is not produced on a mass global scale – which also means there are no speculators trying to make killing on lobster futures.” From “Food prices are soaring, so why is lobster cheap?”, staff article, August 17, 2008.

of very low ex-vessel price. Indeed, at this stage of distribution, it is commonly believed that income elasticity of demand is higher than price elasticity.

Longer imbalance of excess supply can persist. To augment demand, lobster can be frozen, canned or otherwise incorporated into several preparations and sold nationally or internationally. These products involve cost and pricing differences, with margins varying over time.⁶ Other species of lobster and other shellfish varieties also provide a competitive substitute lessening final demand. The combined effect of these factors on lobster fishermen and the entire industry creates a complicated situation, filled with both known risks and uncertainty. Being an entrepreneur in this industry is not a sensible choice for those with little risk tolerance.

SUPPLY AND DEMAND ANALYSIS OF 2003-2016 EVIDENCE

Data on Maine Lobster Catch and the Average Price paid ex-vessel are shown in Appendix Table 1. The quantity (pounds) data was obtained from Federal Government data (NOAA Fisheries, NMFS Landings) while average price from the same data source was calculated using the total paid for landings divided by the number of pounds shown. Figure 1 (see Appendix), based on the same data, features a left vertical axis for pounds of landings while the right vertical axis indicates price per pound. Using a chart of this type allows us to examine the direction of movements in quantity and price over time.

The data and accompanying chart demonstrate that price has fluctuated over the period, bottoming in 2012 in what appears to be a cyclical pattern with a mean of \$3.66 and a standard deviation of .57. For quantity (pounds), there is a strong upward trend over the 2007-2012 period, but not much change before or after that sub-period. Still, over the entire period, there has been an, but interrupted, trend, with landings in the last year shown (2016) 2.4 times higher than at the beginning of the period (2003). Thus, quantity has generally increased over the entire period, while price initially fell but subsequently returned to an earlier level. (But preliminary data for 2017, discussed later, indicate a substantial drop in quantity).

The price line shows movement over the period in what appears to be a cyclical pattern. Price generally fell from 2005-2009, fluctuated in a narrow range from 2009-2012, and rose from 2012-2015. with a mean of \$3.66 and a standard deviation of .57. There does not appear to be a significant trend present over the entire period, but price recovered after bottoming out in 2012.

Movements in year-to-year prices and quantities can be explained in terms of supply-demand interaction. The diagrams in Figure 2 in the Appendix show the anticipated qualitative effect on price and quantity due to supply and demand changes, represented by shifts in the curves. Each curve shows the logical quantity-price relationship holding other factors constant, But changes in income, tastes, the price of substitute goods, and the size of the market will shift demand, while climate changes and cost of operating expenses such as fuel price affect supply.

⁶ Laurie Schreiber, in *Mainebiz* (December 14, 2015) writes:” According to GMRI, the live lobster market is divided between lower-price new shells and often-higher-priced hard shells. New shells, caught between July and the end of November, are predominantly used for the summer and fall restaurant market and the processing sector. Processed lobster or value-added products, such as lobster mac-and-cheese, is sold to grocery or food service distributors, who sell to supermarket chains, institutional food providers or food service outfits. The live hard-shell winter and spring product, better able to withstand transportation, goes into local, national and international markets via importers or wholesalers, who then sell to restaurants, grocery chains, or retailers.”

When both supply and demand increase, quantity sold will increase but the effect on price will vary based on the extent of the shift to the right of each curve and the slopes of the curves. This can be seen in the diagrams above, in which S and D represent initial supply and demand curves, while S' and D' are subsequent ones. In the left panel the supply is greater than that in demand, with the consequence that price falls. In the right panel, the supply shift is less than that in demand, causing market price to rise. The consequence of what happens to equilibrium price when supply and demand each decline can be seen by referring to S' and D' as the original values and S and D as the subsequent ones. The diagrams can also be used to explain the effect on equilibrium price (rises) when supply is reduced while demand is increased (let D and D' show the increase in demand, S' and S show the decrease in supply). Reversing the direction of these shifts indicates that price will fall when supply is increased while demand is reduced.⁷

What does this framework suggest about the actual changes noted in Table 1? Lobster prices rose from 2003-2004 as did lobster quantity in the same period. This is consistent with a greater increase in demand than supply. In the next year, quantity fell but price increased, implying that demand was either little changed from the previous year or increasing. In 2006, a sizable increase in supply occurred, driving the price down as demand growth did not match supply. In 2007, supply was reduced, and price rose, implying that demand was either stable or increasing. Price did not quite return to the level it reached in 2005 when supply was less, however. The economic crisis which began in 2007 likely curtailed lobster prices for the latter part of the year, and continued into 2008. Supply increased in 2008 to a little more than what it had been two years earlier, but price fell abruptly, a consequence of lobster's sensitivity to declining income during the Great Recession.

