The Bumpy Road of Demand Growth—An Application to Atlantic Salmon
Author(s): Eivind Hestvik Brækkan and Sverre Braathen Thyholdt
Source: *Marine Resource Economics*, Vol. 29, No. 4 (December 2014), pp. 339-350
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/10.1086/678927
Accessed: 17/11/2014 09:48

The Bumpy Road of Demand Growth—An Application to Atlantic Salmon

Eivind Hestvik Brækkan; Sverre Braathen Thyholdt, *University of Tromsø*

ABSTRACT

We measure demand growth for all salmon-importing regions of the world using an index approach for the 2002–2011 period. Our results demonstrate that there are substantial variations in demand growth by region and over time. Russia and Brazil exhibit the highest demand growth, with average annual growth rates of approximately 20%. More established markets, such as the United States and Japan, demonstrate the lowest annual demand growth, at approximately 3%. During the sample period, the average annual rate of aggregated global demand growth is approximately 9%, whereas total global demand growth is approximately 94%.

Key words: Aquaculture economics, market analysis, seafood markets, unstable demand growth, worldwide.
JEL Codes: D12, Q22.

INTRODUCTION

Aquaculture has been the world's fastest growing food production technology during recent decades (Smith et al. 2010), and salmon production has grown faster than aquaculture production in aggregate. Farmed salmon production, which includes Atlantic salmon, coho, and salmon trout, has increased from a few thousand tons in 1980 to over 2.4 million tons in 2011 (Asche et al. 2013). Atlantic salmon is the dominant species in salmon production and accounted for more than 76% of worldwide output in 2008 (Asche and Bjørndal 2011). The underlying reasons for the tremendous growth in salmon production are dramatic increases in both productivity and demand (Asche 2008).

For many years, the main engine of growth in salmon aquaculture was increased productivity. Increased control over the production process reduced production costs, increased competitiveness, and lowered prices for consumers (Asche, Roll, and Tveterås 2012). Several studies document the productivity growth in salmon aquaculture (Asche and Roll 2013; Nilsen 2010; Vassdal and Sørensen Holst 2011; Asche, Guttormsen, and Nielsen 2013; Roll 2012). This literature also demonstrates the sophisticated methodological framework that has been developed to analyze the impact of technological change on firm behavior. Kumbhakar and Lovell (2000) provide a good overview of the parametric part of this tool kit, whereas Coelli et al. (2005) provide a review of index approaches.

Although there is little doubt that advances in productivity comprise a major factor in salmon aquaculture's tremendous growth, recent studies suggest that productivity increases have slowed since 2005 (Asche, Guttormsen, and Nielsen 2013; Vassdal and Holst 2011). Nonetheless, the price

Eivind Hestvik Brækkan is an associate professor and **Sverre Braathen Thyholdt** is a lecturer, School of Business and Economics, University of Tromsø, N–9037 Tromsø, Norway (email: eivind.h.brakkan@uit.no and sverre.thyholdt@uit.no, respectively).

Received November 2, 2013; Accepted July 22, 2014; Published online October 16, 2014. http://dx.doi.org10.1086/678927

Marine Resource Economics, volume 29, number 4.
0738-1360/2014/2904-000X$10.00.

of salmon has exhibited a slight upward trend even as the quantity supplied has grown over the most recent decade, as shown in figure 1. Thus, demand growth appears to be outpacing productivity growth. Although salmon prices have been relatively volatile for some time (Oglend and Sikveland 2008), price volatility increased markedly since the turn of the century (Oglend 2013). This volatility suggests that either supply or demand—or both—have not been growing at a steady pace since the early 2000s.

Measuring demand growth has not attracted the same attention in the literature as measuring productivity growth, perhaps because the methodological framework to investigate demand growth is not as established. Stone (1945) suggested that time trends should be used in measuring demand growth to allow for systematic changes in tastes. Barten (1967, 1969) followed this approach and introduced a constant term in the Rotterdam system to allow for gradual preference changes. Kinnucan et al. (1997) developed a method to measure shifts in demand caused by new information about a product by using aggregated indices of marketing expenditures, health information, and media coverage. However, the probability of finding structural shifts in demand depends on the choice of functional form, and findings of demand shifts are just as likely to result from using the wrong functional form as from revealing actual shifts in demand (Alston and Chalfant 1991a,b; Chalfant and Alston 1988).

