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Linkages between seafood markets, fisheries management and trade liberalisation theory and applications

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Linkages between Seafood Markets, Fisheries Management and Trade Liberalisation: Theory and Applications

Ph.D Thesis

by

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Contents

Preface

Prior to the commencement of this thesis I worked with fisheries economics as a research analyst at the Danish Research Institute of Food Economics (FOI) in Copenhagen in 1998-2001. The main field of work was market models for fish products. Before that I worked for the Greenland Home Rule in 1993-95 with practical fisheries management. This background has driven my interest in the field of fisheries economics.

In 2001 I embarked upon the Ph.D. programme at the University of Southern Denmark, while continuing my employment at FOI. The thesis was written during the period 2001-2004. This set-up has been possible due to the granting of financial support from both the Danish Agricultural and Veterinary Research Council via the Centre for Fisheries and Aquaculture Management and Economics (FAME) and FOI, which is gratefully acknowledged.

As a part of this thesis I visited the Fisheries Division at the Directorate of Food, Agriculture and Fisheries in the OECD in Paris for a 6-month period during the winter 2001-02. I participated in the project "Liberalising fisheries markets – scope and effects", undertaken by the OECD Committee of Fisheries in the 2001-02 work programme.

Over the past three years I have had the privilege to work with a lot of people, which I am indebted to. I would like to take this opportunity to thank some of them here. At the Department of Environmental and Business Economics at the University of Southern Denmark in Esbjerg, Henning Jorgensen has been my supervisor. He has shown an interest in my work and always been available for support and good advice. He has also read numerous preliminary drafts. Two of the papers in this dissemination (chapters 6 and 7) were written together with Frank Jensen and Eva Roth, who I thank for good cooperation and support.

Also thanks to the evaluation committee for valuable comments on my thesis, namely Niels Vestergaard from the University of Southern

Denmark, Frank Asche from Stavanger University Collage and Peder Andersen from the Danish Economic Council.

At the Fisheries Division in OECD, Carl Christian Schmidt and the staff was an invaluable source of inspiration, who I owe a great deal of thanks for hospitality, inspiration and numerous fruitful discussions on the subject of international seafood trade. I also thank for financial support to the visit in the World Trade Organisation in Geneva, January 2002.

Most of my work has, however, been done at FOI and I would like to express my gratitude to the members of the division of fisheries economics and management. In particular I would like to thank Jorgen Lokkegaard in his capacity as research director for making it possible for me to participate in projects of relevance for my thesis during my 6 years of employment, for his commitment in the project and for inspiration and support underway. I also owe a great deal of thanks to Erik Lindebo, who checked almost all parts of this thesis for the language, to Hans Frost for inspiration and providing assistance and guidance on subjects related to bio-economics, and to Ayoe Hoff for mathematical support. Philip Rodgers has also in his external affiliation to FOI provided support and comments on several of the papers included in the thesis.

A number of people have provided comments and suggestions in relation to individual papers, and they have been noted and thanked in the relevant papers.

Last, but most important, my gratitude goes to my fiancée Dorte, for support and patience, particularly during periods where this thesis take up all my time.

Copenhagen, October 2004
Max Nielsen

Dansk resume

Denne afhandling behandler en række problemstillinger, som man møder når man analyserer liberalisering af handel med fisk og fiskeprodukter. Afhandlingen er baseret på en række særskilte papirer hvorfra hovedresultater gennemgås nedenstående.

Et litteraturstudium af handel med fisk og fiskeprodukter

Det første papir er en gennemgang af den eksisterende neoklassiske økonomisk-teoretiske litteratur der er relevant for denne afhandling om hvordan den internationale handel med fisk og fiskeprodukter modelleres. Formålet er at skabe en ”state of the art” som kan fungere som en referenceramme for de efterfølgende analyser, som hver især går mere i dybden. Områder i litteraturen hvor viden er mangelfuld identificeres og politik anbefalinger gives på grundlag af eksisterende litteratur hvor det er muligt. Metoder til afgrænsning af de internationale markeder for fisk og fiskeprodukter og til analyse af efterspørgsel, udbud og udenrigshandel med fisk og fiskeprodukter er gennemgået. Co-integrationsanalyse af non-stationære prisserier anvendes ofte i litteraturen for at afgrænse markederne og forskellige økonometriske metoder har været anvendt til at estimere efterspørgselsfunktioner. Udbudsmodeller er estimerede, samt kalibrerede på basis af aldersstrukturerede bio-økonomiske modeller. Grundlæggende handelsteori er endvidere udviklet i forbindelse med generelle ligevægtsmodeller og kombineret med økonomien i gendannelige ressourcer med fri adgang. I papiret gennemgås udviklingen af en partiel ligevægtsmodel for liberalisering af handel, baseret på en bestand med fri adgang. Anvendt forskning indenfor området er gennemgået og det er vist hvordan papirerne til denne afhandling udbygger forståelsen af forbindelserne mellem markederne for fisk og fiskeprodukter, fiskeriforvaltningen og handelsliberalisering.

Anvendelsen af toldpolitiske instrumenter på fisk og fiskeprodukter i OECD lande

Det andet papir præsenterer en oversigt over information indsamlet for OECD’s Fiskerikomite vedrørende handelsliberalisering af fisk og fiskeprodukter. Omfanget af toldinstrumenterne for fisk og

fiskeprodukter er vurderet og de vigtigste problemstillinger som opstår vedrørende anvendelsen af disse instrumenter er identificeret. Det fremgår af denne analyse, at det handelsvægtede toldgennemsnit for fisk og fiskeprodukter importeret til alle OECD lande var 3,1% og det simple gennemsnit af de bundne satser 7,0%. Dvs., der anvendes for adskillige fisk og fiskeprodukter toldsatser væsentligt lavere end de bundne satser. Det fremgår også at forskellen mellem arterne er lille, men at toldsatserne for forarbejdede varer er højere end for uforarbejdede. Yderligere påvises at toldsatserne for fisk og fiskeprodukter er små sammenlignet med andre produkter og især sammenlignet med andre fødevarer. Endelig findes at effekten af en reduktion i EU's bunde satser ville være beskeden, eftersom størstedelen af EU's import foregår til satser væsentligt under de bundne satser. I USA er de bindende satser små og i Japan forbliver et stort antal toldsatser ubundne. Det handelsvægtede toldgennemsnit i Japan er på samme niveau som i EU, men i modsætning til i EU er toldsatserne nogenlunde ens.

Udgivet i OECD (2003), *Liberalising Fisheries Markets – Scope and effects*, Paris, pp. 80-92. en tidligere version blev præsenteret på den 89ende session i OECD's Fiskerikomite i Paris, Frankrig, 18-20. marts 2002.

Prisdannelse og markedsintegration på det europæiske førstehåndsmarked for torskefisk

Totalt tilladte fangster for torskefisk i EU's farvande er blevet reduceret hvert år i de sidste fem år, hvorved flådernes omsætning reduceres. Gennem samme periode er priserne dog steget og reduktionen i indkomst er derved delvist udlignet. Imidlertid afhænger prisændringerne af strukturen på de markeder indenfor hvilke priserne dannes. Derfor er strukturen på de europæiske førstehåndsmarkeder er for torskefisk undersøgt i det tredje papir. En vektor auto regressiv model med fejlkorrektion er anvendt til analyse af landingspriserne blandt de vigtigste fiskerinationer, idet co-integrationsanalyse og test for "loven om én pris" er anvendt til at bestemme graden af markedsintegration. Et delvist integreret europæisk førstehåndsmarked for torskefisk er identificeret og som del af dette et geografisk perfekt integreret marked for torsk. Eksistensen af dette forholdsvis løst integrerede marked forklares af stivheder på udbudssiden. Konsekvenserne diskuteres i relation til reduktioner i kvoter på torskefisk og i relation til den gældende markedspolitik.

