School of Business and Economics

Demand Analysis of the Chinese Whitefish Market

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II Abstract

A demand analysis of the Chinese whitefish market was done, using Chinese import data provided by Norwegian Seafood Council. The main whitefish species of Alaska Pollock, Cod, Haddock, Coalfish and Hake was studied using the LA/AIDS model.

Alaska Pollock is the cheapest of the whitefish species, and it has the largest market share, of an average of 50 percent of all Chinese whitefish imports. Because of the price and the large market share, it makes up the main raw material in the Chinese processing industry. But, Alaska Pollock is also the most elastic of the whitefish species, and the Chinese processing industry, with the rising wage costs, cannot manually keep processing Alaska Pollock and still be competitive in the global market. The Chinese processing industry, should therefore start to process more of the costly whitefish, like Cod and Haddock to keep itself competitive.

Keywords: LA/AIDS, China, whitefish, Alaska Pollock, Cod, Haddock, Coalfish, Hake, elasticities.

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1 INTRODUCTION

Seafood is apart from poultry and meat, one of the main sources of animal protein in the human diet, it is so important, that it is estimated that in 2013 half the world's population got almost 20 percent of their animal protein intake from fish (FAO, 2016). Traditionally only coastal communities could enjoy access to fresh seafood, but modern transportation methods and increased globalization has further increased the access to not only seafood, but to cheap and affordable seafood.

One of the countries that have most benefited from increased globalization is China, it is today the biggest consumer, producer and exporter of seafood in the world (IISD, 2011).

Chinas growth to become the biggest consumer of seafood in the world, is the natural combination of China being the most populous country in the world, and becoming the world's second largest economy.

Although, due to heavily overfished stocks, the Chinese government has implemented the policy of zero growth in the size of its fishing fleets and the amount they are allowed to catch. And over time to even reduce the size of the fleet (Normann, 2008) to counter the environmental destruction China is experiencing, due to their astronomical economic growth. But in practice, even though the number of fishing vessels has gone down, the size and catches of each vessel has gone up. The increase in catches however is not enough to meet the total increase in consumption. Since the consumption of seafood grow when income increases, it implies that the growth in consumption cannot only come from increased Chinese catches, but also from other sources.

This has primarily led to a massive increase in fish farms, which in 2014 was estimated to have produced 73.8 million tonnes worldwide, where China accounted for over 60% of that aquaculture production (FAO, 2016). The worldwide aquaculture production has in fact become so immense, that in 2014 worldwide seafood consumption from aquaculture, was for the first time, higher than the consumption of wild-caught fish (FAO, 2016).

Secondarily this has led to increased Chinese import of fresh and frozen seafood from catches overseas. One of the reasons behind the growth in demand for especially imported seafood, is the combination of the growing middle class and the enduring food safety scandals in China.

Research show that some of the reasons Chinese consumers find imported food attractive, is because they believe imported foods have higher production standards and comes from countries with less pollution (NSC, 2015). This has therefore led the Chinese consumers to trust foreign companies more than Chinese companies. The rise in demand for imported foods, especially in wealthier urban areas, has also driven the Chinese consumers from shopping in traditional supermarkets into more and more to shop in online channels (NSC, 2015). This has the added benefit of making it much simpler for foreign food companies to export their goods to Chinese consumers.

The increase in Chinese demand for imported seafood is limited by the fact that Chinese consumers prefer to consume fresh fish, compared to frozen (PROMAR, 2009). This may also partly explain the reason why seafood consumption is higher in the coastal areas of China than inland China. The other reason for this is most likely that the disposable income in urban coastal areas, is higher than rural inland areas.

Coastal areas of China have benefited more from the country's economic growth than the rural inland areas. Thus, another limit to Chinese consumption of imported seafood, is that even with the colossal economic rise of China in recent years, most marine fish, specifically the imported fish, is still too expensive for the average Chinese consumer to eat regularly (PROMAR, 2009). Research shows that over 50% of the frozen fish imported to China is being processed for export, rather than consumption within China (PROMAR, 2009). This implies that the increase in imports is not only due to increased seafood consumption, but also may explain the fact that China is the biggest processor for seafood in the world (Clarke, 2009). More recent studies suggest that the size of seafood import for processing purposes may have increased from about 50 percent to 67 percent. Chinese seafood imports between 1998 – 2011 indicate that 31 percent of the total seafood import was of whitefish, it was followed by 28 percent other fish, 13 percent Octopus and 8 percent pelagic fish. All of this, except for Octopus, was primarily imported, not for Chinese consumption, but for processing and export (Xie, Myrland & Egeness, 2014).

The reasons for the growth and todays domination by the Chinese seafood processing industry, are many, but here are some of the major factors behind the growth. The developments of technology introduced on-board ship freezing and better freezing and defrosting methods, have led to better finished products. Increased globalisation has led to lower shipping cost. These, combined with the massive supply of workers in China, and thus low wage cost, has made China an attractive place to process the fish. Low wage cost, reduces the need for expensive investments in machines, and gives a higher yield rate of the processed fish. The difference in machine and manual filleting can be significant, when considering that machine filleting Cod, only give a yield of 55 percent, while manual filleting of the same fish gives a yield of 70 percent (Egeness, 2013). This has therefore led to a situation where the Chinese industry not only processes the fish cheaper than their competitors, but also with higher yield. As China started to process more and more of the world's fish, it has led to the creation of industry clusters, and the processing industry could start to offer a larger spectrum of processing, and tailor the processing after the customers wishes. Since the processing industry brought jobs, the Chinese government also helped, by making a simple bureaucratic framework, that for example simplified the import and export of processed seafood (Xie et al., 2014). However, this would never have happened, if there was no change in consumer behaviour, in accepting and buying seafood that had been frozen twice. Consumers naturally prefer fresh fish compared to frozen or refrozen fish, but their acceptance of refrozen seafood is probably influenced by price, as research suggest that price play an important factor in consumer preference, especially when it comes to frozen fillet products (Bendiksen, 2006)

This has induced to a situation where the Chinese seafood processing industry is the largest in the world. The seafood processing industry can be broken down to four distinct sectors. The first sector focus on the more traditional processing of seafood, like curing, salting or smoking. The second sector produce canned seafood, often from low quality fish. The third sector produce fishmeal and fish oil, usually as by-products, but this sector has grown in importance and revenue as feed for the increased aquaculture production (Lindkvist, Wang, Hansen, Haarstad, 2005). The fourth and last sector, is where frozen whole fish from the main seafood exporters in the world like Russia, US, Peru, Chile and Norway is imported to China, where they are partly defrosted. At that time, depending on what the market demands, the seafood can be, processed either into fillets, seasoned, dried, decapitated, breaded and/or packaged. they are then re – frozen, and exported to other countries.

The last sector is also the biggest of the different processing sectors, since its estimated that 76 percent of Chinese export of seafood between 2008 – 2012, has been frozen fillets of whitefish (Xie et al., 2014). The value chain of this sector is the following, the fish is either on-board frozen or kept on ice, and frozen when landed onshore. It may also enter primary processing on the ship or on land, where it is gutted and decapitated. After it is frozen, it is shipped to China, where it can sit between 3 – 5 months in cold storage. It is then partly defrosted, and processed after specification, for most products it means filleting, weighing and packaging before its refrozen again, and depending on demand, it may be stored 1 – 2 months in cold storage, before its shipped to the final consumption market. After arriving in the final consumption market, it may be shipped directly to the wholesalers, who sells it to retail stores and restaurant, or it may enter one last processing stage, where its packaged after wholesaler or retailer specification, before being sold to the consumers. The whole process from catching the fish, till its exported from China, therefore takes an average of six months.

It has been estimated that 63 percent of the processed fillets from China is exported to the European Union, while 28 percent is exported to the United Stated. Canada and South Korea stands for the rest of respectively 4.3 and 1 percent of the fillets (Xie et al., 2014).

However, as China experience an annual 20 – 30 percent growth in wages, which stands for close to 50 percent of the processing cost (Xie et al., 2014) their main comparative advantage is slowly diminishing. After years of growth, the Chinese seafood industry experience a slight decline in 2015, while the same year, Vietnam, another low wage cost country, grew to become the world's third largest exporter of seafood (FAO, 2016).