Although the question of whether tastes are stable has produced an intriguing debate (Pollak 1978, 1970; Stigler and Becker 1977), stable tastes do not necessarily translate into stable demand. Instead, demand growth or contraction may occur for various reasons, including changes in income, prices of substitute and complementary products, demographics, socioeconomic conditions, marketplace, population growth, and the appearance of new product information. Changes in

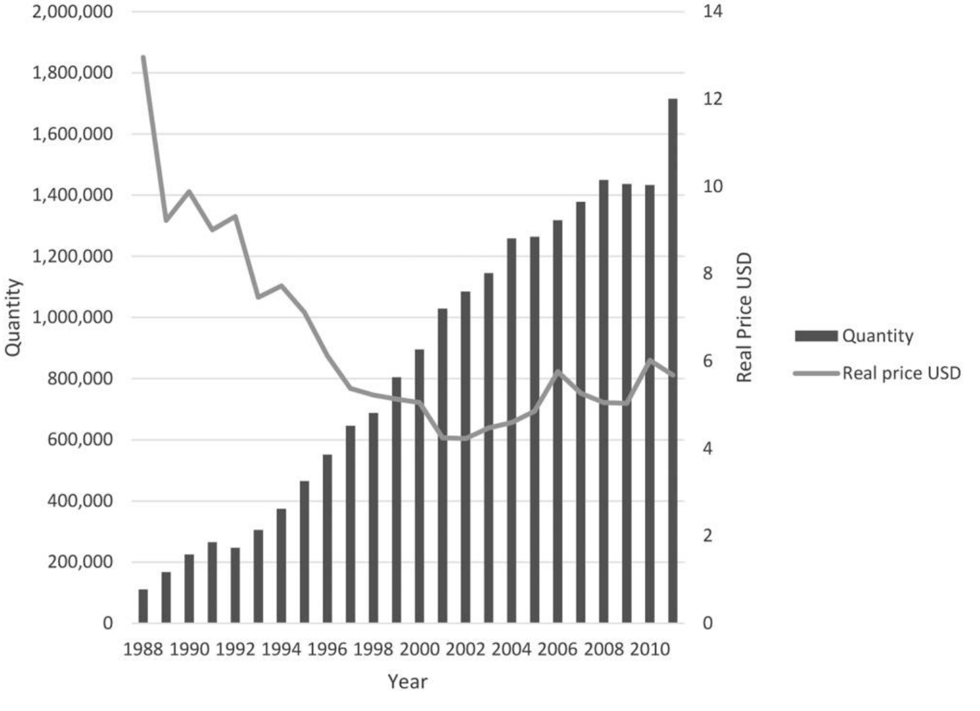

Figure 1. Quantity and Real Price of Farmed Salmon in USD 1988–2011

quality and product forms will also affect demand. Such a multitude of effects on demand suggests that demand growth is complex for any product and that there is no reason to expect demand growth to be smooth over time, as is assumed when using time trends.

Marsh (2003) developed a method for measuring the total changes in demand caused by factors other than product price. This approach allows demand to vary independently between years and avoid restrictions that require smooth demand growth over time. Given a specified elasticity of demand, the approach measures the difference between the actual price changes of a product and the expected price change under the assumption of no demand shift from the previous period. A shift in demand is the relative difference between the actual price change and the expected price. Marsh's approach has also been used to measure the yearly demand shifts for salmon in the European Union and France, where measurements specify the shift in demand in quantity direction (Asche et al. 2011). A demand shift in quantity direction is the relative difference between the expected and actual quantity under the assumption of no demand shift since the last period. With a small adjustment to the original approach, a demand shift measured using this approach can be defined as the percentage change in quantity demanded at a given price.

Because salmon is a globally traded commodity with significant demand growth since the early 2000s, we choose to extend the analysis of Asche et al. (2011). During the last decade, several regions have experienced vast increases in salmon consumption, whereas other regions have experienced little or no consumption growth. Using our adjusted approach, we measure demand growth in all major salmon-consuming regions worldwide. This method allows for an examination of both salmon demand and variation in demand growth among regions and over time. We perform a sensitivity analysis to account for the uncertainty of the demand elasticity parameters. The sensitivity analysis illuminates the importance of using proper elasticity parameters and indicates the precision of the computed shifts in demand.

THEORY AND METHOD

The approach utilized by Marsh (2003) measured demand shifts vertically, where a demand shift can be interpreted as a shift in the consumer's willingness to pay (WTP) for a given quantity of a product. Asche et al. (2011) argue that quantity is the relevant choice variable for salmon consumers and that price can be assumed to be exogenously given. They suggest that shifts in salmon demand should be measured in the quantity direction; i.e., horizontally. Although we agree that quantity, rather than price, is the relevant choice variable for salmon importers, we also argue that the choice of measuring the shifts in the quantity or price direction is simply a matter of preference. Any shift in demand is a movement of the demand schedule between two periods. A demand shift measured using this approach is a local measure of the size of this movement. Whether one measures this movement horizontally or vertically does not depend on the price or quantity being exogenously given. For any shift in the quantity direction (horizontally), the corresponding shift in the price direction (vertically) can also be computed (Sun and Kinnucan 2001). Figure 2 illustrates a demand shift measured in the quantity direction; i.e., horizontally.