Optaget til snarlig udgivelse i Marine Resource Economics. En tidligere version blev præsenteret på den fjortende årlige konference i den europæiske forening af fiskeriøkonomer i Faro, Portugal, 25-27. march 2002.

International markedsintegration og efterspørgsel: det norske og danske marked for sild
Det fjerde papir gennemgår en metode hvor tests for international integration anvendes til at identificere markedsstrukturer før estimation af efterspørgselssystemer. Metoden anvendes til analyse af det europæiske marked for produkter af sild. En vektor autoregressiv model med fejlkorrektion anvendes til at identificere co-integrationsvektorer mellem prisserier samt, baseret på dette, til at teste "loven om én pris". Eftersom denne er i kraft mellem de to største globale udbydere, Norge og Danmark, estimeres en samlet invers efterspørgselsfunktion for de to lande. Resultaterne er anvendt i fortolkningen af stigningen i priserne på sild på det danske førstehåndsmarked i 2001, givet stabilt udbud samt stabile priser på afsætningsmarkederne for forarbejdede produkter af sild. Implikationen er at på trods af at Danmark ikke eksporterede til de vigtigste norske eksportmarkeder i det tidligere Sovjetunionen og i Østeuropa blev de danske landingspriser påvirket af situationen der.

Publiceret i Food Economics, 1 (3), 175-84, 2004. En tidligere version blev præsenteret på den femtende årlige konference i den europæiske forening af fiskeriøkonomer i Brest, Frankrig, 14-16. maj 2003.

Anvendelse af IAIDS (Inverse Almost Ideal Demand System) til velfærdsanalyse
Det femte papir præsenterer de teoretiske egenskaber af IAIDS systemet og anvender det på tidsseriedata for torsk, sild og rødspætter i Danmark (1986-2001). Endvidere gennemgås begrænsninger i anvendelsen af systemet til velfærdsanalyse. Som følge af at efterspørgsels-systemet er en anden ordens approksimation af det sande system, er det ikke generelt anvendeligt til velfærdsanalyser. Det opfylder ikke

betingelserne for beregning af forbrugeroverskud (negativ hældning og positiv skæring med prisaksen). Den teoretiske pointe er illustreret ved et empirisk eksempel af det danske fiskemarked. Der er anvendt en vektor autoregressiv model i fejlkorrektions form for at løse problemet med non-stationaritet af data og systemet er estimeret. For torsk er skæringen negativ og for sild og rødspætter er hældningen af efterspørgselsfunktionen positiv i det undersøgte interval. Systemet kan således ikke anvendes til velfærdsanalyser.

Fremsendt til bedømmelse til *Marine Resource Economics*. En tidligere version blev præsenteret på den femtende årlige konference i den europæiske forening af fiskeriøkonomer i Brest, Frankrig, 14-16. maj 2003.

En cost-benefit analyse af en offentlig mærkningsordning for kvalitet af fisk

Formålet med det sjette papir er at introducere en ny metode der kan identificere velfærd af kvalitetssorterede fisk, under anvendelse af en hedonisk prisfastsættelsesmetode for rødspætter i Danmark. I dag eksisterer der ikke noget mærkningssystem rettet mod slutforbrugere for forskellige kvaliteter af fisk. En mærkningsordning forefindes kun for fisk i første omsætningsled. Ud fra dette udvikles en generel teoretisk og empirisk metode til at sammenligne omkostninger og fordele ved det hypotetiske valg mellem fuldstændigt fravær af en offentlig mærkningsordning med indførelsen af et offentligt mærkningssystem, som fuldt ud informerer forbrugerne om kvalitet og samtidig tillader producenterne at differentiere priser mellem kvalitetssorteringer. Det påvises, at den økonomiske velfærd forbundet med et offentligt mærkningssystem er minimum 263.000 Euro. En følsomhedsanalyse viser at dette resultat er robust. Den politiske konsekvens er at en offentlig mærkningsordning ikke bør indføres af økonomiske grunde. Årsagen er at efterspørgsels- og omkostningsfunktionerne har lave elasticiteter.

Fremsendt til bedømmelse til *Environmental and Resource Economics*. En forkortet version vil blive præsenteret på den sekstende årlige konference i den europæiske forening af fiskeriøkonomer i Rom, Italien, 5-7. april 2004 og en tidligere version er udgivet som arbejdspapir 53/2004 fra institut for miljø og erhvervsøkonomi på Syddansk Universitet.

Velfærdseffekter af udvidelsen af EU i relation til torsk fra den østlige Østersø.
I den nyere forskning er der advaret mod at liberalisering af handelen med produkter fra vildt levende fisk, givet utilstrækkelig fiskeriforvaltning, kan medføre yderligere overudnyttelse, formindske fiskebestandene og derved reducere den bæredygtig velfærd. Det sidste papir vurderer og kvalificerer denne advarsel for torsk fra den østlige Østersø ved at udvikle en aldersstruktureret bio-økonomisk model, kombineret med en partiel ligevægtsmodel for handel mellem to lande. Velfærdseffekterne af handelsliberalisering identificeres og kvoter, input begrænsninger, maskevidderegulering samt delt ejerskab af bestandene tages i betragtning. Det vises, at selv om liberalisering af handelen med disse varer kan medføre velfærdsreduktioner i producentlandene, vil velfærdsforringelserne være små sammenlignet med velfærdsgevinsterne fra en hypotetisk ændring mod optimal forvaltning. Derfor er forbedringer i fiskeriforvaltningen meget vigtigere end at forsøge at modvirke de negative konsekvenser af handelsliberalisering, eftersom selv små forbedringer af fiskeriforvaltningen kan opveje negative konsekvenser af handelsliberaliseringen.

Fremsendt til bedømmelse til *Ecological Economics*. En tidligere version blev præsenteret på den ellevte konference i det internationale institut for fiskeriøkonomi og handel i Wellington, New Zealand, 19-22. august 2002 og en anden tidligere version blev præsenteret på workshoppen ”nye politikker og muligheder i fiskeriforvaltning i Esbjerg, 26-28. januar 2004.

CHAPTER 1

Introduction

1.1 Background

The main purpose of this thesis has been to develop integrated models, which can be applied to study the linkages between seafood markets, fisheries management and trade liberalisation. On traditional non-seafood markets the development of integrated models focus on linking markets and trade liberalisation, with resource implications being of secondary importance. In seafood markets, however, models should take into account that fisheries management plays a key role. The reason includes the presence of externalities. In addition to the presence of externalities, products are perishable and there is a high level of international trade (relative to production) in seafood products. Hence, fisheries economic analysis demands to a certain extent models that are different from other sector analyses, although analyses in e.g. environmental and resource economics can also enrich fisheries economics analysis. This thesis studies the linkages between seafood markets, fisheries management and trade liberalisation, emphasising the distinctive features of seafood compared to the modelling of trade in other products.

Key factors of seafood markets

Seafood markets are particular in many ways. The main distinctive feature of seafood trade and the cause of present concerns is that there are externalities in the production process, i.e. at the harvesting level. These appear since the harvest of a single fishermen affect the future catch possibilities in a potentially negative way. Individual fishermen do not own the factors of production, since common property resources are included. Thus, the free market will not secure that the social optimum is reached, implying that fisheries management is necessary. That this is important for the fisheries sector have been evidenced by many authorities, in particular the Food and Agriculture Organisation of the

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The author wishes to thank Henning Jorgensen, Carl-Christian Schmidt, Jørgen Løkkegaard and Erik Lindebo for comments on preliminary versions of this chapter.

