The Demands They Are a-Changin'

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Abstract

We present an approach for decomposing a gross shift in demand between the impact of specific economic variables and a residual demand shift caused by unaccounted-for variables. This approach permits demand to vary independently between periods, while quantifying the impacts of any variable of interest where data is available. By disentangling the impact of economic factors like changes in relative prices and income, the impact of non-economic factors is determined. This provides an alternative to the use of trend indicators for measuring demand shifts caused by such factors. We apply this procedure to all major salmon-importing regions from 2002 to 2011. The results indicate a substantial variation in demand growth both over time and between regions. The average residual shift in demand accounts for more than half of the total demand shift in every region except Russia. This suggests changes in income and relative prices account for less than half of the recent growth in salmon demand. The standard errors of the residual demand shifts are large for all regions. This indicates unexplained shifts in demand are unsystematic; therefore, using time trends to capture unexplained demand shifts is inappropriate for explaining year-on-year shifts. The large residual demand growth and standard errors suggest further research is necessary to understand the reasons behind development of the demand for salmon. The results also demonstrate that any demand analysis focusing only on relative prices, income and a trend variable will not appropriately account for the large variation in salmon demand in any region.

Key words: Demand Analysis, Structural Demand Shift, Aquaculture Economics, Farmed Salmon

Introduction

Non-systematic demand shifts have received little attention in the literature, despite the large literature on the parallel feature on the production side in terms of technological change. For the demand and the supply side, the effect of exogenous shocks like weather changes and seasonality as well as group effects such as household or firm are handled in similar manners. This is also the case for smooth changes in preferences or technical change over time, which can be represented with a trend variable. However, if technical change or changes in preferences are not smooth, the approaches to measuring these effects are very different. A sophisticated tool kit has been developed to analyze the impact of technological change on the behavior of the firm (e.g. Coelli, Rao, O'Donell, & Battese, 2005; Kumbhakar & Lovell, 2000) using techniques such as stochastic frontiers and indices. The literature on demand growth have mainly relied on using smooth operators such as a time trend (Stone, 1945; Deaton & Muellbauer, 1980), sometimes augmented by relatively smooth variables like advertising expenditures or media coverage (Kinnucan et al 1997).

Pollak (1970) provides a theoretical foundation for smooth consumption paths, arguing that consumption in previous periods influences current demand and preferences for a product. He refers to this as *habit formation*. Pollak and Wales (1995) show how exogenous factors like advertising can influence demand equations in a similar fashion to demographic variables via demographic scaling or translating. Stigler & Becker (1977) take the position that tastes and preferences do not change over time, but that the accumulation of *consumption capital* from consuming a product in previous periods influences current quantity demanded. Pollak (1978) later argues that the differences between these two views are merely a matter of semantics, not substance. Stone (1945) suggests that time trends, either linear, quadratic or sigmoid, should be used to allow for changes in tastes, which of course can also be interpreted as shift in the consumption capital. Barten (1967; 1969) followed this approach and introduced a constant term in the Rotterdam-system to allow for gradual changes in preferences.

Demand growth or contraction may occur for a number of reasons. Economic reasons are changes in income and changes in the prices of substitute and complementary products. Other sources of demand shifts are changes in demographics such as older, more educated consumers (Tomek, 1985); changes in socioeconomic factors such as income distribution (Brown & Deaton, 1972); the appearance of new information of a product or accumulation of consumption capital (Tomek, 1985; Stigler and Becker, 1977); changes in product attributes such as product forms and quality (Ladd & Suvannunt, 1976). Furthermore, following Becker

(1965), consumers are in essence both producers as well as consumers; by combining inputs (like food) with time they produce commodities (meals, for instance) according to the cost-minimization rules of the traditional theory of the firm. Increasing incomes increase the opportunity cost of using time as an input, while growth in capital and technology increases the productivity of the consumer's time[1], thus reducing the amount of time needed to produce a commodity. Changes the productivity of the consumer's time will in turn affect the demand for food inputs. To summarize this section, we see little reason to expect that demand for food products should follow a smooth path.

A substantial number of studies have investigated whether changes in consumption patterns are caused by structural changes in demand (e.g. Chalfant & Alston, 1988; Eales & Unnevehr, 1988, 1993; Moschini & Meilke, 1989). This exercise is not unproblematic; testing for structural change is difficult, especially when the same data are used both for estimating demand equations and for testing their stability (Chalfant & Alston, 1988). The appearance of structural change in demand analysis can be due to changes such as those mentioned in the previous section, as well as due to methodological issues caused by using the wrong functional form (Alston & Chalfant, 1991a, 1991b). More specifically, vast efforts have been carried out to explain changes in U.S meat consumption patterns (see for instance Piggott & Marsh, (2004) and references therein). This research has yielded mixed evidence, and there is no consensus whether changes in consumption patterns are caused by changes in relative prices and income alone, or whether other factors also impact demand.

Taylor and Taylor (1993) take a different approach, and split demand growth for interstate telephone calls into predicted and unexplained growth. The predicted growth is due to changes in prices, income, and population growth, while the latter is a residually measured part due to other factors not explained by their model. The total shift in demand is the sum of predicted and residual demand shifts. Marsh (2003) introduce a method for measuring total shifts in demand that vary independently between years in the form of an index approach, and apply the index to measure demand shifts in the US retail beef market. We extend Marsh's approach by decomposing the total demand shift into predicted and unexplained impacts on demand, in line with the distinction made by Taylor and Taylor. This allows determining the direction and the magnitude of shifts caused by both known and unknown demand shifters. In particular, it allows for the separation of shifts caused by economic factors such as income and changes in substitute prices, the effect of other known factors such as seasonality, and a

[1]One example of technology improvement is the introduction of microvawes in households (Park & Capps, 1997).