A sizable increase in supply in 2009 accompanied the first signs of a recovering economy, but the increase in demand did not match that of supply so that price fell. Another sizable increase in supply in 2010, however, was associated with a rising price as demand was buoyed by a more rapidly recovering economy. Another increase in supply in 2011 pushed prices down, and a much larger supply increase in 2012 drove prices down much farther. As mentioned, the market for live lobster is augmented by markets for frozen lobster and lobster preparations. By 2012, live lobster for these markets were most often transported to Canada for processing, but incidents were reported of arriving trucks meeting with rejection that year.⁸ Schreiber, *ibid*, noted by year's end the industry still managed to fare well: "when an early shed created a supply of new-shell lobsters before processing plants were ready to take them, and the live market was unable to absorb the supply. This depressed value, with fishermen generally earning less than \$3 per pound. Nevertheless, the fishery's overall value that year held steady because fishermen made up for low earnings by bringing in more product."

⁷ A source of much confusion is the failure to distinguish movements along the supply or demand curves (changes in 'quantity supplied' or changes in 'quantity demanded') from shifts in the curves over time (changes in supply, changes in demand), where the former is caused by a price change while the latter depends upon factors noted above.

⁸ The Ellsworth American reported: "Lobster Prices and Supply Roil Maine-Canada Relations," by Stephen Rappaport, August 2, 2012: "The approach of the New Brunswick lobster fishing season and low lobster prices precipitated an international incident last week, as Canadian lobstermen tried to block processors from buying cheap Maine lobster." Additional plants have been built in Maine since then.

Quantity changed little in 2013, and a stronger demand from the economy's growth led to a rebound in lobster prices. In the ensuing period, supply changes were relatively small but prices rose. This reflected further increases in domestic demand from the recovering economy and a rapid growth in export demand, primarily coming from Asia. In late 2015 columnist Laurie Schreiber wrote⁹: "thanks to industry marketing initiatives and a growing processing sector that eliminates the need for consumers to deal with live crustaceans, lobster is gaining broader appeal as a healthy, wild-caught protein." In the same article, then President of the Maine Lobster Dealers Association, David Cousins, was quoted as saying "There's more market now ...The Asian market has taken off and the domestic market is doing better. More people are eating lobster: They understand the health benefits. Plus, the economy is better. All of that works together." As noted earlier, the lobster harvest surged in 2016. As to the accompanying gain in income, the Portland Press Herald reported:¹⁰ "In 2016, the state's 6,000 licensed lobster fishermen landed an extra 8.4 million pounds of lobster, which is 6 percent more than in 2015, data shows. With the per-pound boat price remaining stable ...the extra catch in 2016 netted them \$31.8 million more than 2015."

PERFECT COMPETITION, REVENUE AND PROFIT OF INDIVIDUAL LOBSTERMEN

Up and down movements in ex-vessel price and the relatively low profitability of entrepreneurs is behavior consistent with the workings of perfect competition. That structure describes an industry characterized by large numbers of independent sellers producing identical products, the free entry and exit of producers, and the widespread availability of price and other relevant information. Each seller is in a "take it or leave it" situation, lacking pricing power. For the entire industry, price movements occur in response to changes (i.e. shifts) in demand and supply. Profits for the individual firm, meanwhile, tend towards the "normal level," representing compensation for owner's time, effort and other resources expended at opportunity cost (alternative pursuit remuneration), but no more. While not all assumptions in the model are met here (notably, license restrictions preventing free entry) or in any other actual situation, it has proven useful in understanding price, quantity, and profitability behavior in many different contexts. (Markets for several agricultural products, for example, have been characterized as good examples of the workings of perfect competition.)