United Nations (2001) who assess that the majority of the global fish stocks today are overexploited. The implication of this has, however, also been that fisheries management has become a necessary alternative to open access.

Several different fisheries management schemes exist. They range from regulated open access via regulated restricted access to optimal management, i.e. a continuum of possibilities. The implication of the presence of externalities combined with improper management is that the supply of fish does not increase globally with prices (average costs), as for most other products. In an open access fishery the supply from a fish stock will rise until the maximum sustainable yield is reached and fall subsequently, as the take from the stock exceeds reproduction. Consequently, open access long run seafood supplies must be analysed in backward bending supply models. This feature of the supply regime in fisheries was raised for the first time by Copes (1970), but the basic framework for such an analysis can be dated back to the article "On rent of fishing grounds" written in 1911 by the Danish economist Jens Warming (Andersen 1983). The shape of the supply model of a managed fish stock will depend on the management system in place.

Due to quantity limitations in fisheries the causality in the price formation process goes from changing demand to price on first-hand markets. It is not the other way around as for most other products, where it is possible to change quantities to respond to changing price. One reason for this is that short and medium run quantities are determined by circumstances such as bio-economy, weather, fishery management, etc. In the long run the externalities, the fisheries management and the natural factors determine the quantity.

Concurrently, seafood is a perishable product not easily stored. Therefore, demand for seafood at first-hand markets should be analysed in inverse demand models, where the causality goes from changing demand to price, given exogenous short run quantities.

A third distinctive feature is that trade in seafood products is relatively important compared to landings. Although differences remain for different species and product forms, almost all seafood markets are international, implying that prices follow each other over time in different countries. There are several reasons for seafood markets being international. The most important is, as for all other goods, that all countries win, since they can specialise in what they are best at, i.e. in productions where they possess comparative advantages. However, seafood trade is distinct as countries are very differently endowed with fish stocks. Some countries are land-locked and do therefore not have any production of seafood (except for freshwater species). Others, with large populations and high income cannot fully meet their own demand, whereas some countries with large coastal zones and rich fish stocks may not be able to consume their production.

The present fisheries situation is the result of many years of history of the fishing industry. The first milestone for the sector was the introduction of the 200 nautical mile exclusive economic zones in 1977, codified in the United Nation (1982) Convention on the Law of the Sea (UNCLOS). With UNCLOS, property rights of fish stocks within the zones were given to the coastal states. Hence, traditional fishing nations with large distant water fleets, which were also the large seafood consumer countries, were excluded from their traditional fishing grounds. This implied that new fishing nations replaced them and built their own fleets. The result was that international trade in seafood products increased. Simultaneously, however, it became common practice of some countries including the European Union (EU) to negotiate access to markets for the new fishing nations in return for access to fishing in their waters. This development would have limited the increase in international trade.

In the EU, UNCLOS was followed by the introduction of the common fisheries policy in 1983. According to Holden (1996), this policy includes four elements; conservation, structural adjustment, markets and external fisheries. The structural adjustment and the market policies are similar to the common agricultural policy in that it includes a subsidy and a minimum price element. The difference is, however, that in fisheries the subsidies have been directed for measures such as modernisation and decommissioning, where in agriculture subsidies have mainly, until recently, been connected to production. Today, it is decoupled and connected to land. Minimum price schemes are applied in both areas, but in fisheries as opposed to agriculture the subsidy element of this scheme is small. One reason is that minimum prices are relative lower in fisheries, since the EU is a net importer of seafood products.

Another important reason for the high level of international trade in seafood products is that over the last two decades several rounds of multilateral trade negotiations as well as the formation of free trade areas have reduced trade barriers on industrial products, including seafood. Today, therefore, tariffs on seafood products are relatively small compared to other food products. It is noted that seafood products in the multilateral trade negotiations have been treated as an industrial product and not an agricultural product. Due to the use of anti-dumping measures, however, countervailing duties still exist on a higher level in a few countries. The Norwegian salmon export to the United States is an example. Seafood also remains a part of the World Trade Organisations agreement on the application of sanitary and phytosanitary measures (SPS), motivated in food security requirements, and of the agreement on technical barriers to trade (TBT).

Fisheries have become an important issue in international trade negotiations after the Doha Ministerial Meeting in November 2001. At the Ministerial Meeting fisheries subsidies, but also tariffs on seafood products, were placed on the agenda for the on-going multilateral round of trade negotiations. In recent years, the Committee for Trade and Environment under the World Trade Organisation was also formed to address environmental issues (including fisheries) in order to meet potential negative consequences of trade liberalisation. This body has, inter alia, addressed the US ban on imports of non-dolphin friendly tuna (i.e. tuna caught without preventing by-catches of dolphins).

Key issues in seafood market analysis

The subject of international seafood trade modelling is important seen in the light of the simultaneous developments in the fisheries and seafood trade sector. Overexploitation is gradually forcing the introduction of better fisheries management while trade barriers are gradually relaxed. These two developments are closely related to the two policy areas, fisheries management and trade policy, which have different objectives. Where the main objective of fisheries management is to correct for the market failure in the form of the externality, the main objective of the trade policy is to secure supplies of seafood as a food product and the protection of the domestic industry. However, important cross effects remain. The trade policy affects the fish stock through the prices and serves as an indirect tax in an exporter country and an indirect subsidy in an importer country. Thereby, the trade policy serves indirectly as a fisheries management tool. Similarly, fisheries management does affect trade through the supplies. Hence, in order to reach the Pareto optimal situation, coordination of changes in the two policy areas is necessary. Furthermore, the externality in the fisheries is not only a national issue, it becomes an international issue with the emergence of trade; this implies that one country cannot secure the optimal situation alone. For example, it is necessary for an exporting country to coordinate its fisheries management with the trade policies in the countries of their market outlets. It is also necessary for an importing country to base its trade policy on the fisheries management in its supplier countries.

With the internationalisation of seafood markets the distribution chains have become long and often include two or more countries. Hence, markets might consist of many sub-markets and signals might therefore not be transferred perfectly between these markets. Therefore, the price formation process is complex and a more detailed understanding of the price formation process at the international markets is needed. This includes knowledge of the sizes and boundaries of international markets, a better understanding of substitutability between species and knowledge of the demand and supplies on the markets. Only through such detailed knowledge is it possible to analyse the effects of changes in some parts of the distribution chain on other parts. This is important since only through such an understanding is it possible to coordinate fisheries management and the trade policy.

Coordination of trade and management polices are important when consumers shift preferences. An example of a preference shift in recent years is consumers increasing interest in environmental concerns. For seafood products this means that they demand seafood caught from sustainably managed fisheries. This environmental requirement stems from the final consumers but has effects throughout the distribution chain i.e. supermarket chains will demand fish caught from sustainably managed fisheries from their sub-contractors, which again will require the same further down the chain. Now, provided that the optimal coordinated policy is to be reached after the preference shift, the fisheries management and the trade policy should be changed correspondingly. That such a shift in preferences actually appeared in the mid-nineties is underlined by the fact that an international certification organisation for sustainable fisheries, the Marine Stewardship Council, was formed in 1996.

