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Quadratic Almost Ideal Demand System approach

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Abstract

There is an endangerment of cod stocks in Sweden. It has been found that farmed salmon from aquacultures is a more sustainable alternative to the overfished and endangered cod. In terms of the consumption relationship between salmon and cod, is it complementary or substitutional?

This thesis conducted a consumption analysis on the economic relationship between salmon and cod by Quadratic Almost Ideal Demand System (QUAIDS) approach using data on daily barcode observations from ICA Maxi Nacka, Sweden. The own-price elasticities for salmon and cod showed that the own-price elasticities of fish are negative, implying that both cod and salmon are normal goods for Swedish consumers. This is in line with previous literature and expectations. The hypothesis of salmon being a substitute to cod was rejected as the cross-price elasticities results implied that salmon and cod are complements to each other. There is scarcity of cod demand and substitutions studies that are published. This complication gave this study the possibility to fill a small part of that huge gap of cod studies and contribute with new research on the topic.

Keywords: substitution, complements, demand, cross-price elasticities,

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Abbreviations

AIDS	Almost ideal demand system
LA/AIDS	A linearized almost ideal demand system
QUAIDS	Quadratic almost ideal demand system
PPP	Polluter pay principle

1. Introduction

1.1 Problem Description

Overfishing is a worldwide spread problem and for many years marine scientists have tried to spread awareness about this ongoing catastrophe. Overfishing is harvesting marine life at a rate too high for the marine life to replace themselves. Global leaders are aware of the problem, but as fishing is an important part of most countries' economies, not many efforts have been made to reverse the damage of our oceans. Fish populations have a chance to be restored with better enforcements of laws and governing catches, as well as instituting quotas on how much that is allowed to catch. An increased use of aquaculture, like the farmed Salmon in Norway, could also help (National Geographic, 2022).

Swedish waters are not excluded from the problems of overfishing, and it is one of the reasons that half of the Swedish most important fish stocks have difficulty reproducing, that the structure and function of fish stocks is strongly impaired, as well as the species has become more sensitive to threats such as environmental toxins. In the waters around Sweden, four important cod stocks are highly endangered (Kinell & Kristensson, 2007). cod is a kind of whitefish, and it is Sweden's most important fish species. The lack of substitutes has made the demand for cod become way too high for a fish that is highly endangered, this in turn has increased the price of the Cod. Kinell & Kristensson investigated if Alaskan Pollock and Hoki, which are similar to Cod, could work as substitutes but their research showed that Swedish fish consumers don't see these as substitutes to Cod.

Even though cod is known to be the most important species of Swedish fish, the most economically important fish species in the world is salmon (Asche & Bjørndal, 2011). Salmon is also the most popular fish for consumption in Sweden while cod is the second most popular one (Statista, 2021). Norway supplies up to 55% of the world's salmon consumption, which makes it the biggest and most popular supplier of Salmon. Second is Chile that supplies 25.5% of the Salmon consumption (Tridge, 2022).

Sweden acts as a "trade hub" for Norwegian salmon, and therefore Sweden is ranked third of the top exporters of salmon. This means that Sweden imports salmon from Norway, process it in different ways such as filleting and smoking and then

continues to re-export it within the EU (Seafood, 2012). Sweden's total fish imports consist of 80 percent farmed salmon, from Norwegian aquacultures. 86% of the imported salmon is exported again (Tridge, 2022).

The salmon trade between Sweden and Norway can be explained both by proximity, that the two countries are neighbouring countries. As well as the fact that they have strong economic ties together with common culture which increases chances of successful business ventures significantly. The high export rates of farmed salmon from Sweden are interesting for many reasons. In this research it is interesting as the hypothesis for this research is that farmed salmon could work as a substitute for cod in the Swedish market, and the exports of salmon in Sweden could then reduce, through an implemented policy.

1.2 Aim and objective

The aim of this study is to investigate the consumption relationship between salmon and cod. Researchers have put effort into estimation models for salmon and cod substitutes separately. However, the substitution possibilities between salmon and cod have not been studied from an economic or sustainability point of view. The gap of cod demand and substitution studies is where this study aims to fill in. The objectives of this paper are to: (1) See if farmed salmon could work as a substitute for cod in the Swedish food market, and (2) provide policymakers with useful information to consider when they create new policies for fish.

With attention to the problem description this study seeks to answer the research question:

- *"Is farmed Salmon a complement or substitute for Cod?"*

To answer the research question a Quadratic Almost Ideal Demand System (QUAIDS) is estimated using suitable data transformed into several variables. The model, data and the variables will be explained and discussed in section 4 of this paper. How the specific model was decided upon will be explained under section 3 and 4 as well.

1.3 Disposition

The following of the paper is structured as follows: Section 1 presents the problem description of the topic as well as the aim, objectives, and the research question. Section 2 presents political background and previous literature. In section 3 the theoretical framework as well as a review of AIDS studies, are presented. Section 4 is where the method, data and empirical model is presented. Section 5 presents

the results from the estimations. In section 6 the results are discussed and analysed. Finally in section 7 the conclusions are presented as well as suggestions for further research.

2. Background and literature review

2.1 Political background

Sweden joined the EU in 1995 and since then Sweden is a part of the EU'S common fisheries policy, which obligates Sweden to not have regulations regarding fishing that are contrary to the EU´s provisions. The policy also gives Sweden's fishermen the right to fish in waters of other EU members and land their fish in any port in the EU. Some regulated species have exceptions, such as cod, which is only allowed to be landed in some ports (SOU, 2005).