The supply and demand model of the ex-vessel lobster industry presented earlier, moreover, is logically consistent with a market structure of perfect competition. There the focus was on the effect of external factors on industry price and quantity movements. Here the focus turns to the behavior of individual firm profitability. Some actual evidence on this was offered in Schreiber (ibid), who reported that a Gulf of Maine Research Institute study indicated that in 2010, net profit of lobster fishermen after expenses averaged less than \$25,000. This occurred in a year which, as discussed earlier here, price and output had risen from previous years.¹¹ Schreiber also noted: "The price per pound makes a big difference in earnings. Although 2014 landings were on par with 2013 and 2012, fishermen earned \$86.65 million more in 2014 than they did in 2013." A

⁹Laurie Schreiber, "From trap to plate: Maine lobster distribution is a complex system, Mainebiz, December 14, 2015.

¹⁰ Penelope Overton, "Maine lobster catch tipped the scale at a record 130 million pounds in 2016." Portland Press Herald, March 3, 2017.

¹¹A recent CBS News Report (August 8, 2018) featured lobster fisherman Steve Train, who remarked that profits have been low for several years, compared to what he was making years ago.

rough estimate here, then, is this added on average around \$15,000 to the gross profit of lobster fishermen.

Implications of changes in industry supply and demand changes on price and quantity have been considered, but that discussion is now extended focus on the profitability of individual firms. In Figure 3 (see Appendix), the graph on the left-hand side is for the entire industry, while that on the right is the situation of a representative firm. The latter is a very small part of the market, and the prevailing industry price puts the lobsterman in the same ‘take it or leave it’ situation, regardless of amount offered by the producer. The demand curve facing the firm thus appears as a horizontal line with perfect price elasticity, as is shown (d_1). Given the producer’s marginal cost curve (mc_1), the maximum profit can be earned by harvesting quantity q_1 .

External changes such as a more favorable climate can affect productivity and lead to a lower marginal cost curve (mc_2) for the firm and a related outward shift in industry supply.¹² When this occurs (as it did in 2014), market price is lowered to P_2 and the individual producer now faces demand curve d_2 . The new profit maximizing output of the firm is q_2 , which occurs at the intersection of the firm’s demand (or marginal revenue) curve and mc_2 . As this adjustment is made by all firms, the situation can appear as a seamless adaptation of industry supply and demand to a new equilibrium, with a new equilibrium price-quantity combination for the representative firm. Sales revenue for the industry after this change is $P_2 \times Q_2$, compared to prior revenue of $P_1 \times Q_1$ with each of these represented by the appropriate price times quantity rectangles in the left panel of the diagram. While theory cannot determine whether revenue rises or falls in this situation, the data for 2013 and 2014 suggest actual revenue was little changed between the years.

But what of profit for the individual firm? Does it fall because price is lower? The answer in this circumstance is not necessarily, because the lower price resulted from productivity gain which drove down marginal cost. Profit realized by the firm before the climate or other external factor change appears in the right panel of the diagram as equal to the difference between price and marginal cost times quantity (i.e. p_1 minus atc_1) times q_1 . After climate change, profit is equal to $(p_2$ minus atc_2) times q_2 . Because the way the curves have been drawn makes it appear here that profit has actually risen (the latter rectangle is larger than the former), in general there is no rule as to what will be the case.

THE 2017 DECLINE

Preliminary data released by the DMR confirmed the bad news that many had expected, a sizable drop in quantity of landings and a fall in price.¹³ Quantity was down 15.3% from the previous year and price at \$3.91 per pound, more than a 4% decline.¹⁴ Together, these resulted in almost \$100 million less revenue, an average of nearly \$17,000 per licensed fisherman. Using 2010 data cited earlier, the profit rate on average is about 25%, so ‘a back of the envelope’ calculation suggests profit fell, on average, a little over \$4000 per licensed fisherman. DMR Commissioner Patrick Keliher noted (ibid) it was unusual for a quantity decline to be associated with a lower price, creating a challenge to explain what just occurred.

¹² See Gaby Carpenter, “The effect of temperature on the supply and demand for the American Lobster (*Homarus americanus*) in the state of Maine,” Honors Thesis, Colby College, Spring 2016.

¹³ The preliminary estimate is 110,879,760 pounds, according to NMFS data.

¹⁴ Overton, March 2, 2018, ibid. Other quotes in this paragraph are from the same article. Calculations of the percentage drop in price and in average revenue made here are based on these data.

