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# **Price Transmission for the French and UK Salmon Markets**

by

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## **Abstract**

This study analyzes price transmission from Norwegian export prices of fresh salmon to retail prices of consumer salmon products in France and UK. For different reasons, changes in salmon export prices do not need to be fully transmitted to retail prices of salmon products based on Atlantic salmon from Norway. This study tries to shed light on these price links between different levels in the value chain. Specifically, this study attempts to quantify the degree of price transmission on a broader set of consumer salmon products than has been analyzed in earlier studies. Moreover, this is the first study that analyzes differences in price transmission between branded products and supermarkets' private label salmon products.

The results from this study show a high degree of price transmission from Norwegian export prices to retail prices of natural fresh products such as fillets, steaks and whole. However, price transmission to retail prices decreases as more processing are involved; for fresh whole salmon price transmission is complete, while in highly value added products such as fresh ready main meal the price transmission can be close to zero. The econometric results further suggest that the transmission is higher from the Norwegian export price to the retail prices of private label salmon products compared to prices of branded salmon products. Again, this is an indicator that there are higher marketing costs for branded products. The increasing range of salmon products marketed to satisfy the different consumer tastes therefore reduces transmission from salmon export price to retail prices. Nonetheless, supermarkets' private label products appear to have the opposite effect on price transmission.

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## 1. Introduction

Salmon is one of the most successful aquaculture species and has experienced a tremendous growth in production from 172,000 tonnes in 1980 to over 3.2 million tonnes in 2013 (FAO, 2014). Aquaculture production of salmon is concentrated in a handful of countries. Norway has historically been the world's largest farmed salmon producer with a global production share of 69% in 2012. On the demand side of the salmon market, France and the UK are two of the largest salmon markets in the world and most of their salmon consumed comes from Norway.

We can say that salmon markets in France and UK have reached a mature stage; total salmon consumption has reached a high level in these two markets but growth is moderate or even declining. It seems that one of the current marketing strategies to maintain or further increase consumption at these high levels is by increasing the variety of value-added salmon products. For example, new consumer groups can be tempted to buy salmon when retailers offer more convenient salmon products that require less time to prepare at home. In the French case in particular, there is available a wide selection of value-added salmon products offered at a range of different prices. However, the most popular product forms in France remains salmon products with relatively modest value-added processing such as fresh steaks and fillets. Supermarket chains are also tapping into this market by offering private label products that is slightly cheaper than branded fresh salmon products. This gives consumers an increased selection in the product segment of little processed salmons as well.

This study analyses price links between Norwegian exported salmon and retail prices in France and UK. When we look at price links, it is natural to believe that there is a strong relationship between the Norwegian export price and retail prices in France and UK, especially when the fish is the most important input in the final consumer product. This is especially true for salmon products where there is little additional processing involved like fresh salmon fillets and steaks. However, it is important to take into account that France and UK are markets with

a high variety of salmon products. Therefore, a considerable share of salmon receives additional processing in the final destination or in some country along the way, resulting in value added products such as smoked salmon or convenient ready-made meals. Processing salmon into value-added consumer products involve other inputs like labour and machines, often adding other ingredients, packaging, branding and marketing. All of these additional marketing costs can reduce the price transmission.

When the degree of value-added increases it is therefore not obvious how strong is the price link between the Norwegian export price and the final retail price for salmon consumer products. Besides value added components, other factors that can contribute to asymmetric or incomplete price transmission from export to retail product including storage (Heien, 1980; Wohlgenant, 1985), menu costs (Heien, 1980), market power (Asche, Nostbakken, Oglend, & Tveteras, 2011; Fofana & Jaffry, 2008; Guillotreau, Grel, & Simioni, 2005), and the type of sales arrangements used such as contracts vs spot sales (Asche, Dahl, Valderrama, & Zhang, 2014; Larsen & Asche, 2011). The fact that supermarkets have taken over much of salmon marketing is also the reason why many of these price transmission issues are relevant.

As was pointed out above, supermarket chains try to create more sales by catering to differences in consumers' tastes, purchasing power and need for convenience. This gives incentives to develop new value-added products, which results in a larger difference between the export price and the retail price of the final consumer product. Supermarkets also try to generate more sales and profits by reaching new market segments with lower priced private label products. This type of pricing strategy may also influence price transmission from export prices.

The main objective of this study is to investigate the relationship between the Norwegian export price and retail prices of salmon products with different degrees of value added in France and in UK. We use basic economic price theory and previous studies on price transmission in

salmon markets as a guide to formulate models of price transmission. To empirically estimate salmon price transmission models, we use an econometric framework suitable for time series variables. We will compare Norwegian export prices for salmon destined to France and UK with retail prices in those two markets of a number of different salmon products. To analyze price transmission between different stages in the value chain studies mostly use cointegration. This is because in statistical terms many price series are characterized as being nonstationary. This means that statistical inference using ordinary least squares (OLS) regression to analyze price relationship is not valid when using levels of the price variables (Engle & Granger, 1987). We consider different estimation strategies depending on whether the price series are characterized as being stationary or nonstationary.

In the next section we review the relevant theory to analyze price transmission. Then we proceed to give an overview of the French and UK salmon markets. Then follows a description of the econometric methodology, data and the results of the model estimations. Finally, the thesis ends with a concluding discussion.

## 2. Price Theory

Price transmission is the study of how the prices in different part of the value chain are linked. Specifically, price transmission measures the change in one price in the value chain (e.g., downstream) due to a change in the price in another part of the chain (e.g., upstream). In this study we use traditional economic theory on pricing. The theory on demand and supply is a natural starting point to discuss price transmission. There is an important distinction between the price of the primary product and the prices of the inputs used to produce it. The demand for the primary product is determined by the “utility” attached to them, while the demand for the inputs is only indirectly related to the utility of the final product and can therefore be viewed as *derived demand* (Friedman, 2007). If there is a fixed amount of the inputs required in the final product, the link between the derived demand of the inputs and the demand for the final product will be strong. Marshall deals with the special case under the heading of “the theory of joint demand”:

“The demand for each of several complementary things is derived from the services which they jointly render in the production of some ultimate product, as for instance loaf of bread, a cask of ale. In other words there is a joint demand for the services which any of these things render in helping to produce a thing which satisfies wants directly and for which there is therefore a direct demand: the direct demand for the finished product is in effect split up into many derived demand for the things used in producing it (Marshall, 1920, page 230)”

Friedman (2007) provides as an example of this, with demand for knives using two inputs: blade and handle in a fixed proportion. The fixed proportion technology means that the price of a knife is closely linked to the price of the blade and the price of the handle used to produce it. Likewise, fresh salmon steaks packed in Styrofoam consist of more-or-less fixed proportions of salmon raw material and packaging material. A change in the price of the salmon raw material is therefore expected to influence the price of the finished product – for example, the fresh salmon steaks sold in supermarkets. It is the degree that these prices are linked together

that price transmission measures. To better understand what influences the degree of price transmission we turn to the demand and supply modelling framework.

Specifically, price transmission between two different levels in the value chain can be thought of as an interaction of demand and supply, say, in the market for the primary product and for the input factor of interest. This will be more clear if we start by looking at the profit maximization problem of the retailer that needs to decide how much to produce of the primary product and how much to buy of the input factor. Following the notation in Tomek and Kaiser (2014), let us define the price of the primary product as  $P_r$  and the price of the input factor of interest as  $P_d$ . The profit maximization problem for the primary product can then be formulated as:

$$\pi_r(P_r, P_d, \mathbf{P}_z) = \max_{Q_d, \mathbf{Q}_z} P_r F(Q_d + \mathbf{Q}_z) - (P_d Q_d + \mathbf{P}_z \mathbf{Q}_z), \quad (1)$$

where  $F(Q_d + \mathbf{Q}_z) = Q_r$  is the production function for the primary product  $Q_r$ ,  $P_d$  and  $Q_d$  is the price and quantity used of the input we wish to investigate (*i.e.*, the salmon raw material in our case), and  $\mathbf{P}_z$  and  $\mathbf{Q}_z$  are a vector of prices and quantities of other inputs used in the production of the primary product. The demand for the primary and derived product can be obtained by Hotelling's lemma, that is, by taking the derivative of the profit function on their respective prices,  $P_r$  and  $P_d$ . We assume the firm is a price taker, meaning that it has no influence on input prices or output price. This gives the following expressions for the primary and derived demand:

$$\partial \pi / \partial P_r = Q_r(P_r, P_d, \mathbf{P}_z), \text{ and} \quad (2)$$

$$\partial \pi / \partial P_d = -Q_d(P_r, P_d, \mathbf{P}_z) \quad (3)$$

$$\partial \pi / \partial \mathbf{P}_z = \mathbf{Q}_z(P_r, P_d, \mathbf{P}_z). \quad (4)$$

Often the vector  $z$  will be denoted by a single variable, the marketing cost. That is, all inputs, besides the main raw material input is lumped together as one single factor. The marketing cost can also sometimes be treated as a fixed cost (Asche, 2002). In the continuation we disregard these marketing cost and concentrate on the primary demand and the derived demand of the main raw material input.

The price elasticities that corresponds to the primary and derived demand in equation 1 and 2 are denoted as  $E_r$  and  $E_d$ .<sup>1</sup> The price elasticities of demand are relevant since we can use them to formalize how demand and prices between the two levels in the value chain are related. Specifically, the relationship between these two elasticities can be formulated as:

$$E_r = E_d \left( \frac{P_d}{P_r} \right). \quad (5)$$

In the special case that primary and derived curves are parallel the price elasticity of demand could be calculated directly from one demand curve to the other. Figure 1 shows an example of this, where an increase in the demand of the primary product, smoked salmon, leads to a corresponding shift in the derived demand for fresh whole salmon. The price of the primary product  $P_r$  and input  $P_d$  change equally so that the margin remains the same.

This amounts to constant margin  $c$  between the price of the primary product  $P_r$  and the price of the derived product  $P_d$ . A constant marketing margin can be written as  $c = P_r - P_d$ . In this special case the elasticity for derived demand  $E_d$  will always be lower than for the primary product,  $E_r$ . This follows from equation 1; Since the price of the primary product,  $P_d$ , is always higher than the for the input,  $P_r$ , the ratio in the parenthesis will always be larger than one. As

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<sup>1</sup> Demand elasticities measure the response in demand to change in own price. For example, for primary demand the price elasticity is defined as  $E_r = \left( \frac{dQ}{dP_r} \right) \left( \frac{P_r}{Q} \right)$ , where  $Q$  is the quantity demanded of the final product.



a result,  $E_d$  must be lower than  $E_r$  to fulfill equation 1. Therefore demand will be more elastic for the primary product than for the derived product.

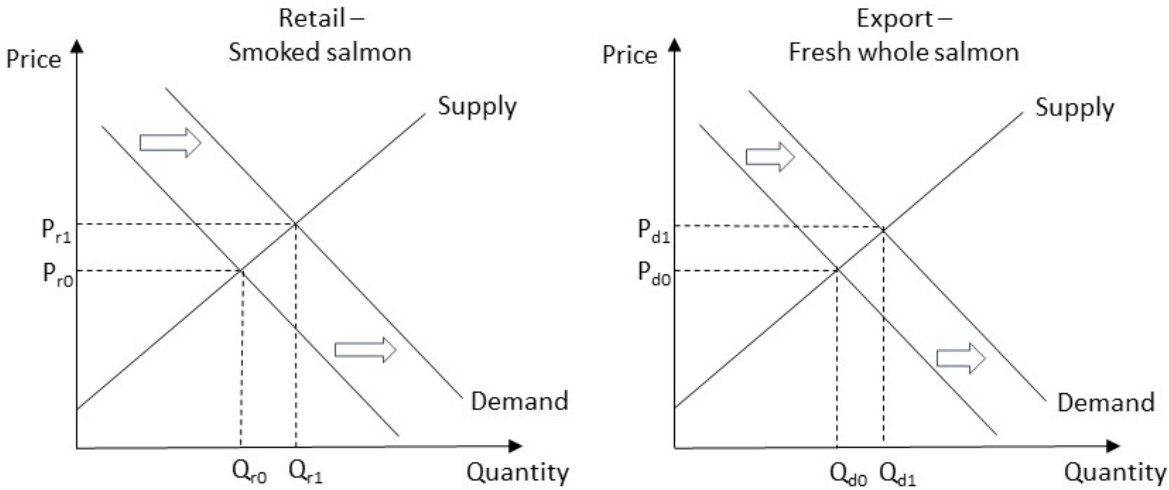


Figure 1. Demand interaction between primary and derived for smoked salmon

Price transmission does not only occur due to changes in demand but can also be driven by supply shocks. In figure 2 the derived supply curve contracts leading to a lower volume and higher price upstream. This is transmitted downstream to the retail level and lead to a similar reduction in supply. Consequently, price in the retail level also increases.

Another alternative is a fixed percentage margin between the primary product and input prices. This means that pricing of the primary product is based on a fixed markup. If a markup pricing like this is upheld the elasticity of primary and derived demand will be equal for a given quantity sold of the product. Price transmission will then be complete as a given rise in the price of exported salmon, for example, will be fully transmitted to the price of the final product, at least if salmon accounts for nearly all marketing cost of the final product.