Though China is losing its main comparative advantage in low wages, it still has other important advantages, like superior logistics, large seafood processing clusters and simple bureaucratic framework. These advantages will still make China an attractive country to process the fish, but it's no denying that the Chinese seafood processing industry have big challenges ahead.

1.1 Research objective

This paper will focus on the species that make up the largest part of Chinese seafood imports, namely whitefish, where the five main species are Alaska Pollock, Cod, Haddock, Coalfish and Hake. These species are primarily imported with the intent of processing and exporting. This paper will investigate the demand for whitefish in China by looking at import data from China for frozen whole whitefish, and use the date to do estimations to analyse the Chinese demand for whitefish.

The objective of this paper is to give a clearer picture of the frozen whitefish demand for different species of whitefish in both the Chinese processing industry, and in the domestic consumption market. This analysis will also implicitly give a better picture of the demand for different type of whitefish species in the final main consumption markets of US, EU and Japan.

This is important because, with rising wage costs, Chinas competitive advantage is slowly diminishing, in order to stay competitive, China will need to find sectors in the whitefish processing, where it still can compete.

1.2 Structure

The introduction chapter covered the reason and the aim of this study, the next chapter, will delve deeper into research done by others. Chapter 3 will introduce the LA/AIDS model used in this study. Chapter 4 will provide a description of the different species of whitefish and the data used in this study. Chapter 5 will cover the price history of the different species of whitefish, and present the final theoretical model. Chapter 6 will present the estimations and elasticities for the different species of whitefish. Chapter 7 will discuss the results, while Chapter 8 will present the concluding remarks.

2 LITERATURE

This paper builds on the data and research done in FHF project “Produksjon i Kina: Faktorer som påvirker markeder for hvitfisk”

Xie et al, (2014) found that the majority of the imported whitefish was either Alaska Pollock, Cod or Haddock. Alaska Pollock was mostly imported from Russia, while Cod was mostly imported from the US and Russia, and Haddock was mostly imported from either Norway or Russia. All together they found that almost ¾ of the whitefish imported to China comes from Russia, while the rest comes from the US and Norway.

According to the paper the Chinese manual filleting of Alaska Pollock yielded between 67 – 72 percent, while the manual filleting of Cod yielded between 75 – 80 percent. It is also interesting to note that Atlantic Cod yielded on average 2 percentage more than Pacific Cod, and that all Cod on average gave a 5 percent more yield than Alaska Pollock. Whitefish that had their head and entrails removed also yielded 8 percent more than those with. Machine filleting on the other hand not only needed bigger investments, but also gave much lower yield, between 53 – 57 percent.

In the same report they found that the processing cost of Alaska Pollock and Cod was between 1010 – 1060 dollars per ton in 2012, 490 dollars of this went to wages. In the same year the Chinese processing industry lost between 200 – 300 dollars per ton of processed Alaska Pollock fillets, while they made a profit of between 100 – 200 dollars per ton of processed Cod fillets. In 2013 the loss on processing Alaska Pollock fillets had decreased to around 150 dollars. It will be interesting to see if this trend is continuing, especially when considering that the average wage in China increase 10 – 20 percent per year. If the trend has continued, expectations will be that Alaska Pollock will be more elastic, while Cod will become much less elastic.

The elasticities found in the paper suggested that if the cost of processing increased by 10 percent, the price of the final product will increase by 2.1 percent, this will in turn lead to a 2.3 percent decline in total demand for frozen fillets of Alaska Pollock and Cod.

After the whitefish been processed, they found that the majority of the fillets are exported to either the EU or the US, which stood for respectively 63 and 28 percent of all exported whitefish from China between 2008 – 2012. An interesting fact they found is that Chinese processed Cod fillets, on average was sold 1 – 2 Euros per kg below than Norwegian processed Cod fillets.

At the whole, the paper found that during the time of the study, that the Chinese processing industry had huge challenges ahead. With weakening demand in the final consumption markets, because of the economic crisis, and with rising wage cost that put pressure on the profit margins of the whole industry. But also that the price of the final product, depend more on the Chinese currency, than the processing cost and supply, since a strong currency make the imported raw material relatively cheap, compared to the wage costs.

Another report, published in the same project by Xie, Myrland & Gao (2013), they found that although most of the whitefish imported to China, was processed to be exported, more and more of the processed fish, stayed in the Chinese market for domestic consumption. This trend was caused by two effects, first, the final markets in EU and US experienced a slow – down in their respective economies, that induced lower demand for the processed fillets. This caused the Chinese processors to look at other markets for their fillets. The second effect, is that the demand for fillets started to grow in the domestic market. This change in demand was caused by different factors like, increase in income, that led to higher protein demand. But as written in the introduction, this increase in demand, could not be met by an increase in catches, because of the Chinese government policy of zero growth in domestic catches, this led to increased import. The frequent food safety scandals also helped making the imported whitefish more attractive to domestic consumers. Lastly, they found the strengthening of the Chinese Yuan, made the fillets relatively cheaper and more affordable, and thus increased the demand.

In the same report they found that the different whitefish species often went under the generic Chinese name of “Xueyu”. Most of the whitefish sold under the name “Xueyu”, was Alaska Pollock, but since the name itself is generic, it made it difficult for Chinese consumers to differentiate between cheaper species like Alaska Pollock, and more expensive species like Cod.

They also found that most of the high – quality seafood was sold in hotels and restaurants, and that the processed fillets were sold more in the coastal urban areas of China, while unprocessed frozen whole fish was sold more inland.

3 MODEL

The system of demand equations was presented by Richard Stone in 1954 (Deaton & Muellbauer, 1980). Since then, different models have been presented to estimate demand, including the Trans log model (Christensen, Jorgensen & Lau, 1975), and the Rotterdam model by (Barten, 1964) and (Theil, 1965). The model used in this paper is called Almost Ideal Demand System (Deaton & Muellbauer, 1980), which compared to the Rotterdam model does not use random preferences, but use theorems to give more exact preferences, called PIGLOG. The demand functions for the AIDS model as given by Deaton and Muellbauer (1980), can be written as:

$$\mathrm{w_i} = \alpha_i + \sum\nolimits_j \gamma_{ij} \log p_j + \beta_i \log\{\tfrac{x}{P}\}$$

Where $\mathrm{w_i}$ is the budget share given from $w_i = \frac{p_i q_i}{x}$, α_i is the intercept that measures the trend line for each good, γ_{ij} is the coefficient for price, p_j is the price of each good, β_i is the coefficient for expenditure, x is the total expenditure, and p is the price index, and together they give the real expenditure. The translog price index, gives the non – linear price index P, Deaton and Muellbauer mentioned in their paper that if prices where collinear, an approximation to P, that was proportional to a known index P^*, could be used. Since time series data is used in this paper, and it has a tendency to be collinear, the Stone price index as suggested by Deaton and Muellbauer will be used. The stone price index can be written as:

$$\log P^* = \sum_i \mathrm{w_i} \log p_i$$

this changes the price index from non – linear to linear, and simplifies the estimations.

The restrictions for the AIDS model, to conform to economic theory are:

Adding up restrictions: $\sum_{i=1}^{n} \alpha_i = 1$

$\sum_{i=1}^{n} \gamma_{ij} = 0$

$\sum_{i=1}^{n} \beta_i = 0$

Homogeneity restriction: $\sum_j \gamma_{ij} = 0$

Symmetry restriction: $\gamma_{ij=}\gamma_{ji} \ \forall i \neq j$

Adding up restrictions states that the sum of the coefficient for the intercept must be equal to 1, while the sum of the coefficients for price and expenditure must be equal to 0. This implies that the consumer chooses the combination that provides maximum utility by choosing at the boundary of the opportunity set.

Homogeneity restriction states that the equation is homogenous of degree zero, this implies that an equal change in price and income, will not affect the budget share.

The elasticities are found using the following formulas:

Expenditure elasticity: $A_i = 1 + \frac{\beta_i}{R_i}.$

Marshallian own – price elasticity: $\varepsilon_{ii} = \frac{\gamma_{ij}}{R_i} - \beta_i - 1.$

Marshallian cross – price elasticity: $\varepsilon_{ij} = \frac{\gamma_{ij} - R_j\beta_i}{\mathrm{R_i}}$

Hicksian elasticity trough Slutsky equation: $\varepsilon_{ij}^{*} = \varepsilon_{ij} + w_j A_i.$

The expenditure elasticity explains the change in demand for a good, that comes from a marginal change in real income. A positive elasticity, imply that a rise in income, leads to a rise in demand for the good, and it’s a normal good, if the elasticity is more than 1, it’s a luxury good. A negative elasticity, imply that a rise in income, leads to a decrease in demand, and it’s called an inferior good.