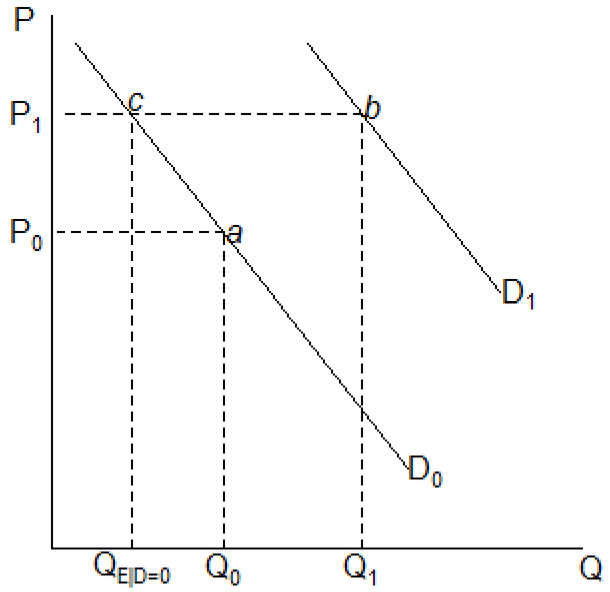
residual that can be interpreted as the effect of unidentified or omitted variables. The specification of a shift in demand as measured by Marsh is equal to the impact of an exogenous variable on the demand schedule as described by Muth (1964). The difference between Muth and our interpretation is that while Muth describes the demand shift as the impact of one specific variable affecting demand, our application defines the total demand shift as a vector of the impact of all exogenous variables affecting demand. The decomposition of a demand shift illuminates to what extent known and unknown demand shifters contribute to the demand side of market shocks like the recent food price hike. While it stretches the comparison, Muth's approach is comparable to labour productivity while our approach resembles total factor productivity.

Our approach is illustrated with an application to the global demand for farmed salmon. Aquaculture has been the world's fastest growing food production technology during the last decades (FAO, 2013; Smith et al, 2010), and salmon production has been growing faster than aquaculture in aggregate. As production has increased, the market has expanded in geographical as well as product space (Asche and Bjørndal, 2011), which is perceived as demand growth from the producers´ perspective. During the last decade production growth has been on average 6 percent annually with a stable price, indicating substantial demand growth. The salmon market thus provides an excellent example for computing shifts in demand in different regions of the world, and assigning the shift to known and unknown factors.

Deriving a shift in demand

Following the approach by Marsh (2003), we start by illustrating a shift in demand in the quantity direction, i.e. a horizontal shift in demand. This is shown graphically in figure 1.

Figure 1. Horizontal shift in demand between two periods.



In Figure 1, D_0 is the demand schedule for period *0*, and D_1 is the demand schedule for period *1*. P_0 and Q_0 are equilibrium price and quantity in period *0*, and P_1 and Q_1 are equilibrium price and quantity in period *1*. Given the observed price P_1, if demand had not increased, the expected equilibrium quantity in period 1 would have been $Q_{E\,|\,D=D_0}$ instead of Q_1.

The absolute demand shift is equal to the difference between the expected quantity level $Q_{E\,|\,D=D_0}$ and the observed quantity level Q_1. This can be measured by the horizontal distance between point *b* and *c* in Figure 1. The relative shift in demand D_1' can be specified as follows:

$$1)\quad D_1' = (Q_1 - Q_{E|D=D_0})/Q_0$$

Adding and subtracting Q_0 in equation *(1)* yields:

2) $D_1' = \frac{(Q_1 - Q_0) - (Q_{E|D=D_0} - Q_0)}{Q_0}$

Which is simply the difference between the actual and the expected proportionate (or percentage) change in quantity, given the observed price in period 1. The value of the expected quantity change can be determined using the common definition of the price elasticity of demand:

3) $\eta = \frac{\%\Delta Q}{\%\Delta P} = \frac{(Q_{E|D=D_0} - Q_0)/Q_0}{(P_1 - P_0)/P_0}$

Inserting the observed price change and a predetermined value for the elasticity parameter in *(3)*, the expected quantity change is equal to:

4) $(Q_{E|D=D_0} - Q_0)/Q_0 = \eta \times (P_1 - P_0)/P_0$

Inserting equation *(4)* into equation *(2)*, the demand shift can be expressed as:

5) $r_1 = Q_1^* - \eta P_1^*$

Alternatively:

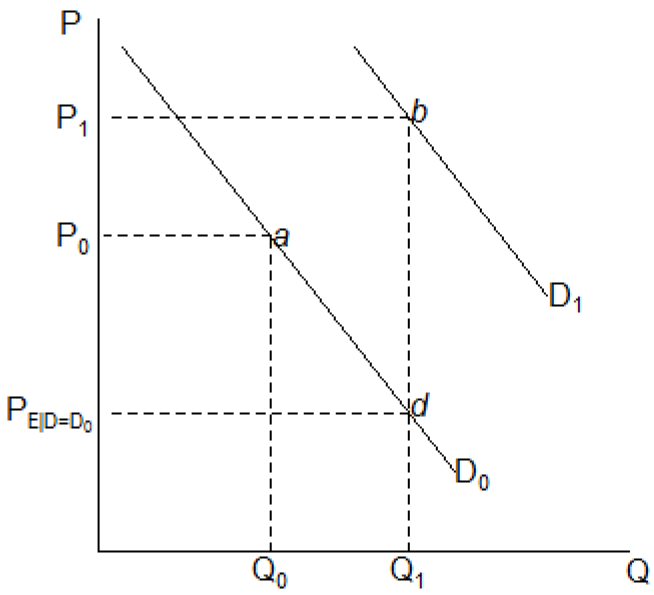
6) $Q_1^* = \eta P_1^* + r_1$

Where asterisks denote relative change throughout the paper. Here $r_1 = D_1'$, is the horizontal gross shift in demand from *(1)*, i.e., the shift measured in the quantity direction. The shift in demand is equal to the residual of an equation with relative quantity change as the dependent variable, and relative price change as the independent variable.[2]

The equivalent demand shift measured in the price direction, i.e. a vertical shift, is illustrated in Figure 2 below.

Figure 2. Vertical shift in demand between two periods

[2] Note that the common properties of a residual from econometric models are not applied to the residual in *(6)*.