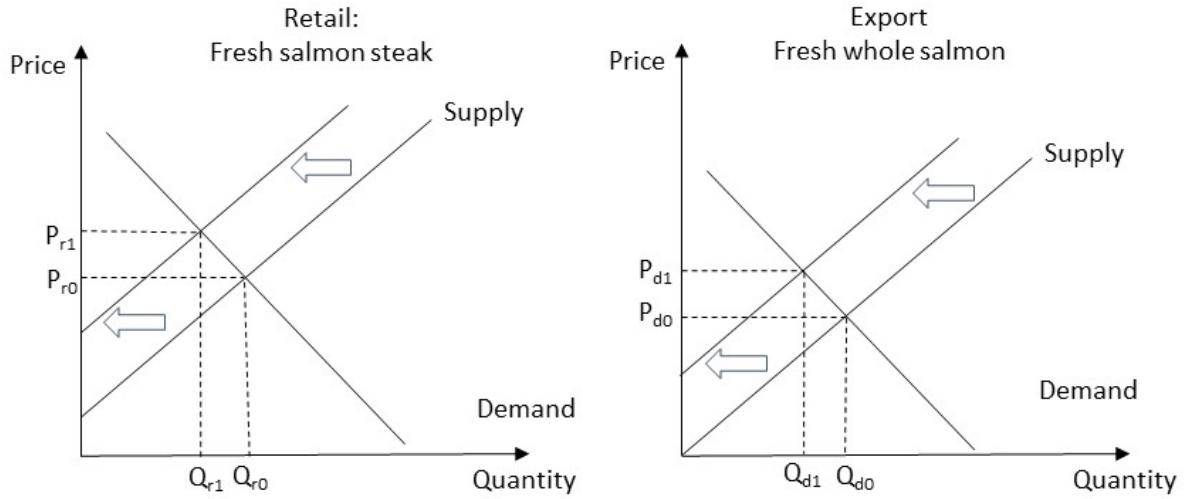


Figure 2. Supply interaction between primary and derived for smoked salmon.

To estimate price transmission we can formulate an empirical model based only on prices that can be interpreted as a variation of equation 5. Following the standard approach in the literature we will estimate the equation:

$$\ln P_{r,t} = \alpha + \beta \ln P_{d,t} + e_t, \quad (6)$$

where we have taken the logarithm of the two prices of interest.  $t$  denotes the time period and  $\alpha$  measures the margin. The error term  $e_t$  is assumed to be white noise. The key parameter of interest is  $\beta$ . Full price transmission implies that  $\beta = 1$ , so that any change in the price of the input is fully transmitted to the retail price or vice versa. Conversely, if  $\beta = 0$  there is no relationship between the two prices. If  $0 < \beta < 1$  then there is a relationship between the prices but price transmission is incomplete.

Even if the margin between the primary and input price in many cases may be viewed as approximately constant over time, the underlying behavior of a price margin will likely to be more complex than the two alternatives above imply. The reason is that the margin depends on the interaction of demand and supply on two different marketing levels, export and the

consumer market. Moreover, it involves the interplay of other inputs and marketing services. For example, the export price of salmon may decrease due productivity increases and subsequent cost reductions in salmon farming. Increased supply of salmon at lower price allows processors in France to use their installed processing capacity more efficiently, lowering unit marketing costs. This affects retail pricing and therefore primary demand. Consequently, derived demand for the salmon raw material will also change. A change in the price of exported salmon caused by supply side changes may therefore affect the derived demand for the exported salmon. Nevertheless, it is difficult to say whether the margin will increase or decrease as it also relates to technology and capacity utilization in the provision of other marketing services required for the final product (Tomek & Kaiser, 2014).

What we can say is that the price margin will depend on other factor prices involved in the production of the final product; efficiency in providing marketing services; and the mix of marketing services involved in providing the final product. New marketing services are introduced as salmon products increasingly are converted into a broader selection of value-added friendly consumer products, decreasing the cost-component of the salmon raw material in the final product. Whether this actually will decrease or increase derived demand for salmon depends on the popularity of the new salmon products being introduced to consumers.

Still, we can say something general about the behavior of price margins. First, for a salmon product where the cost of other marketing services are small (i.e., fresh salmon fillets), it is reasonable to expect that the price margin will remain relatively stable over time. This is because the cost of the processing and packaging services normally will be quite stable and also they do account for limited share of the total cost in providing the finished product. Second, in the case that there are few other marketing services involved it is reasonable to believe that causality will run from the salmon export price to the retail price. Third, temporary changes in the price margin can be caused by lagged response of retail prices to, for example, changes in

the export price of salmon. The lagged responses will typically be larger when there is more processing involved. These lagged responses can also be triggered by changes in the primary demand of the final salmon product, which then takes time to be transmitted on to derived demand. It is important to note that these lagged responses in price transmission are temporary, but not permanent. Thus, in the long run one would still expect close to complete price transmission for a product with little additional processing, such as fresh whole salmon or fresh salmon fillets.

Price transmission has received much attention in empirical studies of the salmon market (Asche et al., 2014; Asche, Jaffry, & Hartmann, 2007; Guillotreau et al., 2005; Simioni, Gonzales, Guillotreau, & Le Grel, 2013; Tveteras & Asche, 2008). These studies have investigated price transmission at different levels of the supply chain and found various degrees of transmission from upstream prices to downstream prices. While Asche et al. (2007) found evidence of high degree of price transmission for smoked salmon, other studies using more recent data indicate that price transmission from producer to consumer prices in the salmon market has decreased (Asche et al., 2014; Guillotreau et al., 2005; Simioni et al., 2013). The explanations why price transmission has decreased are structural changes in the fish processing and retailing. The fact that supermarkets have taken over most of fish marketing at the retail level in Europe have had implications for pricing strategies and practices. One consequence is that an increasing share of the salmon sold in French supermarkets are private label (Guillotreau et al., 2005) and increasing share of salmon is bought on contracts (Larsen & Asche, 2011).

### 3. Data

To analyze price transmission from export to retail, it is necessary and sufficient to have price data at the export and retail level. However, we decided to also include volume figures because it gives a fuller picture of the market situation at any given time. In this study both prices and volume figures are used to analyze price transmission. In the following, we provide a more detailed description of the data.

All consumer and export seafood data used in this thesis has been provided by the Norwegian Seafood Council (NSC). This includes salmon export statistics from Norway to France and UK by value and volume. The trade statistics spans the period January 2000 to December 2014 showing monthly exported quantity and value by salmon product and by market (i.e., France and UK). The export prices are obtained by dividing value with quantity. This means that they are unit values. The retail data is obtained from household consumer surveys in France and UK. The data runs from January 2008 to December 2014. The data from France include 12 000 households that participate in the monthly surveys while in UK, 20 000 households participate.

The French and UK household data include the reporting of respectively 33 and 23 different salmon products. One reason why the French data has more product categories, is because retail chains' private label and branded products are separate categories. In any case, France appears to have a wider selection of processed salmon products. Retail prices are calculated by dividing the households' expenditure on a particular salmon product category in a month on the quantity they bought. The time span for analysing price transmission is defined by the available household data. This means that price transmission is analysed from January 2008 to December 2014. In the next chapter, we use the export and household data to describe the French and UK salmon markets.

## 4. The Salmon Market in France

Before we describe the French salmon market, we start by looking at the Norwegian export of salmon to France. This will give a picture of the volumes that are imported and the degree of value added processing in France that the imported salmon undergo. This last aspect will be clearer when in Section 4.2 gives an overview of the different salmon consumer products and their market shares.

### 4.1 Norwegian salmon exports to France

Total salmon exports in 2013 from Norway to France was 126.7 thousand tonnes with a total value of 679.3 million euro. The salmon exports to France account for 15 percent of the total Norwegian salmon export to Europe measured in volume and 13 percent when measured in value. Figure 3 shows that 97% of Norwegian exports to France were fresh salmon when measured in volume and a total of 82% were whole fresh. In other words, most of the salmon exported to France receives minimal additional processing. An important implication of this is that very little value-added processing takes place in the country where the salmon is farmed. Instead most of the additional processing of farmed salmon takes place in countries closer to or in the final markets themselves.

The most important reasons to explain this pattern of further processing is high labor cost in Norway and that Norwegian salmon exporters faces higher import tax for processed fish products compared to the unprocessed products. The most profitable solution for Norwegian salmon producers is than to export the fish with little additional processing. Finally, note that when looking at the value of the exports the figure remains mostly the same, only that fresh fillet occupies a larger share because the price per kilo is higher compared to whole salmon. The salmon export to France account for six percent of the Norwegian salmon export to Europe and five percent of total Norwegian salmon exports measured in value.

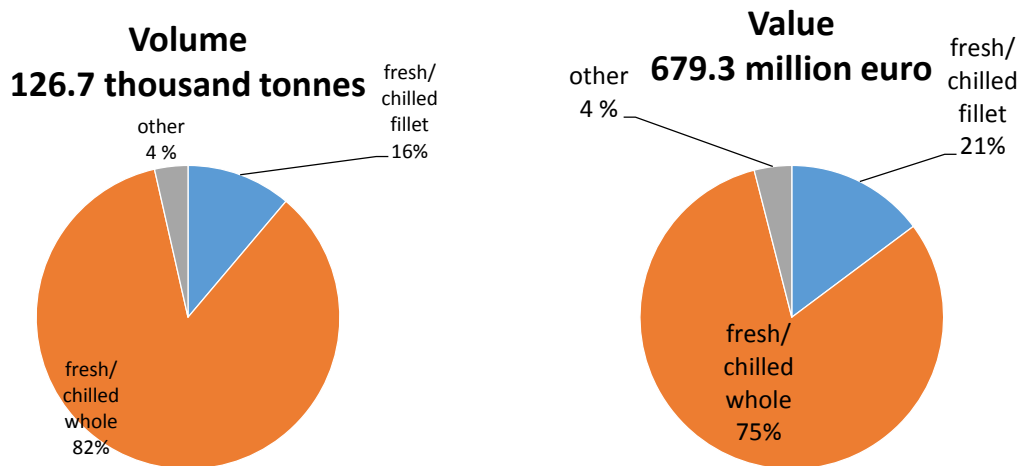


Figure 3. Product category shares of Norwegian salmon export to France in 2013

#### 4.2 The French Salmon Retail Market

The total sales volume to French households in 2013 was 72.5 thousand tonnes in product weight, and the corresponding value 1.29 billion euro. Figure 4 shows the consumption shares by the main groups of salmon products in France in 2013. Either we look by value of volume, it is smoked fresh and natural fresh categories that dominate. Jointly they account for 69% of the value and 75% of the value.

Note also that in terms of volume natural fresh is the largest category, but by value smoked fresh is clearly the largest. This reflects the additional value added processing involved with smoked salmon compared to fresh salmon. As we will see later, the popularity of smoked salmon in France is particularly linked to holiday season in December. In third place is natural frozen salmon followed by prepared fresh, then prepared frozen and finally prepared canned. This ranking is the same when measured in volume or value.

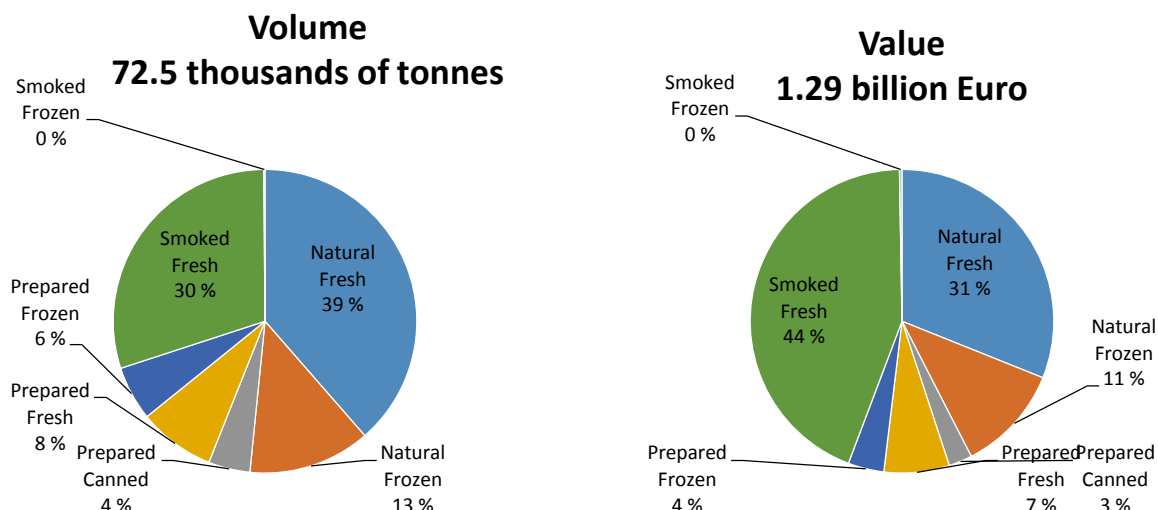


Figure 4. French households' consumption shares of main salmon product groups by volume and value in 2013 (NSC)

Figure 5 breaks the main product categories shown in Figure 4 into subcategories. For example the upper left figure shows the natural fresh category broken down in fillets, whole and steak/fish meat. Furthermore, each of these three categories are divided into prepacked (PP) or not prepacked (NPP). Prepacked refer to salmon products that have been packed by suppliers to the supermarkets, while not prepacked are salmon packed by the supermarkets themselves, and can thus be considered as salmon sold as private labels. As can be seen, a substantial share of the natural fresh salmon is sold as not prepacked. This means that a majority of the natural fresh category is processed, packed and marketed by the supermarkets themselves. This does not mean that the supermarkets do the actual packing themselves but rather outsource this to processors (Guillotreau et al., 2005). In terms of product format, steak is the most common (46 %) followed by fillets (43 %) and whole (12 %). This indicates that preference for convenient product presentations like steak and fillets rather than whole salmon that requires additional processing in the kitchen bench.