The decline in both quantity and price in 2017 seems to reflect a combination of factors that led to a reduction in both supply and demand. Bad weather and a late molt were cited as reasons for depressed supply while the that demand was adversely affected by two developments: “A Canadian-European trade deal that eliminated the tariffs on European imports from the Maritimes depressed demand for U.S. lobsters ... Demand also dipped in several U.S. cities hit by hurricanes.” Lobster dealer Scout Wuerthner added: “A decline in one year’s catch does not always mean a dip in available supply... Canadian dealers and processors still had a lot of live and stored frozen lobsters left over from a banner 2016 catch to sell in 2017, which kept a lid on both the demand and price of the 2017 catch.” The head of the Maine Lobster Dealers Association, Annie Tselikis, emphasized the growing availability of substitute products. She was quoted as saying:¹⁵ “Huge international crab and shrimp harvests also helped keep lobster prices down because they gave international buyers, especially the Chinese, affordable alternatives to lobster for those big celebratory meals.” In interpreting these comments in terms of the perfect competition model, it seems 2017 was a year of decline in both supply and demand. The decline in demand was greater, however, because the lower price implies so, presumably for the reasons such as the Canadian-European tariff and other reasons reduction cited.

Unlike the 2014 situation, profits were clearly adversely affected as marginal cost was likely raised by external developments at the same time as demand was lowered. These changes would have produced at a minimum a lower per unit profit (price minus average total cost), perhaps a per unit loss, multiplied by a smaller quantity. After several good years, one bad year was met with concern but unlikely to lead to many firms exiting the industry. Commissioner Keliher said: “One year of decline does not make a trend...The way I look at it, we were down 16 percent compared to the highest year on record. It was still the seventh year we landed over 100 million pounds, the sixth highest on record and the fourth highest in value. That’s pretty damn good. Will the industry survive one bad year? Yes. Will it hurt individual lobstermen? Yes.”¹⁶

EXPORTS TO CHINA AND THE EFFECT OF 2018 TARIFFS

Lobster exports to Asian countries rose over the 2013-2017 period,¹⁷ but nowhere as fast as in China. Revenue and quantity of lobster exported to China more than tripled from beginning to end (see Appendix Table 2). Because the price at which these exports were sold rose, increase in value exceeded that in quantity. Exports to China also increased more rapidly than U.S. exports worldwide, resulting in a rising proportion of all U.S. *Homarus* exported. Figure 4 (see Appendix) illustrates this.¹⁸ A rough estimate is that in 2017, exports to China were equal to 14% of the

¹⁵ Lori Valigra, “Maine lobster exports to China fell steeply in July as Trump trade war intensified,” Bangor Daily News, October 13, 2018.

¹⁶ Quoted in Overton, March 2, 2018, *ibid*.

¹⁷ Patrick Whittle (*ibid*) noted: “Thailand, which imported its largest total in history last year at more than 675,000 pounds. The country imported less than 50,000 pounds in 2010. South Korea imported less than 700,000 pounds of American lobster in 2010 and more than 2.4 million pounds last year. Vietnam imported almost nothing in 2010 and took more than 4 million pounds last year.”

¹⁸ Schreiber (*ibid*) provided a quantitative perspective on where lobster exports were going in 2014: “According to Jeff Bennett, a senior trade specialist with the Maine International Trade Center, Maine exported \$365 million worth of lobster in 2014. Of that, \$349 million was shipped live, \$16 million frozen, with \$300 million of that going to Canada for processing; \$40 million going to

Maine lobster.¹⁹

While 2017 was a year of low *Homarus* harvest, it was also a year of high export to China. More than half of these exports (52.8%) occurred between September and December's end. Lobster exports to China in the first half of 2018 were on track to far surpass 2017, but tariffs imposed in July brought that trend to a screeching halt. Revenue lost for the rest of the year is likely at least as much as that received from January to August, given the experience of 2017.

Table 3 and Figure 5 (Appendix), which match monthly live *Homarus* exports to China from January to August during 2017 and 2018 show this. Lobster exports began 2018 at much higher levels than in 2017. They fell precipitously (59%) from February to March, coincident with the reported concern over U.S.- China trade policy. Yet attributing much of that drop to trade tension might be an overstatement. Patrick Whittle, *ibid*, reported: "China's hunger for American lobsters is helping keep prices high to U.S. consumers, but a tariff on the seafood does not appear imminent." In 2017 a similar percentage decline (56%) occurred between January and February, so the drop appears to primarily reflect seasonality. Lobster exports moved in a narrow range between March and June 2018, besting 2017 numbers by a considerable margin. After tariffs against U.S. exports became effective (July 6), a steep drop in those exports occurred, resulting in quantities falling far below levels experienced in the same months in the previous year. The worsening impact of the tariff on U.S. exporters was quickly felt.