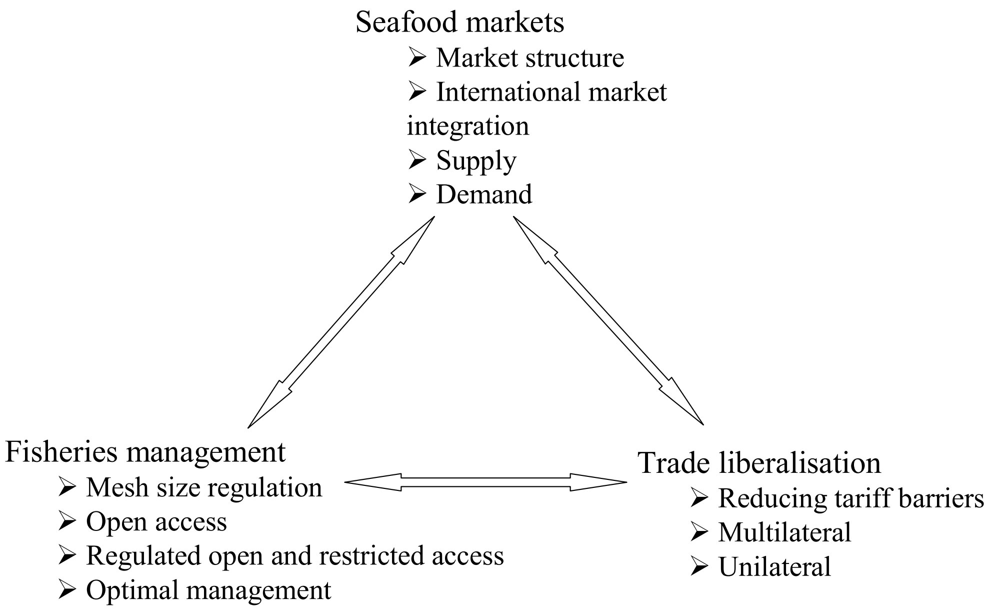
Furthermore, the ongoing internationalisation is important for seafood market analysis, since analysis of single countries in several and presumably most cases will be misleading. Seafood markets are international and cannot be analysed consistently ignoring the international dimension.

Finally, the subject is of relevance for other sectors with negative externalities in the production, such as forestry and production sectors with pollution emissions. As fisheries, forestry is based on renewable resources, which might be subject to open access in some countries, e.g. tropical timber in some developing countries. Although long run in forestry is considerably longer than in fisheries, since the growth of forests is slower than most fish stocks, the theoretical analysis of this paper also applies to assessing the welfare effects of liberalising trade in timber products. The theoretical analysis also holds for production sectors with pollution emissions, since trade liberalisation might imply increased production and thereby pollution.

1.2 Issues

This thesis is built around the development of integrated models, applicable to studying the linkages between seafood markets, fisheries management and trade liberalisation, as shown by the double arrows in Figure 1.1.

FIGURE 1.1 **Integrated analysis of seafood markets.**



Integrated models of traditional non-seafood markets focus on the linkage between markets and trade liberalisation. The structure of markets is decisive for the outcome of a trade liberalisation and a trade liberalisation implies e.g. that new markets appear. The analysis of seafood markets is, however, not that simple. The reason is that fisheries management affects the market through supplies as well as being decisive for the effects of trade liberalisation. Proper fisheries management implies that steady state supplies are maintained at a high and sustainable level, where insufficient fisheries management in the extreme can cause extinction.

This thesis focuses on seafood markets, fisheries management and trade liberalisation both individually and on the linkages between them. Emphasis is on subjects where seafood products face distinctive features compared to other goods. Hence, the focus is on the linkages between 1) fisheries management and seafood markets and 2) fisheries management and trade liberalisation. The papers in the dissertation discuss these subjects and the linkages. Chapter 2 is a literature review covering the whole area, chapter 3 relates only to trade liberalisation and chapter 6 only relates to seafood markets. Chapters 4, 5 and 7 discuss linkages between seafood markets and fisheries management and chapter 8 concentrates on the linkage between fisheries management and trade liberalisation.

1.3 Methodology

On the demand and market side, the theoretical basis is traditional microeconomics with emphasis on consumers. A market is defined as "the area within which the price is determined, allowances being made for transportation costs" (Stigler 1969). Hence, the size and boundaries of markets in relation to both geographical area and product coverage are identified on the basis of whether prices move together over time. Provided that prices move together over time, the products are sold on the same market and can be modelled as one product. If this is not the case, products are sold on different markets, which have nothing to do with each other. Demand is identified by maximising utility given income and analysed in the first hand market where the behaviour of the intermediate buyers also reflects the behaviour of the final consumers. Thus, the analyses are of derived demand. Inverse demand systems where quantities determine prices are applied, since supplies can be considered exogenous, due to the widespread use of quotas and input limitations in fisheries management. Demand and market analyses have been applied in four of the papers (chapters 4, 5, 6 and 7).

Valuation of non-market goods has been applied in chapter 7. The basis is valuation of public goods, although the method is used to evaluate the private characteristic quality of fish. Actual behaviour of consumers is revealed indirectly on the basis of existing data, as opposed to asking consumers directly, since data have been readily available.

The estimation methodology applied is co-integration analysis, which has been used to determine integration, sizes and boundaries of markets and to estimate demand systems. In market integration tests, co-integration is applied instead of traditional econometrics such as seemingly unrelated regression, since time series of prices in most cases are non-stationary. That is, they follow a trend over time. Hence, provided that price series are not properly differenced, seemingly unrelated regression is invalid. Co-integration then forms a more structured framework for analysis. In the estimation of demand systems, both co-integration and seemingly unrelated regression can be used, dependent on the structure of the data. Where time series of prices in most cases are non-stationary, time series of quantities might or might not be non-stationary. Using co-integration, however, claims that time series of both prices and quantities are non-stationary. Therefore, co-integration is only used in this thesis to estimate demand systems where time series of both prices and quantities are non-stationary. Co-integration has been applied as the main tool in four of the subsequent papers (chapters 4, 5, 6 and 7).

On the supply side, the theoretical basis is welfare economics with emphasis on bio-economic production theory. Thereby, included in the analyses is that the renewable resource is not priced and that externalities in the production exist. The main methodology applied is an age-structured bio-economic model, which is chosen instead of an aggregated bio-economic production model (a Schaefer model), since the fishing mortalities of different years differ, and since constant recruitment is more realistic in most fisheries than an assumed dependency between harvesting and stock size. The age-structured bio-economic model has been applied in two of the papers in this thesis (chapters 2 and 8).

The theoretical basis for the trade analysis is the Neo-Classical direction of international economics, including the recent developments related to renewable resources. The main methodology applied is an integrated bio-economic supply and trade model (a partial equilibrium model). This model is applied instead of traditional trade theory since it is capable of taking the externality into account. The model is applied instead of a general equilibrium model of trade in a renewable resource, since it is capable of taking factors such as fisheries management, mesh size regulations and shared ownership of fish stocks into account in a more realistic manner. This is important since the inclusion of these factors might be decisive for the results. The choice of model is made since focus is on the seafood market. Provided that emphasis should be given to interactions of the fisheries sector with other sectors of the economy, general equilibrium models might be a better choice.

To support the developments of these methodologies a range of courses were followed. These include "advanced econometrics" at the University of Copenhagen in the spring 2001, "dynamic analysis and applications in resource and environmental economics" arranged by the

Centre for Fisheries and Aquaculture Management and Economics (FAME) in November 2001, "applied general equilibrium theory" arranged by the University of Southern Denmark in the spring 2002 and "international trade, resources and environment" arranged by FAME in March 2003.