The Marshallian own – price elasticity explains the change in demand for a good, that comes from a marginal change in its own price. The bigger the elasticity is, the more responsive the good is for change in price. A negative elasticity implies that an increase in price for a good, leads to decrease in demand, this implies that the good in question, is a normal good. A positive elasticity implies that an increase in price for a good, leads to an increase in demand, which implies that the good is either a Giffen or a Veblen good. Most goods tend to be normal goods, that conform to economic theory, which states that increased prices, leads to decreased demand.

The Marshallian cross – price elasticity explains the change in demand for a good, that comes from a change in price for another good. A positive cross – price elasticity implies, that the 2 goods are substitutes, meaning that an increase in price for good 1, leads to a decrease in demand for good 1, but an increase in demand for good 2. A negative cross – price elasticity implies that the 2 goods are complements, meaning that an increase in price for good 1, leads to a decrease in demand not only for good 1, but also for good 2, that did not have a price change.

The Hicksian elasticities has the same explanation as the Marshallian elasticises, with the difference being that Hicksian shows the compensated price elasticities, meaning the change in demand that is only caused by the substitution effect.

4 DATA

4.1 Data for Chinese import

The model is based on Chinese import data, provided by the Norwegian Seafood Council to the FHF-project "Production in China: Factors that influence the market for whitefish".

Since there are sometimes several data points in the import data for each month, the data has been aggregated into monthly values. Chinese import data for whitefish exist from January 1998 – June 2015, but the import data have periods where there is no data registered, specifically in the late 90s and early 2010s. If the entire time period where to be used as basis for our estimation, data have to be aggregated up to quarterly or semi-annual in order to be useful. In order to use monthly import data, the period December 2005 – June 2015, have been chosen.

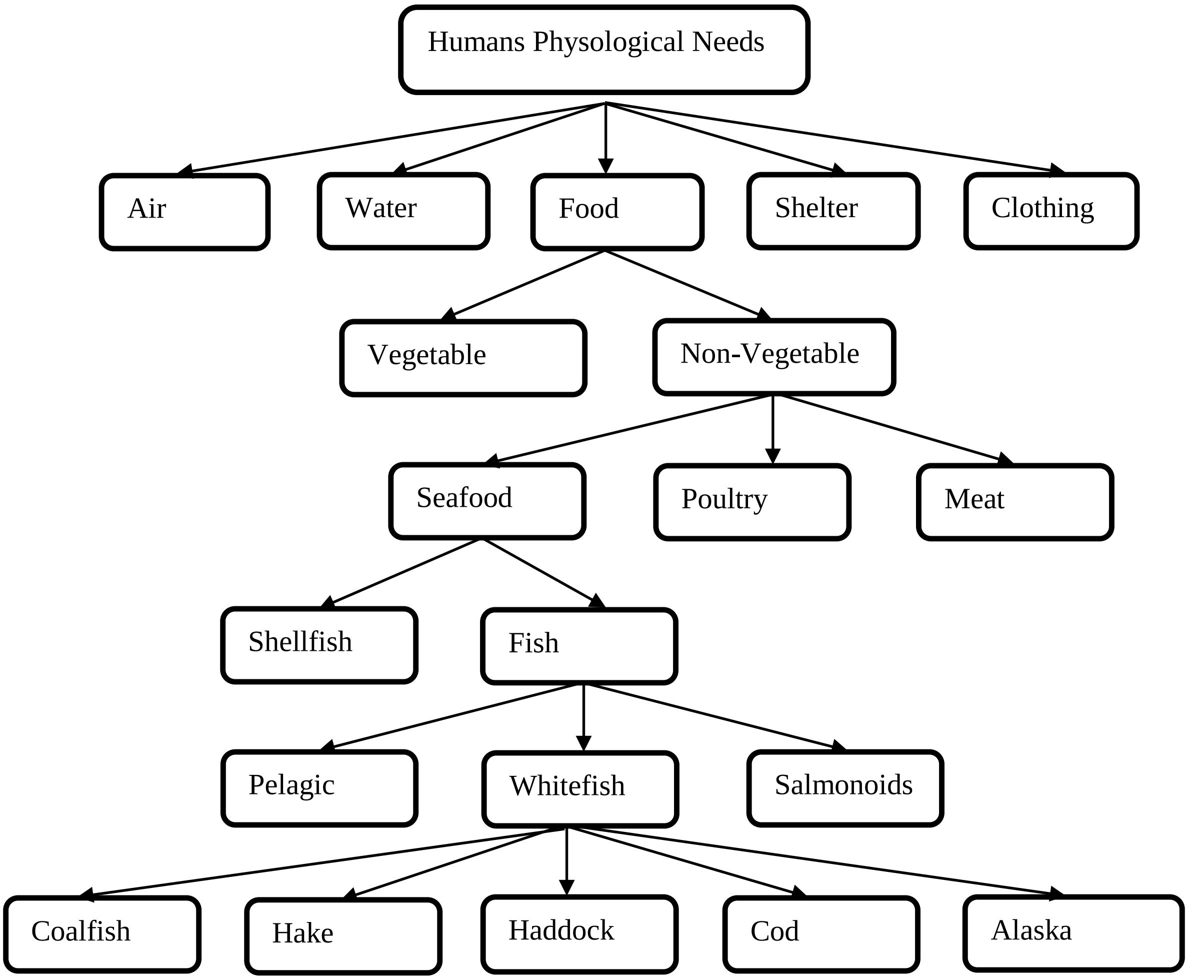
The amount of whitefish is measured in 1000 metric tons, while the value of whitefish is measured in 1000 NOK, the prices are derived each month from dividing the amount imported with the value of the amount.

Data for the main species of whitefish have been chosen to be used in this paper, they are Hake, Haddock, Coalfish, Cod and Alaskan Pollock. The data file use Norwegian names for some fish, and English name for other fish. In order to be uniform on the description, the different species of whitefish is described using English names. To avoid misunderstanding with translation, this paper uses Haddock for Hyse, Coalfish for Sei, Cod for Torsk, while Hake and Alaskan Pollock remains unchanged from the name on the data file.

It is worth noting that Chinese import data is not entirely reliable, since it has a problem with miscoding species. This paper tries to avoid the problem by looking at which country the fish is imported from, but even so, it is worth keeping in mind that there are issues of trustworthiness with the data.

4.2 Utility tree

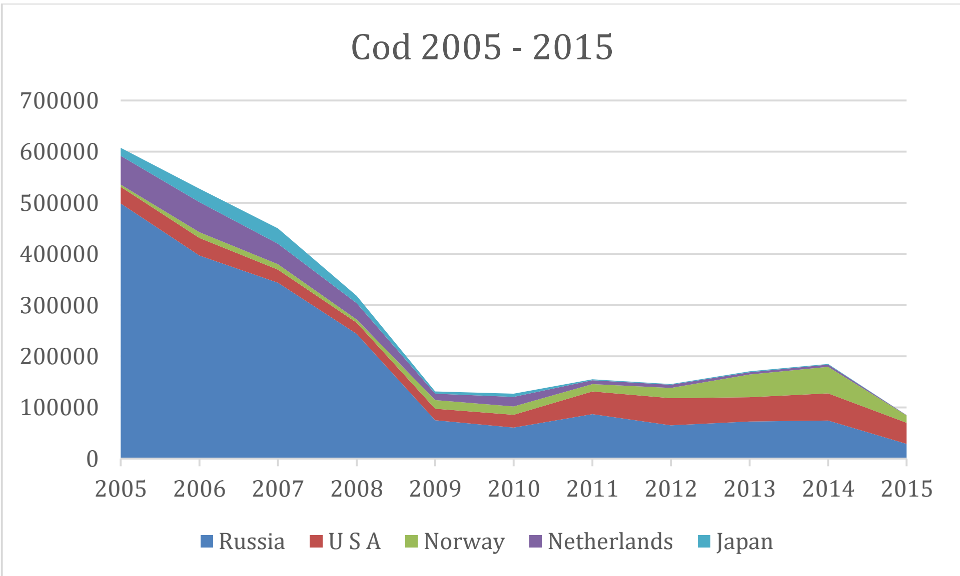
Figure 1: Human physiological needs, drawn according to Maslow's hierarchy of needs (Maslow, 1943)