An article in *Seafoodsource* ("Maine lobster industry feels impact of China's tariffs," by Chris Chase, August 16, 2018) reported that Stephanie Nadeau, a lobster dealer who relies heavily on China exports "thought she'd reduce her prices and take some small losses to make it through the year... However, the Chinese have changed more than just adding tariffs... they're no longer pre-clearing her product like they once did, and are instead doing manual inspections. They can leave your product there for a very long time'... that proposition means her product may spoil by 'the time its cleared.'" In response to the situation, Nadeau was quoted (*ibid*) as saying: "**I can cut my variable costs and tuck my head in and see if this storm passes.**" (emphasis mine). Her company, it was reported, was laying off four people, one quarter of the wholesale staff.

PERFECTLY COMPETITIVE INDUSTRY ANALYSIS OF CHINA TARIFFS

While the tariff discussion above focused on dealers, the impact would be passed along to affect other parts of the supply chain, including lobster fishermen. Using the perfect competition model, the analysis now separately considers the situation for the former and the latter, which are conceptually and practically somewhat different. The immediate effect of the tariff hits dealers who have relied upon China exports, so that is considered first.

The lefthand panel of Figure 6 (Appendix) shows the situation for the dealer sub-industry as a whole, while the righthand one applies to the situation for the representative firm. Supply prior to the tariff is depicted as S and demand by China buyers as D . The subindustry initial equilibrium price is P_1 and the equilibrium quantity is Q_1 . The imposition on tariffs on the exported product would reduce subindustry supply (shift the supply upward) from S to S' , as is shown in

Asia (China \$21 million, Korea \$11 million, Hong Kong \$8 million); and \$10 million to Europe (United Kingdom \$6 million, Italy \$4 million)."

¹⁹ Calculated by dividing .83 of U.S. exports by size by weight of the Maine harvest in 2017. The rationale is since 83% of the U.S. 2017 harvest came from Maine (see footnote 1), a tentative assumption in the absence of specific data is that 83% of exports also came from Maine. No correction is attempted for export of lobster stored in a previous year.

the panel on the left.²⁰ This drives the equilibrium price upward to P_2 and the equilibrium quantity falls to Q_2 . What the lobster dealers receive however is less than P_2 by the amount of the tariff, T (i.e. at Q_2 , dealers receive $P_2 - T$).²¹ In turn, this leads to a downward shift in demand for the representative firm (d_1 to d_2). The firm shown is unprofitable at P_1 since that price is below average total cost at the profit-maximizing output level of q_1 . Because that price more than covers average variable cost avc_1 , however, the firm is cutting its losses by continuing to operate and produce q_1 . When price received by the firm is reduced to P_2 (the market price) minus the tariff T (i.e. $P - T$), however, that price is less than avc_2 (the loss minimizing level of output if it continued to operate). Since the cannot cover its variable cost, it would lose less by shutting down.²²

Not all firms in the industry are equally productive, though, nor are they equally reliant upon China exports. More efficient ones (with a lower atc and avc curves) or those who are better insulated from tariffs on China exports may be able to continue to operate without incurring an operating or overall loss. Shut-down here refers to the China export market, and does not necessarily imply leaving the subindustry, nor does it imply permanently abandoning the China market, unless the situation is anticipated to continue. Still, dependence on China exports recently accounted for one-seventh of demand for the entire industry, so the effect will be felt. Less efficient or more China-dependent firms may be part of an industry downsizing, unless they adapt by becoming more efficient or finding new sources of demand. As the Head of the Maine Lobster Dealers said: “Some companies already are feeling it and some aren’t ... We have not fully figured out what the impact of the tariffs will be.”²³

The impact of the tariff on lobster fishermen is not as direct, but will subsequently be felt as final demand for the product is reduced by a substantial amount. In this case, the demand curve for the subindustry falls as the China market is lessened but supply (the curve) remains unchanged. This is shown in Figure 7 (Appendix) in the lefthand panel. As the equilibrium price falls from P_1 (for the demand curve D_1 prior to the tariff to either D_2 or D_3 , the result, respectively, of a less severe and more severe tariff and other restrictions.