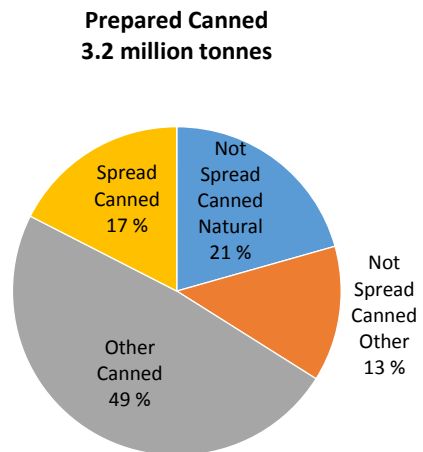
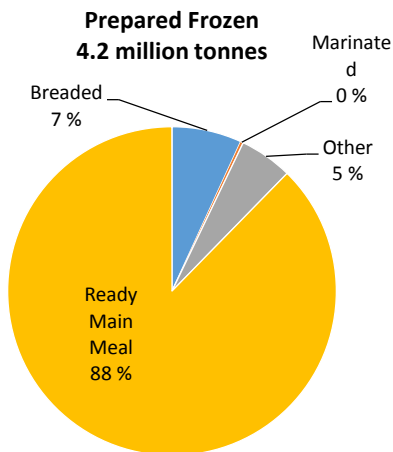
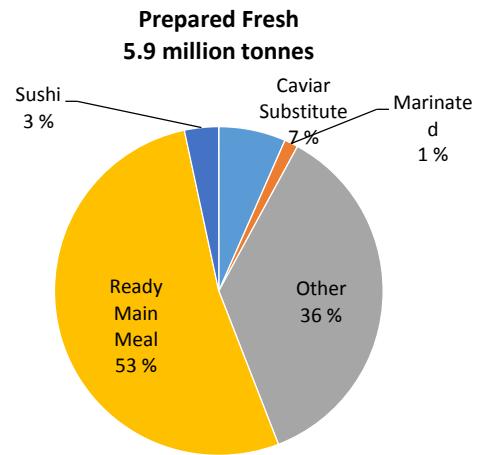
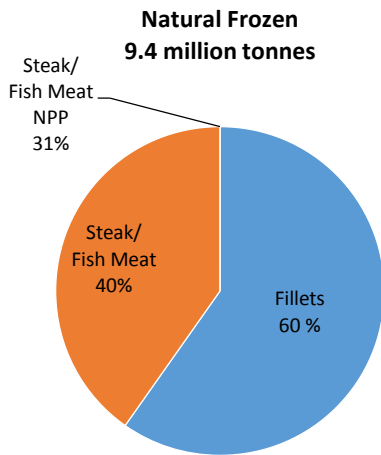
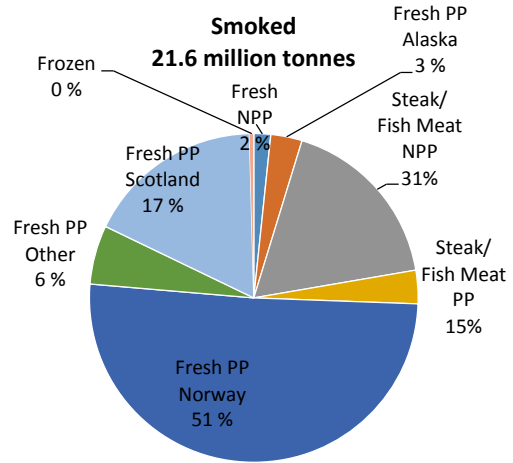
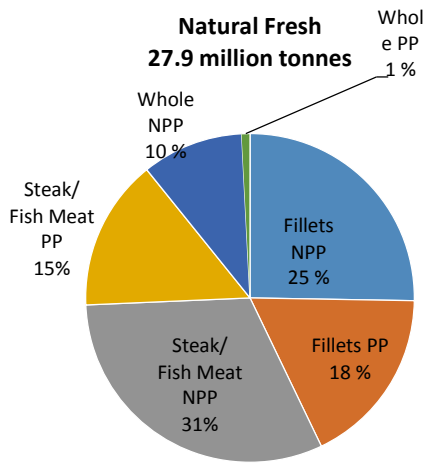


Figure 5. French households' consumption shares of subcategories of salmon product by volume in 2013 (NSC)

For smoked salmon a majority is prepacked and usually labelled with the origin of salmon, even if most of this salmon is smoked in France. Of the smoked salmon origin labels suggest the majority is imported from Norway (51 %) followed by Scotland (17 %) and Alaska (3 %). 33 % of the smoked salmon are not prepacked (i.e., they are sold as supermarkets' private label products). Frozen salmon is marketed as either fillets (60 %) or steaks (40 %) and is predominantly prepacked. Prepared fresh contain more elaborate fresh salmon products such as ready main meals (53 %), caviar substitutes (7 %) and sushi (3 %). These more elaborate products are all prepacked. Also in the frozen prepared products ready main meal (88 %) is the dominating product. Finally, canned products are divided between spread (17 %) and not spread (34 %) salmon. There is also a large category of other canned products (49 %). We now turn to a description of the salmon market in the United Kingdom.

## 5. The Salmon Market in the United Kingdom

This chapter follows the same structure as the previous chapter for France. First a brief overview is given of the Norwegian salmon exports to UK, before we proceed to look at the composition and size of different salmon products and its consumption in UK.

### 5.1 Norwegian salmon exports to the UK

Total salmon exports in 2013 from Norway to UK was 47.8 thousand tonnes with a total value of 233.9 million euro. Figure 6 shows that the profile of Norwegian salmon exports to UK is very similar to France, although the volume is considerably smaller. The same explanations why most of the Norwegian salmon products are exported with limited additional processing to France also applies for exports to UK. Importantly, it implies that most of the value added takes place in the UK.

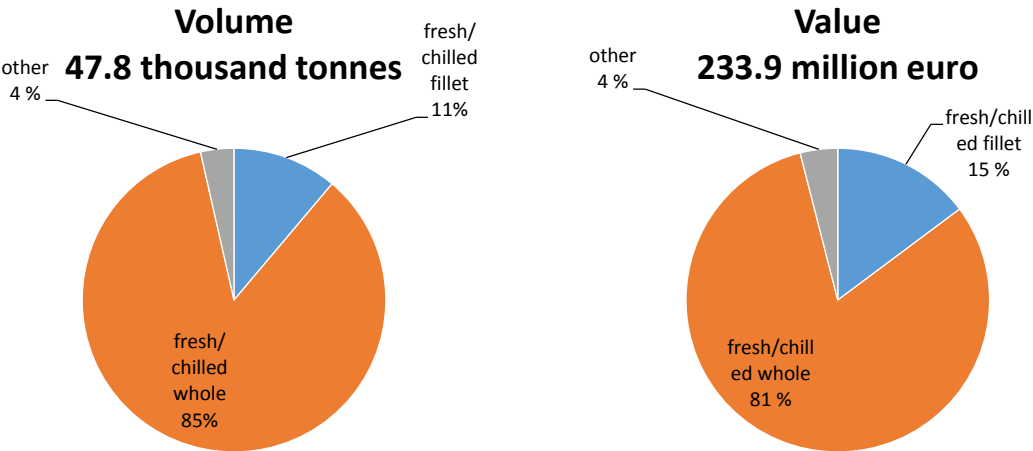


Figure 6. Product category shares of Norwegian salmon export to France in 2013

### 5.2 UK Salmon Retail Market

As in France, supermarkets in UK have increasingly taken over retailing of fresh fish. Fofana and Jaffry (2008) observe that the share of fresh fish sold through large supermarket chains have increased from 16% in 1988 to 86% in 2003. According to their study, the

increasing concentration in fish retailing have led to supermarkets to exert increasing levels of influence on suppliers in terms of health and safety regulation, packaging and processing requirements. In the UK salmon market, natural fresh is the most important main product category both when measured in volume and in value in 2013, as shown in figure 7. Next follows prepared fresh (18 %), smoked (15 %) and prepared frozen (12 %) and natural frozen (6 %). In terms of value, smoked fresh is the second most important (24 %) superseding prepared fresh (17 %), implying that the price of smoked salmon is higher than prepared fresh.

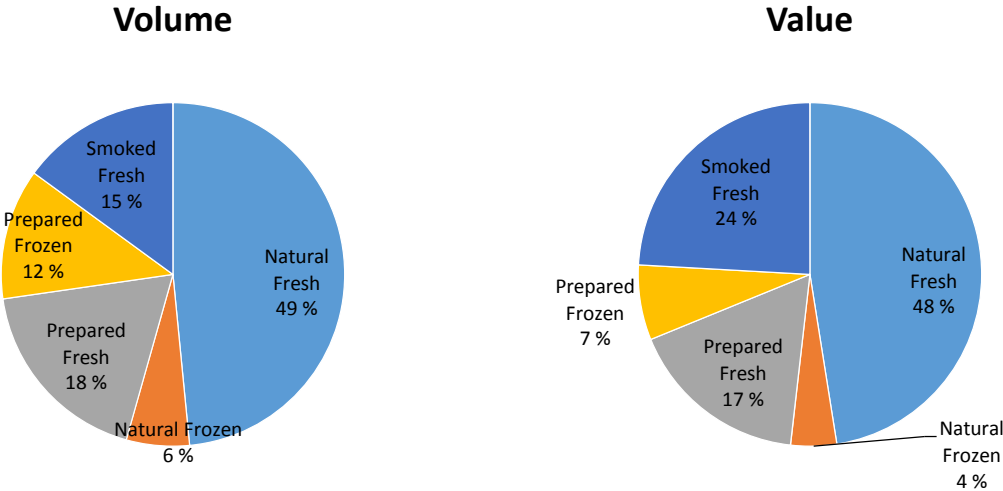


Figure 7. UK households’ consumption shares of main salmon product groups by volume and value in 2013 (NSC)

Figure 8 breaks down three of the four most important categories in more detailed product categories. These main categories are natural fresh, prepared fresh and prepared frozen. Smoked fresh is not included in figure 8 because the main category cannot be divided into finer sub-categories. Neither natural frozen is included since it consists only of frozen fillets. For natural fresh is dominated by fillets (84 % of the volume) followed by whole (6 %), fish meat (6 %), and steak (4 %). For prepared fresh the dominating category is value added (78 %) followed by breaded (22 %). Finally, for prepared frozen consists for ready main meal (64 %),

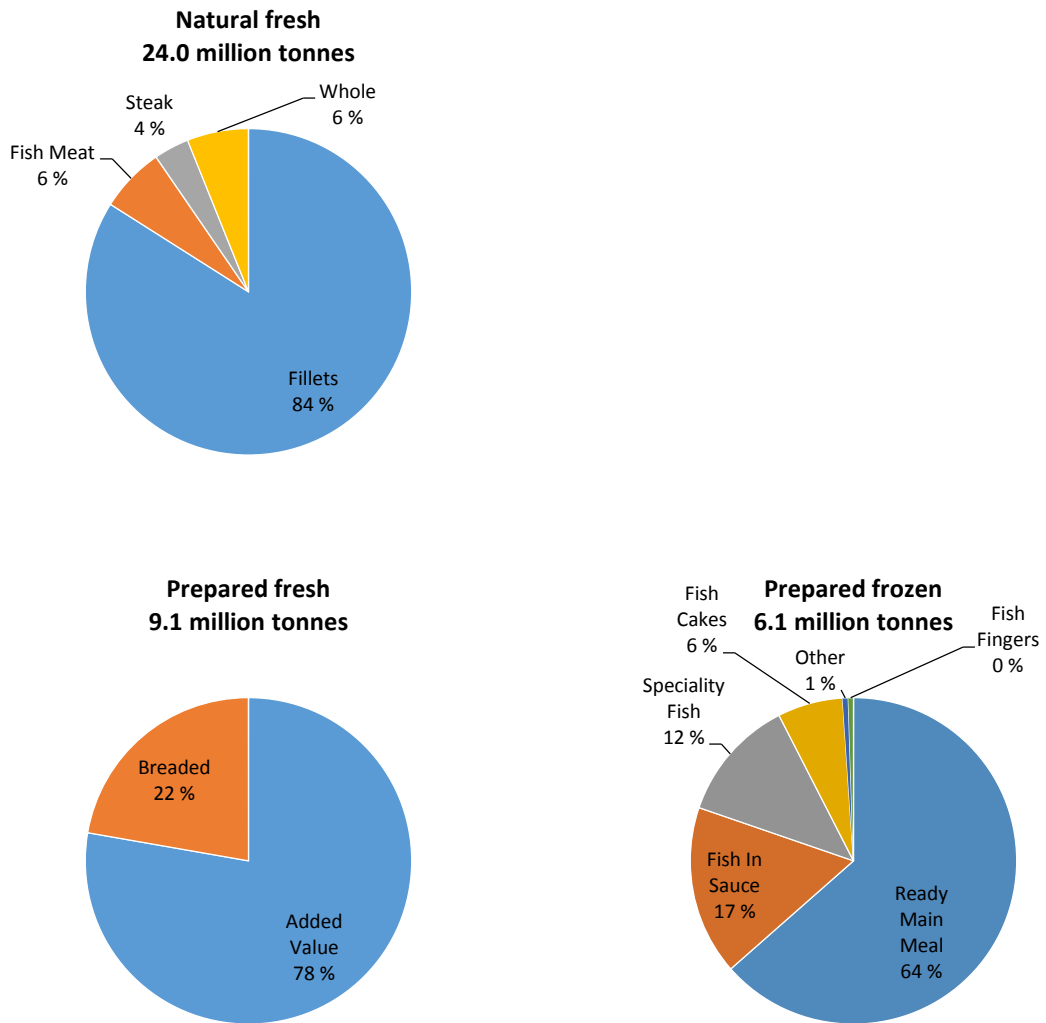


Figure 8. UK households' consumption shares of subcategories of salmon product by volume in 2013 (NSC)

fish in sauce (17 %), speciality fish (12 %), fish cakes (6 %) and other (1 %). This shows that there is a wide selection of value added salmon products available to consumers even if fresh salmon fillets and fresh smoked salmon dominate the total supply at the retail level in UK.

## 6. Comparisons of French and UK markets

Figure 9 shows salmon exports from Norway to France and UK on a monthly basis from 2000 to 2014. The figure shows that salmon exports to France are substantially larger than to

UK. Exports to France increased until it peaked in the end of 2012 and then started to stagnate in 2013 and onwards. In contrast, Norwegian salmon exports to UK leveled off after a strong growth in 2005 and did not start increasing again before 2012. In the exports to France there is a clear seasonal pattern that reflects a high demand during the December holiday season. In contrast, the seasonal effects appears to be modest for UK with no clear visual pattern. Next we explore retail price levels for different salmon products in France and UK.