1.4 Summary of the papers included in the thesis

A literature review of studies of international seafood trade

The first paper is a literature review of existing Neo-classical economic-theoretic literature on how international seafood trade and markets are modelled, which is relevant for this thesis. The purpose is to create a "state of the art" which serves as a frame of reference for the subsequent in-depth analyses. Shortages in the knowledge provided by the literature are identified and policy recommendations are drawn on the basis of existent literature, where possible. Methods for delimiting international seafood markets and analysing international seafood demand, supply and trade are reviewed. Co-integration analysis of non-stationary price series is used in the literature to delimitate markets, where different econometric methods are used to estimate demand functions. Supply models are both estimated and calibrated on the basis of age-structured bio-economic models. Basic trade theory is further developed in general equilibrium models in the literature and combined with the economics of open access renewable resources. In the paper a bio-economic supply model combined with basic trade theory is also developed to analyse the effects of liberalising trade in an open access fish stock. Applied research within the area is reviewed and it is demonstrated how the papers contained in this thesis improves our understanding of the links between seafood markets, fisheries management and trade liberalisation.

The use of tariff measures on seafood products in OECD countries

The second paper present an overview of the information gathered for the OECD Committee of Fisheries' Study on Market Liberalisation. The extent of the use of tariff measures on seafood products in OECD countries are assessed and key issues arising from the use of these measures identified. It is found that the applied trade weighted tariff average for imports of seafood products to all OECD countries was

3.1% and the simple average of the bound rate 7.0%. Hence, several seafood products are traded at tariff rates lower than the WTO bound (most favoured nation) rate. It is also found that the difference between seafood species is small, but that tariffs on processed products are larger than on unprocessed. Furthermore, it is found that tariffs on seafood products are low compared to other products and particular compared to other food products. Finally it is found that in the EU a reduction in the WTO bound tariff rates would have small effect on the level of protection, since the majority of the EU import is on applied rates below bound rates. In the USA the bound rates are small and in Japan a large number of tariff rates on seafood products remain unbound. The trade weighted tariff average in Japan is on the same level as in the EU, but in opposition to in the EU, tariff rates on most seafood products are of the same size.

Published in OECD (2003), *Liberalising Fisheries Markets – Scope and effects*, Paris, pp. 80-92. An earlier version was presented at 89th session of the OECD Committee for Fisheries in the study "Liberalising Fisheries Markets: Scope and effects", Paris, France, 18-20 March 2002.

Price formation and market integration on the European first-hand market for whitefish

Total Allowable Catches (TACs) for whitefish in European Union (EU) waters have been reduced each year for the past five years, thereby reducing fleet revenue. During the same period prices increased, partly offsetting the reductions in income. However, price changes depend on the structure of the market within which they are formed and, therefore, the third paper examines the structure of the European first-hand market for whitefish. A Vector Auto Regressive model in Error Correction form is used to analyse landing prices among the main fishing nations, using co-integration tests and tests for the Law of One Price to determine the degree of market integration. A partially integrated European first-hand market for whitefish is identified and as a part of this a perfectly spatially integrated cod market. The existence of this relatively loose market integration is explained by the presence of rigidities on the supply side. The implications are discussed in relation to reductions in the EU whitefish total allowable catches and quotas and to the market policies applied.

Forthcoming in *Marine Resource Economics*. An earlier version was presented at the XIVth Annual Conference at the European Association of Fisheries Economists in Faro, Portugal, 25-27 March 2002.

International market integration and demand: analysis of the Norwegian and Danish herring market

The fourth paper provides a method where pre-tests for international market integration are used to identify market structures before estimating demand systems. The method is applied to the analysis of the European herring market. A Vector Auto Regressive model in Error Correction form is used to identify co-integration vectors between price series and, based on this, allowing test for the Law of One Price. The Law of One Price is in force between the landing markets for herring in the two largest global supplier countries, Norway and Denmark. Therefore, an inverse demand function is estimated for the combined Norwegian and Danish market. The results are used in the interpretation of the increase in the prices of herring on the Danish ex-vessel market in 2001, given the stability of the Danish market. The implication is that even though Denmark did not export to the main Norwegian export markets in the former Soviet Union and Eastern Europe, the Danish landing price is influenced by the situation there.

Published in *Food Economics*, 1 (3), 175-84, 2004. An earlier version was presented at the XVth Annual Conference of the European Association of Fisheries Economists in Brest, France, 14-16 May 2003.

Application of the inverse almost ideal demand system to welfare analysis

The fifth paper presents the theoretical properties of the Inverse Almost Ideal Demand System and applies the system on time series data for cod, herring and plaice in Denmark (1986 to 2001). Furthermore, the shortcoming of the Inverse Almost Ideal Demand System when applied to welfare analysis is discussed. The properties of the demand system show that - since the demand system is a second-order approximation to the true system - it does not have global applicability for welfare measurement. It may, therefore, not satisfy the conditions for calculation of consumer surplus (negative slope and positive point of intersection with the price-axis). The theoretical point is illustrated by an empirical example of the Danish fish market. Using a vector auto regressive model in error correction form to overcome the problem of non-stationarity of data, the Inverse Almost Ideal Demand System is estimated. For cod the intercept is negative and for herring and plaice the slope of the demand function is positive in the data interval investigated. Thus, the estimated demand system is not suitable for welfare analysis.

Submitted to *Marine Resource Economics*. An earlier version was presented at the XVth Annual Conference at the European Association of Fisheries Economists in Brest, France, 14-16 May 2003 and another earlier version was published in Working Paper 43/2003 from the Department of Environmental and Business Economics, University of Southern Denmark.

A Cost-Benefit Analysis of a Public Labelling Scheme of Fish Quality
The purpose of the sixth paper is to introduce a new method capable of evaluating the economic welfare for quality graded fish products using the hedonic price method for plaice in Denmark. Today no labelling scheme exists for the final consumers of different qualities of fish. A scheme does only exist at the first hand market. On this basis, a general applicable theoretical and empirical method is developed to compare the costs and benefits of the hypothetical choice between the total absence of labelling and the presence of a public labelling scheme, which fully inform consumers on the quality and simultaneously allow the producers to differentiate prices between quality grades. It is shown that the economic welfare associated with a public labelling scheme is at minimum 263,000 euro. Sensitivity analysis shows that this result is robust. The policy implication is that a public labelling scheme should not be implemented as the demand and cost functions have low elasticities, implying that the welfare gain is low.

Submitted to *Environmental and Resource Economics*. An earlier version will be presented at the XVIth Annual Conference at the European Association of Fisheries Economists in Rome, Italy, 5-7 April 2004 and another earlier version was published in Working Paper 53/2004 from the Department of Environmental and Business Economics, University of Southern Denmark

Welfare implications of the EU enlargement: the case of East Baltic cod
Recent research has warned that liberalising trade in capture fish products originating from inefficient managed fisheries might cause over-exploitation, reduced fish stocks and thereby reduced steady state welfare. The final paper qualifies the warning in a case study of the East Baltic cod market by developing an age-structured bio-economic model combined with a basic theory of trade between two countries. Welfare effects of trade liberalisation are identified taking fishing quotas, input limitations, mesh size regulations and shared ownership of stocks into account. It is shown that even though liberalising trade in products supplied by such a fishery might cause steady state welfare reductions in the supplier countries, these welfare reductions are small compared to the welfare gains from a hypothetical change to optimal management. Hence, the introduction of better fisheries management is much more important than trying to meet potential negative consequences of trade liberalisation, since even small improvements in fisheries management may offset the negative effects of trade liberalisation. The consequence is that the argument against trade liberalisation in certain situations gains less validity and conventional wisdom from the Neo-classical theoretical tradition regains validity at several and probably most fish markets globally.

Submitted to *Ecological Economics*. An earlier version was presented at the XIth Bi-annual Conference at the International Institute of Fisheries Economics and Trade in Wellington, New Zeeland, 19-22 August 2002 and another earlier version was presented at a workshop entitled “New Policies and Options in Fisheries Management”, Roskilde, Denmark, 26-28 January 2004.