In figure 2, Q_0 and P_0 are the quantity and price levels in period *0*, whereas Q_1 and P_1 are the quantity and price levels in period *1*. The demand schedules for each period are given by the demand curves D_0 and D_1. Assuming no shift in demand from period *0* to period *1*, $Q_{E|D=D_0}$ is the expected quantity demanded at price P_1. The horizontal distance between $Q_{E|D=D_0}$ and Q_1 in figure 2 is the absolute shift in demand. Thus, the absolute demand shift is the horizontal distance between the demand schedules in periods *0* and *1*. Expressing this shift in relative terms facilitates the interpretation.

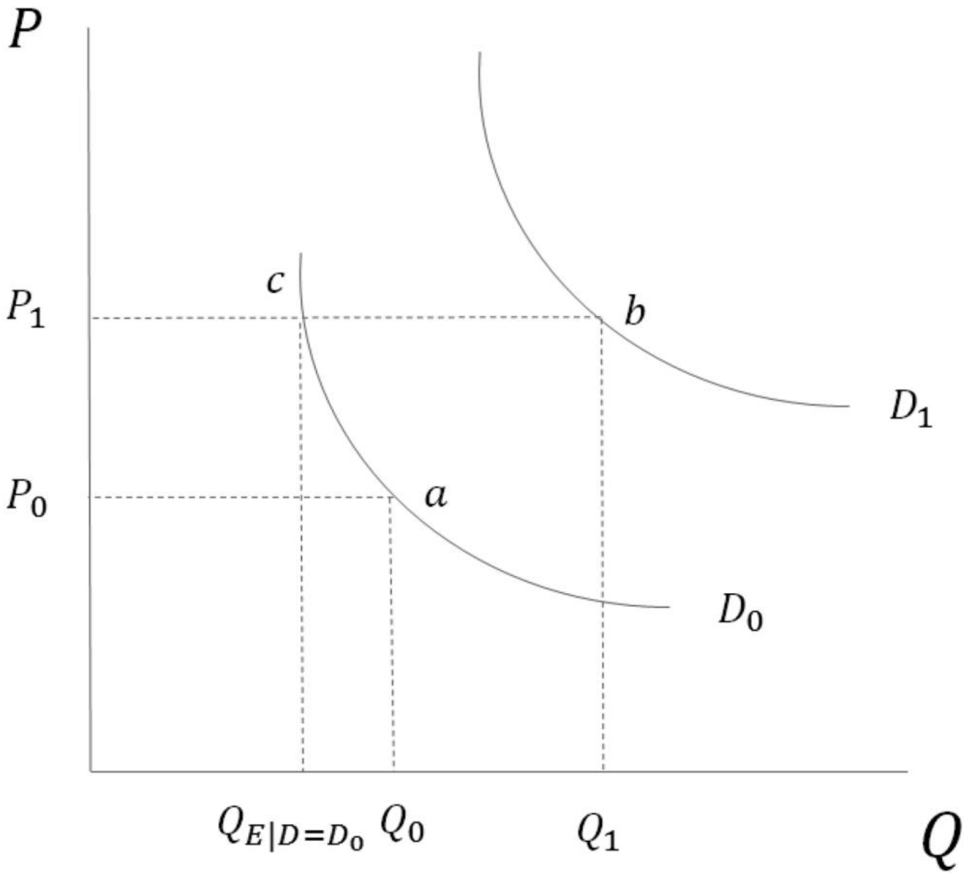

Figure 2. A Horizontal Shift in Demand

Previous measures of demand shifts using this approach have specified the shifts relative to the expected quantity, $Q_{E|D=D_0}$ (Marsh 2003; Asche et al. 2011). We will rather specify the shift in demand relative to the quantity in the first period Q_0. This decision implies that a positive demand shift of, for instance, 5%, can be interpreted as a 5% increase in the quantity demanded, keeping the price of the product constant. This calculation is consistent with the specification of horizontal shifts in demand in equilibrium displacement models (Alston, Norton, and Pardey 1995; Muth1964). Kinnucan and Myrland (2006) derived a one-step procedure for estimating a shift in supply using the Marsh (2003) approach. We impose this adjustment for the shift in demand. Figure 2 shows that the horizontal relative shift in demand from period 0 to 1 can be defined as follows:

$$\alpha = (Q_1 - Q_{E|D=D_0})/Q_{0.} \tag{1}$$

Some slight manipulation of (1) yields:

$$\alpha = (Q_1 - Q_0)/Q_0 - (Q_{E|D=D_0} - Q_0))/Q_0 = Q^* - Q_E^*, \tag{2}$$

where $(Q_1 - Q_0)/Q_0 = Q^*$ is the observed relative change in quantity, and $Q_{E|D=D_0} - Q_0))/Q_0 = Q_E^*$ is the relative difference between the expected quantity in period *1* and the observed quantity in period 0. We now must determine the value of Q_E^*. Using the common definition of the price elasticity of demand:

$$\eta = \frac{\frac{Q_1 - Q_0}{Q_0}}{\frac{P_1 - P_0}{P_0}} \tag{3}$$

where we use the expected quantity $Q_{E|D=D_0}$ instead of Q_1:

