Estimation of a demand system for UK consumption of Scottish Salmon

1. One of the key inputs to delineate the relevant market is the set of price elasticities that provide information on customer substitution patterns. In particular, the cross-price elasticities help to establish how close a substitute two products are. To uncover these demand elasticities, the CC estimated an econometric model of the UK demand for Scottish salmon.

2. This empirical analysis considers how UK demand for Scottish salmon varies with *(a)* the price of Scottish salmon in the UK and with *(b)* the price of Norwegian salmon in the UK. In a log-log formulation, the coefficient for *(a)* will yield the own-price elasticity of demand for Scottish salmon (ie an estimate of how demand for Scottish salmon responds to changes in the price of Scottish salmon), whilst the coefficient on *(b)* will yield the cross-price elasticities between Scottish and Norwegian salmon (how demand for Scottish salmon responds to increases/decreases in the Norwegian price).

3. The estimated model casts the log of quantity demanded (in tonnes; LQ) as a function of log price for Scottish salmon (£/kg) (LSP) and Norwegian salmon (£/kg) (LNP) as well as log consumer food expenditure in current prices (LEXC), to isolate the income effect (ie so the model can distinguish between movement of prices and quantities along the demand curve as opposed to isolate shifts in the demand curve).[1]

[1]Income growth (among other factors such as advertising and changes in preferences) will shift the position of the demand curve: to be able to isolate the impact of prices on demand we need to factor this effect into our regression analysis.

4. Monthly UK demand of Scottish salmon has been computed by subtracting monthly UK exports from Scottish production. The majority of UK salmon exports is in the form of fresh, with a small amount of smoked and value-added products. Export data held by Kontali measures exports in product weight terms, whilst Scottish production is measured in whole fish equivalent (wfe). To make the two data series comparable we have converted exports in the same unit of measurement as Scottish production (ie wfe) using the following conversion factors derived from the range provided by the merging parties:

Fresh: product weight = 85% of wfe (mid-point of the 80–90% range provided)

Smoked: product weight = 55% of wfe (between the 45–60% range provided)

Fillet: product weight = 60% of wfe (mid-point of the 55–65% range provided)

5. As a sensitivity test, we rerun the estimation using consumption data derived under different conversion assumptions. This is discussed in more detail below.

6. To proxy UK Scottish and Norwegian salmon prices we have used the monthly average of aggregate prices paid for 2000 to 2006 by a significant purchaser of farmed salmon, whose suppliers include the merging parties. Ideally we would have used a spot measure for both products (and some average across a large group of customers); however, there were no suitable market statistics available on Scottish salmon prices. The SSPO (then SQS) stopped monitoring Scottish salmon prices in 2003 and neither Kontali, Norwegian Seafood Federation (FHL) nor Intrafish hold data on Scottish salmon prices charged in the UK. The parties were able to supply only average price data back to early 2003. The price series used by the CC may therefore reflect differences in prices for reasons specific to this particular customer, such as whether the proportions of spot and contracted sales vary between Scottish and Norwegian purchases. We note that the data displays some differences to other indications of market prices, for example Norwegian prices often exceed Scottish

prices. The parties noted that the prices used were inconsistent with prices reported by them. However, we consider that price movements are consistent with overall market movements shown in other sources. We compared the average price for this significant customer with the average price charged by Marine Harvest over a few years and found that the two price series move in the same direction. The difference in the two price series would if anything lead us to estimate a more conservative price effect.

7. Monthly income was proxied using the ONS monthly index on non-seasonally adjusted household expenditure in predominately food stores (2000 = 100).

8. Because prices are potentially endogenous (ie the outcome of shifts/movements along both the demand and the supply curve) we needed to use an instrumental variable estimator. 'First-stage' regressions indicate that the NOK/£ (N2P) exchange rate could serve as an instrument for the Scottish price (LSP), while monthly feed costs (MFC) and the €/£ (EU2P) exchange rate could act as an instruments for the Norwegian price LNP. This would result in over-identifying restriction for the Norwegian price. The appropriateness of this restriction is discussed in more detail below.

9. Preliminary regressions indicate virtually no heteroskedasticity in the estimated residuals, but significant serial correlation can be detected. To enhance efficiency in estimation, the model is therefore estimated by GMM, using a heteroskedasticity and autocorrelation consistent (HAC) estimator to reweight the moment functions. The estimation results obtained from this approach are summarized in Table 1.