1.5 Conclusions
This section summarises the main findings and policy implications of the work in the thesis and discusses them in a broader perspective. The general finding of chapter 3 is that even though tariff barriers on seafood products are small compared to other products, they still remain and could be further reduced. Furthermore, with new non-tariff barriers emerging motivated by, inter alia, food security and environmental concerns, there is still some way to go to a fully liberalised world seafood market. Hence, potential effects of trade liberalisations remain.

On this basis, the lessons to be learned from this thesis are discussed for the three types of linkages introduced above as well as for methodological issues and in relation to future research.

Issue 1: Linkages between fisheries management and seafood markets
Five papers (chapters 2, 4, 5, 7 and 8) have shown aspects of how fisheries management and seafood markets interact. Fisheries management affect seafood markets through determining steady state supplies and seafood markets affect fisheries management through demand and prices.

The general finding in the literature is that fisheries management is a decisive determinant for the sustainable supplies from fish stocks. Open access may in the extreme case result in the extinction of a commercially exploited stock, where optimal management, for example in the form of individual transferable quotas, results in welfare surpluses.

In chapters 2 and 8 supplies under regulated open and restricted access are analysed. Furthermore, the wide use of compulsory mesh size regulations is included. Taking such measures into account implies that the supply curves are approximately vertical in the relevant range, a situation which may be relevant in several and probably most commercially important fisheries globally that are under some form of management. The implication is that the risk of extinction is largely non-existent for most fish stocks. Hence, overexploitation becomes an economic problem of larger than necessary costs of fishing, more than a biological problem. The risk of extinction, however, remains in countries with inefficient or no fisheries management; this is in particular the case in developing countries.

An implication of the exogenously determined supply is that increased demand results mainly in increased prices. Thus, provided that an integrated world market where prices move together over time exists, the effects of increased demand in parts of the world will increase the prices throughout the whole market. Increased global demand of seafood might not be unrealistic in the near future, since the purchasing power of several developing countries is on the increase. This may in particular be important for seafood products, which may be considered a luxury good in many of these countries. The condition is, however, that markets are integrated internationally and in chapter 4 it is shown that a perfectly integrated European first-hand cod market, albeit imperfectly integrated with markets for other whitefish, exists. In chapter 5 it is shown that an international herring market exists, including markets for direct landings in Denmark and Norway, and the Norwegian export markets in the former Soviet Union. Hence, increased demand in e.g. Russia helps to pressure first-hand prices upwards, internationally and thereby also in Denmark. Therefore, and despite export of herring products from Denmark to Russia being largely non-existent, increased demand in Russia will increase first-hand prices in Denmark. The herring market can therefore not be analysed consistently ignoring the international dimension of the market.

In chapter 4 it is further shown that, provided that an internationally coordinated quota reduction is undertaken and that markets are integrated internationally, studying demand and price formation in single countries yields invalid results. Since the EU Commission fixes the quotas in the EU and as European cod markets are found to be integrated between countries, analysis of the European cod markets must be international. Hence, the present literature, wherein most studies are made for single countries, tends to underestimate the effects of prices resulting from international coordinated quota reductions.

In chapter 5 it is found that herring prices would be more sensitive to changes in quantities when individual transferable quotas are introduced. The reason is that such a scheme leaves more flexibility for the fishermen in choosing when they want to fish. Hence, they can fish when the price is high. This is in itself Pareto-improving. A likely effect of the introduction of individual transferable quotas is a change from traditionally being supply-driven to become partly demand-driven in the long run. Such an outcome of the introduction of the scheme in the Danish herring fishery is unrealistic, however, since Denmark only supplies a limited share of the international market. Norway should also, as the main herring producer nation, join such a scheme.

In chapter 7 the subject of meeting consumer requirements is analysed. The introduction of a public labelling scheme of fish quality, allowing consumers to choose the desired quality and giving an incentive for the fishermen to catch and land higher quality fish, is studied. For plaice in Denmark the benefit of such an introduction is so modest that there is no economic justification for introducing the scheme.

Issue 2: Linkages between fisheries management and trade liberalisation
The analysis of the linkage between fisheries management and trade liberalisation is studied in chapters 2 and 8. It is clear that provided that the two policies are not coordinated only sub-optimal solutions can be achieved. The optimal integrated policy is to regulate fisheries, for example by individual transferable quotas, and simultaneously fully liberalise seafood markets.

The main finding in chapter 8 confirms the result in the literature, warning that liberalising trade in seafood products originating from inefficiently managed fisheries might cause reduced steady state welfare in exporter countries. It is, however, found only to be the case under certain conditions that are unrealistic in several fisheries. In the case study of the east Baltic cod fishery under the assumption of open access, the result was confirmed. If, however, the price increase (caused by the trade liberalisation) in the exporter country had been sufficiently large, welfare gains would have resulted. The reasons are that the cod stock is shared, subject to mesh size regulation, and exploited at such a high level, so the supply curve becomes almost vertical. Therefore, the exporting country increases its share of the total fishing effort, with the total supply being almost unchanged.

When assuming the presence of either regulated open or restricted access, it is found that the steady state welfare effects is small and accounts for less than 7% of the landing value both in the importer and exporter countries. Under the assumption of open access the welfare effect of liberalising trade also accounts for less than 7%. Hence, no matter which of the three management systems is applied the welfare effect of liberalising seafood trade is small.

Furthermore, if optimal fisheries management resulted from the enlargement, welfare gains would have been twenty times larger than the welfare effects of trade liberalisation. Hence, the introduction of better fisheries management is much more important than trying to meet potential negative consequences of trade liberalisation, since even small improvements in fisheries management may more than offset the negative effects of trade liberalisation.

Since the situation of the east Baltic cod fishery is similar to several other fisheries, the result that welfare effects of trade liberalisation are small might also hold for these fisheries. This implies that the conclusion of Brander and Taylor (1998) that "while we are convinced that none of our results is sufficient reason to abandon ongoing trade liberalisation around the world, we are equally convinced that trade liberalisation is a two-edged sword for a country with a comparative advantage in renewable resources and weak property rights in these sectors" should be modified for seafood trade. Along the same line, the conclusion of Emami and Johnston (2000) that "the World Trade Organisation should not always insist on free trade, rather they must pay careful attention to the particular relationships between trade conditions and natural resource policies among trading nations" should also be modified for seafood trade. The reason is that even though the conclusions are not strictly incorrect, they are less valid, since the most commonly used fisheries management systems globally are regulated open and restricted management, subject to mesh size regulations and overexploited stocks (Food and Agriculture Organisation of the United Nations 2001). Hence, the argument that warns against trade liberalisation in certain situations is less valid and conventional wisdom from the Neo-classical theoretical tradition seem more appropriate in several and probably most fisheries globally. Findings by Brander and Taylor (1998) and Emami and Johnston (2000) are not sufficient reasons to abandon the ongoing trade liberalisation.

Issue 3: Linkages between seafood markets and trade liberalisation

The linkage between seafood market integration and trade liberalisation is important for unilateral trade liberalisation, as opposed to multilateral. This is due to the fact that if an exporter country forms a small part of an integrated world market, the only effect of trade liberalisation of a specific country would be that the country forces others out of the market. In the case where a single country is subjected to a countervailing duty, the effect is that the country is forced out itself. Hence, since a European market for cod was identified in chapter 4, the only effect of liberalising trade for a single exporter country is that it forces other out. Further, as the only effect of a country being subjected to a countervailing duty is that the country is forced out by others.

Furthermore, provided that the international trade in herring products was fully liberalised, i.e. the main markets in the former Soviet Union countries removed all trade barriers, traditional theory would predict that Denmark as a herring exporter country would start to sell to these countries. This would, however, not necessarily be the case, since most of the Danish export is in processed forms at higher prices than these markets are prepared to pay. Hence, the Danish export might due to the market structure being unaffected by the trade liberalisation.