$$\eta = \frac{\frac{Q_{E|D=D_0} - Q_0}{Q_0}}{\frac{P_1 - P_0}{P_0}} \tag{4}$$

The expression in the numerator is now equal to the expected relative change in quantity Q_E^*. Following the slope of the demand schedule, D_0, the price change corresponding to Q_E^* is the relative price change, $\frac{P_1 - P_0}{P_0} = P^*$. Given the change in price, P^*, and a predetermined elasticity of demand, η, we can solve (4) for Q_E^*:

$$Q_E^* = \eta P^*. \tag{5}$$

By substituting for Q_E^* from (5) into (2), the relative shift in demand is as follows:

$$\alpha = Q^* - \eta P^*. \tag{6}$$

The shift in demand can be measured in the price or quantity direction; i.e., vertically or horizontally. The associated shift in the price direction is obtained by dividing the horizontal shift by the negative of the corresponding elasticity of demand (Sun and Kinnucan 2001). This vertical demand shift can be expressed as the following:

$$\alpha^V = \frac{\alpha}{-\eta} = -\frac{Q^*}{\eta} + P^*. \tag{7}$$

For instance, a vertical demand shift of 10% would imply a 10% increase in the WTP for a given quantity of the product. The size of the vertical and horizontal shifts is identical when the elasticity of demand is −1. As discussed above, we measure the shifts in demand in the quantity direction; i.e., horizontally.

DATA AND ELASTICITY PARAMETERS

Our data cover the yearly global import values and quantities of salmon over the 2002–2011 period and were made available to us by the Norwegian Seafood Council. The unit prices are computed and expressed in local currency for each importing region and in USD for the rest of the world (ROW). The quantities are converted to raw weight equivalents (RWE). The prices are deflated using the OECD's consumer price indices (CPI) for each region. For ROW, we deflate using the world CPI.

Historically, the United States, the European Union, and Japan have been the largest markets for farmed salmon, although emerging markets, such as Brazil and Russia, have experienced substantial import growth in recent years. Therefore, we focus on these regions specifically and compute the shifts in the ROW, of which Southeast Asia comprises a significant part of the volume. Because we are using are import data, we limit our focus on the European Union to the EU mainland to avoid bias caused by not being able to account for local production in Scotland and Ireland. Therefore, all references to the European Union in the rest of the article refer to the EU mainland. Reliable consumption data for all markets in this analysis are impossible to obtain, and Asche et al. (2011) used import data for similar reasons.

To compute shifts in demand for a region, we must determine a value for the elasticity of demand. Studies have found substantial variations in the estimated elasticities of demand for salmon. Asche (1996) showed that demand became less elastic as production increased. Studies using datasets from the 1990s and earlier have typically found that the demand for salmon is elastic (Asche, Bjørndal, and Salvanes 1998; Asche, Bremnes, and Wessells 1999; Asche, Salvanes, and Steen 1997; DeVoretz and Salvanes 1993), whereas a review of the recent literature, using data from the late 1990s to 2010, has reported elasticity values both in the elastic and inelastic ranges; between −0.2 and −1.7 (Aasheim et al. 2011; Chidmi, Hanson, and Nguyen 2012; Davis, Lin, and Yen 2007; Fousekis and Revell 2004; Hong and Duc 2009; Jones, Wozniak, and Walters 2013; Muhammad and Jones 2011; Sakai et al. 2009; Singh, Dey, and Surathkal 2012; Tiffin and Arnoult 2010; Xie, Kinnucan, and Myrland 2009; Xie and Myrland 2011). There are variations in the reported elasticity values for different product forms, markets, and methodologies.

For markets in which previous studies have reported elasticities of demand for salmon, we set the elasticity parameter to the mean of the reported values. This process yields the following elasticity values: for the United States, −0.7 (Jones, Wozniak, and Walters 2013; Davis, Lin, and Yen 2007); for the EU mainland, −1.1 (Xie and Myrland 2011); and for Japan, −1.5 (Sakai et al. 2009). Markets such as Brazil, Russia, and the ROW have a lower average income than the European Union and Japan, for instance, and it might be expected that the income difference would be reflected in more elastic salmon demand. However, salmon consumption is typically higher among high-income consumers, and these consumers generally have less elastic demand (Davis, Lin, and Yen 2007). Thus, it is likely that the bulk of the consumption in Brazil, Russia, and the ROW is by high-income consumers. We, therefore, hesitate to draw inferences about any correlations between the average income in a market and the elasticity of demand for salmon. For Brazil, Russia, and the ROW, we set the elasticity of demand to −1, based on Xie et al.'s (2009) global aggregate export elasticity of farmed salmon demand that was estimated using a data set covering the 1998–2005 period.