For the vertical shift in demand the argument is similar to that of the horizontal shift. Given the observed quantity, Q_1, and assuming that demand has not changed since period *0*, the expected price level in period *1* is defined by $P_{E\,|\,D=D_0}$ at point *d* on the demand curve from period *0*. The absolute shift in demand is equal to the difference between the expected price $P_{E\,|\,D=D_0}$ and the observed price P_1, or equivalently, between points *b* and *d*. Solving *(6)* for price:

$$7)\ P_1^* = \frac{Q_1^*}{\eta} - \frac{r_1}{\eta}$$

Here $-\frac{r_1}{\eta} = \frac{D_1'}{-\eta} = D_1^V$ is the vertical shift in demand. The vertical shift in demand is equal to the horizontal shift divided by the negative of the elasticity of demand. The vertical shift in demand is equal to the impact of an exogenous variable on the demand schedule as described by Muth (1964). Muth (p. 223, 1964) describes the shift as "*the relative increase in price at any given quantity on the new demand schedule*". To compute a shift in demand, in either the horizontal or vertical direction, one only needs data on price and quantity changes, as well as an appropriate elasticity of demand. For any market where price is exogenous to the consumer, quantity is the variable of choice and a horizontal demand shift is the appropriate approach. In a market where quantity is exogenous, computing shifts in demand in the price direction may be the appropriate approach. If neither price nor quantity is exogenous, which at least in the long run may be the case for most markets, the choice of computing shifts in demand in the vertical or horizontal direction depends on the purpose of the research. Taking into account the market in question, the elasticities that are used for computing demand shifts are probably more accurate for observed prices and quantities. Hence, for computing shifts in demand in a market with a relatively stable price, but with large shifts in quantities, the horizontal (quantity-oriented) demand shift is likely to be more accurate than a vertical shift. For a market with a large price increase, but not a substantial change in quantities, the vertical demand shifts are probably more accurate. The remainder of the paper will focus on the horizontal shift, as quantity purchased is the choice variable for most consumers.

Decomposing the demand shift

The shift in demand as defined in the previous section can be interpreted as the total shift in demand between two periods, in Asche, Gordon, Trollvik, & Aandahl (2011) referred to as the gross demand shift. Whereas r_1 (or D_1') in equation (6) is denoted as a residual, it can also be interpreted as a vector of all variables affecting the demand for a product. By purging the effects of specific variables from the gross (or total) shift in demand, the demand impact of each variable of interest may be computed, as well as the size of the remaining, unexplained shift in demand. Consider the general demand equation:

8) $Q = f(P, Z)$

Where P is price and Z is a vector of all variables affecting demand. To evaluate the effects on demand we totally differentiate (8) and convert the partial derivatives to elasticities to yield:

9) $Q^* = \eta P^* + \Psi Z^*$

Where η is the own-price elasticity of demand, ΨZ^* is the total shift in demand defined as r_1 in (6), $\Psi = \frac{df}{dZ}\frac{Z}{Q}$ is a vector of the elasticities corresponding to the variables in Z. The impacts of all variables for which data and appropriate elasticity parameters are obtainable can be disentangled from ΨZ^*. For instance, if data on income Y and a substitute price P_j as well as appropriate elasticity parameters are available, equation (8) can be re-written as:

$$10)\ Q^* = \eta P^* + \eta_Y Y^* + \eta_j P_j^* + \Psi' Z'^*$$

Where Ψ' and Z' are vectors of all elasticities and corresponding variables other than those of income Y and substitute price P_j. η_Y and η_j are elasticities of income Y and substitute price P_j. Defining $\mathrm{r}' = \Psi' Z'^*$ as the residual horizontal demand shift, we rewrite the expression as:

$$11)\ Q^* = \eta P^* + \eta_Y Y^* + \eta_j P_j^* + r'$$

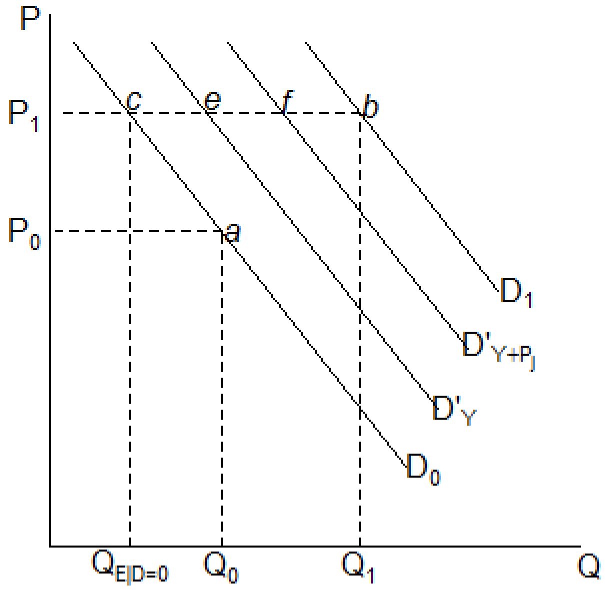
Solving for r' in *(11)* yields:

$$12)\ r' = Q^* - \eta P^* - \eta_Y Y^* - \eta_j P_j^*$$

Where $r = Q^* - \eta P^*$ is the gross shift in demand, $\eta_j P_j^*$ accounts for the demand shift due to a change in substitute price P_j, and $\eta_Y Y^*$ accounts for the demand shift due to income change. Additional variables can of course be introduced to account for other known factors such as demographics or advertising. Subtracting the impact of substitute price and income changes from the gross demand shift gives us the residual demand shift r'.

Figure 3 below illustrates the procedure of disentangling the gross shift in demand graphically.

Figure 3. Disentangling horizontal shifts in demand between two periods.



In Figure 3, the impact of income change and the price of a substitute product are purged from the gross demand shift. The gross demand shift is still the horizontal distance between demand schedules D_0 and D_1. This shift is now split into three parts. The impact from a change in income Y on demand is taken into account by the new demand schedule D'_Y. Adding the impact of a shift in substitute price P_j gives the demand schedule D'_{Y+P_j}. The (absolute) demand shift due to income change is the distance between D_0 and D'_Y, measured by the distance between points *c* and *e*. The impact of a change in the substitute price is the distance between D'_Y and D'_{Y+P_j}, measured by the distance between points *e* and *f*. The residual net shift in demand is the distance between D'_{Y+P_j} and D_1, or between points *f* and *b* in Figure 3. Dividing the absolute demand shifts by Q_0 as expressed in equation (10) yields the respective relative shifts in demand.