Methodological issues

The main methodological lessons to be learned from this thesis relate to the analysis of demand and to the use of the integrated model of bio-economic supply and basic trade theory.

In chapter 5 a new method, where pre-tests for international market integration are used to identify market structures before estimating demand systems, is suggested. In the use of the procedure on the European herring market it is shown that if knowledge of international market integration were not taken into account, the model would have predicted relatively stable conditions on the ex-vessel herring market in Denmark in 2001. The prices actually increased by 80%, due to changing supply and demand on another part of the integrated international market. Hence, demand systems can only be estimated consistently based on the knowledge of international market integration obtained from the market integration tests.

Another issue of demand is raised in chapter 6 where it is shown that the commonly applied Inverse Almost Ideal Demand System is not suitable for welfare measurement. The reason is that it may not globally have negative slopes and positive points of intersection with the price-axis. In a case study of the Danish fish market it is shown that none of three fish species (cod, plaice and herring) included in the estimation of the system fulfil the conditions for being suitable for welfare analysis. The implication is that welfare analysis must be based on the estimation of simpler demand systems, where a specific form of the utility function is postulated. This conclusion remains equally valid for ordinary Almost Ideal Demand Systems.

In chapters 2 and 8 an applied age-structured bio-economic model is developed and combined with basic theory of trade between two countries. The model is developed to identify welfare effects of trade liberalisation, taking detailed information on fishing quotas, input limitations, mesh size regulations and shared ownership of fish stocks into account. The model is developed as an alternative to a computable general equilibrium model. This is due to the general equilibrium model not being well suited for taking the detailed factors into account and with the detailed factors being decisive for whether welfare gains or losses result from trade liberalisations. Therefore, reliable empirical analysis of trade liberalisation of seafood markets cannot be based on a computable general equilibrium model. A model explicitly focussing on the detailed factors, such as the model developed in chapters 2 and 8, is required.

Future research

On the basis of the results obtained in this thesis, there are several future research opportunities. These relate to market and trade analyses.

With the development of co-integration tests around 1990, the market integration tests evolved and it became possible to undertake analysis based on detailed knowledge of market structure and integration. Although the literature on delimiting seafood markets has increased since, only a fraction of the structure and integration of different international seafood markets have been subject to analysis to date. This literature is expected to develop. The purpose of such a development may allow us to study the effects of changes in one part of the distribution chain on other parts of the chain. This will only be possible if further delimitation studies are performed between countries and seafood species. Only through such studies can a microeconomic basis for economic models be obtained. The international dimension is of decisive importance for the opportunity of creating reliable analysis, since the distribution chain of seafood product in most cases covers more than one country. The increased focus on food security and environmental concerns among consumers also demands increased knowledge of the market structure and integration, as well as of trade patterns.

The analysis of trade liberalisation performed in this thesis, based on the bio-economic supply model combined with basic theory of trade between two countries, focuses on the seafood market and treats other sectors of the economy as exogenous. Thereby, the model is not capable of analysing the effects of the liberalisation of e.g. all other foodstuffs in relation to seafood. Emphasising the interactions between different sectors of the economy, the development of a computable general equilibrium model is therefore needed. If the analysis, however, is to be reliable for the included seafood products, the model should not be introduced at the expense of the details offered by the integrated bio-economic supply and trade model. Hence, the challenge is to integrate the two models.

The integrated bio-economic supply and trade model could also be applied to identify the welfare effects of reducing fisheries subsidies, which according to World Trade Organisation (2001) is the problem of the fisheries sector with highest global priority. The model can easily be expanded to identify the welfare effects of reducing subsidies.

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"Price formation on the European first-hand whitefish market", paper presented at the XIVth Annual Conference at the European Association of Fisheries Economists in Faro, Portugal, 25-27 March 2002.

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"Application of the Inverse Almost Ideal Demand System to Welfare Analysis", paper presented at the XVth Annual Conference at the European Association of Fisheries Economists in Brest, France, 14-16 May 2003.

"Market integration and demand: analysis of the European herring market", paper presented at the XVth Annual Conference at the European Association of Fisheries Economists in Brest, France, 14-16 May 2003.

"Analyse af prisdannelsen på det europæiske marked for torskefisk" (An analysis of the price formation on the European market for whitefish), presentation at a fishnet.dk seminar entitled "Fish, humans and ethics", Frederiksberg, Denmark, 13-14 January 2004.

"Welfare implications of the EU enlargement: the case of East Baltic 3

CHAPTER 2

A literature review of studies of international seafood trade

Max Nielsen

Abstract. The first paper is a literature review of existing Neo-classical economic-theoretic literature on how international seafood trade and markets are modelled, which is relevant for this thesis. The purpose is to create a "state of the art" which serves as a frame of reference for the subsequent in-depth analyses. Shortages in the knowledge provided by the literature are identified and policy recommendations are drawn on the basis of existent literature where possible. Methods for delimiting international seafood markets and for analysing international seafood demand, supply and trade are reviewed. Co-integration analysis of non-stationary price series is used in the literature to delimitate markets, where different econometric methods are used to estimate demand functions. Supply models are both estimated and calibrated on the basis of age-structured bio-economic models. Basic trade theory is further developed in general equilibrium models in the literature and combined with the economics of open access renewable resources. In the paper a partial equilibrium model of liberalising trade in an open access fish stock is also developed. Applied research within the area is reviewed and it is demonstrated how the papers contained in this thesis improves our understanding of the links between seafood markets, fisheries management and trade liberalisation.

1. INTRODUCTION

The purpose of the present chapter is to review the existing Neo-classical economic-theoretic literature on how international seafood trade and markets are modelled, which are relevant for this thesis. Creating a general "state of the art" serves as a frame of reference for the further in-depth analyses in the papers in chapters 3-8. Shortages in the knowledge provided by the literature are identified, motivating the relevance of analysing the issues in the remaining chapters. There is an

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analytical angle where policy recommendations are drawn on the basis of existent literature, where possible. Furthermore, the purpose is to explain the innovative value of the detailed subsequent chapters in coherence with existing literature. This is done through the description and assessment of methods applied for:

- The co-integration estimation methodology.
- Defining and delimiting international seafood markets.
- Analysing international seafood demand.
- Analysing international seafood supply.
- Analysing international seafood trade.

The paper is separated into five sections after this introduction. In section two the co-integration estimation methodology is reviewed and in section three the literature on market delineation studies is examined. In section four and five, demand and supply models are examined. Finally, in section six general and partial equilibrium models of trade are reviewed and a synthesis on the effects of international seafood trade liberalisation is given.

2. THE CO-INTEGRATION ESTIMATION METHODOLOGY

The co-integration estimation methodology is used in the literature to test for market integration and to estimate demand systems. Other estimation methods, such as Ordinary Least Square (OLS) and Seemingly Unrelated Regression (SUR), are also used in the literature to estimate demand. In the present section, however, only the co-integration estimation methodology is reviewed, since it is the core methodology adopted in this thesis.

The co-integration estimation methodology is used when data series are non-stationary. Data series are stationary when they move randomly around a constant mean over time and the mean and variance are independent of time, and non-stationary if they follow a trend. Data series shall be integrated of the same order (a data series is said to be integrated of order one, I(1), if the differenced data series are stationary), since otherwise spurious correlation might result. The co-integration methodology is used when data are non-stationary and SUR methods when data are stationary. Provided that data are properly differenced, SUR methods can also be used for non-stationary data. The co-integration methodology is, however, superior to SUR models in that it is based on a pre-defined structure where all variables are endogenous and explained by their own lagged variables. The disadvantage of the co-integration estimation methodology is that it can only be undertaken with relatively few variables.