The objective of the "Common fisheries policy" was to conserve our fish stocks, protect the marine environment, ensure that EU fleets were economically viable as well as providing consumers of high-quality fish products for food consumption.
In 2002 a reform was introduced, the goal of the reform was to sustain and use the aquatic resources in a balanced way environmentally, economically, and socially. The introduced reforms of 2002 were not sufficient to stop overfishing, and a depletion of many fish stocks continued at an even faster pace. In 2013 the EU Commission launched a public consultation on the reform of the 2002: s "Common Fisheries Policy" with the goal to introduce new principles to govern EU fishing activities. The consultation was successful, and a new common fisheries regime was agreed on. The reform aims to ensure that activities in the fisheries and aquaculture sectors are environmentally sustainable in the long term and managed in a proper way following the objectives of achieving economic, social and employment benefits (Breuer, 2022). The reform is especially important for the endangered species such as cod, and it is the EU council of ministers that decide yearly how much fish that is allowed to be fished by the endangered and regulated species, this policy is called "Total allowable catches" (TAC) (SOU, 2005).

Since 1997, Swedish quotas have fallen every year throughout the spring investigation period. In 2007, the Swedish quota was only 28% of what it was 10 years earlier. Thus, fishing in the EU is not free and is regulated by quotas for several fish species, such as cod. The consequence of the quotas is a smaller supply of fish which results in a higher price. The EU has laid a price floor for the fish, to be able to stabilize the market and guarantee the fishermen a decent income and

give them a better negotiating position at sale of the catch. This does not affect the cod price so much as the cod price is and has been high for a long time due to the low stock levels (Fiskeriverket, 2002). However, the price is not high for the sake of cod being endangered, but for the fact that it is harder for the fishermen to find and catch smaller populations of fish.

While reviewing the political background of fish I realize that the implemented reforms has not been enough for getting more healthy cod stocks. This thesis will hopefully give some direction on how to deal with the cod stocks problems.

2.2 Literature Review of Salmon Consumption

This section of the study is providing a summary of earlier research on the topic of fish demand and substitute studies. The function is to provide a deeper background to the importance of this study. The studies presented has a focus on one of two strands (1) related to consumer fish and seafood demand (2) fish substitution and elasticities

For a long time, the demand for salmon in the fish market has been studied. In recent years the focus has mainly been on the farmed salmon according to Xie et al. (2009) and Xie & Myrland, (2011). Farmed salmon in aquacultures is one of the most successful species with production growing at a faster rate than aquacultures in general. Asche (1997) argues that increases in productivity was the most important factor for this growth. However, in the last decade the Vassdal & Holst (2011) has found that productivity growth has slowed down. Asche et al. (2011) argues that productivity and demand growth of salmon has been equally important to be able to explain the production increases of the salmon aquacultures since the end of 1990s.

In the traditional way, demand analysis normally focuses on price sensitivity of demand and the degree of substitution between competing products as well as on income or expenditure effects using the elasticity concept. The literature review of several demand studies that are related to fish, or seafood provided by Asche, Bjørndal, and Gordon (2005) found that whitefish species has an own-price elasticity about -1 or more elastic. Their paper also states that the own-price elasticity for Salmon used to be highly elastic. However, the trend since 1990s is different, researchers such as Asche et al., (1996 & 1998), Bjørndal, Salvanes, & Andreassen (1992) and Devoretz & Salvanes, (1993) has found that Salmon demand is now less price elastic than it used to be. According to Xie et al. (2009) recent research has proved that world demand for salmon is becoming even less price elastic.

Frank Asche, Trond Bjørndal and Kjell G. Salvanes (1997) argues that the substitution relationship between the different Salmon products is important when it comes to market power questions in the EU and when the effects of trade restrictions are discussed. Especially as there have been several attempts to stabilize the price of fresh Salmon by implementing a minimum price on imports to the EU and by controlling supply. Their study also investigates the importance of product form and origin in the European salmon market. The product forms fresh and frozen are relevant for their study, as they are the most important product forms imported to the European Union. This is one of the reasons this paper also chose to use only fresh or frozen salmon and cod products. Their study utilizes the AIDS model, in line with many other fish and seafood demand studies, to estimate their demand equations.

The review of the existing literature has shown that dense literature on salmon demand exists but on the other hand the literature on cod demand is almost non-existent. Therefore, this review is focusing mainly on salmon demand and substitution. The lack of cod demand and substitutions studies that are published is interesting and gives this study the possibility to fill a small part of that huge gap of cod studies. There are a few bachelor studies on the topic of cod, which also inspired this study to investigate cod demand and substitute. One of those studies will be presented under the method section “3.2 Review of AIDS studies” part of this paper.

3. Theoretical framework

This section of the study describes the theory used to understand and interpret the estimations. The first section will present the theoretical framework, and the second section will present a review of AIDS studies used to be able to choose a proper model to use to estimate the results.

3.1 Demand Theory

"Supply equals demand" is one of the most important things to know about economics. A commonly known model of econometricians is the supply-and-demand model that describes how consumers and suppliers interact to decide the price and quantity of a good sold in a market.

To use the model, you need to know (1) consumers behavior, (2) suppliers' behavior and (3) their interaction with each other. Consumers decide how much of a good to buy according to the price, their own taste, information, income, government actions as well as other factors. The prices of other goods also affect consumers' purchase decisions. Before deciding to buy a good (1) the consumer might check the price of similar good (2), if the price is much lower on a good (2) that is similar to the good (1) that the consumer is considering purchasing, the consumer might buy the cheaper good (2) instead. This kind of goods are called substitutes. Similarly, the price of a good (1) that the consumer consumes together with the good (2) that the consumer is considering buying - may affect the consumer decision. This kind of good is called complements (Perloff, 2012). It is important to understand this concept for this study as I am trying to investigate if salmon and cod are substitutes or complements to each other.