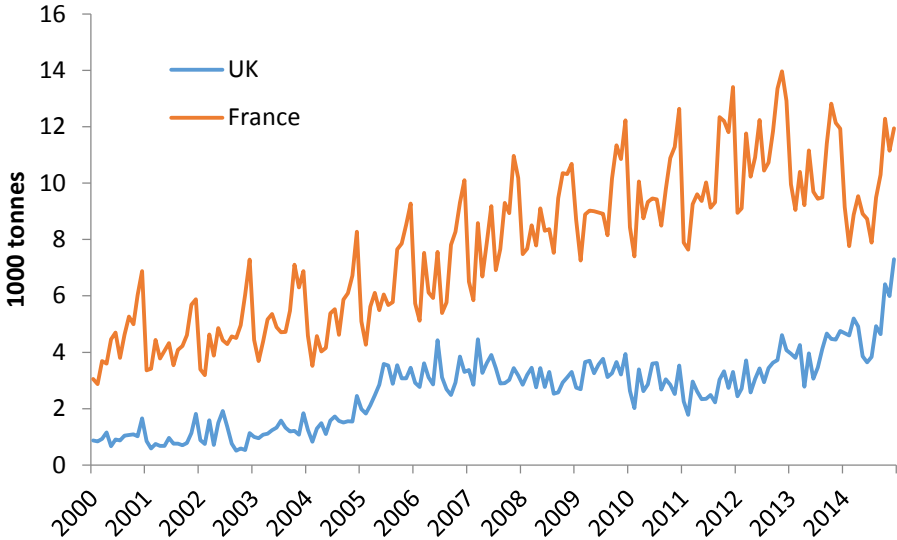


Figure 9. Monthly Norwegian exports to France and UK in volume (all product forms) (NSC)

Figure 10 shows average prices in 2013 for the different subcategories presented above for France and UK in figures 3 and 6. A good starting point is to see the price of natural frozen whole salmon in France, which in 2013 where sold for EUR 3.50 on average. This is arguably the product with least value added. If we compare natural fresh whole, which is another product with little value added, the prices in France and UK are very similar with EUR 7.22 and EUR 7.40 respectively. Thus for a salmon product where there is little value added prices are very similar across the two markets. However, this changes as the degree of value added increases. For example, in the two most important product groups, natural fresh fillets and natural fresh

steak/fish meat the price levels in France are respectively 22 % and 20 % higher than in UK. In another important product group like smoked fresh prices are 34 % higher in France than UK, and in natural frozen fillets this retail price difference is 75 %.

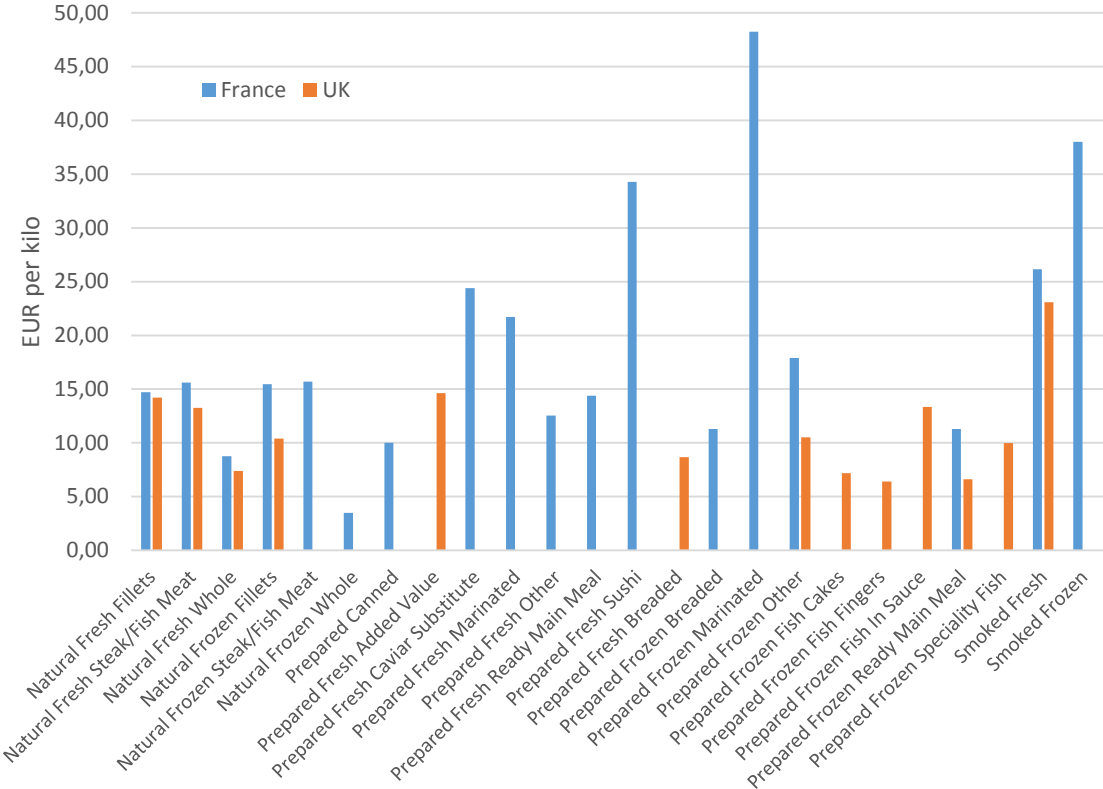


Figure 10. Price levels of different subcategories of salmon products in France and UK in 2013 (NSC)

Figure 8 shows the average price received per salmon product category in 2013 in France and UK. A picture that emerges from figure 8 is that France has a wider selection of salmon products compared to UK. Moreover, France has the value added products that obtain the highest prices (e.g., prepared frozen marinated priced at EUR 48.25 and prepared fresh sushi priced at EUR 34.27). For product categories that are available in both France and UK such as fresh fillets, fresh steak, fresh whole etc. it appears that prices are slightly higher on average in France compared to UK. An explanation for asymmetric pricing across the two markets could

be influenced by differences in tax levels (e.g. V.A.T. levels), import tariffs (Kinnucan \* & Myrland, 2005) and supermarket chains' market power (Asche et al., 2011; Fofana & Jaffry, 2008; Guillotreau et al., 2005). Another explanation might be the presence of higher marketing costs or raw material costs. Although this study will not be able to identify the nature of such price differences these are issues we will discuss in more detail related to the empirical price analysis. Now that we have a theoretical background and an overview of the two markets subject for the empirical analysis we proceed to present the methodological framework that will be used to analyze price transmission.



## 7. Methodology

In this chapter we review key concepts related to time series econometrics and the two main analytical approaches that we use: cointegration analysis and autoregressive distributed lag models. These are the econometric tools that will be used to empirically analyze price transmission.

### 7.1 Time Series Econometrics

Studies of price transmission are normally based on time series regression techniques and particularly the use of cointegration analysis (Asche et al., 2014; Asche et al., 2007; Guillotreau et al., 2005; Larsen & Asche, 2011; Simioni et al., 2013). Before we introduce the methodological framework for cointegration analysis and other relevant time series regression models, let us first discuss some aspects and concepts related to analysis of time series data. The reason why time series analysis have evolved as a separate discipline in econometric analysis is that time series variables do not fulfill key assumptions in classical regression analysis. Because of this, time series often require a modified methodological framework. In particular, when using ordinary least squares (OLS) regression it is assumed that the variables included in the regression model are identically and independently distributed (i.i.d.). The observed outcomes in time series variables will seldom be independent of each other since the realized value in one period tend to be influenced by realizations of the variable in preceding periods. That is, those factors that influenced the outcome a variable in one period will often prevail for some time periods leading to a similar outcome in the next period. For example, if a salmon price is low (high) in one period it will tend to be low (high) in the next period. This relationship between observations across time is captured in the measurement of autocorrelation. Autocorrelation measures the degree of correlation between this period and a preceding period (often the previous period). The formula to calculate the sample autocorrelation is:

$$\hat{\rho}_j = \frac{\text{cov}(\widehat{Y}_t - \widehat{Y}_{t-j})}{\text{var}(\widehat{Y}_t)}, \quad (7)$$

where the numerator measures the autocovariance between variable in  $Y_t$  in period  $t$  and  $t-j$ , and denominator is the variance of  $Y_t$ . If  $j=1$  then we measure the correlation between previous and current period. The higher is the autocorrelation coefficient the stronger will be the association between the observations over time. The degree of autocorrelation is also relevant when determining whether a time series is stationary or nonstationary. This distinction is an important one that will determine what kind of econometric framework is the correct to apply.

A stationary time series has the same probability distribution over the entire sample period. Stationarity thus requires that the future to be like the past, in a statistical sense. This implies that the mean, variance and autocorrelation of a series does not change. For example, a stationary price series for a retail salmon product would exhibit the same average price level and volatility when one compares two different sub-samples in the entire sample period. This could be the case for certain retail prices that are relatively stable over a period or commodity prices that are only exposed to short term shocks. Mathematically, if we have an autoregressive process of first order, AR(1), written as:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t, \quad (8)$$

where  $u_t$  is i.i.d. error term, then a stationary process implies that  $\beta_0 = 0$  and  $|\beta_1| < 1$ . In this case the series will always return to the expected value zero. However, for commodity prices that experience supply shocks these assumptions are less likely to hold. Commodity prices are more likely to be nonstationary, which imply that the mean and variance will tend to

change and the sample autocorrelation coefficient will be close to 1 (James Stock & Watson, 2007). This is equivalent to saying that the price series is characterized by a random walk process. Mathematically, if we have a autoregressive process of first order, AR(1), written as:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t, \quad (9)$$

where  $u_t$  is i.i.d. error term, then a pure random walk process implies that  $\beta_0 = 0$  and  $\beta_1 = 1$ , so that the change in  $Y_t$  is i.i.d. This can easily be seen by inserting these values for  $\beta_0$  and  $\beta_1$  and rewriting equation 2 so that  $Y_t - Y_{t-1} = \Delta Y_t = u_t$ . If  $\alpha \neq 0$  then this translates to a random walk with drift. If  $\alpha$  is positive then  $Y_t$  increases on average and conversely if  $\alpha$  is negative.

The main issue of having a stochastic trend driving the changes in a series  $Y_t$  is that the OLS estimator of the autoregressive coefficient and its t-statistic can have non-normal distributions, even in large samples. Another problem with stochastic trends is that of spurious regression; two time series might appear to be related even if they are not. The normal procedure to detect if a time series contains a stochastic trend is to test for unit roots. A unit root refers to the characteristic equation obtained by a reformulation of the AR(1) equation. In the case that  $\beta_1 = 1$  the characteristic equation will contain a unit root and thus be nonstationary. To test for nonstationarity we use the augmented Dickey Fuller (ADF) test, which is a widely used unit root test (Dickey & Fuller, 1979).

As was pointed out, nonstationary series do not conform to the regular t-distribution. This is because the underlying distribution will be more complicated than that implied by a normal distribution. As a consequence Dickey and Fuller developed new critical values. The critical values of the ADF test are based on the outcomes of a random walk process (i.e., a nonstationary process). Even if a series is based on a random walk process, there can be

additional deterministic components in data generating process like an intercept or a trend. The ADF test can be expanded to include such components. Moreover, an AR(1) process might not account for all autocorrelation in the process. For the following reason the ADF specification allows for a more general AR(p) structure, where p is the number of lags of own value included. Specifically, the ADF equation can be formulated as:

$$\Delta Y_t = \rho Y_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta Y_{t-i} + \mu + \gamma t + u_t. \quad (10)$$

This equation can be viewed an AR(P) process that contains a constant,  $\mu$ , and a trend,  $t$ , included. Moreover, the difference form of  $Y_t$  has been obtained by subtracting each side of the equation with  $Y_{t-1}$ . Thus, on the right hand side the term  $\rho Y_{t-1} = \beta_1 Y_{t-1} - Y_{t-1} = (\beta_1 - 1)Y_{t-1}$ . Since a unit root implies that  $\beta_1 = 1$ , the ADF test of a unit root consists of testing whether  $\rho$  is equal to zero.

In general, the lag length p is unknown so some type of procedure needs to be used to determine the appropriate lag length. One common technique to determine the lag length is by using the Aikake Information Criteria (AIC). The AIC can be formulated as:

$$AIC(p) = \ln\left(\frac{SSR(p)}{T}\right) + (p + 1)\frac{2}{T}. \quad (10)$$

SSR(p) is the sum of squared residuals of the estimated of the estimated AR(p) and T is the number of observations. As the number of lags p increase the SSR(p) will decrease, since more of the variation in data will be accounted for. However, the second term on the right hand side increases as p increases, thereby penalizing adding more parameters to the model. This means that there is a trade off when increasing p. The p that minimizes AIC(p) yields the appropriate lag length for the ADF test. Studies suggest that is better to have too many lags than

too few to estimate  $p$  for the ADF statistic, so it is recommended to use the AIC instead of the Bayes Information Criteria (BIC) (Haldrup & Jansson, 2006; J Stock, 1994). We follow this advice for our study. Next, we turn to the cointegration framework that will be central for the price transmission analysis.

### 7.2 Cointegration Analysis

Cointegration is a term applied when two or more series share common stochastic trend. That is, they will tend to move similar over time. This can be exemplified by looking at the Norwegian export prices to France for fresh fillet and fresh whole salmon in figure 11. These products are substitutes in production. This implies that their prices are exposed to the same production shocks and respond to the same market impulses. For these reasons the Norwegian salmon export prices will tend to increase and decrease in the same manner. An implication of

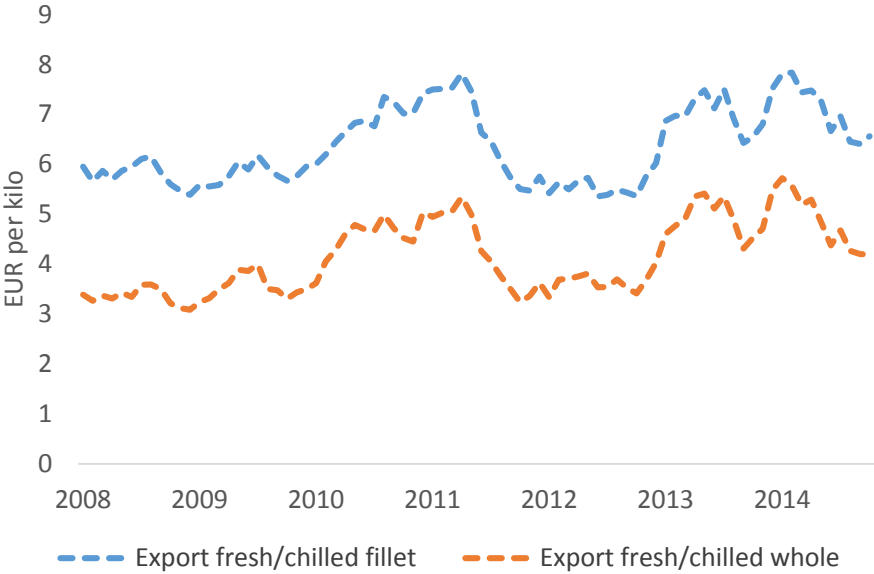


Figure 11. Monthly Norwegian export prices of fresh fillet and fresh whole salmon.

this behavior is that they will have a common stochastic trend. Price transmission also implies that there is a degree of commonality in price movements of products in different levels of the

value chain. Since price series often are nonstationary, then cointegration analysis can be an appropriate tool to analyze price transmission.