RESULTS AND DISCUSSION

The results are reported in table 1. Global shifts in demand are computed by aggregating the demand shifts in each region weighted by quantity. We set the base year, 2002, at 100, adding

Table 1. Demand Shifts 2002–2011

Year	European Union	United States	Japan	Brazil	Russia	ROW	Global
2002	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2003	100.0	106.6	82.8	104.7	124.6	102.6	101.7
2004	105.1	102.6	98.9	146.3	179.5	121.6	107.9
2005	123.4	105.2	103.1	119.9	276.1	163.1	123.7
2006	147.9	120.6	136.3	174.0	245.0	225.6	148.0
2007	137.5	123.0	117.3	203.3	285.2	254.5	146.8
2008	135.9	113.8	108.0	310.9	266.2	259.5	144.4
2009	151.2	111.0	87.3	388.5	341.4	286.5	156.7
2010	197.1	108.7	97.0	374.6	490.7	313.6	187.0
2011	185.2	128.9	118.1	411.3	500.7	357.4	193.5
Average Shift	7.75%	3.17%	3.40%	19.16%	21.66%	15.80%	7.89%

Index of demand shifts from 2002–2011, with average annual shifts. 2002 = 100.

demand shifts in each consecutive year, thereby illustrating aggregated shifts in demand throughout the period. The final row in table 1 reports average annual shifts in demand.

Although all regions have positive shifts in demand on average, the United States and Japan hibit considerably lower annual demand growth than all other regions at just above 3% annually. In some periods, the index is also sinking, which indicates negative demand growth. Brazil and Russia have the highest demand growth—and the highest variations in shifts between years—with an annual rate of demand growth of approximately 20%. Growth in the European Union, the largest market, is consistent with the findings of Asche et al. (2011), with average annual demand growth at a rate of 7.75%. This rate mirrors global demand growth (7.89%). The differences in demand growth between regions suggest that Brazil, Russia, and the ROW are becoming increasingly important markets, whereas established markets, such as the United States and Japan, show signs of saturation. This observation suggests that expanding by means of emerging markets may be attractive, although established markets continue to grow, perhaps because of an increase in the number of product forms (Asche and Bjørndal 2011). However, due to the relative sizes of different markets, a 1% increase in salmon demand from the European Union translates to a much larger increase in the quantity demanded than a 1% increase in demand from Russia, for instance. The results must be interpreted with this size factor in mind.

Thus, our results show that demand growth varies considerably from year to year both globally and for each region examined.

SENSITIVITY ANALYSIS

The reported differences in region-specific elasticity values between different studies may reflect real differences in the elasticities between regions to a certain extent. However, it is also possible that elasticity estimates differ among regions due to different methodological approaches. It also may not be likely that elasticity parameters are constant over time within each region. To account for this uncertainty, we run a simulation to investigate the sensitivity of the results to the choice of elasticity parameters. Specifically, in our simulation we use a truncated normal distribution and do not allow a positive elasticity of demand. Setting the variance to 0.5, and using the means for each region, we simulate 10,000 elasticity values for each region per year and allow them to vary between years. We recompute the shifts in demand using the simulated elasticity values.

Table 2 reports the mean and the 5th and 95th percentiles of the average annual rates of the simulated shifts in demand for each region and globally.

The simulation illustrates that demand growth is positive, on average, for all regions except for Japan, where average demand shifts may not differ significantly from zero. The simulation illustrates that there is some uncertainty as to the size of the demand shifts for each region. For Brazil, the size of the average yearly demand shift is the most uncertain, with 5th and 95th percentiles of 13.5 and 25%. The simulated means in all other regions vary considerably less.

Table 2. Average Simulated Yearly Shifts in Demand 2003–2011

Percentile/Region	EU (%)	US (%)	Japan (%)	Brazil (%)	Russia (%)	ROW (%)	Global (%)
5%	3.96	1.34	−0.38	13.48	18.04	13.34	5.96
Mean	7.77	3.53	3.38	19.22	21.63	15.84	8.00
95%	11.68	6.05	7.14	25.06	25.19	18.44	10.07

The European Union has the second highest difference between the 5th and 95th percentile, followed by Russia. The average aggregated global shift in demand has a lower variation than the demand shifts for any individual region, whereas the United States and the ROW have the lowest and second lowest variation among the specific regions, respectively. Nonetheless, the overall pattern remains. Emerging markets such as Brazil, Russia, and the ROW have significantly larger demand shifts than established markets, such as Japan and the United States, whereas the European Union is level with global average demand shifts.

Considering the yearly shifts in demand, figure 3 shows yearly box plots of the simulated shifts in demand for each region.

There is more variation in some regions than in others, and this variation differs considerably among years within each region. This variation is due to the nature of the procedure. If price remains unchanged between two periods, the shift in demand will be equal to the relative shift in quantity, regardless of the value of the elasticity parameter. For a larger price change, the size of the demand shift is influenced more by the choice of elasticity value. This phenomenon can be observed in 2006, when all regions experienced a substantial price increase. There is a larger variation in the simulated demand shifts in all regions for 2006 than for most other years. The opposite can be observed in 2004, when the price change was relatively small for all regions.