The equivalent vertical shifts in demand are retrieved in the same way as with the gross shift in demand in the previous section. To get the corresponding vertical shifts in demand divide each component of the horizontal demand shifts by the negative of the own price elasticity η.

The total demand shift is now split in three parts: the impact of income change, change in the price of a substitute product, and the residual shift in demand. To compute these effects one need data on each variable, as well as appropriate elasticity parameters. The impact of any other variable where such information is readily available, in terms of data and an appropriate elasticity parameter, can also be purged from the gross demand shift.

An application to salmon markets

Marsh' approach for measuring total demand shifts has also been applied to farmed salmon markets (Asche et al., 2011; Brækkan & Thyholdt, 2014). Results indicate substantial demand growth since the early 2000s, although with large variation both between regions and within regions over time. This raises the question as to what the underlying causes behind these results might be, a question we turn to shortly.

Production of farmed salmon has increased from a few thousand tons in 1980 to over 2 million tons in 2013. Initially, this development was possible due to strong productivity growth, and real prices declined by two thirds from the early 1980s to the mid-1990s (Asche and Bjørndal, 2011), as reducing price was an important factor in attracting new consumers. In this process the market expanded to become global (Asche, Bremnes and Wessells, 1999). However, as illustrated in figure 4, from the late 1990s real prices have been relatively stable despite rapidly increasing production. This indicates substantial positive shifts in demand (Asche et al, 2011), thus providing an excellent application for our analysis.

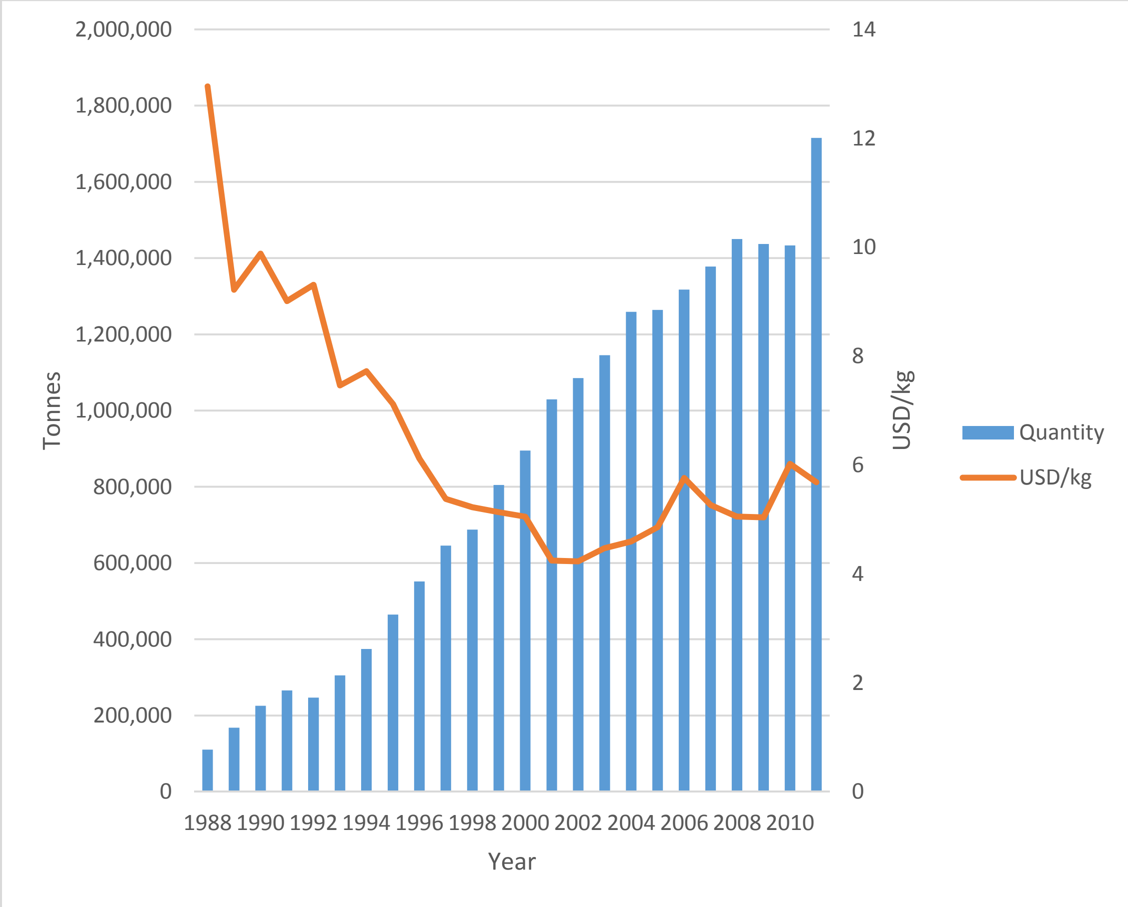


Figure 4. Quantity and real price of farmed salmon in USD/kg 1988-2011

Data

We use annual trade data for fresh and frozen salmon imports for the period 2002-2011, presented in table A-1 in the appendix, to the main market regions for farmed salmon where there is little or no own production – the EU, the U.S., Japan, Brazil, Russia as well as Rest of the World (ROW)[3]. For ROW, we aggregate the data for all other salmon-importing countries. Data is made available by the Norwegian Seafood Council. Unit prices are computed and expressed in local currencies for each importing region except for ROW where we use the average world price measured in USD. Quantity is expressed as Live Weight Equivalents (LWE). Since consumers will alter their consumption by smaller amounts if income change is perceived as temporary rather than permanent (Hall & Mishkin, 1982), we use total household consumption as a proxy for income, in line with Friedman's (1957) permanent income hypothesis. Household consumption data are retrieved from the World

[3] Because we use import data we are not able to account for changes in domestic supply from salmon production in Scotland and Ireland in the EU. For this reason we limit our focus on the EU to the EU in continental Europe, where there is almost no own production of salmon. All references to the EU throughout the paper refer to the continental EU.