3.2 Elasticity

Elasticity and inelasticity of demand refer to the degree to which the demand responds to a change in another economic factor, price, income level or substitute availability. Elasticity measures how demand shifts when other economic factors change. When fluctuating demand is unrelated to an economic factor, it is called inelastic and if it is related to an economic factor, it is called elastic. Price is the

most common factor used when determining elasticity or inelasticity and is the economic factor that is important for this paper. Cross-price elasticity of demand is the percentage change in the quantity demanded in response to a given percentage change in the price of another good.

$$\frac{\%\ change\ in\ quantity\ demanded}{\%\ change\ in\ price\ of\ another\ good} = \frac{\Delta Q}{\Delta Po}\frac{/Q}{/Po} = \frac{\Delta Q}{\Delta Po} * \frac{Po}{Q}$$

When the cross-price elasticity is negative, the goods are complements. So, if the cross-price elasticity is negative between the two goods, the consumer will buy less from good (1) when the price of good (2) increases. If the cross- price elasticity is positive the goods are substitutes, this suggests that when the price of good (2) increases the consumer will buy more of good (1). When making business and policy- decisions, cross-price elasticity is important (Perloff, 2012). Cross-price elasticity is the focus in this paper, to be able to measure if salmon and cod are substitutes or complements.

3.3 Normal good and collective commodities

Normal good is a good that has an increase in its demand when there is a rise in the consumers' income. This means that when the wages of the consumers increase the demand for the normal goods also increases, and when the wage decreases the demand also decreases (Kenton, 2020). This is simple economic theory and will be interesting when analyzing the results in the results section of this paper.
Salmon and cod goes under the group fish and seafood. Fish and seafood is a semi-collective commodity, which means that it is not exclusive but rival (Axelsson et al. (1992).

Not exclusive means that everyone has the right to catch fish, rival means that the fish that one consumer is consuming, another person can't consume. Collective commodity means that it is under collective ownership, which means that not one person or company is owning the fish in the seas/lakes in the EU, due to a non-defined ownership. This becomes a problem as it creates an inadequate pricing system. Especially for the vulnerable cod, as the cod price does not reflect the availability of the species. The price of the cod only reflects the capital, labour input of the fishermen and not the real value of cod. This can and has resulted in the "tragedy of the commons" which is a situation in which individuals that shares access to a shared access (here; cod) act in their own interest which leads to depletion of the resource (McDowell et al. 2006). This is not an economical or sustainable way to fish.

3.4 Review of AIDS Studies

This section of the paper reviews studies that have utilized the LA/AIDS, QUAIDS and AIDS system. This in order to choose the best fitting model to use for this study's analysis. The review goes beyond published journal papers, looking at both bachelor and master thesis from different students and Universities. I decided to also review studies with different products other than studies that are only fish related. A sample of the three most interesting papers that was reviewed is presented here.

Yulia Pyanchenkova (2017), a former master student in the Arctic University of Norway, investigated why the Salmon prices has increased. Her research has shown that in France, Salmon faces less competition from other fish and seafood products. The study has shown that Norwegian farmed salmon is a better substitute for whitefish, Scottish Salmon, and Chilean Salmon than vice versa. She has also found that the consumers in France find it hard to substitute the demand for Norwegian Salmon. These factors increase the price of the Norwegian Salmon significantly. However, Salmon from all major supply sources is becoming less expenditure elastic over time. This result is logical due to the finding that French consumers usually consider Salmon to be more suitable for everyday meals, and salmon is becoming a central part of the regular diet. This contributes to the increasing Salmon demand which in turn increases the Salmon prices. Pyanchenkova mainly used the Almost Ideal Demand System (AIDS) model to receive the earlier mentioned result.

Christopher Jahn (2015), a former bachelor student at Uppsala University, investigated the relationship between the European Union mainland's import of different product forms of cod. His results have shown that almost all the product forms are substitutes with each other except for fresh and dried cod, which are complements. Jahn used a Linearized Almost Ideal Demand System (LA-AIDS) to analyze the demand for fresh, frozen, clip, salt and dried cod using a data set from 1988-2014. Another interesting part of his paper is that he found very few studies on the demand for different product forms of cod, a complication that this study also faced when looking for cod demand studies.

Hanna Lindström (2021), investigates the consumer demand for organic and conventional milk. Even though the study has nothing to do with fish the study is still interesting for two reasons – the chosen model and the data source. The results from the uncompensated ownprice and cross-price elasticities show that demand for organic milk is relatively elastic and that the demand for branded products is less elastic compared to private label products. This was interpreted as consumers probably has strong preferences for traditional and regional brands. Lindström used weekly scanner data from the Swedish retail market for the years 2011–2017. The

study estimated own- and cross-price elasticities of demand by using a quadratic almost ideal demand system.

This review of the existing literature that uses different AIDS models has given the realization that most recent studies adopted the LA/AIDS and AIDS model, for instance Yulia Pyanchenkova (2017) used the AIDS model and Christopher Jahn (2015) used LA/AIDS model among others. However, Lindström (2012) used the QUAIDS model, and her paper is similar to what this paper is trying to investigate. She, in line with this paper, utilizes data on barcode level to estimate own- and cross-price elasticities. The main difference between her and this study is that she investigates goods in another product form. I also considered the shortcomings of those studies, and therefore this study decided to use the QUAIDS model as an empirical strategy of estimation based on its advantages that will be discussed in the 4th section of this paper.