Formally, cointegration occurs if two series  $Y_t$  and  $X_t$  both are integrated of order one and there is some coefficient  $\theta$  that makes  $Y_t - \theta X_t$  integrated of order zero (i.e., stationary) (Engle & Granger, 1987). One way of making a series that is integrated of order one stationary is by taking its first difference,  $\Delta Y_t = Y_t - Y_{t-1}$ . However, if  $Y_t$  and  $X_t$  are cointegrated, another way to eliminate the trend is by including  $Y_t - \theta X_t$  in a regression analysis. This is the basis of the cointegration framework developed by Engle and Granger (1987). The term  $Y_t - \theta X_t$  can be as a long-term steady state equilibrium in an economic framework. However, short run dynamics can also be studied if one applies the Johansen framework (Johansen, 1988, 1991). The Johansen framework also has the advantage that one do not need to choose which variable should be the dependent one, in contrast to the Engle and Granger framework. Economic theory can only suggest which variable to treat as the dependent, but in the end this is an empirical question when it comes to the analysis of price transmission. Another advantage is that the Johansen framework allows hypothesis testing on price leadership and law of one price.

The Johansen procedure is capable of handling a multivariate system of non-stationary variables in a way that produce statistical valid test results (Johansen, 1988). Following Dickey, Jansen, and Thornton (1991), the starting point is a vector autoregressive (VAR) system:

$$\mathbf{Y}_t = A_1 \mathbf{Y}_{t-1} + A_2 \mathbf{Y}_{t-2} + \dots + A_p \mathbf{Y}_{t-p} + \mathbf{u}_t, \quad (11)$$

where  $\mathbf{Y}_t$  and its lagged equivalents are 1 by n vectors and the  $A_i$ 's are n by n matrix of parameters, and finally  $\mathbf{u}_t$  is a 1 by n vector of errors. This is the standard representation of a VAR system. However, Johansen (1988) reparameterizes the VAR as follows:

$$\Delta \mathbf{Y}_t = \Gamma_1 \Delta \mathbf{Y}_{t-1} + \Gamma_2 \Delta \mathbf{Y}_{t-2} + \dots + \Gamma_{p-1} \Delta \mathbf{Y}_{t-p+1} - \psi \mathbf{Y}_{t-p} + \mathbf{u}_t, \quad (12)$$

Where  $\psi = (I - A_1 - A_2 - \dots - A_p)$ .  $\psi$  can be written as the product of two  $n \times k$  matrices, given that the rank of  $\psi$  is less than  $n$ . Specifically, in the Johansen framework,  $\psi = \alpha\beta'$  where  $\alpha$  and  $\beta$  are  $n$  by  $k$  matrices of rank  $k$ . Thus,  $\psi$  contains the long-run parameters which can be interpreted as the mechanism that brings the system back to a steady state equilibrium. In other words, there has to be a matrix  $\psi$  that makes  $Y_{t-p}$  stationary when multiplied. When that matrix is decomposed,  $\alpha$  can be interpreted as the speed of adjustment to equilibrium, and  $\beta$  as the matrix of long-run coefficients (i.e., what corresponds to  $\theta$  in the  $Y_t - \theta X_t$  mechanism). Importantly, in bivariate cointegration tests the  $\beta$  corresponds to the price transmission elasticity in equation 6. In total  $\beta Y_{t-p}$  can represent up to  $n-1$  cointegration vectors. For the multivariate model to converge to a long term equilibrium there has to be at least one cointegrating vector. More precisely, if the number of cointegrating vectors  $k$  is an integer, it is only the presence of  $0 < k < n$  cointegrating vectors that is of interest. If  $k = n$  it implies that the variables  $Y_{t-p}$  form cointegration vectors in themselves. What this really means, is that the variables can be interpreted as stationary, which is a trivial solution; in this case we do not identify any relationship between the variables of interest. In the case that  $k = 0$  then the series are nonstationary but we do not identify any relationship between them.

### 7.3 Testing in the Cointegration Framework

To test the number of cointegration vectors  $k$  in the Johansen framework there are two Likelihood Ratio tests that are (Johansen and Juselius, 1992), the maximum (max) eigenvalue test ( $\lambda_{max}$ ) and the trace test ( $\lambda_{trace}$ ). The null hypothesis for both tests is that there are maximum  $k$  cointegration vectors. However, the alternative hypothesis is different for the two tests; for the max test the alternative is that there are more than  $k$  cointegration vectors, while the null of the trace test is that there is  $k + 1$  cointegration vectors. Compared to the max test, the trace shows more robustness against skewness and excess kurtosis in the error (Cheung &

Lai, 1993). It could therefore be more prudent to rely more on the trace test than the max test if they produce different results.

To evaluate the estimated models three goodness of fit measurements are applied, a measure of autocorrelation in the residuals, a measure of normality of residuals, a measure of heteroscedasticity of residuals and, finally, a measure of functional specification. There first is a LM test of no autocorrelation in the residuals. This test is performed by running the auxiliary regressions modelling the residuals as dependent on the original variables and lagged residuals. The null hypothesis is no autocorrelation. The test of normality is equivalent to testing of skewness and kurtosis is incompatible with a normal distribution (Doornik & Hansen, 2008). The null hypothesis is that of normally distributed errors, that is, no skewness and no kurtosis. Moreover we have a test for heteroskedasticity based an auxiliary regression of the squared residuals on the original dependent variables and their square values (White, 1980). The null is unconditional homoscedasticity. Finally, the Ramsey's RESET test of functional specification tests if the linear specification gives the best fit, by adding nonlinear terms of regressors (i.e., squared values) and testing if they are statistically significant (Ramsey, 1969). The null hypothesis is of no functional misspecification.

Besides testing for the number of cointegration vectors and model goodness-of-fit there are other useful information to be obtained from the Johansen framework. Importantly, in a price transmission analysis we are interested to obtain information about the causality of price changes: is the changes in export prices that leads to changes in the retail prices or vice versa. This will give us valuable information about whether it is demand and supply changes in the export market that are determinant of price changes downstream in the value chain, or if it is demand and supply changes in the retail level that drive changes. Price leadership can be analyzed by testing for weak exogeneity in a VAR framework where there are two or more prices involved.



A variable  $\Delta Y_{it}$  can be viewed as weakly exogenous in the VAR system if there is no loss of information by not modelling the determinants of  $\Delta Y_{it}$  (Harris, 1995). In other words, the other variables in the VAR system do not contribute significantly to predict  $\Delta Y_{it}$  and for the same reason we can treat it as exogenous in the system. The practical implication is then that we can treat  $\Delta Y_{it}$  as a right hand variable in the model. For example, if we have a bivariate VAR system consisting of two price variables where one is determined to be weakly exogenous, the system can be reduced to a single equation model. Thus following Asche et al. (2007), testing for weak exogeneity solves the simultaneity problem that arises because economic theory does not give any answer about the direction of the relationship. In the Johansen framework, a test of weak exogeneity is a Likelihood Ratio test of whether the speed of adjustment parameters  $\alpha$  corresponding to the variable  $\Delta Y_{it}$  are not significantly different from zero. Rejection of the null hypothesis implies that  $\Delta Y_{it}$  is not weakly exogenous.

The demand and supply framework underlying price transmission (illustrated by figure 1 and 2) is closely related to the concept of market integration. Market integration can be seen as a way of testing where the boundaries of a market stretches by analyzing how tightly knit are price movements across related markets. Price transmission is an equivalent analysis, but an investigation of vertical rather than horizontal price relationships. Thus, when studying horizontally related prices in a bivariate VAR system the presence of one cointegrating vectors implies market integration; when studying vertically related prices it implies the presence of price transmission (Asche et al., 2007). Likewise, a test of the law of one (LOP) price in a market integration context is a test of whether markets are perfectly integrated, while in price transmission context it is a test of whether price transmission is complete. The LOP hypothesis (or, conversely, the complete price transmission hypothesis) can be tested in the Johansen framework by imposing restrictions that

$$Y_{1t} = -\beta Y_{2t} \quad (13)$$

where  $Y_{1t}$  and  $Y_{2t}$  are the price variables. The restriction implies that the relative relationship between the prices is constant. In a price transmission setting this can be interpreted as the markup in the retail price over the export price is constant.

In the VAR framework for cointegration by Johansen it is only possible to determine the rank of  $\alpha\beta'$  and testing constraints like that of equation 13. However, it is possible to obtain estimates of the long run price transmission elasticities  $\beta$  by normalizing on one of the prices in the bivariate cointegration tests. If price variables are not nonstationary I(1) or there is not evidence of cointegration between prices then the cointegration analysis is not the appropriate approach to obtain price transmission elasticities. We therefore supplement with estimation of autoregressive distributed lag (ARDL) models, which allow us to obtain additional price transmission elasticities. This single equation modeling framework is presented in the next section.

### 7.3 Autoregressive Distributed Lag Models

ARDL models have been used for a long time (Griliches, 1967), but more recently have become very valuable for testing long-run relationships between variables. Cointegration analysis has increased the types of time series data that can be handled with more confidence in the ARDL framework. For example, Panopoulou and Pittis (2004) show that the ARDL model fares well both in terms of estimation precision and reliability of statistical inferences compared to the dynamic OLS (DOLS) - a single equation cointegration approach by J. H. Stock and Watson (1988).

The general ARDL model can be formulated as

$$Y_t = \alpha_0 + \sum_{i=1}^p \alpha_i Y_{t-i} + \sum_{j=1}^n \sum_{i=0}^q \beta_{jp} X_{jt-i} + u_t \quad (14)$$

Where  $Y_{t-i}$  are lagged values of the dependent variable,  $X_{jt-i}$  are contemporaneous and lagged values of exogenous explanatory values and  $u_t$  is white noise residual.  $\alpha_0$ ,  $\alpha_i$ 's and  $\beta_i$ 's are parameters to be estimated. A compact manner of denoting the model is then ARDL(p,q) where p is the lag length of the dependent variable and q is the lag length of the explanatory variables.

By imposing restrictions on the estimated parameters in (2), a range special cases can be obtained such as e.g. partial adjustment, finite distributed lag, static, differences and dead start. All of these variants of the ARDL model impose restrictions on the dynamic process. For example the partial adjustment model, also known as the Koyck model, imposes a decaying lag structure. The dead start model impose that there is no contemporary relationship between  $Y$  and  $X$ . Griliches (1967) noted that it is not easy to distinguish among alternative lag structures because of potential unstable solutions and biases. Autocorrelation is often interpreted as a sign of misspecification, because, unless the errors are truly autoregressive, autocorrelation will often arise if the model is dynamically misspecified, the functional form is misspecified or the model is subject to a non-modelled structural break.

These issues can to some extent be remedied by adopting general-to-specific modeling strategy as proposed by Hendry (1995). In the context of ARDL models, a general-to-specific modeling strategy is based on starting with a rich selection of explanatory variables and lags. Because of the dimensionality issue, however, it is necessary to start with a subset of variables. Applying tests of Granger causality can then be used to reduce to a more parsimonious model with well-behaved (Gaussian) residuals and parameter constancy.

Let us assume that we wish to model the relationship between some time series variables, where we take into account if they are stationary or not and if there is some cointegrating relationship between the series. Then the ARDL model can deal with the following situations in straightforward manners. First, all the series  $I(0)$  and therefore

stationary. Then we simply proceed by inserting the variables in equation 14 and for example estimate with OLS. Second, if the variables are I(1) and cointegrated we can also estimate the variables in levels using OLS. Alternatively, we can reformulate the ARDL model as an error-correction model (ECM), which will also allow us to model the short term dynamics. Third, if the variables are I(1) but not cointegrated or a mix of I(1) and I(0) then the correct procedure will be to take the first difference of the variables and estimate equation 14 with OLS.

The long run solution where we can infer the price transmission elasticity is found by rewriting equation 14 in the following manner:

$$Y = \alpha_0 / (1 - \sum_{i=1}^p \alpha_i) + (\sum_{j=1}^n \sum_{i=0}^q \beta_{jp} / (1 - \sum_{i=1}^p \alpha_i)) X_j. \quad (15)$$

The price transmission elasticities are the elements in the expression in right hand component of equation 15. The  $t$  subscripts have been removed to indicate that this is a long term solution. If only two prices are included so there is only one  $X$  variable will be one price transmission elasticity.  $t$ -statistic for this long-run price elasticity can then be calculated for the non-linear combinations of estimated parameters that make up the price transmission elasticity. In the next two chapters, the empirical applications of the econometric models described in this chapter are carried out using the econometric software package PcGive version 10.0.

## 8. Empirical Results for France

In this chapter we present the results from the analysis of price transmission from the Norwegian salmon export price to the retail prices of salmon products in France. We provide descriptive statistics of the export and retail prices before we proceed with the cointegration analysis and estimation of ARDL models. First we turn to a description of the price series.

### 8.1 Descriptive Statistics of French Salmon Prices

Figure 12 shows all but three price series used for analysis of price transmission of the French market. The three omitted price series include natural fresh fillet not prepacked (NPP), natural fresh steak/fish meat NPP, and natural fresh whole NPP. As was pointed out earlier, not prepacked refers to food retailers' private label products while prepacked (PP) can be viewed as branded products supplied to retailers by seafood producers. The reasons for excluding the private label products (i.e., NPP) is to make it easier to distinguish between the trends of the included price series. Moreover, the same category branded products are already included in the figure. Table 1 summarizes the key descriptive statistics of all the price series. The sample from January 2008 to October 2014 implies that there are 84 observations for each variable.