4.3 The main whitefish species

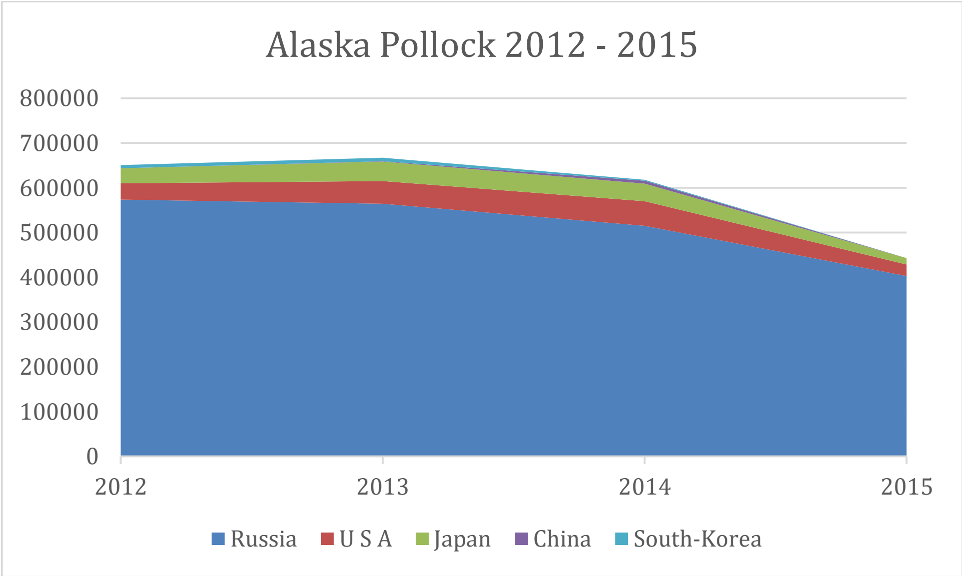
Approximately 90% of all frozen whole Atlantic and Pacific Cod imported to China comes either from Russia, US, Norway, Netherlands or Japan. As seen in Figure 2, Russia and US are the biggest exporters of frozen whole Cod to China. Cod is the most popular of the whitefish species, due to its mild taste and flaky meat. Manuel filleting of Cod yields between 75-80 percent.

Figure 2: Chinese Cod imports between 2005 - 2015



Alaska Pollock is, after anchovies, the second largest caught species in the world, its mild taste reminds of Cod, but at a far cheaper price, it makes a main ingredient in popular dishes, such as crabstick, fish sticks and in fast food like McDonalds Filet-o-fish. Manuel filleting of Alaska Pollock yields between 67-72 percent.

Figure 3: Chinese Alaska Pollock imports between 2012 – 2015



The data for Alaskan Pollock is especially complicated to find, since Alaskan Pollock was not named Alaskan Pollock in Chinese official statistics until 2012. Although it is difficult to find correct data before 2012 for Alaska Pollock, it is not impossible. What can be seen from the 2012 – 2015 import data, is that Russia was the biggest exporter of Alaska Pollock to China, with over 90 percent of the total import, so a reasonable assumption, is that Russia was also the biggest exporter of Alaska Pollock to China before 2012. But if so, where in the Chinese import data was Alaska Pollock registered? One place to look is the Chinese import data of whitefish from Russia without any species identification.

Figure 4: Chinese "other fish" imports between 2005 – 2015

As seen in Figure 4, the import of non – specified whitefish from Russia started to increase from 2005, until it dropped to zero at 2012, the same year China started to specify Alaska Pollock. It's therefore a reasonable assumption that all of whitefish imported from Russia without identification between 2005 – 2015 was Alaska Pollock. The same conclusion was also drawn by Xie et al, (2014).

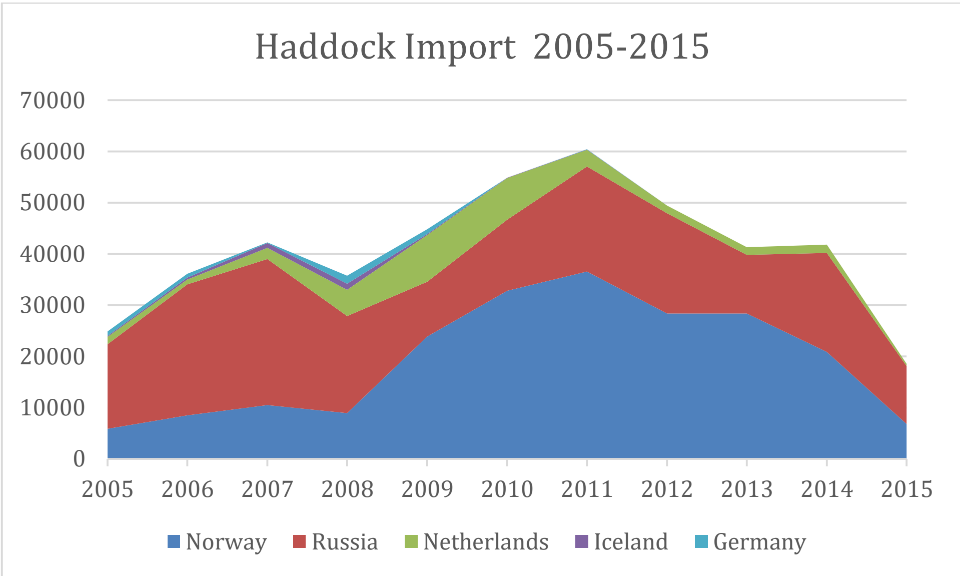
Another interesting observation is that Alaskan Pollock in non – specified whitefish category didn't start to increase until 2005, and as seen from Figure 2, imported Cod from Russia started to fall from 2005 till 2009, the same year Figure 4 has a maximum point. It can therefore be reasonably assumed that before 2005 Alaska Pollock imported from Russia was mislabelled as Cod. Clarke (2009) suspected that Alaska Pollock could be also imported under the same import code as Cod, since both Pacific Cod and Alaskan Pollock are fished in the Bering Sea, this finding confirms Clarkes suspicion.

Another reason for Alaskan Pollock being miss-coded can be that Coalfish is also known by the name Pollock, so Alaskan Pollock can then be miss-coded as Coalfish, or Coalfish can be miss-coded as Alaskan Pollock. (Clarke, 2009)

This paper aggregates the non – specified whitefish from Russia between 2005-2015 and the data for Alaska Pollock between 2015 – 2015 to one category called Alaska Pollock. As for the mislabelled Cod we simplify that all is Cod, since extracting the right value for Cod and Alaska Pollock will be too complicated, and out of reach for this study.

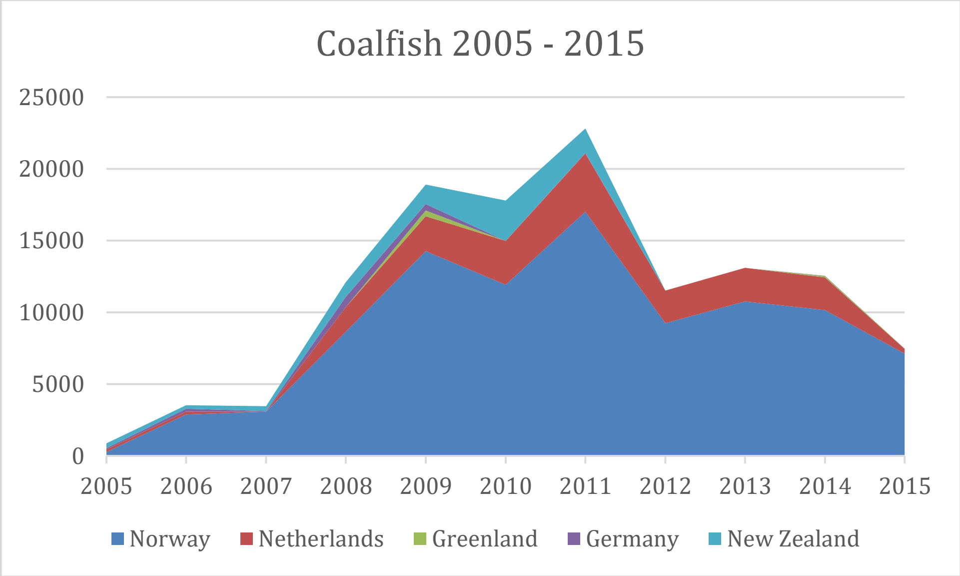
For Haddock approximately 98% of all haddock imported to China, comes from these five countries, as seen in Figure 5, Norway and Russia is by far the biggest exporters of Haddock to China. Haddock is a popular fish, and have a slightly sweeter taste than Cod, its often used in fish and chips in Northern England, while Cod is used in fish and Chips in Southern England.