4. Method, Data, and empirical model

This section of the study presents the method, data, and empirical model. The first section specifies the type of data, sources, and used variables. The second section presents the empirical model and how it is used to estimate the results.

4.1 Data

Swedish retail data on fish and seafood products was provided to this study by Sarah Säll, researcher at the Swedish University of Agricultural Sciences. Säll sourced the data from ICA Maxi Nacka in Stockholm, Sweden. The data contains of daily purchase data on barcode level observations of different fish/seafood species in frozen and fresh product form. It contains of 21 804 observations of fish/seafood products. The data cover the period from 2nd December 2020 to 31st March 2021. The data is collected from a large sample from the store, intended to provide an accurate representation of the market.

The dataset contains of information on specie, country of catch, date, product group, product name, quantity of sold fish/seafood product, kilo per packaging, kilos sold fish/seafood product, value total on sold fish/seafood product and kilo price in SEK. The fish/seafood products originate from different supply sources such as Norway, Sweden, Island, France, Germany, Netherlands, China, Canada, Alaska, Brazil, United Kingdom (UK), and the Rest of the World (ROW). It is important to understand that most of the salmon that is sold in Swedish markets originates from aquacultures in Norway. Therefore, this study aggregates the Salmon from different supply sources into one single category as "Farmed Salmon" in this study. The cod endangerment is not tied only to Sweden. It is endangered in other places in the world as well, which is why it was decided in this study that cod products from different supply sources to be aggregated into one category "Cod". The rest of the fish/seafood specie products are aggregated into the last category "Other fish & seafood". The different species included in the category "Other fish & seafood" can be located under "Appendix 1" further down this paper.

The data had to be modified to fit the model. That's why quantity of sold fish/seafood product, kilo per packaging, kilos sold fish/seafood product, value total on sold fish/seafood product and quantity in kilos is summarized to have only one observation per category and day. The mean of kilo price in SEK of fish/seafood

products was calculated for the same reason, to only have one observation per category and day.

To retrieve the variables needed for this study, budget shares for each category “Cod”, “Farmed Salmon”, “Other fish & seafood”, as well as total expenditure on all fish and seafood products had to be calculated from the data. Kilo price for each category was also calculated, as mentioned earlier, calculating the mean of the kilo price for each category “Cod”, “Salmon”, “Other fish & seafood”. The variable name and definition can be found under “Table 2. Variables”.

4.1.1 Table 1. Variables

Table 1 Variables

Variable	Definition
BSC	Budget share for Cod products
BSS	Budget share for Salmon products
BSO	Budget share for other fish/seafood products
Kiloprice 1	The mean price in Kilo for Cod products
Kiloprice 2	The mean price in Kilo for Salmon products
Kiloprice 3	The mean price in Kilo for other fish/seafood products
Totalfishexp	The total expenditure on all fish/seafood products

4.1.2 Limitations

The present study is limited to frozen and fresh salmon, cod, and other fish/seafood species products. Other fish products such as breaded, smoked, or cooked fish are therefore excluded from this study's analysis, in accordance with studies in the previous literature section.

4.2 Empirical model

This study utilizes, in line with much of earlier literature, an Almost Ideal Demand System (AIDS) to estimate own- and cross-price elasticities of demand for Salmon and Cod. The AIDS system was developed by Deaton and Muellbauer (1980). The AIDS model has been proved to be a better choice in demand analysis than the Rotterdam and translog models as it aggregates perfectly over consumers without invoking parallel linear Engel curves and that it has a functional form which is consistent with known household-budget data. This makes the model simple to estimate. It also avoids the need for nonlinear estimation, which makes it possible to use it to test the restrictions of homogeneity and symmetry through linear

restrictions on fixed parameters. These advantages can be provided with the other models separately, but the AIDS model possesses all of them simultaneously (Deaton & Muelbauer, 1989).

This study chose to extend the AIDS model and use the Quadratic Almost Ideal Demand System (QUAIDS). QUAIDS is an extension of the AIDS model and was first introduced by James Banks, Richard Bundell and Arthur Lewbel (1997) in their paper "Quadratic Engel Curves and Consumer Demand". They found that there exists a polynomial relationship between supernumerary income and some goods. This is important due to budget share equations given by the AIDS model only allow for straight Engel curves. The authors suggest including an additional term which is quadratic in supernumerary income which further fleshes out the income expansion paths of any consumer demand.

4.2.1 QUAIDS Equation and Theoretical Restrictions

In QUAIDS, the budget share wi^h on good i = 1,...,N for household h = 1,...,H with log total-expenditure x^h and the log price N-vector p^h is obtained by the expression

$$w_i{}^h = \alpha_i + \gamma_i{}'\mathrm{p}^{\mathrm{h}} + \beta_i \{\mathrm{x}^{\mathrm{h}} - \mathrm{a}(\mathrm{p}^{\mathrm{h}}, \theta)\} + \lambda_i \frac{\{x^h - a\,(p^h, \theta)\}^2}{b(p^h, \theta)} + u_i{}^h$$

With the nonlinear price aggregators

$$a\,(p^h, \theta) = \alpha 0 + \alpha' \mathrm{p}^{\mathrm{h}} + \frac{1}{2}\mathrm{p}^{\mathrm{h}'}\,\Gamma \mathrm{p}^{\mathrm{h}}$$
$$a\,(p^h, \theta) = \exp\,(\beta' p^h)$$

Where a = $(a_1,\ldots,a_N)$', β = $(\beta_1,\ldots, \beta_N)$', Γ = $(\gamma_1,\ldots, \gamma_N)$, θ is the set of all parameters, and u_i^h is an error term. The parameters mentioned is required to satisfy three sets of theoretical restrictions: (1) all must summarize to zero over all equations. The constant term though, must summarize to one (additivity) (2) log price-parameters must summarize to zero within every equation (homogeneity) (3) the effect of log price i on budget share j must equal the effect of log price j on budget share i (symmetry)

The additivity constraint is satisfied mechanically in the demand model. The homogenous and symmetry constraints need to be tested and imposed.