In figure 12, the differences in the price levels reflects that as salmon products get more elaborated the more costly it is to provide them. This is because increasingly more inputs and marketing services are involved in the production of the final product when the degree of value added increases. This was also discussed in the theory chapter. Consequently, the export prices of fresh whole and fresh fillet are on average the lowest closely followed by the retail price of natural fresh whole salmon. This is also evident from the means reported in Table 1 with descriptive statistics. Further, the graph shows that the retail prices of fresh fillets and fresh steaks are around twice as high as the export price of fresh fillets. The prices of salmon in prepared main meal is also around the magnitude of these fresh fillet and fresh steak, while that of fresh smoked salmon is the dearest of all products.

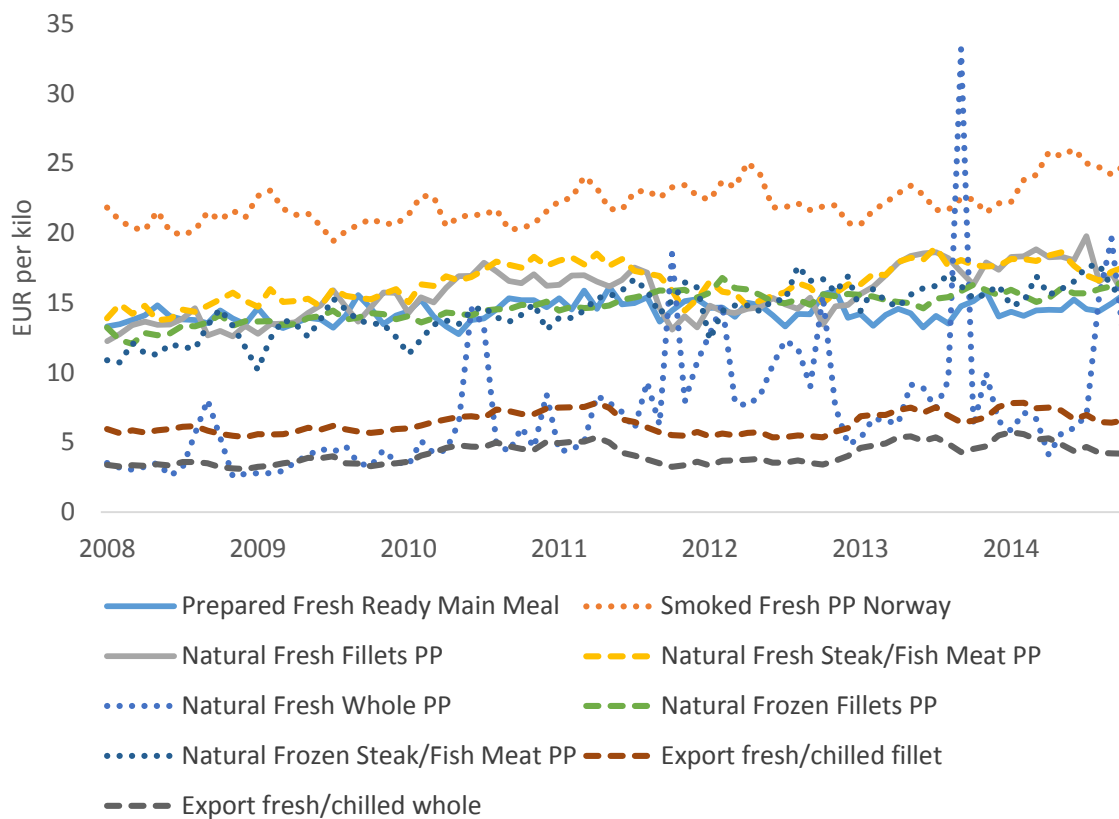


Figure 12. Export prices to and retail price in the French salmon market

The coefficient of variation (CV) in the right-hand column in table 1 provides a measurement of the volatility of the price series relative to the mean. The price series with the two lowest coefficient of variation are fresh ready main meal and frozen fillets, while the highest are fresh whole prepacked and fresh whole not prepacked. This conforms to expectations as the least processed products that cannot be stored usually have the highest volatility.

Table 1. Descriptive statistics of price series from January 2008 to October 2014.

<i>Variable</i>	<i>Obs.</i>	<i>Std.</i>		<i>Minimum</i>	<i>Maximum</i>	<i>CV</i>
		<i>Mean</i>	<i>Dev.</i>			
<b><i>Export:</i></b>						
Fresh fillet	84	6.376	0.749	5.357	7.843	0.117
Fresh whole	84	4.147	0.731	3.090	5.725	0.176
<b><i>Retail:</i></b>						
Fresh fillet NPP	84	12.062	1.476	9.590	15.040	0.122
Fresh fillet PP	84	15.624	1.834	12.240	19.770	0.117
Fresh steak NPP	84	13.860	1.265	11.610	16.610	0.091
Fresh steak PP	84	16.435	1.355	13.760	18.960	0.082
Fresh whole NPP	84	6.824	1.278	4.490	11.390	0.187
Fresh whole PP	84	7.259	4.715	2.560	33.200	0.650
Frozen fillet PP	84	14.744	1.029	12.052	16.776	0.070
Frozen steak PP	84	14.465	1.750	10.189	17.736	0.117
Smoked fresh PP Norway	84	22.128	1.458	19.430	26.010	0.176
Fresh prepared ready main meal	84	14.372	0.739	12.747	16.122	0.051

The differences between the PP (branded) and NPP (private label) prices of same product category are interesting in itself and are therefore shown in a separate figure 13. We can see that the branded products are on average higher priced than retailers' private label counterparts. For fresh fillet and fresh steak the branded products receive prices that are respectively 30 % and 19 % higher than the private label products. In monetary terms this means a markup of 3.56 euro per kilo and 2.58 euro per kilo of prepacked products compared to their private label counterparts. Thus, there appears to be a significant price difference between branded and private label products. An interpretation is that the private label products are directed to more price sensitive consumers. Finally, the thin volumes of the fresh whole prepacked salmon explains why its price is volatile, as there are few reasons to brand a salmon

marketed without any further processing. Since the majority of whole salmon is sold as not prepacked we disregard price comparison of this product category in this context.

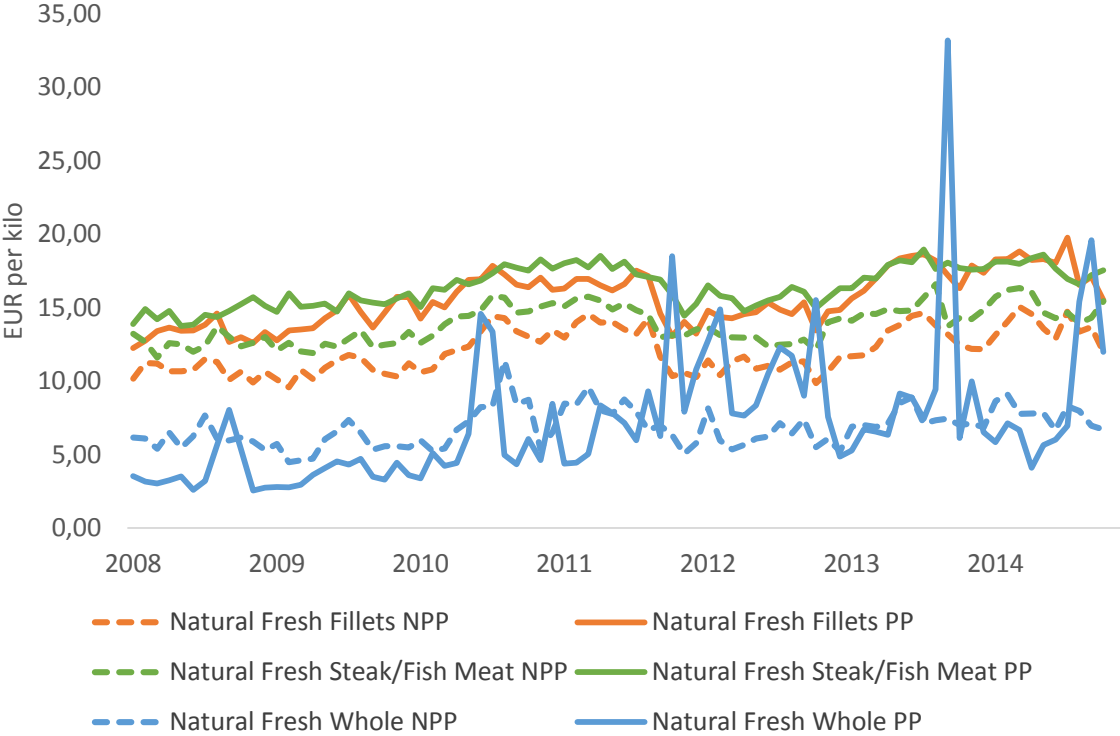


Figure 13. Comparison of prepacked (PP) and not prepacked (NPP) retail prices for natural fresh salmon products in France

After this visual inspection of the price series the next step is to proceed to a formal analysis of the data. The first step is to conduct unit root tests of the price series. Table 2 shows the results of the augmented Dickey-Fuller (ADF) tests for unit roots. Each variable were transformed using the natural logarithm and by taking the first difference of the natural log. For each of the two variable transformation (i.e., log and first difference of log) two model formulations of the ADF tests were conducted; one tests only includes only a constant while the other includes both a constant and a trend. Initially, three differenced lags are included in all the specification to account for autocorrelation. The appropriate lag length was chosen based on the Aikake Information Criterion. In table 2, the chosen lag length is reported next to the



ADF test statistic. According to the formulation including only a constant all series but whole salmon fresh and ready main meal appears to be nonstationary. This can be seen as the hypothesis of a unit root is not rejected at log levels, but is rejected for the log difference of the price series. By including a trend a few more series appears to be trend stationary, that is, stationary around a trend. Besides fresh whole salmon and ready main meal, now also frozen fillet, frozen steak and fresh smoked salmon are deemed stationary. In summary, it is the export

Table 2. Augmented Dickey Fuller unit root test results

<i>Variable</i>	<i>Log</i>	<i>Diff-Log</i>	<i>Log</i>	<i>Diff-Log</i>
	<i>ADF:</i>	<i>ADF:</i>	<i>ADF:</i>	<i>ADF:</i>
	<i>Constant</i>	<i>Constant</i>	<i>Constant &amp; Trend</i>	<i>Constant &amp; Trend</i>
<b><i>Export:</i></b>				
Fresh fillet	-2.342 (2)	-7.484** (0)	-2.490 (2)	-7.433** (0)
Fresh whole	-2.253 (1)	-7.178** (0)	-2.797 (2)	-7.149** (0)
<b><i>Retail:</i></b>				
Fresh fillet NPP	-2.571 (0)	-9.643** (0)	-2.818 (0)	-9.585** (0)
Fresh fillet PP	-2.063 (1)	-11.01** (0)	-3.001 (0)	-10.97** (0)
Fresh steak NPP	-2.431 (0)	-7.824** (1)	-2.963 (0)	-7.759** (1)
Fresh steak PP	-1.949 (1)	-11.23** (0)	-2.271 (1)	-11.20** (0)
Fresh whole NPP	-4.067** (0)	-11.02** (0)	-4.476** (0)	-10.95** (0)
Fresh whole PP	-3.077* (1)	-7.315** (2)	-5.443** (0)	-7.266** (2)
Frozen fillet	-2.008 (1)	-10.81** (0)	-3.903* (0)	-10.77 (0)
Frozen steak	-2.225 (3)	-8.270** (2)	-5.819** (1)	-8.260** (2)
Smoked fresh Norway	-2.689 (0)	-7.831** (1)	-3.721* (0)	-7.798** (1)
Fresh prepared ready main meal	-5.570** (0)	-7.903** (3)	-5.589** (0)	-7.841** (3)

prices of salmon together with fresh fillet and fresh steak prices that appears to be nonstationary, while the remainder can be treated as stationary. As a result, analysis of price

transmission using cointegration techniques appears only to be appropriate for the retail prices for fresh fillet and fresh steak in conjunction with the export prices.

## 8.2 Price Transmission Analysis of French Salmon Prices

According to the ADF tests of unit roots in Table 2 French retail prices of fresh whole (not prepacked and prepacked) and fresh prepared ready main meal are stationary. Moreover, frozen fillet, frozen steak and fresh smoked appear to be trend stationary. However, for the time being we will treat the trend stationary as nonstationary and include them together with the other nonstationary retail price in bivariate cointegration tests against the Norwegian export price for whole salmon. The results of the bivariate cointegration tests are reported in Table 3. Since there is a total of four nonstationary retail prices and three trend stationary (treated as nonstationary), there is a total of seven cointegration tests. Choice of lag length in the different bivariate VAR models is made to assure that error term is well behaved, that is, no autocorrelation or nonnormality.

Moreover, in the bivariate VAR model formulations seasonal dummies are also included. The seasonal dummies are included to account for a fixed seasonal pattern that could be present in the price movements. The four first cointegration tests indicate that the French retail prices for fresh fillet and fresh steak are cointegrated with the Norwegian export price of fresh whole salmon. This is shown as both the Trace test and Max test reject the hypothesis of zero cointegrating vectors, but keep the hypothesis of maximum one cointegration vector. Combined these tests therefore indicate that there is a cointegrating vector that describes the long-run relationship between the two prices. This indicates that there is a strong relationship between the export price and these retail prices.

However the bivariate cointegration tests frozen fillet, frozen steak and fresh smoked salmon do not exhibit cointegration with the export price. The trace test for frozen fillet and frozen steak indicate that there are at least two cointegration vectors, implying to that the series

are stationary rather than cointegrated. In the cointegration test of fresh smoked, however, there is not evidence of any cointegration vector as the hypothesis that  $k = 0$  is not rejected.

In the column after the trace and max test of Table 3 are the Chi-square values of the Likelihood Ratio (LR) tests of the law of one price. The law of one price hypothesis is rejected for the top four retail prices suggesting that price transmission from export price to retail prices is incomplete. In contrast, the law of one price hypothesis is not rejected for the three last cointegration tests. These final results should be interpreted with care as there are not evidence of cointegration between the Norwegian export price in the three bottom retail prices.