From the perspective of the individual firm shown in the panel on the right, these changes appear as shifts in demand from d_1 to either d_2 or d_3 . While the firm is profitable prior to the tariff (because p_1 is greater than atc at the profit-maximizing output level q_1), it is not so at p_2 , but will lose less by continuing to operate (because p_2 is greater than avc at q_2). Should price fall to p_3 , however, the firm is unable to recover all of its operating expense and would fare better by shutting down (because price is less than avc). Again, more efficient producers would have lower costs than the representative firm, and they could continue to be profitable or cover their variable cost.

²⁰ While the additional China tariff is nominally 25%, in which case the supply curves shown would grow apart rather than be parallel, lobster dealer Stephanie Nadeau (ibid) noted that in practice, it is a fixed amount added to price.

²¹ The incidence on price of the tariff falls upon both dealers and Chinese buyers. The portion paid by buyers is the difference between the new price and the old ($P_2 - P_1$), while the portion paid by dealers is the difference between what they were paid and what they receive after the tariff is imposed ($P_1 - (P_2 - T)$). Nadeau in fact (ibid) noted that Chinese buyers would be made worse off because of this tariff. The full burden on both buyers and sellers also includes a quantity reduction.

²² Higher costs due to manual inspections (see comments by Nadeau) would shift the three cost curves upward, resulting in an exit at a higher take-home ($P - T$) price.

²³ Comment by Annie Tselikis reported in “Maine lobster exports to China fell steeply in July as Trump trade war intensified,” Bangor Daily News, October 13, 2018.

CONCLUDING REMARKS

While the application of the model is both timely and relevant in offering considerable insight into the workings of the American Lobster industry, there are some limitations. Because the tariff situation is still evolving, those in the industry may logically continue to function while incurring an operating loss. As a course in Decision Theory teaches, such operators may use a strategy that is optimistic, or one that weights a subsequent positive outcome more highly than a negative one (expected value approach). Alternately, entrepreneurs might take a longer-term financial perspective, worrying about transactions costs from industry exit and perhaps later reentry, and believing that the expected present value of remaining active in the industry outweighs the present value of cost. Because the industry consists of small entrepreneurs, moreover, profit maximization is not always the overriding objective. As Maine Senator Susan Collins (posted Aug 19, 2018) noted, “Lobstering has served as an economic engine and a family tradition in Maine for generations.”

Entrepreneurial ability is not limited to the role expressed in the model. What it does not show is that creative entrepreneurship may find new opportunities to benefit from the situation. Such appears to be the case with potentially increased exports to Canada. While U.S. exports would be subject to a severe tariff and other restrictions in China and in Europe, Canadian exports are not. Enter the possibility of Canada importing more U.S lobster, with the intent of reselling that product in China or Europe. There are reports of this already happening. This form of arbitrage raises supply chain costs, but would benefit both U.S. and American interests, and keep prices from rising to China consumers (discussed earlier) as well. U.S. lobster dealers who export might have to offset the higher cost of this additional stage in the supply chain by accepting a somewhat lower price, but they appear to have pricing power which lobster fishermen do not. If so, the remaining question becomes how much of the increased cost of this roundabout delivery system would be absorbed by dealers, and how much of the burden would fall upon U.S. lobster fishermen. If U.S. lobster fishermen are operating near the shutdown point, most of the burden might fall on the lobster dealers.

Growing sales in the domestic market or that in other countries to offset existing tariffs is another course of action. As a principle of finance, diversification rather than country specialization could be a way to maintain returns in the face of growing risk and uncertainty. Better industry marketing and improved transportation and storage could help this occur. But there is a possible huge downside in the longer term. If continued temperature change in Maine coastal waters continues, the lobster population might move to deeper waters²⁴ (raising harvest cost) or migrate northward, causing a leftward shift in industry supply and a higher price. Other ways to offset the tariff might include dealers buying but storing more of the harvest for future (anticipated higher) sales, or tighter restrictions on the amount of lobster caught. Revenue would not necessarily diminish from the latter because the higher price could offset lower quantity, which would be the case if demand were not price elastic.

²⁴ Zheng, Xinhi. Shifts in thermal habits in the Gulf of Maine under climate change: A case study on American Lobster, Honors Thesis, Colby College, 2017.

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