In this model households' heterogeneity enters the demand system through the α's, that are modelled as linear combinations of a set of sociodemographic variables (s^h) observed in the data

$$a^h = A_s^h, \qquad A = (a_i{}')$$

This approach is called translating and allows the level of demand to depend upon demographic variables. This approach is more restrictive than the scaling approach used by Poi (2012), which allows the slope of total expenditure terms to depend upon demographic variables, the conditional linearity of the model is preserved by it (Lecocq, S., Robin, J-M., 2015).

4.3 Estimating the QUAIDS model

The econometric software STATA16 is used for the estimations. The QUAIDS model is estimated using the command aidsills developed by Sebastien Lecocq and Jean-Marc Robin (2015) for the Stata journal. The aidsills command is used for estimating AIDS and the QUAIDS extension. The aidsills command was chosen over nslur (Poi, 2008) and quaids (Poi, 2012) commands as it can test and control for the potential endogeneity of prices and total expenditure and with it the estimation is performed using linear techniques. Other advantages of aidsills over nslur and quaids are that it allows to fit unconstrained, homogeneity constrained, or homogeneity and symmetry constrained models, and it is possible to test whether these theoretical restrictions hold. However, aidsills does not provide the option of the post command vce() that is available with the quaids command. Eventually, expenditure and price (both uncompensated and compensated) is obtained using the postestimation command aidsills_elas. The command does not compute elasticities for individual observations, this is something that the quaids vce() command can compute. However, aidsills can compute elasticities at the mean point of a user defined sample with their standard errors.

After importing the data to STATA16 and aggregating it as well as modifying it as described in 4.1 the variables was run through the earlier described aidsills command to retrieve the results, the command is showed here:

```
aidsills (w0-w2), price (kilopris0, kilopris1, kilopris2) expenditure (totalfishexp) quadratic
```

After running aidsills, the postestimation command aidsills_elas gives the predicted shares, budget, and price elasticities with their standard errors. The results from the estimation such as the unconditional and conditional cross-price elasticities between the different categories “Farmed Salmon” “Cod” and “Other fish & seafood” will presented under section 5. “Results”.

5. Results

In this section of the study the results of the estimation model are presented.

5.1 Quadratic AIDS regression estimates

Table 2 General statistics

Equation	Obs.	Parameters	RMSE	"R-sq"	F(5, 237)	Prob > F
Cod budget share	243	5	.058	0.376	28.57	0.000
Salmon budget share	243	5	.103	0.289	19.28	0.000
Other fish/seafood budget share	243	5	.116	0.402	31.83	0.000

Table 3 QUAIDS estimations

	Coef.	Std. Err.	Z	P>|z|	[95% conf.	Interval]
Cod budget share						
ln.Cod Kiloprice	-.298***	.083	-3.60	0.000	-.456	-.136
ln.Salm Kiloprice	-.627***	-.101	-6.23	0.000	-.825	-.430
ln.o. f/s Kiloprice	.686***	.112	6.15	0.000	.467	.904
lnTot. Exp.1	-.212***	.070	-3.03	0.002	-.349	-.075
lnTot. Exp.2	.013	.008	1.60	0.110	-.003	0.0299
constant	2.394***	.457	5.24	0.000	1.499	3.289
Salm. Budget share						
ln.Cod Kiloprice	-.135	.091	-1.48	0.139	-.313	0.438
ln.Salm Kiloprice	-.710***	.117	-6.09	0.000	-.940	-.482
ln.o. f/s Kiloprice	-.356**	.134	-2.65	0.008	-.620	-.0927
lnTot. Exp.1	.137	.114	1.20	0.230	-.086	.361
lnTot. Exp.2	-.016	.014	-1.16	0.248	-0.441	.011
constant	6.992***	.847	8.26	0.000	5.332	8.652

O. f/s budget share						
ln.Cod Kiloprice	.432**	.103	4.20	0.000	.231	.635
ln.Salm Kiloprice	1.338**	.156	8.60	0.000	1.033	1.643
ln.o. f/s Kiloprice	-.330**	.157	-2.10	0.036	-.638	-.0217
lnTot. Exp.1	.075	.131	0.57	0.568	-.182	.332
lnTot. Exp.2	.003	.0159	0.18	0.854	-.028	.0342
constant	-8.387***	.907	-9.25	0.000	-10.164	-6.608

5.1.1 Discussing the quaids estimations

Table 2. shows the general statistics for each equation. Table 3. gives estimates for each of the fish categories budget shares. Each budget share equation for each specie has one dependent value which are: cod budget share, salmon budget share and other fish/seafood budget share.

Table 3. also gives the detailed parameters of the estimations. The coefficients, standard errors, Z scores, P values and the 95% confidence intervals. The independent values include for each budget share equation the lnCod kilo price, the lnSalmon kilo price, the lnother fish/seafood kilo price and the log of total fish expenditure terms:

$$lnTotal\ Expenditure1 = (lnx1) - a$$
$$lnTotal\ Expenditure2 = (lnx2)/b(*)$$

The last row of each budget share equation is the constant. The constant for each dependent variable is significant and it indicates if all the explanatory variables included in the model are zero then the value of the dependent variable will be equal to the constant term.