CONCLUDING REMARKS

Salmon is an aquaculture species that has experienced market expansion both geographically and through an increasing number of product forms (Asche and Bjørndal 2011). Although other species (such as sea bass) have experienced price declines that are similar to salmon over recent decades, the increase in production volume for sea bass does not compare to the increase in production volume for salmon. This difference suggests a major increase in demand for salmon compared with sea bass and other species with more limited production growth. Our results confirm that there has been significant demand growth for salmon, but to varying extents in different regions.

We used an index approach developed by Marsh (2003) to examine demand growth in all major salmon-importing regions of the world between 2002 and 2011. The results indicate that emerging markets, such as Russia and Brazil, have experienced the largest demand growth in the period examined—at an average annual rate of approximately 20%—and that in more established markets, such as Japan and the United States, demand has experienced the lowest growth; approximately 3% per year. Our results indicate that demand growth for salmon is indeed unstable and is characterized by large variations between regions and over time within regions. These variations may partly explain the high volatility of salmon prices.

Whether this result is isolated or applies to other commodities remains to be determined. Nonetheless, attempting to measure demand growth as a smooth process may oversimplify a complicated process, and alternative paths should at least be considered before being rejected. Furthermore, whereas total global demand for salmon shifted upwards by approximately 94% from 2002 to 2011, production volume increased by approximately 50%. This difference illustrates the apparent discrepancy between supply and demand growth, which has led to increasing prices. Assuming similar levels of demand growth in the future, the results indicate that production could grow at a faster pace compared to the last 10 years without causing prices

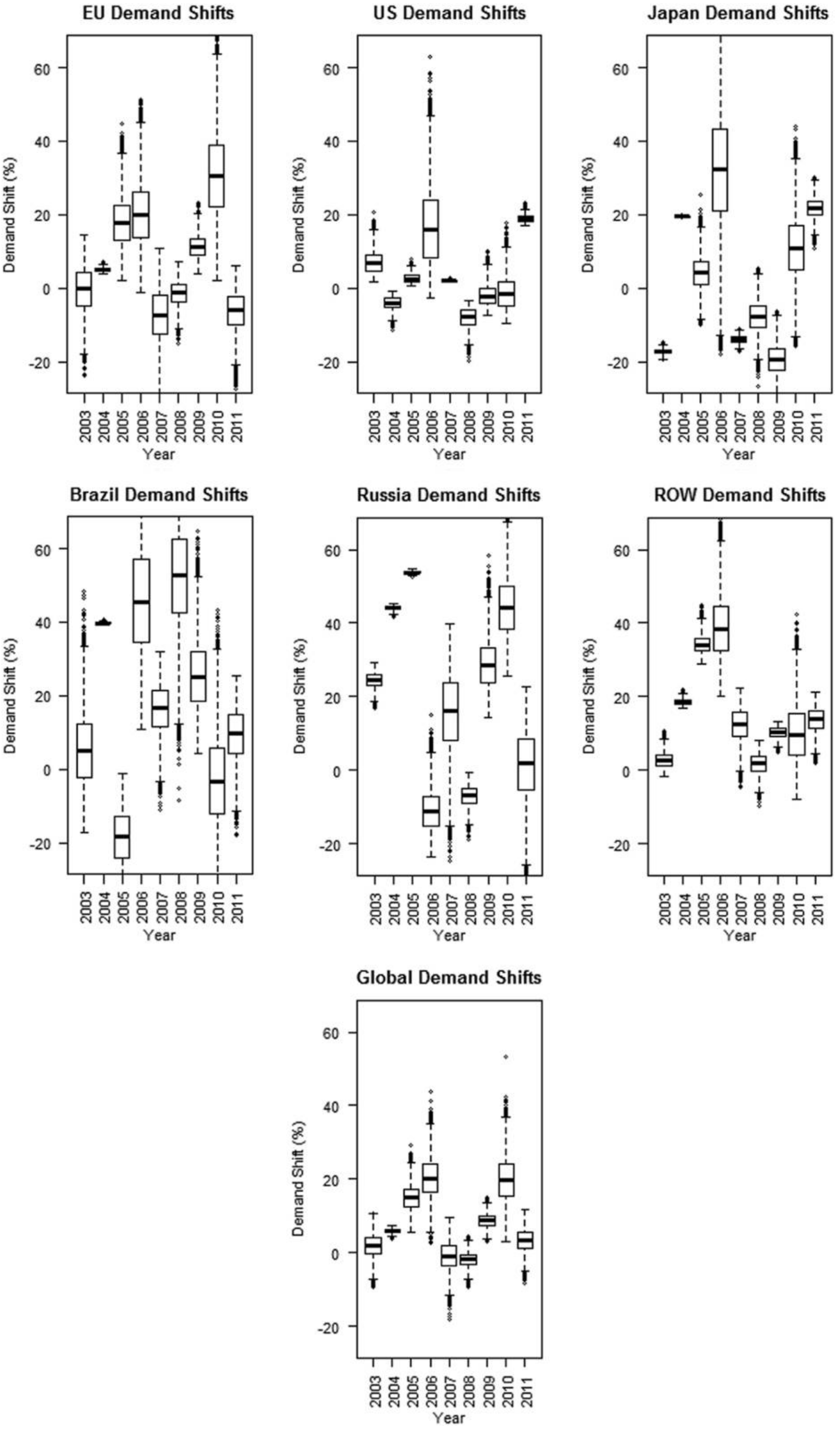

Figure 3. Simulated Demand Shifts Over Time for each Region and Globally

to fall from today's levels over the long run. In the short run, however, the unstable path of demand growth will continue to contribute to the volatility of salmon prices.