Figure 5: Chinese Haddock imports between 2005 – 2015



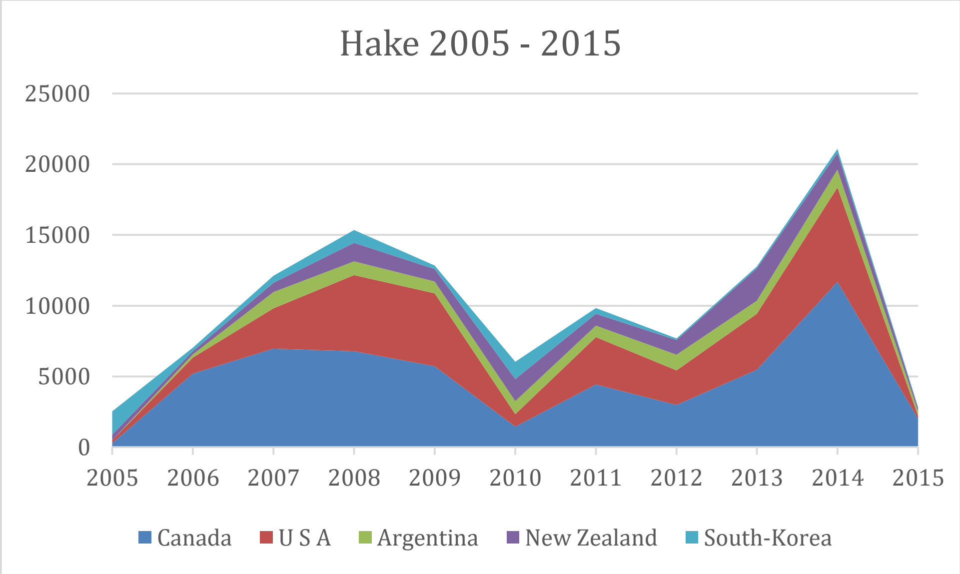
Approximately 95% of all Coalfish imported to China, come from these five countries. As Seen in Figure 6, Norway is the biggest exporter of Coalfish to China. Coalfish is considered to have an exceptional taste, compared to Cod, but the meat is darker, and unless it’s been properly handled right after the catch, it gets a bloodstained greyish colour, that consumers find unappetizing.

Figure 6: Chinese Coalfish imports between 2005 – 2015



Approximately 88% of all Hake imported to China, comes from these five countries. As seen in Figure 7, Canada and US are the biggest exporters of Hake to China. Hake is in the same family as Cod, but the meat is darker and is slightly pink, therefor it's called "saumon blanc", or white salmon in France. It has a mild taste and a subtle flavour compared to Cod. Along with Alaska Pollock, Hake is a popular ingredient in crab sticks.

Figure 7: Chinese Hake imports between 2005 – 2015



Clarke (2009) used the import data from US, EU and Japan to estimate that on average, between 2004 – 2007. China produced 210 000 tons of Alaska Pollock, and 110 000t of Cod products. But during that same years it only produced 7000 tons of Haddock, 3000 tons of Coalfish and 1000 tons of Hake.

Consumers have traditionally avoided both Hake and Coalfish, as they were considered “trash fish”. But in modern times, their popularity is increasing, but as seen from Figure 6 and 7, the amount imported each year is not large, and thus they have a very small market share, respectively 1% and 2%. Because they share similarities in the traditional view of them, and since their market share is so small, it is therefore natural to aggregate the data for Hake and Coalfish together.

For all the whitefish species, we can observe that the majority of imports to China comes from either Russia, US, Norway or Japan. Common for all the species is also that the volume of import has decreased in the recent years. This is likely due to overcapacity in the Chinese processing industry, and the lack of economic growth in the main consumption markets in EU and US. Part of the reason for the decline may also come from increased wage costs that have made China less competitive compared to other low – cost processing countries like Vietnam and Poland.

5 ESTIMATIONS

The estimations were computed by using the statistical computing software R.

5.1 Price development of whitefish species.

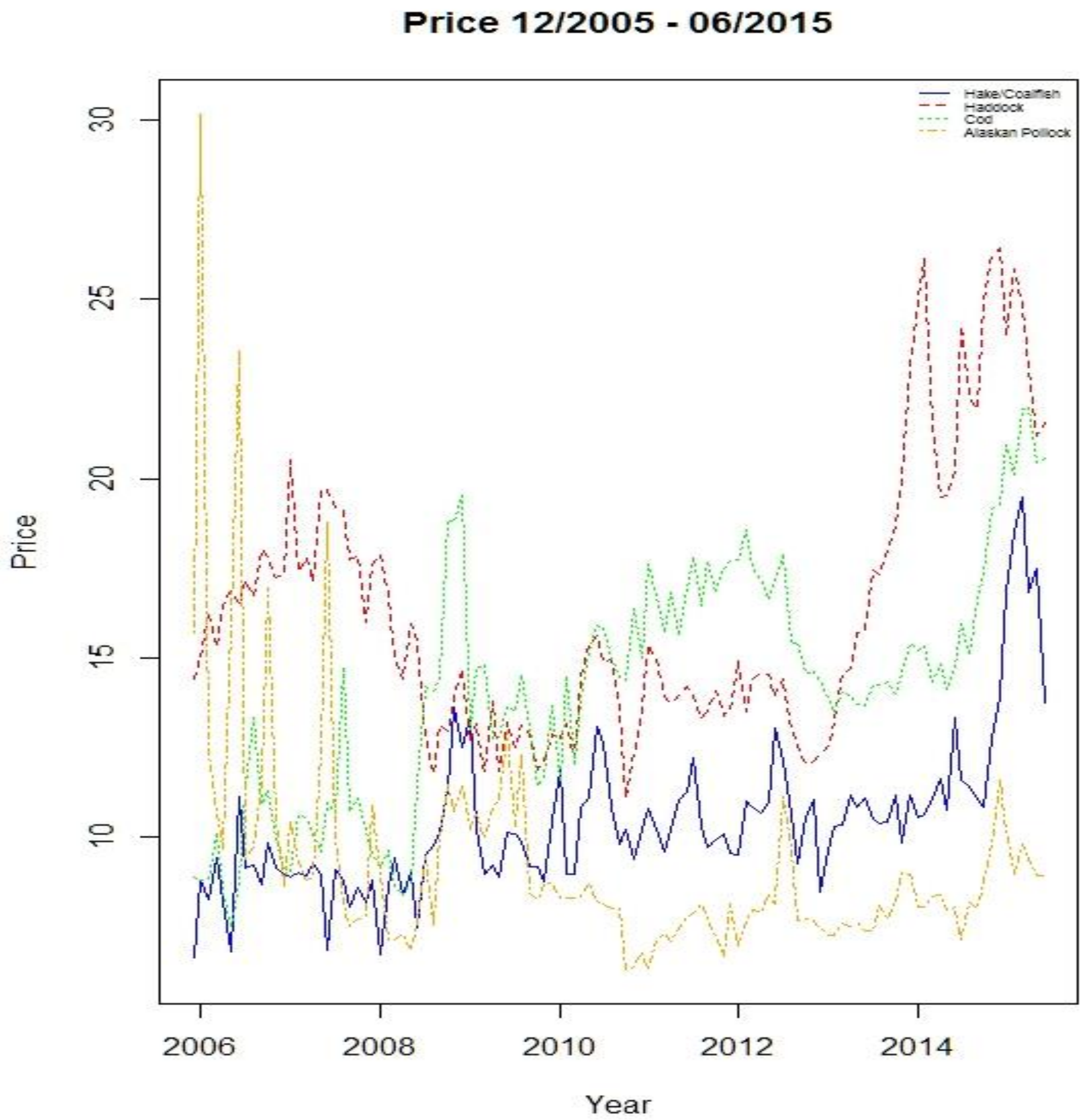
As seen from Table 1 below, the cheapest whitefish species during the period studied is Alaskan Pollock, followed by Hake/Coalfish and Cod, While Haddock is the most expensive whitefish species.