The interesting part of table 3. are the significant independent variables. Their significance is interpreted from their low p-value (should be lower than 0.05). For the first equation, where the dependent variable is cod budget share, five out of the six variables are significant and has a relation to the dependent variable. The first significant variable is ln.Cod Kiloprice and the coefficient tells us that when cod budget share increases with one unit the cod Kiloprice decreases with -0.298. ln.Salmon Kiloprice decreases with -0.627. ln.Other fish/seafood Kiloprice increases with 0.686. lnTot. Expenditure.1 decreases with -0.212.

For the second equation, where the dependent variable is salmon budget share, three out of the six variables are significant. The first significant variable is ln.Salmon Kiloprice and the coefficient tells us that when Salmon budget share increases with one unit the salmon Kiloprice decreases with -0.627. ln.Other fish/seafood Kiloprice decreases with -0.356.

For the last equation, where the dependent variable is other fish/seafood budget share, three out of the six variables are significant. The first significant variable is ln.Cod Kiloprice and the coefficient tells us that when other fish/seafood budget share increases with one unit the cod Kiloprice increases with 0.432. ln.Salmon Kiloprice increases with 1.338.

The fact that some of the independent variables show to not to be significant to their dependent variable in the equations makes the model less reliable. These results are presented but will not be discussed further as the focus in this study is the elasticity estimates in section 5.2.

5.2 Elasticity estimates

Table 4 Uncompensated cross-price elasticities

	Cod Kiloprice	Salmon Kiloprice	Other fish/seafood Kiloprice
Cod budget share	-1.484*** (0.205)	-1.775*** (0.373)	1.322*** (0.275)
Salmon budget share	-0.400*** (0.123)	-2.353*** (0.225)	-0.633*** (0.164)
Other fish/seafood budget share	0.883*** (0.219)	3.059*** (0.390)	-0.715** (0.289)

*p<0.1, **p<0.05, ***p<0.01

Table 5 Compensated cross-price elasticities

	Cod Kiloprice	Salmon Kiloprice	Other fish/seafood Kiloprice
Cod budget share	-1.415*** (0.205)	-1.571*** (0.371)	1.452*** (0.267)
Salmon budget share	-0.227*** (0.123)	-1.844*** (0.224)	-o.307* (0.159)
Other fish/seafood budget share	1.107*** (0.219)	3.718*** (0.386)	-0.293 (0.281)

*p<0.1, **p<0.05, ***p<0.01

5.2.1 Discussing the elasticity estimate results

The elasticity estimates indicate that the compensated (Hicksian) price elasticities are smaller in value and significance level, but not significantly different from the uncompensated (Marshallian) price elasticities. In line with previous literature such as Lindström (2021), the analysis will focus on uncompensated price elasticities of demand. Own- and cross-price elasticities for each product category are presented in Table 4. Own-price elasticities are found on the diagonal and represent the percentage change in demand for a product given a 1% change in the product's price. They are all statistically significant and negative, implying that Swedish consumers are price sensitive to all three categories of fish. Demand is the least price elastic for "other fish/seafood" (-0.715), followed by cod (-1.484) and demand is the most price elastic for salmon (-2.353). Salmon being the most price elastic goes against the trend since 1990 that researchers such as Asche et al., (1996 & 1998), Bjørndal, Salvanes, & Andreassen (1992) and Devoretz & Salvanes, (1993) found that Salmon demand is now less price elastic than it used to be. Xie et al. (2009) recent research has also proved that world demand for salmon is becoming even less price elastic. The fact that salmon is quite price elastic in this study can be due to the data coming only from one food store in a certain area, the results might be different including data from other food stores from other parts of the country. However, an elasticity around −1 or lower for whitefish is in line with previous literature and expectations such as Asche, Bjørndal, and Gordon (2005). The result that the own price elasticity is negative for each fish category is also satisfactory as it follows the economic theory of fish being normal goods.

The hypothesis of this paper was that salmon could work as a substitute for cod. This was tested through the QUAIDS elasticity estimation, and the hypothesis was rejected as the results shows that salmon and cod are complements to each other.

-1.775 is the percent change of quantity demanded of cod when there is a percent change in the price of Salmon. As the value is negative this means that salmon is a complement to cod. -0.400 is the percent change of quantity demanded of salmon when there is a percent change in the price of cod. Here the value is negative again, cod therefore a complement to salmon. However, when Salmon is a complement to cod the elasticity is more sensitive (-1.775) than when cod is a complement to salmon (-0.400), this implies that the demand of salmon as a complement to cod is more price sensitive than the demand of cod as a complement to salmon. This is interpreted as costumers will purchase more cod when the price of salmon is cheaper, but they will purchase less cod when the salmon is more expensive.

Furthermore, the results show that other fish & seafood is a substitute for cod (1.322) and vice versa (0.883). This is interesting as it implicates that included in the category of "other fish & seafood" there is fish and seafood species that could be considered substitutes to cod. In a further analysis where the other fish & seafood are divided in more proper categories, the exact specie or species that are considered

a substitute to cod could be identified. Other fish/seafood is a complement to salmon (-0.633) and salmon is a substitute to other fish/seafood (3.059). The results that cover the category of "other fish & seafood" is important to interpret with caution as the category "other fish &seafood" includes many different species of fish and seafood (see appendix 1) and doesn't show the actuality for each species included individually.