REFERENCES

Aasheim, L. J., R. E. Dahl, S. C. Kumbhakar, A. Oglend, and R. Tveteras. 2011. "Are Prices or Biology Driving the Short-Term Supply of Farmed Salmon?" *Marine Resource Economics* 26(4):343–57.

Alston, J. M., and J. A. Chalfant. 1991a. "Can We Take the Con Out of Meat Demand Studies?" *Western Journal of Agricultural Economics* 16(1):36–48.

———. 1991b. "Unstable Models from Incorrect Forms." *American Journal of Agricultural Economics* 73 (4):1171–81.

Alston, J. M., G. W. Norton, and P. G. Pardey. 1995. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Ithaca, NY: CAB International.

Asche, F. 1996. "A System Approach to the Demand for Salmon in the European Union." *Applied Economics* 28(1):97–101.

———. 2008. "Farming the Sea." *Marine Resource Economics* 23:527–47.

Asche, F., and T. Bjørndal. 2011. *The Economics of Salmon Aquaculture*, 2nd ed. Chichester: Wiley-Blackwell.

Asche, F., T. Bjørndal, and K. G. Salvanes. 1998. "The Demand for Salmon in the European Union." *Canadian Journal of Agricultural Economics* 46:69–81.

Asche, F., H. Bremnes, and C. R. Wessells. 1999. "Product Aggregation, Market Integration, and Relationships between Prices: An Application to World Salmon Markets." *American Journal of Agricultural Economics* 81(3):568–81.

Asche, F., R. E. Dahl, D. V. Gordon, T. Trollvik, and P. Aandahl. 2011. "Demand Growth for Atlantic Salmon: The EU and French Markets." *Marine Resource Economics* 26(4):255–65.

Asche, F., A. G. Guttormsen, and R. Nielsen. 2013. "Future Challenges for the Maturing Norwegian Salmon Aquaculture Industry: An Analysis of Total Factor Productivity Change from 1996 to 2008." *Aquaculture* 396–399:43–50.

Asche, F., and K. H. Roll. 2013. "Determinants of Inefficiency in Norwegian Salmon Aquaculture." *Aquaculture Economics & Management* 17(3):300–21.

Asche, F., K. H. Roll, H. N. Sandvold, A. Sørvig, and D. Zhang. 2013. "Salmon Aquaculture: Larger Companies and Increased Production." *Aquaculture Economics & Management* 17(3):322–39.

Asche, F., K. H. Roll, and R. Tveterås. 2012. "Innovations and Productivity Performance in Salmon Aquaculture." In *Advances in Production Management Systems: Value Networks: Innovation, Technologies and Managemen. IFIP Advances in Information and Communication Technology 384*, ed. J. Frick and B. T. Laugen, 620–7. Berlin Heidelberg: Springer.

Asche, F., K. G. Salvanes, and F. Steen. 1997. "Market Delineation and Demand Structure." *American Journal of Agricultural Economics* 79(February):139–50.

Barten, A. P. 1967. "Evidence on the Slutsky Conditions for Demand Equations." *The Review of Economics and Statistics* 49(1):77–84.

———. 1969. "Maximum Likelihood Estimation of a Complete System of Demand Equations." *European Economic Review* 1(1):7–73.

Chalfant, J. A., and J. M. Alston. 1988. "Accounting for Changes in Tastes." *Journal of Political Economy* 96(2):391–410.

Chidmi, B., T. Hanson, and G. Nguyen. 2012. "Substitutions between Fish and Seafood Products at the US National Retail Level." *Marine Resource Economics* 27(4):359–70.

Coelli, T. J., D. S. P. Rao, C. J. O'Donell, and G. E. Battese. 2005. *An Introduction to Efficiency and Productivity Analysis*, 2nd ed. New York, NY: Springer Science+Business Media, LLC.

Davis, C., B. Lin, and S. Yen. 2007. "Consumer Demand for Meat Cuts and Seafood." Paper presented at the 2007 Annual Meeting of the American Agricultural Economics Association, July 29–August 1, Portland, OR.

DeVoretz, D. D. J., and K. G. K. Salvanes. 1993. "Market Structure for Farmed Salmon." *American Journal of Agricultural Economics* 75(1):227–33.