Table 1: Average Price

Average Price between 12.2005 – 06.2015.	
Whitefish	Mean(NOK/kg)
Hake/Coalfish	10.46
Haddock	16.30
Cod	14.20
Alaskan Pollock	9.28

But this does not hold true for the entire period studied. As seen from Figure 8 below, the price of each species of whitefish varied a lot during the period studied, and we can observe that during the start of the Alaska Pollock was actually the most expensive whitefish, while Cod was the most expensive whitefish between 2008 – 2013. During 2012 all the whitefish species experiences a decrease in price, but common for all of them, is that the price started to increase the last few years. The price of Alaska Pollock, Hake, Coalfish and Cod started to increase in mid-2014. While the price of Haddock, started already to increase at the end of 2012, and it became the most expensive whitefish today.

Figure 8: Price history of whitefish, by species between 12.2005 – 06.2015



5.2 Estimations

Table 2: Average Market Share

Average Market Share between 12.2005 – 06.2015.	
Whitefish	Market Share
Hake/Coalfish	0.03
Haddock	0.08
Cod	0.39
Alaskan Pollock	0.50

As seen from Table 2, Alaskan Pollock have the biggest market share of 50%, this confirms with other research that found a similar pattern of Alaska Pollock being the main fish in Chinas processing industry (Xie et al., 2014).

Durbin – Watson was used on the static AIDS model to check for autocorrelation problems, the estimates below show that there is a problem with autocorrelation for all the whitefish equations, and it is especially serious for Cod and Alaskan Pollock equations. This indicate that a model that is adjusted for autocorrelation should be used.

Table 3: Durbin – Watson test

Durbin – Watson test	
Whitefish	Durbin-Watson
Hake/Coalfish	1.34
Haddock	1.23
Cod	0.70
Alaskan Pollock	0.72

A Log- likelihood test is used to test if the restrictions of homogeneity and symmetry is appropriate for the data. A dynamic AIDS model without imposed homogeneity and symmetry was estimated, and then used as a base model to compare with other dynamic AIDS models, with imposed restrictions.

The estimation results show that seasonal dummies are statistically significant, therefore the non – restricted base model is chosen to be the dynamic model with monthly dummies.

Table 4: Log – likelihood test

Log – likelihood test			
Model	Df	Likelihood values	χ^2
Dynamic AIDS	60	722.92	134.09(<001)
Dynamic AIDS with homogeneity imposed	57	720.30	128.85(<001)
Dynamic AIDS with symmetry imposed	57	718.94	126.14(<0.001)
Dynamic AIDS with homogeneity and symmetry imposed	54	717.81	123.88(<0.001)

The estimation results show a better fit, without imposed restrictions, however to be in line with economic theory, a model with imposed restrictions have been chosen

The elasticities from a dynamic AIDS model was better than the elasticities from a static AIDS model. Therefore, a dynamic AIDS model with imposed restrictions for homogeneity and symmetry, to make the equation compatible with demand theory, and with seasonal dummies was chosen.

5.3 Final Theoretical Model

The final theoretical model will build on the LA/AIDS model presented in chapter 3, and was stated as:

$$\mathrm{w_i} = \alpha_i + \sum\nolimits_j \gamma_{ij} \log p_j + \beta_i \log\{\tfrac{x}{P^*}\}$$

Where $\mathrm{w_i}$ represent the four equation for expenditure share of each whitefish species as following:

w_1 = Hake & Coalfish

w_2 = Haddock

w_3 = Cod

w_4 = Alaska Pollock

For each species of whitefish, the following coefficients will be estimated. The intercept α_i for each specie, the price coefficient γ_{ij}, that shows the change in demand for one specie, when the price change in another specie. Lastly the expenditure coefficient β_i, that shows the change in demand for one specie, when income changes.

To account for seasonal deviations, eleven dummy variables are introduced into the LA/AIDS model. The final model can thus be stated as:

$$\mathrm{w_i} = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left\{\frac{x}{P^*}\right\} + \sum_t^{11} \lambda_{it} M_{it}$$

January is used as a base variable, and is therefore dropped from the equations.

6 RESULTS

6.1 Coefficients

Estimated coefficients for dynamic LA/AIDS model with monthly dummies and imposed homogeneity and symmetry, the t-values are given in parenthesis. The coefficients for Alaska Pollock was found by replacing the equation for Cod with the equation for Alaska Pollock in the model.

Table 5: Coefficients

Variables	Hake/Coalfish	Haddock	Cod	Alaskan Pollock
dln p1	0.012 (1.152)	-0.005 (-0.424)	0.004 (0.342)	0.001 (0.120)
dln p2	-0.005 (-0.424)	0.057* (2.245)	-0.036′ (-1.742)	-0.049* (-2.134)
dln p3	0.004 (0.342)	-0.036′ (-1.742)	0.109* (2.568)	-0.066 (-1.262)
dln p4	-0.011 (-1.344)	-0.016 (0.278)	-0.076′ (-1.858)	0.113* (2.581)
dln $\frac{x}{P^*}$	-0.034*** (-5.020)	-0.013 (-1.090)	-0.122*** (-3.451)	0.164*** (4.180)
M2	-0.014* (-2.551)	-0.053*** (-5.606)	-0.025 (-0.886)	0.088** (2.782)
M3	0.023**	0.004	0.042	-0.050

	(3.151)	(0.330)	(1.152)	(-1.221)
M4	0.002 (0.368)	0.007 (0.863)	-0.012 (-0.469)	0.009 (0.326)
M5	0.004 (0.731)	0.021* (2.105)	0.008 (0.283)	-0.037 (-1.121)
M6	0.001 (0.099)	0.058*** (5.048)	0.026 (0.780)	-0.098** (-2.620)
M7	0.029*** (5.194)	-0.045*** (-4.036)	0.006 (0.221)	-0.008 (-0.220)
M8	-0.027*** (-4.833)	0.016′ (1.672)	-0.020 (-0.746)	0.040 (1.338)
M9	0.004 (0.679)	-0.048*** (-4.976)	0.030 (1.055)	0.015 (0.476)
M10	0.011* (2.019)	0.037*** (3.659)	-0.002 (-0.093)	-0.036 (-1.155)
M11	-0.017** (-3.154)	-0.004 (-0.399)	-0.043 (-1.606)	0.057’ 1.878
M12	-0.002 (-0.369)	0.012 (1.383)	-0.028 (-1.050)	0.012 (0.558)
R^2	0.673	0.707	0.382	0.566

Adjusted R^2	0.618	0.657	0.278	0.493
Diff R1	-0.053 (-0.581)	0.215* (2.317)	-0.027 (-0.281)	-0.052 (-0.592)
Resi R1	-0.523*** (-5.00)	-0.668*** (-6.798)	-0.163** (-2.820)	-0.151* (-2.486)

$*** \, p < 0.001, \quad ** \, p < 0.01, \quad * \, p < 0.05, \quad ' p < 0.1$

The parameters for price shows that four of them are statistically significant at 5% level, while 3 of them are statistically significant at 10% level. The elasticities below will give a clearer picture of how demand is affected by price changes.

The expenditure for Hake/Coalfish, Cod and Alaska Pollock are statistically significant at 0.1% level, while the expenditure for Haddock does not show any significance.

The R^2 values varies from the low end of 0.382 for Cod to the high end of 0.707 for Haddock, this implies that the LA/AIDS model does not describe very well, the changes of the dependent variables for Cod, compared to the changes of the dependent variables for Haddock and Hake/Coalfish.

6.2 Elasticities

The Marshallian elasticities reflect both the income and substitution effect on demand when consumers want to maximize their utility, given a fixed budget. Its shows the relationship between the price of a good, and the quantity demanded of that good.