6. Discussion

In this section of the study the estimation results legitimacy is discussed, and policy implications mentioned.

The results from this study indicate that fish and seafood are elastic goods and that the demand of fish and seafood will decrease relative to a hypothetical price increase. This implies that a tax on cod will have a relatively immense effect on the demand for cod. Taxation is the imposition of compulsory levies on individuals or entities by the government in Sweden. It allows policy makers to hold on to the polluter pay principle (PPP) (Cox, et al. 2022) and could force fish fleets and aquacultures to pay the negative external effects that are related to farmed fish and fishing. Furthermore, taxes are used to control consumers behaviour, in this study the implication would be to push consumers to purchase farmed salmon, or other farmed fish instead of the wild- caught cod. The taxation could also be used to increase the governmental income to enable investments/subsidies to more aquacultures. A recent study from the United Nations (UN) has shown that the use of aquaculture can improve food security and nutrition by increasing the amount of seafood available for humans to eat. If maintained correctly, aquaculture can increase food production, boost economic growth in rural as well as coastal areas, while keeping the waterways clean and the fish stocks healthy (Fisheries, 2021).

However, it is important to interpret this study's results with caution since the data is retrieved from only one store in a certain area, it is possible that consumers from that market could have different preferences than consumers from other parts of Sweden. It is also important to keep in mind that the data is daily data over a few months, and it does not cover the summer months of the year. Including data from the summer months could possibly change the results, as would expanding the data to cover a full, or more years. This is an idea for further research.

Throughout this study the intention was to extend the analysis and create more fish categories out of the "other fish/seafood" category. Keeping the different species in separate categories instead of aggregating them into one category. By doing so it would be possible to show the cross-price elasticities between several fish and seafood products. This is especially interesting for this study's advancement as the category "other fish & seafood" is according to the estimations, a substitute to cod. Extending the analysis could help finding the exact specie or

species that are substitute to cod. Due to limitations in time and resources, this study had to focus on only estimating cross-price and own price elasticities of salmon and cod. However, a more expanded QUAIDS system including other species is an interesting approach which could be relevant for further studies.

7. Conclusion

In this section of the study the conclusions are presented as well as suggestions for further research. The aim of this study is to investigate the consumption relationship between salmon and cod for Swedish consumers for daily meals.

The aim of this study is to contribute to the literature of Cod demand studies with estimations of cross-price elasticities between salmon and cod. The estimations are used to investigate the consumption relationship between salmon and cod for Swedish consumers for daily meals. It answers the research question - *"Is farmed Salmon a complement or substitute for Cod?"* The objectives were to (1) See if farmed Salmon could work as a substitute for Cod in the Swedish food market, and (2) provide policymakers with useful information to consider when they create new policies for fish has also been considered. A QUAIDS analysis with data on barcode level has been used for estimations. Data was retrieved from ICA Maxi Nacka in Stockholm, Sweden. The analysed period covers 2nd December 2020 to 31st March 2021. The QUAIDS was developed using Stata16 with the command aidsills and seven different variables that are mentioned in section 4.1.1. The results show that salmon and cod are complements to each other. However, when Salmon is a complement to cod the cross-price elasticity is more sensitive (-1.775) than when cod is a complement to salmon (-0.400), this implies that the demand of salmon as a complement to cod is more price sensitive than the demand of cod as a complement to salmon. The results do not support the hypothesis of this study, that farmed salmon could work as a substitute to cod in the Swedish market. However, this study is only for a few months and can be considered "short run". The own price- and cross-price elasticity might indicate different results over a longer time. Another thing to consider is that an immense number of fish species are aggregated into one category "other fish/seafood" products, which could be sorted into more proper categories.

Lastly it would be interesting to compare this study's results and data with other analysis over fish species data in other food markets in different parts of Sweden, which would maybe give more significant variables for the quaids estimation, this, and considering the other mentioned shortcoming of this study, would maybe give other and more appropriate results in a more developed analysis.

References

Asche, F. (1996). A system approach to the demand for salmon in the European Union. Applied Economics, 28(1), 97-101. doi:10.1080/00036849600000012

Asche, F., Bjørndal, T., & Salvanes, K. G. (1997). The Demand for Salmon in the European Union: The Importance of Product Form and Origin. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 46(1), 69-81. doi:10.1111/j.1744-7976. 1998.tb00082.x

Asche, F. (1997) Trade disputes and productivity gains: the curse of farmed salmon production? *Marine Resource Economics*, 12, 67 – 73.

Asche, F., Bjørndal, T., & Salvanes, K. G. (1998). The Demand for Salmon in the European Union: The Importance of Product Form and Origin. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 46(1), 69-81. doi:10.1111/j.1744-7976. 1998.tb00082.x

Asche, F., Bjørndal, T., & Gordon, D. V. (2005). *Demand structure for fish Working paper* (SNF: Samfunns- og næringslivsforskning), Vol. no. 37/05.

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

Asche, F., R.E. Dahl, D.V. Gordon, T. Trollvik,& P. Aandahl (2011) Demand growth for salmon in the European market. *Marine Resource Economics*, 26, 255–265.