Bank database, and Eurostat for the EU. Changes in income are expressed as nominal changes in total household consumption measured in local currency units, thus also encompassing the impacts of population growth on demand for salmon.

Demand analyses of salmon have not identified any clear substitutes for salmon. It appears that salmon have not been chosen in favor of one specific product, but have instead taken small market shares from a large number of products (Asche & Bjørndal, 2011). For that reason, we use regional food price indices from FAO as proxy variables for changes in substitute prices in each market. Considering salmon constitutes a very small share of total food consumption, the impact of changing salmon prices on food price indices is most likely negligible. For ROW, we use values for global GDP growth and the world food price index.

Elasticity parameters and operationalization

The annual residual shift in demand is computed as follows:

$$12') \; r_i' = Q_i^* - \eta_{i,}P_i^* - \eta_{i,Y}Y_i^* - \eta_{i,j}P_{i,j}^* \qquad i = EU, US, JA, BR, RU, ROW$$

Where subscript *i* refer to regional data and elasticity parameters. To compute a shift in demand we need appropriate values for the elasticities of demand, substitution and income in each region. In regions where estimates of relevant elasticities have been reported in previous studies, we set the elasticity parameters to the mean of reported values. For markets where there are no published estimates based on recent data, we use the mean of reported elasticities from the literature on salmon demand in various markets.

In most of the literature where income elasticities for salmon are reported these elasticities are expenditure elasticities conditional on total expenditures *M* on a group of fish commodities. In this study we are evaluating the impact of changes in total income on salmon demand, not the impact from a change in total expenditure on fish. To get the unconditional expenditure elasticity of salmon, or income elasticity $\eta_{i,Y}$, we have to take into account the impact of an income change on total expenditure of fish. An estimate of this can be obtained by multiplying the conditional expenditure elasticity for salmon $\eta_{i,\mathrm{M}}$ by the elasticity of demand for fish with respect to total income $\eta_{i,fish,\mathrm{Y}}$ (see e.g. Manser (1976)). The income elasticity of salmon in region *i* is given by:

$$13) \; \eta_{i,Y} = \frac{\partial \mathrm{Q}}{\partial \mathrm{Y}}\frac{\mathrm{Y}}{\mathrm{Q}} = \frac{\partial \mathrm{Q}}{\partial \mathrm{M}}\frac{\mathrm{M}}{\mathrm{Q}}\frac{\partial \mathrm{M}}{\partial \mathrm{Y}}\frac{\mathrm{Y}}{\mathrm{M}} = \eta_{\mathrm{i,M}} \times \eta_{\mathrm{i,fish,Y}}$$

Where Q is quantity of salmon, Y is total income, and M is total expenditure on the fish commodities of which the conditional expenditure elasticity of salmon $\eta_{\mathrm{i,M}}$ is computed. For all regions but Japan[4], as a proxy for $\eta_{fish,\mathrm{Y}}$ we use the results for unconditional expenditure elasticities for fish from a cross-country analysis of demand for various food groups by Muhammad, Seale, Meade, & Regmi (2011). The elasticities of substitution are retrieved from the homogeneity assumption that the sum of all elasticities should be zero. The elasticity parameters are reported in table *1*.

Table 1. Elasticity parameters

Region/Elasticity	η_i	$\eta_{i,Y} = \eta_{i,M} \times \eta_{i,fish,Y}$	$\eta_{i,j}$
The EU	-1.01[1]	0.45 = 1.22[4] × 0.37[5]	0.56
The U.S.	-0.99[2]	0.27 = 1.04[2] × 0.26[5]	0.72
Japan	-1.5[3]	1.1 = 2.08[3] × 0.53[3]	0.4
Brazil	-0.95[4]	0.7 = 1.22[4] × 0.57[5]	0.25
Russia	-0.95[4]	0.65 = 1.22[4] × 0.53[5]	0.3
ROW	-0.95[4]	0.63 = 1.22[4] × 0.52[5]	0.32

[1]Based on reported elasticity values for France, the largest market in the EU, from (Xie & Myrland, 2011)

[2]Based on reported elasticities from (Davis, Lin, & Yen, 2007; Jones, Wozniak, & Walters, 2013)

[3]Based on reported elasticities from (Sakai, Yagi, Ariji, Takahara, & Kurokura, 2009)

[4]Based on reported elasticities from: (Chidmi, Hanson, & Nguyen, 2012; Davis, Lin, & Yen, 2007; Fousekis & Revell, 2004; Hong & Duc, 2009; Jones, Wozniak, & Walters, 2013; Muhammad & Jones, 2011; Sakai, Yagi, Ariji, Takahara, & Kurokura, 2009; Tiffin & Arnoult, 2010; Xie, Kinnucan, & Myrland, 2009; Xie & Myrland, 2011)

[5]Based on reported elasticities from (Muhammad et al., 2011), for EU we use the computed value for France, which has the highest salmon consumption in in the EU(Asche and Bjørndal, 2011).

We compute global demand shifts by quantity-weighted aggregation of the demand shifts from each region as follows:

[4] For Japan, we use elasticity values from (Sakai et al., 2009) where $\eta_{\mathrm{i,fish,Y}}$ is estimated with regards to the conditional elasticity $\eta_{\mathrm{i,M}}$, and $\eta_{i,Y}$ is computed following the same procedure as in this paper.

14) $r'_{global} = \sum_i^6 k_i r'_i \,, i = EU, US, JA, BR, RU, ROW$

Where k_i is the quantity share of global imports for each region. The same approach is used to compute global income and substitution effects.