Table 6: Marshallian Elasticity

Marshallian Elasticities				
Quantity of	Price of Hake/Coalfish	Price of Haddock	Price of Cod	Price of Alaska Pollock
Hake/Coalfish	-0.636**	-0.054	0.502	0.132
Haddock	-0.051	-0.355	-0.342	-0.109
Cod	0.020	-0.061	-0.617***	-0.050
Alaska Pollock	-0.037**	-0.068**	-0.322***	-0.943***

$*** \, p < 0.001, \quad ** \, p < 0.01, \quad * \, p < 0.05$

A negative cross – price elasticity, like the one between Haddock and Cod, signify that the two different species are complements to each other, indicating that they are often bought or consumed together. This implies that if the price of Haddock increases, while the price of Cod remains unchanged, the demand for both Haddock and Cod will decrease. A positive cross – price elasticity, like the one between Hake/Coalfish and Cod, signify that the two different species are substitutes for each other, indicating that Hake/Coalfish can be replaced by Cod. This implies that if the price of Hake/Coalfish increases, while the price of Cod remains unchanged, the demand for Hake/Coalfish will decrease, while the demand for Cod will increase, as consumers will substitute Cod for Hake/Coalfish.

The Hicksian elasticities below, reflect only the substitution effect on demand when consumers want to minimize their cost, given a fixed utility. It shows the relationship between the price of a good, and the quantity demanded of that good, given that the price of the other goods does not change, and the consumer remains on the same utility level.

Table 7: Hicksian Elasticity

Hicksian Elasticities				
Quantity of	Price of Hake/Coalfish	Price of Haddock	Price of Cod	Price of Alaska Pollock
Hake/Coalfish	-0.634**	-0.049	0.525	0.158
Haddock	-0.020	-0.277	0.015	0.282*
Cod	0.046	0.003	-0.322***	0.273***
Alaska Pollock	0.013	0.056*	0.250***	-0.318***

$*** p < 0.001$, $** p < 0.01$, $* p < 0.05$

The expenditure elasticities reflect the change in demand that come from a change in consumer income.

Table 8: Expenditure Elasticity

Expenditure Elasticities	
Whitefish	Elasticity
Hake/Coalfish	0.056 (0.297)
Haddock	0.858*** (6.575)
Cod	0.708*** (8.358)
Alaska Pollock	1.371*** (16.058)

$*** \, p < 0.001, \quad ** \, p < 0.01, \quad * \, p < 0.05$

7 DISCUSSION

7.1 Own – price elasticities

The own – price elasticities of all species are negative, this implies that as the price increases for each species of whitefish, the demand for that species will decrease. Although negative, the absolute value of all own-price elasticities are smaller than 1, which indicates that the demand for all species of whitefish are relatively inelastic.

The reason for the inelasticity can be as mentioned in the introduction chapter, the process from capture to the fillets are ready to export, takes time. The processing companies can therefore keep the fish in cold storage, if they feel that the market price will be higher a few months into the future. This behaviour makes the processors less sensitive to changes in price, and may partly explain the reason for the inelasticity.

Alaska Pollock is the most elastic of all whitefish species, with a Marshallian own – price elasticity close to -1, with a statistically significant level of 0.1% which implies that a 1% increase in price of Alaska Pollock will lead to a -0.943% fall in demand of Alaska Pollock, it makes it more sensitive to changes in price, than the other whitefish species. The reason for Alaska Pollock to be the most elastic of the whitefish species, can be explained by the fact that Alaska Pollock is not only the cheapest of the whitefish species, but also is the one with the largest market share, making it the most consumed whitefish species in the world. The reason for the relatively high own – price elasticity for Alaska Pollock can therefore be that the consumers that buy Alaska Pollock, is relatively poor. Although wealthy enough to afford seafood in their diet, they are not wealthy enough to handle increases in price. There is therefore reason to believe that if the price of Alaska Pollock increases, consumers will opt out of buying any whitefish altogether, and rather replace it with other animal proteins, as fish will be too expensive to be a part of their regular diet. This is also supported by the findings in the report by Xie et al. (2013) that found that most of the whitefish sold in the Chinese market was Alaska Pollock, and that some of it also was sold frozen whole, instead of filleted and packaged. When sold frozen whole, it can be sold cheaper than the processed whitefish, and thus make it more attractive for low – income consumers that are more sensitive to changes in price.

Cod have the second lowest Marshallian own-price elasticity, with only Haddock being lower, and the second highest Hicksian own – price elasticity, both with a statistically significant level of 0.1%. This is not surprising, given that Cod is the second most expensive whitefish species, and it also have the second highest market share after Alaska Pollock. But as also will be explained deeper in the next section, contrary to Alaska Pollock, Cod has a much lower degree of substitution, thus explaining the high price and relatively low own – price elasticity. The reason for the own – price elasticity to be lower than Alaska Pollock, may also come from that as Xie et al. (2014) found, that the Chinese processing industry was losing money processing Alaska Pollock, while they at the same time made a small profit processing Cod. It stands to reason, that the processing industry thus demand Cod more than Alaska Pollock, and partly explain the reason for Cod having a lower own – price elasticity than Alaska Pollock. Another reason for the lower own – price elasticity can also be that, unlike Alaska Pollock, which are also sold a lot in the Chinese market, Cod is mostly processed and exported to the final overseas markets, mostly because all whitefish are known under the generic name of "Xueyu" in China, Xie et al. (2013). It is therefore difficult for Chinese consumers to see the difference between to species of whitefish that are called the same, but one being far more expensive than the other.

Haddock is the only specie of whitefish that does not have any statistically significant own – price elasticity. As seen earlier in results, Haddock along with Hake and Coalfish, had relatively low R^2 values, thus making the LA/AIDS model used to estimate the elasticities, less effective to explain the change in the variables. But nonetheless, what can be observed is that it has the lowest own – price elasticities of all the whitefish species, despite it being the most expensive whitefish, and also having the second lowest market share. This is surprising, but can be explained by the fact that most Haddock is imported from Norway, a high – cost country, therefore there may not be any other choice for the Chinese processors, but to buy an expensive raw material.

Hake and Coalfish have the highest Hicksian own – price elasticity of -0.634, this is very close to the Marshallian own – price elasticity of -0.636 for the same species, both elasticities with a statistically significance level of 1%. This indicates a strong substitution effect on the demand for Hake and Coalfish, this is not surprising, when considering that both species are viewed as "trash fish". Thus consumers may, if given the choice, choose to consume Alaska

Pollock, a specie that is both cheaper and have a better reputation, rather than consume Hake or Coalfish.

7.2 Cross – price elasticities

The Marshallian cross – price elasticity in table 6, for the Alaska Pollock equation shows that to be a complement to the other whitefish species. The cross – price elasticities for Alaska Pollock against Hake, Coalfish and Haddock are relatively low, and close to zero, and have a significance level of 1%. The cross price elasticity against Cod is higher, and have a significance level of 0.1%.

Alaska Pollock is the cheapest of the whitefish species. Thus, when the price of Alaska Pollock increase, it's more difficult for consumers to substitute with other whitefish species. This supports the earlier assumption of Alaska Pollock being a whitefish species that is consumed more by relative low – income consumers.

The Hicksian cross – price elasticity in table 7, for the Alaska Pollock equation shows it to be a substitute to the other whitefish species. Again, the cross – price elasticities against Hake, Coalfish and Haddock is close to zero, while the cross – price elasticity against Cod is higher. The cross – price elasticity between Alaska Pollock price and demand for Haddock has a significance level of 5%, while the cross – price elasticity between Alaska Pollock and Cod has a significance level of 0.1%.

Xie et al. (2014) mentioned in their report that the Chinese processing industry lost between 150 – 300 dollars per ton of processed Alaska Pollock fillets in 2012 and 2013. This is supported by the own – price and cross – price elasticities of Alaska Pollock, as the processors cannot increase the price of fillets, since the consumption will just twist the consumption away from whitefish, to other cheaper sources of animal proteins.

The Marshallian cross – price elasticity in table 6 for Cod, show it's a substitute to Hake and Coalfish, while being a complement to Haddock and Alaska Pollock. The cross – price elasticity is close to zero against all the other species, and the cross – price elasticity against Alaska Pollock have a statistically significant level of 0.1%.

The Hicksian cross – price elasticities of Cod in table 7, show that it's a substitute to all the other species of whitefish, and having a statistically significant level of 0.1% for the cross – price elasticity against Alaska Pollock.