The tests of weak exogeneity, which is a test of price leadership (see section 7.3), indicate that all retail prices but frozen fillet are endogenous in the bivariate models. Moreover, in all models the hypothesis of weak exogeneity (i.e., price leadership) is not rejected for the Norwegian export price. This imply that causation mainly run from export prices to retail prices, and not vice versa. The only exception is frozen fillet where it appears that neither the export price nor the frozen fillet price have any influence on each other; that is the speed of adjustment parameters  $\alpha$  appear to be zero for both equations.

In the final column are the long-term parameters  $\beta$  that correspond to the price transmission elasticities. This parameter shows the degree of price transmission from the export to the retail price. The highest price transmission appears to be from the export price to the fresh fillet NPP price with an elasticity of 0.695. The price transmission elasticity to the fresh fillet PP is slightly lower 0.646. Price transmission to fresh steak NPP and PP is slightly lower than for fresh fillet with elasticities of 0.508 and 0.464 respectively. The lowest price transmission is to frozen fillet with a  $\beta$  of 0.347, while for frozen steak it is 0.611 and for fresh smoked it is 0.577. Again, we have to be careful in interpreting these last three price transmission given that there is not any evidence of cointegration between the retail and export prices.

Table 3. Bivariate cointegration tests of the French market

<i>Export price of whole salmon with retail prices:</i>	<i>H0: rank = P</i>	<i>Trace Test</i>	<i>Max Test</i>	<i>Law of one price</i>	<i>Weak Exogeneity†</i>	<i>Price Transmission Elasticity (<math>\beta</math>)</i>
Fresh fillet NPP	$k = 0$	51.99**	49.43**	28.281**	46.740**	0.695
	$k \leq 1$	2.56	2.56		0.799	
Fresh fillet PP	$k = 0$	23.97**	20.81**	10.876**	13.059**	0.646
	$k \leq 1$	3.17	3.17		2.389	
Fresh steak NPP	$k = 0$	50.06**	47.03**	33.822**	43.989**	0.508
	$k \leq 1$	3.03	3.03		1.773	
Fresh steak PP	$k = 0$	33.47**	30.02**	22.637**	26.515**	0.464
	$k \leq 1$	3.45	3.45		0.002	
Frozen fillet	$k = 0$	15.68*	10.48	2.339	3.123	0.347
	$k \leq 1$	5.20*	5.20*		2.049	
Frozen steak	$k = 0$	17.08*	12.32	1.328	6.887**	0.611
	$k \leq 1$	4.76*	4.76*		0.922	
Smoked fresh Nor	$k = 0$	12.64	10.96	1.243	8.701**	0.577
	$k \leq 1$	1.68	1.68		1.416	

\*\* indicate statistical significance at the 1 percent level and \* at the 5 percent level.

† The first test of weak exogeneity is for the retail price, while the second is for the export price in each of the bivariate VAR models

To obtain further estimates of degree of price transmission also for those prices that are not cointegrated with the export price, we proceed to estimate autoregressive distributed lag (ARDL) models. For the sake of completeness we estimate bivariate ARDL models for all retail prices both in levels and in first differences. However, we have to be careful when interpreting the results as some of these regressions violates the OLS assumptions of stationarity or to the special exception of being nonstationary but cointegrated. Taking the first difference leads to a loss of information that may affect the magnitude of the estimated price transmission elasticity. This can be observed when we compare the estimated price transmission elasticities for the ARDL models in log levels with the ones in first difference form.

In addition to the estimated elasticities table 4 reports tests of the residuals are autocorrelated (AC), are normally distributed (Normality) and finally the Ramsey test of model specification (RESET) (Ramsey, 1969). The null hypotheses for these tests are that the residuals are not autocorrelated, are normally distributed, and that the model is well specified. As long as these tests do not reject the null hypotheses we treat the models as well specified besides the reservations concerning nonstationary we already have commented.

Of the ARDL models in levels, fresh fillet not prepacked (private label products) has the highest price transmission elasticity amongst the ones that are statistically significant. The elasticity can be interpreted as 96.3% of changes in the Norwegian export price of whole salmon is transmitted to the retail price of the supermarkets' private label fresh fillet products. However, when the fresh fillet is supplied by seafood producers the price transmission elasticity reduces to 0.613. The price transmission to fresh steaks is lower with 0.510 for private label products and 0.452 for branded products. It is interesting to note that for both fresh fillet and fresh steak price transmission is higher for private label products than for branded products. This indicates that private label products are more strongly linked to the export price than branded products,

possibly because of lower share of marketing costs involved. Not surprisingly, the price transmission elasticity of fresh whole salmon NPP is high with a parameter of 0.818. The price transmission for fresh salmon PP is even higher with 1.012, but this is not statistically significant. Moreover, the magnitude of the elasticity for fresh whole PP is highly sensitive to the choice of lag length. This should reflect the volatility of this price series caused by the thin volumes sold at the retail level. Thus, we should be careful about interpreting the magnitude of this elasticity.

The frozen fillet PP and fresh prepared ready main meal are the lowest with 0.161 and 0.074 respectively. None of these estimates are statistically significant. Neither are frozen steak PP with an estimated price transmission elasticity of 0.478. In contrast, for smoked fresh the price transmission elasticity is significant with 0.566 at the 5 % level. Smoked fresh, however, is not cointegrated with the Norwegian export price, as shown in Table 3, and therefore do not fulfill key assumptions for OLS estimation of the ARDL model.

The results for the ARDL models using variables in first difference form are reported in the right-hand side of table 4. Except for fresh whole NPP and prepared fresh ready main meal, all the estimated price transmission elasticities are of lower magnitudes when price series are differenced. In the case of fresh whole NPP and prepared fresh ready main meal, the estimated price transmission elasticities are very similar in levels and first difference form. Besides that elasticities are overall lower when differenced, the relative magnitudes between the different products remain. The highest price transmission tend to be to those products that receive less additional processing and the not prepacked (i.e., supermarkets' private label) products have higher elasticities than then prepacked (i.e., branded) products. After we have reviewed the results from the price transmission in the UK salmon market in chapter 9 we will discuss these results further in chapter 10.

Table 4. ARDL models of price transmission from export to retail prices in France

<i>Export price of whole salmon with retail prices:</i>	<i>Log</i>	<i>AC</i>	<i>Normality</i>	<i>RESET</i>	<i>Difference log</i>	<i>AC</i>	<i>Normality</i>	<i>RESET</i>
Fresh fillet NPP	0.963** (1)	1.415	2.144	0.446	0.617** (4)	1.193	3.945	0.897
Fresh fillet PP	0.613** (1)	1.835	2.280	0.234	0.536** (7)	0.829	0.333	1.559
Fresh steak NPP	0.510** (3)	2.050	0.324	0.180	0.407** (3)	1.832	1.332	10.519**
Fresh steak PP	0.452** (2)	1.291	2.386	0.855	0.251** (4)	1.625	3.532	0.139
Fresh whole NPP	0.818** (1)	0.733	11.044**	0.940	0.896** (7)	1.431	12.761**	1.481
Fresh whole PP	1.012 (2)	0.472	3.896	1.891	0.555 (3)	0.621	1.251	13.849**
Frozen fillet PP	0.161 (3)	1.494	1.297	0.349	0.073 (1)	1.710	0.009	3.411
Frozen steak PP	0.478 (3)	1.412	4.723	0.380	0.076 (3)	1.226	4.605	0.004
Smoked fresh PP Nor	0.566* (3)	1.114	0.205	2.323	0.002 (3)	1.162	0.605	0.000
Fresh prepared ready main meal	0.074 (1)	1.071	0.079	0.102	0.098 (3)	1.286	0.077	0.691

\*\* indicate statistical significance at the 1 percent level and \* at the 5 percent level.

## 9. Empirical Results for UK

In this chapter we follow the same outline as for the analysis of price transmission in France. First we start with a description of the price series before we proceed with the cointegration analysis and estimation of ARDL models.

### 9.1 Descriptive Statistics of UK Salmon Prices

As shown in figure 14, the price series for the UK market span a longer data period than the French by covering January 2005 to December 2014. The prices have been transformed to EUR per kilo prices to make them easily comparable to the French prices. As in the French market the highest price is obtained for smoked fresh salmon. The price level for smoked salmon in the UK and French market is similar around 22 euro per kilo. This can be seen by comparing the descriptive statistics of France and UK in table 1 and 5. The second highest prices is a group of products that includes fresh added value, frozen fish in sauce and fresh fillet. In the end of the data period the prices of these products are between 13 and 14 euro per kilo. Then follows frozen fillets (10.39 euro per kilo), fresh breaded (9.11 euro per kilo), fresh whole (7.54 euro per kilo) and frozen ready main meal (6.55 euro per kilo). In the bottom are the two export prices for fresh fillet and fresh whole.

It may seem strange that the price of frozen ready main meal is as low as 6.55 euro per kilo given the degree of value added involved. Two reasons can explain this. First, ready main meals consists of several food ingredients besides the salmon raw material like potatoes, rice, pasta, vegetables etc. As long as the kilo price of these inputs are lower than salmon they will reduce the euro per kilo price. Second, in many of frozen main meals it is the lower-priced wild-caught pink salmon that is used instead of farmed Atlantic salmon. Both of these components will tend to reduce the average kilo price of the frozen ready main meals. Other processed salmon products marketed in the UK are based on pink salmon such as fresh breaded and frozen



fish in sauce. This is important to note as it makes it less obvious that there is a strong relationship between the prices of exported farmed Atlantic salmon to the UK and the retail prices of value-added salmon products based on pink salmon. This is an issue we will keep in mind when estimating price transmission.

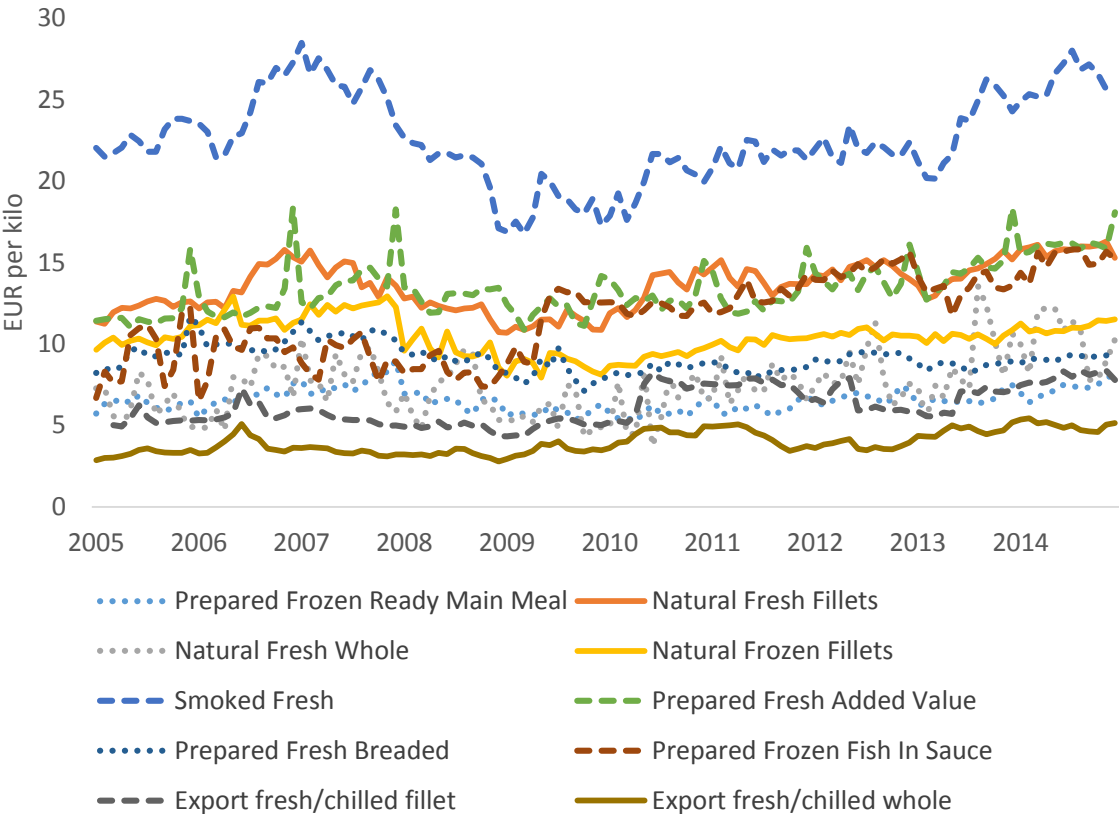


Figure 14. Export prices to and retail price in the UK salmon market

As shown in Table 5, it is the fresh whole retail price that has the highest coefficient of variation in the UK market, just like the French salmon market. However, the price series with the second highest CV is frozen fish in sauce. This is surprising as this type of processed product is not normally one would believe has a higher CV than, say, the export prices of salmon. A visual inspection of figure 14 gives some clues why this value is high. It appears that there is a structural shift upwards during 2009 in the price of frozen fish in sauce that is not directly linked to changes in the Norwegian salmon export price. Thus, prices before and after 2009 will tend

to be lower and higher than the mean inflating the standard deviation. Besides this shift, the price series does not come across as particularly volatile. The two price series with lowest CV is fresh breaded and frozen ready main meal.

Table 5. Descriptive statistics of price series from January 2005 to October 2014.