Results

Geometric averages of annual demand shifts are reported in table 2. Annual demand shifts for each region and globally are reported in table A-2 in the appendix

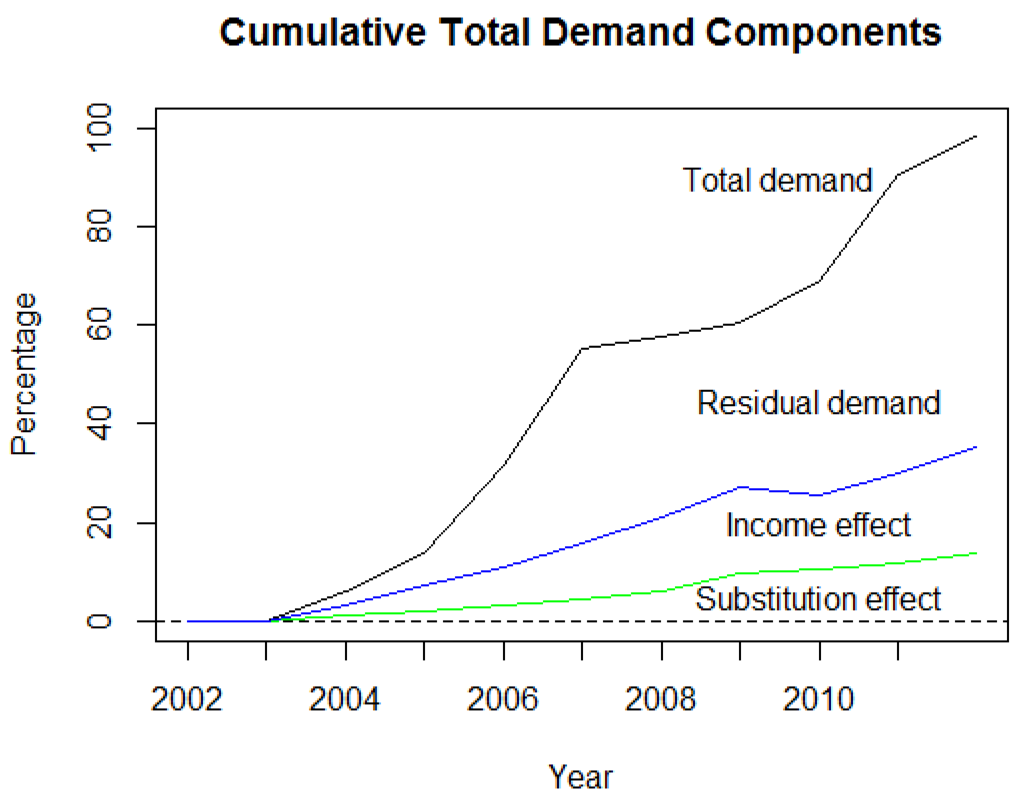
Table 2. Geometric average of annual demand shifts 2002-2011

	Residual demand Shift	Income effect	Substitution effect	Total Shift
The EU	6.9%(0.11)	1.33%(0.001)	0.81%(0.029)	9.16%(0.03)
The U.S.	3.59%(0.35)	1.15%(0.001)	2.01%(0.000)	6.84%(0.09)
Japan	1.92%(0.76)	-0.21%(0.68)	0.05%(0.73)	1.65%(0.81)
Brazil	12.76%(0.11)	8.26%(0.000)	1.96%(0.002)	23.11%(0.01)
Russia	11.5%(0.17)	12.59%(0.000)	3.49%(0.000)	28.07%(0.003)
ROW	11.5%(0.02)	4.97%(0.001)	2.25%(0.000)	18.96%(0.001)
Global	6.78%(0.03)	2.37%(0.000)	1.49%(0.001)	10.7%(0.003)

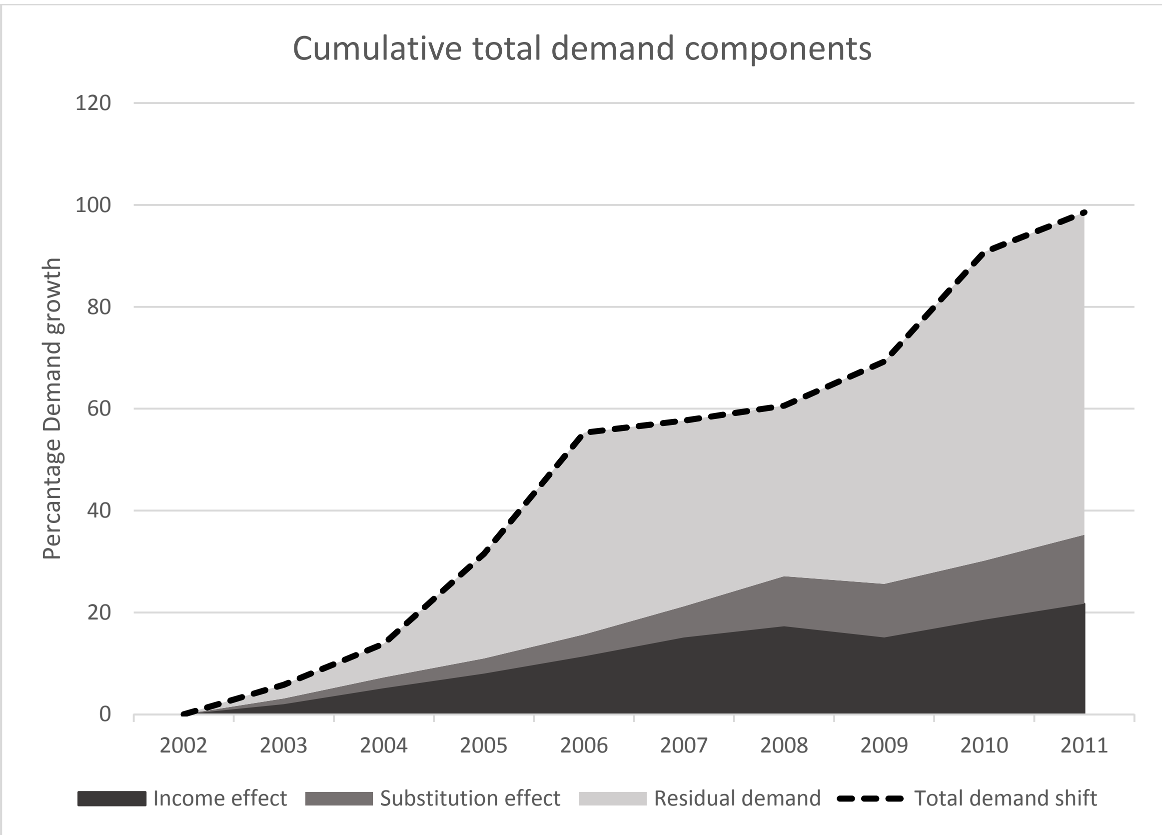
Note: p-values in parantheses.