The cross – price effect between Cod and Alaska Pollock and vice versa, are the highest statistically significant cross – price elasticities, and shows them both to be each other's substitutes, with a cross- price elasticity between 0.250 – 0.273. The Marshallian cross – price elasticities however, show them to be each other's complements, but the Marshallian elasticity of Alaska Pollock and Cod is -0.050 and is close to zero, while the Marshallian elasticity between Cod and Alaska Pollock is -0.322. This suggest that the substitution effect is much stronger than the income effect, when it comes to the elasticity between Alaska Pollock and Cod, but the opposite is not true. This indicate a high demand for Cod, and processors and consumers choosing Alaska Pollock instead of Cod, not because they want it, but either because the price of Cod is too high, or because to supply of Cod is too low.

This is also supported by Xie et al. (2014) that found the Chinese processors made a profit of 100 – 200 dollars per ton of processed Cod fillets in 2012, while they at the same time lost money processing Alaska Pollock fillets. It is therefore reasonable to assume that the Chinese processors will rather process Cod than Alaska Pollock, but that, despite increased Cod quotas, there is not enough Cod available in the market for all processors. It is also supported by Cod having the second highest price for whitefish species, despite increased quotas. Part of the reason for the high price of Cod, may be the Chinese processors themselves, which had to deal with increased wage costs, and weaker demand from final markets, that have made processing Alaska Pollock a losing venture. Therefor there is reason to believe that there is increased competition among themselves to process Cod. This makes the supply of Cod a limited good, and thus increase the price of Cod.

Another reason can be for this, can be that consumers want Cod, and they only consume Alaska Pollock, not because they prefer it, but because they cannot afford Cod as a regular part of their diet, and therefor substitute it with Alaska Pollock. This probably holds true in the final overseas market, rather than the Chinese market, as all whitefish species mostly was sold under the generic name "Xueyu" (Xie et al., 2013), and thus made it harder for the Chinese consumer to differentiate between cheap Alaska Pollock fillets, and expensive Cod fillets.

The Marshallian cross – price elasticities shows Haddock as a complement to all the other species of whitefish, while the Hicksian cross – price elasticities shows Haddock as a complement to Hake and Coalfish, while it's a weak substitute to Cod and Alaska Pollock, with a statistically significance level of 5%. It makes sense that Alaska Pollock is a substitute to Haddock, as Alaska Pollock is a much cheaper fish, so if the price on Haddock increases, consumers are more likely to replace Haddock with Alaska Pollock. But it is surprising that Haddock is a complement to Cod, as research suggest that most consumers, don't know, or can't taste the difference between Haddock and Cod, so we would have expected Haddock to be a substitute to Cod, and not a complement.

The Marshallian cross – price elasticities shows Hake and Coalfish to be complements to Haddock and Alaska Pollock, while it's a substitute to Cod. The Hicksian cross – price elasticities show it to be a complement to Haddock, while being a substitute to Cod and Alaska Pollock. Hake and Coalfish is a substitute to Cod, but Cod is barely a substitute to Hake and Coalfish, this can be explained by the fact that, although Coalfish tastes exceptionally better than Cod, consumers find the bloodstained greyish appearance of its meat is unappealing. Therefore, it may be used as a replacement for Cod in products where the appearance can be hidden, for example breaded products like fish fingers, or fish sausages.

Lastly, the cross – price elasticities for Haddock and Hake/Coalfish are close to zero, indicating that these species are neither substitute or complements towards other whitefish species.

7.3 Expenditure Elasticities

The expenditure elasticities are positive for all species implying that an increase in income, will lead to an increase in demand for all whitefish. Thus all the species are necessary goods. This is supported by (FAO, 2016) that estimated that in 2013, half the world's population got 20 percent of their animal protein intake from fish, thus making fish a necessary food item

Alaska Pollock has the highest expenditure elasticity with 1.371, this implies that Alaska Pollock is a luxury good, and that a one percentage increase in income, will lead to almost 1.4% increase in demand of Alaska Pollock. This is surprising, given that Chinese processors process Alaska Pollock at a loss, the expectations were therefore for Alaska Pollock to have lower expenditure elasticity than Cod, a specie where the processers still make a profit on. The reason for the high expenditure elasticity may rather come from the consumption side, than the processing side, since Alaska Pollock is also the cheapest of the whitefish species. The reason for Alaska Pollock having a high expenditure elasticity can be that most imported fish is still too expensive for the average Chinese consumer to eat regularly. Alaska Pollock is the cheapest of the whitefish species studied in this paper, it is therefore reasonable that when the average Chinese consumer gets an increase in income, he or she will mainly increase their consumption of Alaska Pollock for two reasons. First, even with an increase in income, the other whitefish species may still be too expensive to consume. Second, even if the consumer can afford to buy other whitefish species, Alaska Pollock will remain the specie where they will get most whitefish for their money, and they choose Alaska Pollock because they can afford to eat it more regularly, than the other whitefish species. Alaska Pollock is interesting, as contrary to the other whitefish species, which are mostly consumed overseas, Alaska Pollock with its low price and availability is consumed both in the Chinese and overseas market (Xie et al., 2013). Therefore, the demand comes not only from the main consumption markets in the US and EU, but also from within China.

The expenditure elasticities for Cod and Haddock is positive, making them normal goods, but they are also less than one, making them necessity goods.

The expenditure elasticity for all species of whitefish are statistically significant at 0.1%, except for the expenditure for Hake and Coalfish. Hake and Coalfish also have the lowest expenditure elasticity, close to zero, at 0.056, making it a sticky good, which means than an increase in income, will not lead to any change in demand. The reason for the low expenditure elasticity, can be that both species are, as mentioned earlier, traditionally considered as “trash fish”, so it would explain why, when a consumer gets an increase in income, does choose to not increase his or her consumption of Hake and Coalfish.

All the other whitefish species have a positive expenditure elasticity, indicating that they are normal goods.

8 CONCLUDING REMARKS

As the world as a whole grow wealthier, and more and more people get out of poverty, and into the middleclass, the need for seafood will increase. Since the worldwide catches of wild fish, cannot keep up with the demand, this has already led to the consumption from aquaculture to become larger than the consumption of wild caught fish.

China have great challenges, but also great opportunities ahead. The comparative advantage they had with a large supply of workers, and thus a low wage cost, is slowly disappearing, but as found, China have other advantages, like simple bureaucratic framework and industry clusters that will still keep the Chinese processing industry competitive.

The wage cost has a strong influence on the processing cost, as Xie et al. (2014) found in their report, it can make up close to 50 percent of the processing costs, and have already led to processors losing money when processing Alaska Pollock. This problem will get bigger as the Chinese economy grows, and the easy supply of workers starts to dwindle. As found in the results, Alaska Pollock is the most elastic of the whitefish species, therefore the processors cannot escape the problem of increased wage cost, by increasing the price of the finished product, as it will just lead consumers to look other places to fulfil their animal protein needs. Manual processing of simple fillets of Alaska Pollock thus have a limited future in China, but as Xie et al. (2014) found in their report, Chinese industry can preclude this by moving on to process more value added products, and the results from this paper partly confirm this theory. China can move to process more Cod, a species that is more expensive, and less sensitive to price changes. The Chinese processors has therefore more freedom to increase the price of Cod fillets, and thus handle the rising wage costs by increase the price for the processed product.

The demand for fillets have also been declining because of weak demand from EU and the US, but the most important reason for the decline, is probably the strengthening of the Chinese Yuan. The Chinese Yuan was its strongest against US dollars in 2014, and the strongest against the Euro in 2015. After this the Yuan has weakened both against dollars and Euro. A strong currency makes the imported whitefish relatively cheap for domestic consumers. For the processing industry, with increased wage costs, a strong currency makes export relatively more expensive. This is probably the reason for the decline in whitefish processing during 2015, and the uptick in processing during 2016. This is also supported by (Xie et al., 2014) who found that the price of the final product is more dependent on the currency, than processing costs and supply.

A solution for the Chinese processing industry maybe in only processing Alaska Pollock for the domestic market. As Alaska Pollock, not only are the most elastic specie, but also the one specie with the highest expenditure elasticity. Focusing on processing Alaska Pollock for the domestic market, will help the Chinese processing industry, as it can not only exploit the strengthening of the yuan, but also the high expenditure elasticity Alaska Pollock has.

Although further research is needed, in order to stay competitive, the Chinese processing industry, have to focus on processing the lower value products, like Alaska Pollock fillets for the domestic market, and the more value – added product, like Cod and Haddock fillets for the export market.

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