Axelsson R., Holmlund B., Jacobsson R., Löfgren K-G., Puu T. (1992), Resursfördelningsteori, Studentlitteratur, Lund

Banks, J., Blundell, R., Lewbel, A. (1997) *Quadratic Engel Curves and Consumer Demand. The Review of Economics and Statistics*. Journal of business. President and Fellows of Harvard College and the Massachusetts Institute of Technology 79 (4): 527–539. https://doi.org/10.1162/003465397557015

Bjørndal, T., Salvanes, K. G., & Andreassen, J. H. (1992). The demand for salmon in France: the effects of marketing and structural change. Applied Economics, 24(9), 1027–1034. doi:10.1080/00036849200000080

Breuer, M. E. G. (2022) Den gemensamma fiskeripolitiken: ursprung och utveckling. Faktablad om Europeiska unionen | Europaparlamentet

Cox, M. S., Neumark F., McLure, C. E. (2022) Taxation. taxation - The benefit principle | Britannica

Deaton, A. Muellbauer J. (1980) An Almost Ideal Demand System The American Economic Review, Jun., 1980, Vol. 70, No. 3 (Jun., 1980), pp. 312- 326 Published by: American Economic Association https://www.jstor.org/stable/1805222

Devoretz, D. J., & Salvanes, K. G. (1993). Market Structure for Farmed Salmon. American Journal of Agricultural Economics, 75(1), 227-233. doi:10.2307/1242971

Fisheries (2021) Aquacultures supports a sustainable earth. Aquaculture Supports a Sustainable Earth | NOAA Fisheries

Fiskeriverket (2002), Utvärdering av återtagssystemet http://www.fiskeriverket.se/download/18.1e7cbf241100bb6ff0b80001750/utv_atertagssyst.pdf

Jahn, C. (2015) Analysis of demand for cod in EU mainland; An investigation of the demand for different product forms of cod. The Arctic University of Norway, Master thesis.

Kenton, W. (2020) Normal good. Investopedia. https://www.investopedia.com/terms/n/normal-good.asp

Kinell, G., Kristensson, J. (2007) Torsk på fisk – att ersätta en resurs Uppsala universitet, Humanistisk-samhällsvetenskapliga vetenskapsområdet, Samhällsvetenskapliga fakulteten, Nationalekonomiska institutionen.

Lindström, H. (2021) *The Swedish consumer market for organic and conventional milk: A demand system analysis.* Department of Economics, Umeå University, Sweden. Agribusiness published by Wiley Periodicals LLC.

Lecocq, S., Robin, J-M. (2015) Estimating almost-ideal demand systems with endogenous regressors. Stata journal: 2, pp. 554–573

McDowell M., Rodney T., Robert F., Ben B. (2006), Principles of microeconomics, McGraw Hill Education, Maidenhead

National Geographic (2022) *How overfishing threatens the world's oceans* — and why it could end in catastrophe https://www.nationalgeographic.com/environment/article/critical-issues-overfishing

Perloff, J. M. (2012). Microeconomics / Jeffrey Perloff- 6th edition. p. cm. Includes bibliographical references and index. ISBN 978-0-13-139263-2 (alk. paper) 1. Microeconomics. I. Title. HB172.P39 2012338.5—dc22

Poi, B. P. (2008) Demand-system estimation: Update. Stata Journal 8: 554–556:

Poi, B. P. (2012) Easy demand-system estimation with quaids. Stata Journal 12: 433–446

Pyanchenkova, Y. (2017) Analysis of import demand and consumption of salmon in France. Discovering the reasons behind the increasing salmon prices. The arctic University of Norway, Master Thesis.

Seafoods, A. (2012). Industry handbook The White fish industry 2012. Processing (pp. 1–65).

Statista (2022) *Which type of fish or seafood have you purchased most?* https://www.statista.com/statistics/809485/survey-on-most-purchased-fish-and-seafood-species-in-sweden/

SOU 2005:27 (2005), Den svenska fiskerikontrollen – en utvärdering, Edita Nordstedts tryckeri, Stockholm

Tridge (2022) *Salmon global export.* https://www.tridge.com/intelligences/atlantic-salmon/export

Vassdal, T. & H.M.S. Holst (2011) Technical progress and regress in Norwegian salmon farming: a Malmquist index approach. *Marine Resource Economics*, 26, 329 – 342.

Xie, J., Kinnucan, H. W., & Myrland, Ø. (2009). Demand elasticities for farmed salmon in world trade. European Review of Agricultural Economics, 36(3), 425-445. doi:10.1093/erae/jbp028

Xie, J., H.W. Kinnucan., & Ø. Myrland (2009) The effects of exchange rates on export prices of farmed salmon. *Marine Resource Economics*, 23 (4), 439 – 457.

Xie, J. & Ø. Myrland (2011) Consistent aggregation in fish demand: a study of French salmon demand. *Marine Resource Economics* 26, 267 – 280

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Appendix 1

The following table presents the different fish/seafood species included in this study. The species are presented in their Swedish name. The table show what category each species was sorted into and with the names sorted in colour codes. Green for cod species (category 0), pink for salmon species (category 1) and blue for other fish/seafood species (category 2).

Abborre	Havsabborre	Krabba	Piggvar	Sej	Torsk
Alaska Pollock	Havskatt	Kummel	Regnbåge	Signalkräfta	Turkisk smalklokräfta
Bergtunga	Hummer	Lax	Röd Sumpkräfta	Sik	Uer/ kungsfisk
Bläckfisk	Hällefisk	Lubb	Röding	Sill	Vannameiräka
Clarias	Hälleflundra	Långa	Rödräka	Sjötunga	Venusmussla
Grönmussla	Kallvattenräka	Makrill	Rödspätta	Stillahavslax	Yellowtail
Gös	Knivmussla	Marulk	Rödtunga	Strömming	ej
Hajmal	Kolja	Niltapia	Seabream	Tonfisk	Öring

Category: 0	Category: 1	Category: 2
Cod species	Salmon species	Other fish/seafood species

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