<i>Variable</i>	<i>Obs.</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Minimum</i>	<i>Maximum</i>	<i>CV</i>
<b><i>Export:</i></b>						
Fresh fillet	120	6.1672	1.1668	4.2766	8.3622	0.189
Fresh whole	120	3.9510	0.6944	2.7945	5.4432	0.176
<b><i>Retail:</i></b>						
Fresh fillet	120	13.587	1.4917	10.703	16.290	0.110
Fresh whole	120	7.5464	1.9506	3.7472	13.561	0.258
Frozen fillet	120	10.392	1.0779	7.933	12.943	0.104
Fresh add value	120	13.441	1.6590	10.874	18.369	0.123
Fresh breaded	120	9.1179	0.8398	7.1212	11.714	0.092
Frozen fish in sauce	120	11.665	2.5286	6.5107	15.819	0.217
Frozen ready main meal	120	6.555	0.6970	5.2664	8.9665	0.106
Smoked fresh	120	22.577	2.7336	16.773	28.501	0.121

Table 6 shows the ADF tests of unit roots for the UK price series. The model formulations of the test is same as for French price series. First, the ADF test is formulated by including only a constant and then both a constant and a trend is included. Also, three differenced lags of the price variable were included initially, before choosing the appropriate lag length. In the ADF model formulations where only a constant is included all price series appears to contain a unit root. This can be seen as the hypothesis of a unit root is not rejected at log-levels of the variables, but is rejected after the series have been differenced. When a trend is included it appears that two of the series are trend stationary, namely, the export price of fresh whole and of fresh value added. The implications of these results is that bivariate cointegration

analysis may be influenced by the Norwegian export price exhibiting evidence of being trend stationary. This must be taken into consideration when we evaluate the cointegration results.

Table 6. Augmented Dickey Fuller unit root test results

<i>Variable</i>	<i>Log</i>	<i>Diff-Log</i>	<i>Log</i>	<i>Diff-Log</i>
	<i>ADF: C</i>	<i>ADF: C</i>	<i>ADF: C &amp; T</i>	<i>ADF: C &amp; T</i>
<b><i>Export:</i></b>				
Fresh fillet	-1.780 (0)	-10.27** (0)	-2.587 (0)	-10.24** (0)
Fresh whole	-2.185 (1)	-6.315** (3)	-3.506* (2)	-6.281** (3)
<b><i>Retail:</i></b>				
Fresh fillet	-1.965 (0)	-11.39** (0)	-2.251 (0)	-11.34** (0)
Fresh whole	-2.674 (2)	-13.38** (1)	-3.040 (2)	-13.31** (1)
Frozen fillet	-1.355 (2)	-12.41** (1)	-1.289 (2)	-12.38** (3)
Fresh breaded	-2.843 (0)	-9.162** (1)	-3.129 (0)	-9.117** (1)
Fresh added value	-2.103 (2)	-8.045** (3)	-5.594** (0)	-8.017** (3)
Frozen in sauce	-1.162 (3)	-10.09** (2)	-2.961 (2)	-10.04** (2)
Frozen ready meal	-1.490 (3)	-9.077** (2)	-1.494 (3)	-7.852** (3)
Smoked fresh	-1.752 (0)	-5.708** (3)	-2.050 (3)	-5.730** (3)

#### 9.4 Price Transmission Analysis of UK Salmon Prices

We now turn to proceed to analyze price transmission in UK in the same manner as for the French salmon market. First, we start with the cointegration analysis where bivariate VAR models are estimated using the Norwegian export price of whole salmon jointly with the retail prices for different salmon products in UK. These results are reported in table 7. All of the ten price series appear to be nonstationary I[1] variables, except that fresh value added and the Norwegian export price for fresh whole show evidence of being trend stationary as pointed out above. Nonetheless, we estimate bivariate VAR models with all of the eight retail prices jointly with Norwegian export price. Of the eight bivariate cointegration tests only three retail prices show evidence of being cointegrated with the export price: fresh fillet, fresh added value, and

frozen fish in sauce. This may explain why several of the estimated price transmission elasticities exhibit magnitudes that do not seem plausible. For example, four of the betas are higher than 1, while two are negative. Also, the law of one price hypothesis is not rejected in all but one bivariate test. This may indicate that the trend stationary property of the Norwegian export price invalidates the cointegration analysis. However, fresh fillet that exhibits the strongest degree of cointegration with the export price, based on the trace test, exhibit results that are more in line with that found in the French market. Although slightly lower, the price transmission of 0.570 is similar to that in France, and the weak exogeneity tests also provide evidence that the Norwegian export price is the price leader. Furthermore, the bivariate model with the fresh whole price indicate that the price transmission is complete from the export price. However, given several counterintuitive results in the cointegration tests that follow after fresh whole we choose to ignore them for now and proceed to results from the ARDL models.

In Table 8 are the results from the ARDL models estimating the price transmission elasticities. Following the empirical approach for the French market, we estimate ARDL models for all retail prices in both levels and first differences. As in the case of France, most of the ARDL models in levels produce higher price transmission elasticities than in first differences. Only the models for fresh whole and fresh breaded price series do not align to this tendency. Before discussing the difference between levels and first difference estimates further, let us start to review the results from the top of the table.

Table 7. Bivariate cointegration tests of the UK market

<i>Export price of whole salmon with retail prices:</i>	$H_0: \text{rank} = P$	<i>Trace Test</i>	<i>Max Test</i>	<i>Law of one price</i>	<i>Weak Exogeneity†</i>	<i>Price Transmission Elasticity (<math>\beta</math>)</i>
Fresh fillet	$k = 0$	20.52**	16.86	3.2887	13.166**	0.570
	$k \leq 1$	3.66	3.66		0.001	
Fresh whole	$k = 0$	25.03**	17.50**	0.184	9.969**	1.178
	$k \leq 1$	7.53**	7.53**		0.013	
Frozen fillet	$k = 0$	12.44	9.89	2.471	2.154	-10.086
	$k \leq 1$	2.55	2.55		5.397*	
Fresh breaded	$k = 0$	15.97*	11.86*	7.744**	5.228*	-0.359
	$k \leq 1$	4.11*	4.11*		3.729	
Fresh added value	$k = 0$	21.28*	18.05	2.081	6.914**	0.599
	$k \leq 1$	3.23	3.23		4.751*	
Frozen fish in sauce	$k = 0$	17.12*	13.55	2.4130	1.784	1.516
	$k \leq 1$	3.58	3.58		7.374	
Frozen ready main meal	$k = 0$	14.23	9.50	0.989	2.346	2.586
	$k \leq 1$	4.73*	4.73*		2.904	
Smoked fresh	$k = 0$	13.83	11.02*	1.497	5.837*	2.744
	$k \leq 1$	2.81	2.81		1.537	

\*\* indicate statistical significance at the 1 percent level and \* at the 5 percent level.

† The first test of weak exogeneity is for the retail price, while the second is for the export price in each of the bivariate VAR models

The price transmission elasticity for fresh fillet in levels is 0.576 and in first difference form 0.348. This is slightly lower than the estimated price transmission for fresh fillet not prepacked in France that are 0.963 in levels and 0.617 in first difference form. The levels estimate, however, is almost identical to the one obtained in the cointegration model in table 7. For fresh whole the price transmission is stronger in UK than in France with an elasticity of 1.202 compared to 0.896 (fresh fillet NPP).

For some price series the differences in results between the levels and first differences are very large. This is for example the case for frozen fillet and fresh smoked. For fresh smoked for example, the price transmission elasticity is 1.050 in levels and 0.394 in first differences. Somewhat counterintuitively, the latter estimate is statistically significant, while the former is not. The lower magnitude price transmission elasticity is more in line with the estimates obtained for fresh smoked in the French market, however. In this respect it makes sense that the inflated elasticity is not statistically significant. Also for frozen fillet the elasticity in levels of 0.851 appears high, while the elasticity in differences of 0.189 is more similar to that obtained for France. Otherwise the results are similar for more processed products as price transmission elasticities are low and not statistically significant. Furthermore, the more value added salmon products in UK the ARDL models in differences indicate low price transmission elasticities from export to retail prices.

Table 8. ARDL models of price transmission from export to retail prices in UK

<i>Export price of whole salmon with retail prices:</i>	<i>Log</i>	<i>AC</i>	<i>Norm</i>	<i>RESET</i>	<i>Difference log</i>	<i>AC</i>	<i>Norm</i>	<i>RESET</i>
Fresh fillet	0.576** (1)	0.687	0.647	0.382	0.348** (6)	0.801	0.884	1.631
Fresh whole	1.089** (4)	2.059	1.596	0.000	1.202** (5)	1.520	1.479	1.189
Frozen fillet	0.851** (3)	0.542	27.426	0.531	0.189 (3)	1.214	22.543**	0.281
Fresh added value	0.533** (6)	1.464	16.101**	0.016	0.035 (12)	0.535	2.785	0.756
Fresh breaded	0.010 (3)	1.329	34.903**	0.104	0.031 (12)	0.861	3.830	0.246
Frozen fish in sauce	0.689 (13)	0.511	0.127	0.510	0.130 (13)	0.632	2.056	3.041
Fresh smoked salmon	1.050 (4)	2.006	0.029	0.269	0.394** (3)	1.684	0.012	2.910
Fresh prepared ready main meal	0.731 (6)	0.511	2.275	0.054	0.145 (12)	1.727	15.833**	1.284

\*\* indicate statistical significance at the 1 percent level and \* at the 5 percent level.

## 10. Discussion

The most general result we can draw from the above analysis is that the price transmission tend to be high from export to retail prices when there is limited additional processing or marketing cost involved at the retail level. Both the French and UK case studies indicate that price transmission from the Norwegian export price of fresh whole to retail price of fresh whole is complete. Most of the estimates for fresh fillet retail prices indicate price transmission elasticities between 0.6 and 0.7, while for fresh steak it is slightly lower in the range of 0.4 and 0.5. This shows that the processing and additional marketing costs involved for fresh fillets and fresh steak reduce price transmission compared to fresh whole.

However, the degree of price transmission decreases further as salmon products become more processed. This is also in line with economic theory since an increasing share of marketing cost relative to the raw material input weakens the price signal from the input to the final retail price. Besides the natural fresh presentation, in particular fresh fillet, fresh smoked is one of the most important salmon products at the retail level. Fresh smoked is also amongst the salmon products that receive the highest price per kilo. Smoked salmon is a value added product where the curing allows the product to be stored for some time. This means that its retail price is probably not affected strongly by short-term volatility in the export price. The model results we consider plausible to consider provide price transmission elasticity ranging from 0.0 to 0.6. Despite of the additional processing involved, salmon is the key input and it is difficult to see the export price not exerting any influence in the long term price formation of smoked salmon. Therefore we believe that the result from the differenced ARDL model for France is too low with a price transmission elasticity of 0.0. Also, the estimated elasticities from the ARDL model in differences appear in several of the cases to be biased downwards. Therefore we believe that the long-term price elasticity belong in the range of 0.4 to 0.6.

Frozen fillets and frozen steaks are two other salmon products that are highly storable. Therefore their prices should also be less influenced by changes in the Norwegian export price



in the short run. The majority of price transmission elasticities in France and UK for these two products are in the range of 0.1 and 0.6. An average of all the estimated elasticities within this range suggest an overall price transmission elasticity of 0.3.

For other value added products, such as ready main meals, frozen fish in sauces, fresh breaded and fresh value added price transmission elasticities range from 0.0 to 0.5 (which is the estimate of largest magnitude that is also statistically significant). In this setting we only evaluate the results from the ARDL models, as the cointegration results for UK produced implausible results for most of these products. When we take the average of the relevant elasticities for these products the overall price transmission elasticity is slightly higher than 0.1. Here we should also consider that several value added products in UK are based on wild-caught pink salmon. Besides the additional marketing costs, the use of a substitute (and cheaper) raw material further weakens the price link with the Norwegian export price for farmed Atlantic salmon. This is basically just saying that as more value added components are added the raw material becomes of less importance in the final price. This concludes the discussion of the overall results of price transmission when comparing the French and UK salmon markets.

However, a further topic that deserves discussion are results for the French market where it was possible to distinguish between retail prices for branded (i.e., prepacked) and private label (i.e., not prepacked) products for natural fresh product categories such as fillet, steak and whole. As we noted, the private label products in general had higher price transmission than the branded products. An explanation that may account for these differences are lower marketing costs for supermarkets' private label products compared to products supplied by seafood producers in France. The descriptive statistics show that the average prices are lower for private label products compared to branded products. This could for example be due to supermarkets' market power when contracting processing services (Guillotreau et al., 2005). An additional explanation could be that a higher share of the salmon raw material is bought by spot prices for

private label products. However, we have no documentation to support such claim. In any case, the private label appears to be part of supermarkets' diversification strategy, reaching out to more price sensitive consumers with lower-priced salmon products. This concludes the discussion and we move on to the final conclusion.

## 11. Conclusion

In this thesis we have analyzed price transmission from Norwegian export prices of fresh salmon to retail prices of consumer salmon products in France and UK. The retail prices are based on monthly household surveys in the two countries. For France the household data spans the period January 2008 to December 2014, while for UK it covers January 2005 to December 2014. The data allow analysis of price transmission on a broader set of consumer salmon products compared to what have been used in earlier studies (Asche et al., 2014; Asche et al., 2007; Guillotreau et al., 2005; Simioni et al., 2013; Tveteras & Asche, 2008). The data set also reflects that the range of salmon products have been expanding over the last decade or so. Moreover, this is the first study that analyzes differences in price transmission between branded products and supermarkets' private label salmon products.

The results from this study show a high degree of price transmission from Norwegian export prices to retail prices of natural fresh products such as fillets, steaks and whole. These products account for almost a third of retail sales in France and almost half in UK when measured in value. For fresh whole salmon price transmission is complete, while for fresh fillet and fresh steak, it ranges from 0.4 to 0.7. Another important product is fresh smoked salmon, which account for a quarter of the sales in UK and nearly half in France. The price transmission elasticities for fresh smoked salmon range between 0.4 and 0.6. Frozen salmon products and other value added salmon products lie in the lower end with price transmissions ranging from 0.0 to 0.6. If we evaluate these latter products groups more narrowly the relevant range is probably more representative around 0.1 to 0.3. Besides these price transmission elasticities, the econometric results from this study suggest that price transmission is higher to private label salmon products than branded salmon products. In summary, the increasing range of salmon products marketed to satisfy the different tastes of consumers reduces transmission from salmon export price to retail prices. Nonetheless, supermarkets' private label products appear to have the opposite effect on price transmission.

Changes in marketing practices or consumer demand may have led to permanent changes in the price margin between exported salmon and the retail product. Thus, a further extension of this study could be to test for structural changes in the price margins during the sample period. To really make sense of such analysis it would be necessary to have additional information for instance about the marketing costs, however. As it stands, this study contributes to quantify the degree of price transmission in salmon value chains in a period when there is an increasing number of consumer salmon products available.

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