In all regions except from Russia the residual demand shift is the largest component of the total gross shift in demand. Residual demand shifts are only significantly different from zero for ROW and Global shifts. Large residual demand shifts and high corresponding p-values indicate that a large portion of salmon demand volatility is caused by unknown factors. Income and substitution impacts on demand are significant for all regions but Japan. Figure 5 illustrates the cumulative total global demand growth from 2002 to 2011, and the relative effect of each component.

Figure 5



Cumulative Total Demand Components
Percentage
0
20
40
60
80
100
Total demand
Residual demand
Income effect
Substitution effect
2002
2004
2006
2008
2010
Year



Cumulative total demand components
Percantage Demand growth
0
20
40
60
80
100
120
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Income effect
Substitution effect
Residual demand
Total demand shift

As can be observed in the figure, of a total global demand growth of almost 100 percent from 2002 to 2011, more than 60 percent is due to residual growth in demand, while around 22 percent is due to income growth, and around 14 percent is due to substitution effects.

The results are conditional on the choice of elasticity parameters. Asche et al. (2011) estimated gross demand growth for salmon using three different elasticity values, and found little difference between the main results. An alternative approach would be to specify a probability distribution of each of the elasticity parameters, and run stochastic simulations of the elasticity parameters (see e.g. (Brækkan & Thyholdt, 2014; Zhao, Griffiths, Griffith, & Mullen, 2000). For each simulated elasticity parameter the corresponding shift in demand can be computed. The distribution of the computed shifts in demand would give an indication of the precision of procedure. While it is beyond the scope of this paper to investigate the sensitivity of the results to the choice of elasticity parameters, the results must be interpreted with this in mind.

Concluding remarks

Demand shifts may not be as smooth as usually assumed in demand analysis. This article provides an alternative to the use of trend indicators to investigate unexplained demand shifts over time. We start our procedure by extending an approach by Marsh (2003) for computing the gross (total) demand shift between two periods. As long as data and appropriate elasticity values are available or estimable, the impact of any variable of interest can be disentangled from the gross demand shift. The size of the residual demand shift is determined by disentangling the impacts of specific economic factors such as prices and income from the total demand shifts. We define the residual demand shift as the shift in demand caused by unknown or omitted variables.

We apply this procedure on an annual basis to the global markets for farmed salmon using data from 2002 to 2011. The global salmon market is in this period characterized by large growth in quantities at relatively stable prices, thus suggesting substantial demand growth. We find that residual demand shifts vary considerably both between regions and within regions over time. Unexplained (residual) demand shifts account for more than half of the gross demand shifts in all but one region, and are very volatile. The large residual demand shifts imply that the growth in salmon demand to a large degree is caused by other factors than changes in income and prices. Hence, this study highlights the inability to explain demand growth only by the principal economic factors. The fact that most residual demand shifts are not significantly different from zero suggest that there is large unexplained variation in year-on-year salmon demand, thus implying that smooth trend indicators are inappropriate for capturing unexplained demand shifts.

If the residual demand shift is still large and volatile after disentangling all variables considered important, more research is necessary to understand the nature of demand in the market in question. Alternatively, one is forced to acknowledge that demand shifts are dominated by uncertainty and unexplainable phenomena. Our results show that this is indeed the case for the global farmed salmon market. We suspect this is also the case for most other commodities.

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Appendix

Table A-1. Background data

Year	P EU (EUR)	P U.S. (USD)	P Japan (JPY)	P Brazil (BRL)	P Russia (RUB)	P ROW (USD)
2002	3.47	4.48	473	6.12	86.9	3.38
2003	3.07	4.94	482	8.99	90.2	3.66
2004	3.17	4.89	484	8.83	94.8	3.86
2005	3.70	5.23	527	7.83	106	4.22
2006	4.50	6.73	709	10.6	126	5.16
2007	3.84	6.92	695	9.32	104	4.85
2008	3.67	6.80	651	6.91	115	4.84
2009	3.92	6.98	570	8.67	142	4.80
2010	5.01	7.98	672	11.6	174	5.84
2011	4.57	8.53	636	10.5	150	5.68
Year	**Q EU**	**Q US**	**Q Japan**	**Q Brazil**	**Q Russia**	**Q ROW**
2002	410908	272025	65340	15404	22346	73182
2003	470999	276464	52637	12756	28859	71905
2004	489463	273801	62712	17772	41903	83921
2005	498994	275169	56466	17569	64796	108077
2006	493542	267454	46285	19456	49594	129975
2007	547839	272005	41156	25687	69319	159188
2008	586783	263308	43331	47212	69000	171880
2009	610580	243876	40725	49306	78811	194918
2010	624335	220894	34195	34116	98952	179830
2011	663731	258330	44517	42843	121573	217760
Year	**FPI EU**	**FPI US**	**FPI Japan**	**FPI Brazil**	**FPI Russia**	**FPI ROW**
2002	105.37	105.01	98.6	117.01	136.05	107.95
2003	106.48	107.27	98.4	140.83	151.29	114.28
2004	106.43	110.97	99.3	146.47	166.9	121.53
2005	106.7	113.65	97.8	150.98	189.67	127.19
2006	108.51	116.33	98.29	151.01	207.75	134.32
2007	110.95	120.93	98.58	161.25	226.45	144.55

2008	117.53	127.6	101.13	182.29	273.69	163.5
2009	117.2	129.89	101.32	192.87	290.38	174.24
2010	118.32	130.89	101.03	204.63	327.85	187.11
2011	121.01	135.78	100.62	222.73	361.68	202.95