Fousekis, P., and B. Revell. 2004. "Retail Fish Demand in Great Britain and its Fisheries Management Implications." *Marine Resource Economics* 19:495–510.

Hong, T. T. K. H., and N. M. Duc. 2009. "Competition between U.S. Catfish and Imported Fish: A Demand System Analysis." *Journal of Agricultural Science and Technology* 2009(4):111–8.

Jones, K., S. Wozniak, and L. Walters. 2013. "Did the Proposed Country-of-Origin Law Affect Product Choices? The Case of Salmon." *Journal of Food Products Marketing* 19(1):62–76.

Kinnucan, H. W., and Ø. Myrland. 2006. "Welfare Effects of Supply Expansion with Trade Restrictions: The Case of Salmon." *Journal of International Agricultural Trade and Development* 2(2):185–204.

Kinnucan, H. W., H. Xiao, C. J. Hsia, and J. D. Jackson. 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand." *American Journal of Agricultural Economics* 79(1):13–23.

Kumbhakar, S. C., and C. A. K. Lovell. 2000. *Stochastic Frontier Analysis*. Cambridge: Cambridge University Press.

Marsh, J. M. 2003. "Impacts of Declining U.S. Retail Beef Demand on Farm-Level Beef Prices and Production." *American Journal of Agricultural Economics* 85(4):902–13.

Muhammad, A., and K. G. Jones. 2011. "Source-Based Preferences and U.S. Salmon Imports." *Marine Resource Economics* 26(3):191–209.

Muth, R. F. 1964. "The Derived Demand Curve for a Productive Factor and the Industry Supply Curve." *Oxford Economic Papers, New Series* 16(2):221–34.

Nilsen, O. B. 2010. "Learning-by-Doing or Technological Leapfrogging: Production Frontiers and Efficiency Measurement in Norwegian Salmon Aquaculture." *Aquaculture Economics & Management* 14 (2):97–119.

Oglend, A. 2013. "Recent Trends in Salmon Price Volatility." *Aquaculture Economics & Management* 17 (3):281–99.

Oglend, A., and M. Sikveland. 2008. "The Behaviour of Salmon Price Volatility." *Marine Resource Economics* 23:507–26.

Pollak, R. A. 1970. "Habit Formation and Dynamic Demand Functions." *Journal of Political Economy* 78 (4):745–63.

———. 1978. "Endogenous Tastes in Demand and Welfare Analysis." *The American Economic Review* 68(2):374–9.

Roll, K. H. 2012. "Measuring Performance, Development and Growth when Restricting Flexibility." *Journal of Productivity Analysis* 39(1):15–25.

Sakai, Y., N. Yagi, M. Ariji, A. Takahara, and H. Kurokura. 2009. "Substitute and Complement Relations among Various Fish Species in the Japanese Market: Implications for Fishery Resource Management." *Fisheries Science* 75(5):1079–87.

Singh, K., M. M. Dey, and P. Surathkal. 2012. "Analysis of a Demand System for Unbreaded Frozen Seafood in the United States using Store-level Scanner Data." *Marine Resource Economics* 27(4): 371–87.

Smith, M. D., C. A. Roheim, L. B. Crowder, B. S. Halpern, M. Turnipseed, J. L. Anderson, F. Asche, L. Bourillón, A. G. Guttormsen, A. Kahn, L. A Liguori, A. McNevin, M. O'Connor, D. Squires, P. Tyedemers, C. Brownstein, K. Carden, D. H. Klinger, R. Sagarin, and K. A. Selkoe. 2010. "Sustainability and Global Seafood." *Science* 327:784–86.

Stigler, G. G. J., and G. S. G. Becker. 1977. "De Gustibus Non Est Disputandum." *The American Economic Review* 67(2):76–90.

Stone, R. 1945. "The Analysis of Market Demand." *Journal of the Royal Statistical Society* 108(3/4):286–391.

Sun, C., and H. W. Kinnucan. 2001. "Economic Impact of Environmental Regulations on Southern Softwood Stumpage Markets: A Reappraisal." *Southern Journal of Applied Forestry* 25(3):108–15.

Tiffin, R., and M. Arnoult. 2010. "The Demand for a Healthy Diet: Estimating the Almost Ideal Demand System with Infrequency of Purchase." *European Review of Agricultural Economics* 37(4):501–21.

Vassdal, T., and H. M. Sørensen Holst. 2011. "Technical Progress and Regress in Norwegian Salmon Farming 2001–08: A Malmquist Index Approach." *Marine Resource Economics* 26(4):329–42.

Xie, J., H. W. Kinnucan, and Ø. Myrland. 2009. "Demand Elasticities for Farmed Salmon in World Trade." *European Review of Agricultural Economics* 36(3):425–45.

Xie, J., and Ø. Myrland. 2011. "Consistent Aggregation in Fish Demand: A Study of French Salmon Demand." *Marine Resource Economics* 26(4):267–80.