TABLE 1 **GMM estimation results for LQ = f (LSP, LNP, LEXC) base case**

Variable	*Coefficient*	*Std error*	*t-Statistic*
C	5.474593	2.854563	1.917839
LSP	-3.547447	1.388325	-2.555200
LNP	2.973209	1.415788	2.100038
LEXC	0.746040	0.441153	1.691116

Source: CC analysis.

Note: The sample period is January 2000 to April 2006. The instrument list for the first stage regression is: C MFC N2P EU2P LEXC.

10. The estimation results indicate a negative own-price (–3.5) and positive cross-price elasticity (+3.0), both statistically significant at conventional levels (ie within 5 per cent), with the former dominating the latter in absolute magnitude, as one might expect. The positive cross-price elasticity indicates that the demand for Scottish salmon responds (fairly significantly) to changes in the price of Norwegian salmon. The model also produces a positive 'income' (or rather: food expenditure) elasticity (+0.7), albeit only statistically significant at the 10 per cent level. The above model effectively estimates the relevant elasticities for Scottish salmon over the short run.

11. As discussed above, this estimation has been performed using one instrument (the NOK/£ exchange rate) for the Scottish salmon price (LSP) and two (the €/£ exchange rate and monthly feed costs (MFC)) for the Norwegian salmon price (LNP), raising the possibility of invalid over-identifying restrictions. In particular, it is far from clear whether MFC is conceptually a good instrument for either price (despite the fact that first stage regression confirmed the result obtained via co-integration analysis, that monthly feed costs (MFC) can act as an instrument for the Norwegian price (LNP), but not for the Scottish price (SNP)). We normally use costs as an instrument for price to aid identification of the demand curve where prices are endogenous: in the real world, prices and volumes observed reflect the equilibrium outcome of shifts in both the demand and supply curve. By selecting an instrument for in this case the supply curve, this enables us to shift the supply curve without shifting demand which

means we can trace out the demand curve. However, given the lag in production between setting output and harvesting, it would seem unlikely that cost movements would lead to a contemporaneous shift in the supply curve.[2] To reflect this fact we will re-estimate this model using costs lagged a few periods. The econometric results using lagged feed cost as instruments were not very different, and econometric tests of the hypothesis of the validity of over-identifying restrictions failed to reject it.

12. To address any concerns that our derivation of UK consumption of Scottish salmon might be driving our results we have run the estimation using an additional 12 different formulations of the UK consumption series based on combinations of the conversion factors as set out in Table 2.

TABLE 2 **Conversion factor scenarios used in scenario analysis**

per cent

	# 1 Base case	# 2	# 3	# 4	# 5	# 6	# 7	# 8	# 9	# 10	# 11	# 12	# 13
UK fresh conversion factor	85	80	85	90	80	85	90	80	85	90	80	85	90
UK smoked conversion factor	55	45	45	45	60	60	60	45	45	45	60	60	60
UK fillet conversion factor	60	55	55	55	55	55	55	65	65	65	65	65	65

Source: CC analysis.

13. The estimation results are broadly similar to the ones obtained before. The following findings appear robust across the various volume data inputs:

- statistically significant (at 5 per cent level) negative own-price elasticity, with an average value of –3.58975 across estimations;
- statistically significant (at 5 per cent level) positive cross-price elasticity, with an average value of 3.041753 across estimations;

[2]This could explain why we observe that the Hansen J-statistic (76 x 0.055 = 4.18) is larger than the critical value of a chi^2 with 1 df, ie any one of the over-identifying restrictions may not hold. The test does not permit identification of which of the stipulated orthogonality conditions does not hold. Alternatively, this could reflect an inappropriate lag structure.

- the own-price elasticity dominates the cross-price elasticity in absolute magnitude;
- in terms of its magnitude, the own-price elasticity estimate is more robust across volume data inputs (variance of estimates across estimations = 0.038597) than the cross-price elasticity estimate (variance of estimates across estimations = 0.133127); and
- the food expenditure elasticity, while having the correct sign, is, at best, marginally significant at the 10 per cent level, but not in all estimations.

14. In conclusion, the above estimates indicate a large, positive cross-price elasticity of demand between Scottish and Norwegian salmon. This finding is consistent with Scottish and Norwegian salmon being in the same product market.