Year	HHC EU (EUR)	HHC US (USD)	HHC Japan (JPY)	HHC Brazil (BRL)	HHC Russia (RUB)	HHC ROW (USD)
2002	20756.66	912.06	870.69	289038.30	5541.67	7385.30
2003	23097.40	1052.76	902.57	287514.20	6692.30	7764.30
2004	25704.72	1160.61	937.37	288599.30	8588.10	8257.80
2005	27668.82	1294.23	977.69	291132.60	10792.30	8790.40
2006	29632.20	1428.91	1020.03	293433.30	13129.30	9297.50
2007	33004.32	1594.07	1065.94	294122.00	16217.60	9744.50
2008	35914.27	1786.84	1099.65	292055.40	20183.60	10005.50
2009	34682.36	1979.75	1095.66	282941.70	21202.90	9842.90
2010	37371.65	2248.63	1125.08	285867.10	23843.30	10201.90
2011	41038.79	2499.49	1155.26	284244.30	27192.50	10711.80

P = average annual price in local currency per kg Raw Weight Equivalent. Currency in parentheses (Source: Norwegian Seafood Council)

Q = annual import quantity in metric tons, Raw Weight Equivalents (Source: Norwegian Seafood Council)

FPI = Food price index (Source: FAO)

HHC = Total household consumption in local currency, in billions. Currency in parentheses (Sources: World Bank database, except from the EU where data is from Eurostat)

Data sources:

Household consumption:

http://data.worldbank.org/indicator/NE.CON.PRVT.CN and for EU:

http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_fcs_c&lang=en

Food price indices:

FAOSTAT: http://faostat3.fao.org/download/P/CP/E

Table A-2. Yearly shifts in demand per region and globally

The EU	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	0.96 %	1.54 %	0.59 %	3.09 %
2004	5.55 %	1.65 %	-0.03 %	7.18 %
2005	16.81 %	1.75 %	0.14 %	18.70 %
2006	17.88 %	1.98 %	0.94 %	20.80 %
2007	-6.84 %	1.81 %	1.25 %	-3.78 %
2008	-2.13 %	1.43 %	3.30 %	2.60 %
2009	11.81 %	-0.64 %	-0.16 %	11.01 %
2010	28.33 %	1.20 %	0.53 %	30.06 %
2011	-5.07 %	1.24 %	1.26 %	-2.56 %

The US	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	8.86 %	1.39 %	1.55 %	11.80 %
2004	-6.17 %	1.72 %	2.48 %	-1.97 %
2005	3.90 %	1.74 %	1.74 %	7.38 %
2006	22.33 %	1.56 %	1.70 %	25.59 %
2007	0.35 %	1.30 %	2.85 %	4.50 %
2008	-9.61 %	0.72 %	3.97 %	-4.91 %
2009	-5.61 %	-0.44 %	1.29 %	-4.76 %
2010	3.22 %	0.99 %	0.55 %	4.76 %
2011	19.73 %	1.35 %	2.69 %	23.77 %

Japan	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	-15.91 %	-0.58 %	-0.08 %	-16.57 %
2004	19.04 %	0.42 %	0.36 %	19.82 %
2005	2.96 %	0.97 %	-0.60 %	3.33 %
2006	32.68 %	0.87 %	0.20 %	33.75 %
2007	-14.53 %	0.26 %	0.12 %	-14.15 %

2008	-4.54 %	-0.77 %	1.03 %	-4.29 %
2009	-21.24 %	-3.44 %	0.07 %	-24.60 %
2010	9.92 %	1.14 %	-0.11 %	10.94 %
2011	22.86 %	-0.63 %	-0.16 %	22.07 %

Brazil	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	11.53 %	10.75 %	5.16 %	27.44 %
2004	29.47 %	7.14 %	1.01 %	37.62 %
2005	-20.70 %	8.02 %	0.78 %	-11.90 %
2006	37.85 %	7.25 %	0.01 %	45.11 %
2007	10.24 %	8.05 %	1.72 %	20.01 %
2008	47.58 %	8.42 %	3.31 %	59.31 %
2009	19.53 %	7.52 %	1.47 %	28.52 %
2010	-9.96 %	9.46 %	1.54 %	1.05 %
2011	6.65 %	7.77 %	2.24 %	16.66 %

Russia	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	15.88 %	13.48 %	3.37 %	32.72 %
2004	28.52 %	18.39 %	3.11 %	50.01 %
2005	45.47 %	16.66 %	4.11 %	66.24 %
2006	-22.47 %	14.05 %	2.87 %	-5.55 %
2007	5.22 %	15.27 %	2.71 %	23.19 %
2008	-13.31 %	15.87 %	6.28 %	8.84 %
2009	32.14 %	3.28 %	1.84 %	37.25 %
2010	34.72 %	8.08 %	3.88 %	46.68 %
2011	-2.36 %	9.12 %	3.11 %	9.86 %

ROW	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	-2.90 %	7.10 %	1.88 %	6.07 %

2004	12.75 %	7.11 %	2.03 %	21.89 %
2005	31.29 %	4.81 %	1.49 %	37.59 %
2006	35.36 %	4.47 %	1.80 %	41.62 %
2007	7.16 %	7.16 %	2.44 %	16.76 %
2008	-2.14 %	5.55 %	4.20 %	7.62 %
2009	12.84 %	-2.16 %	2.11 %	12.78 %
2010	5.43 %	4.88 %	2.37 %	12.68 %
2011	9.72 %	6.18 %	2.71 %	18.61 %

Global	Residual shift	Income effect	Substitution effect	Gross demand shift
2003	2.43 %	2.28 %	1.10 %	5.81 %
2004	4.41 %	2.64 %	1.03 %	8.08 %
2005	14.07 %	2.72 %	0.84 %	17.64 %
2006	19.53 %	2.92 %	1.30 %	23.76 %
2007	-2.55 %	3.08 %	1.86 %	2.39 %
2008	-3.59 %	2.82 %	3.69 %	2.92 %
2009	8.36 %	-0.36 %	0.69 %	8.68 %
2010	17.89 %	2.52 %	1.07 %	21.48 %
2011	3.12 %	2.79 %	1.89 %	7.80 %