The first step is to determine the integration order and thereby whether data are non-stationary by testing for unit roots. The null hypothesis H_0 of non-stationarity of the data series (X_t) is tested against the stationary alternative. The regression equation is given in equation 1.

$$\Delta X_t = \pi X_{t-1} + c + \gamma_1 \Delta X_{t-1} + \dots + \gamma_{k-1} \Delta X_{t-k+1} + \varepsilon_t \qquad (1)$$

Firstly, the regression in equation 1 is made unrestricted and afterwards the restrictions in H_0: $\pi = 0$ and $c=0$ are imposed. In terms of equation 1 the alternative hypothesis is that π, γ_1, …, γ_{k-1} is in the stationary range and c is unrestricted. Based on these regressions, the Dickey-Fuller F-test and the Likelihood-Ratio test statistics are given in equations 2 and 3.

$$DF_F = \frac{\frac{RRS_r - RSS_{ur}}{2}}{\frac{RSS_{ur}}{T-k^*}} \qquad (2)$$

$$LR = T \log\left(\frac{RSS_r}{RSS_{ur}}\right) \qquad (3)$$

where *RSS* is the residual sum of squares for the restricted and unrestricted regressions, respectively, *T* is the number of effective observations (number of observations – number of lags) and *k** is the number of exogenous variables in the unrestricted model. The regressions are made for the highest lag significantly different from zero. The regressions exclude the possibility of deterministic trends *a priory*, but such trends can easily be included. Critical values for the tests are given in Kongsted (2001).

Provided that the data series are integrated of order one, multivariate Johansen tests can be used to determine the co-integration rank. A Vector Auto Regressive (VAR) model in Error Correcting (ECM) form is introduced following e.g. Asche, Bremnes and Wessels (1999), according to equation (4):

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-1} + \mu + \varepsilon_t \tag{4}$$

where $\prod$ is the long run solution to the VAR model, which contains the co-integrating relations (or are zero). The rank of the $\prod$ matrix determines the number of stationary linear combinations of X_t. The trace test can be used to test the null hypothesis that there are up to a given number of co-integrating vectors, whereas the alternative hypothesis is that exactly one more co-integrating vector exists. The constant term μ is in the present case restricted to the co-integration space, but a trend term can also easily be included in the regression.

Based on this framework, market integration can be tested with all data series being price series. Provided that the rank is the number of variables, all price series are I(0) and if the rank is 0, none of the price series are stationary. If the rank is between the two extremes, $\prod = \alpha\beta'$, where β contains the co-integrating vectors. In that case, a rank less than the number of variables minus one implies that some of the price series might be formed on separate markets, where a rank of exactly the number of variables minus one implies that a common integrating factor exists and the price series forms part of an integrated marked. Based on a rank of the number of variables minus one, the Law of One Price (LOP) can be tested in order to determine whether the price series forms part of a perfect or partial integrated market. This can be done using Likelihood Ratio tests on β. In a bi-variate set-up, x_t contains two price series and if these price series co-integrate, the rank is one and a test of $\beta' = [1, -1]'$ is the test of the LOP. In a multivariate set-up, a test of the LOP is a test of whether the column in the β matrix sums to zero, implying that the price series are pair wise co-integrated and thereby follow a common trend. In the multivariate test the β matrix is shown in equation 5, for a model with four variables.

$$\beta' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix} \tag{5}$$

Testing whether the LOP holds is now a test of whether imposing the restriction on β' makes $\beta' X_t$ stationary. The tests of the LOP are performed without any identification problems in all cases in this thesis, due to that the rank condition of Johansen and Juselius (1994) is fulfilled.

Based on the framework in equation 4, demand systems in different forms can also be estimated, with X_t now being price and quantity series, all integrated of order one. A simple demand system based on a Cobb-Douglas utility function, with only one price and one quantity series included and with the quantity exogenous, can be estimated using equation 6.

$$\begin{bmatrix} \Delta \log(P_t) \\ \Delta \log(Q_t) \end{bmatrix} = \Gamma_1 \begin{bmatrix} \Delta \log(P_{t-1}) \\ \Delta \log(Q_{t-1}) \end{bmatrix} + \alpha\beta' \begin{bmatrix} \log(P_{t-1}) \\ \log(Q_{t-1}) \end{bmatrix} + \varepsilon_t \qquad (6)$$

where P is price and Q is quantity. Given the absence of misspecification problems, the rank being one and normalising around the price series, the parameter obtained expresses the percentage price change following from an increase in quantity by one percent, since the data series are logarithmic. This estimation procedure can easily be extended to estimate more advanced forms of demand systems.

3. DEFINING AND DELIMITING INTERNATIONAL SEAFOOD MARKETS

To correctly assess the effect of changes in market arrangements and trade policy and to be able to understand the implications of changes in the fisheries policy on markets a proper method for delimiting the relevant market is needed, particularly since the sea food markets most often are internationally integrated and over time increasingly so. Such a method is also needed to correctly understand the development in markets and separate the effect of exogenous changes from the effect of policy. Further the distributional impact of such changes on different groups among consumers and fishing fleets can only be assessed if the market structure is correctly understood.

A market, according to Stigler (1969), is defined as “the area within which the price is determined, allowances being made for transport costs”. Similar definitions of a market are provided by Cournot (1971) and Marshall (1947), who stated the LOP, but the modelling of prices in competing markets dates back to at least Hotelling (1929). Furthermore, these definitions are based on work from the 1800's. The LOP states that if prices of goods move together over time they are formed within the same market. Hence, the delimitation of a market is closely related to a study of prices, where if prices affect each other, goods must to some degree be formed within the same market. This degree can, according to Stigler and Sherwin (1985), "show every level of interdependence from absolute homogeneity to complete independence – the continuity of the conventional criteria of cross-elasticities of demand and supply are enough to suggest that". Thus, a market can either be one where all prices move perfectly together over time, or consist of several sub-markets where prices affect each other without moving perfectly together. If prices do not affect each other they are formed on separate and distinct markets.

Based on such an understanding of the meaning of a market, the theoretical framework for the determination of market sizes and boundaries in empirical testing is described in the present section. The most important results obtained by using the method on the European seafood markets are also presented.

The LOP in the basic simple bivariate form is, according to Stigler (1969), tested by estimating $\ln(p_{1,t}) = B + A\ln(p_{1,t}) + \varepsilon_t$, where the price of good one ($p_{1,t}$) and the price of good two ($p_{2,t}$) are of two different products. A=1 implies that the LOP is in force. This simple bivariate form of the LOP can easily be extended to a multivariate form by adding extra goods, e.g. $C\ln(p_{3,t})$, and then testing jointly whether $A + C = 1$. However, the regression is only valid for stationary price series. A price series is stationary if it demonstrates a random walk around some constant value, i.e. if it oscillates around a constant value over time.

For non-stationary price series, the co-integration analysis of the last section must be used. The point of departure is the Johansen co-integration rank procedure, which is based on a VAR in ECM form, following e.g. Asche Bremnes and Wessells (1999). Based on that model, co-integration and the LOP can be tested for non-stationary price series. Furthermore, long run exclusion of price series can be tested. Finally, testing for weak exogeneity of the individual price series can identify market leaders. Based on the results of these tests, market structure and integration can be determined. Given that the tests for co-integration identify a single integrating factor common to all the price series, and given that the test of the LOP shows that the LOP is in force, the goods analysed are homogeneous, relative prices are constant and markets are perfectly integrated. Thereby, prices can fluctuate according to random shocks in the short run, but will be brought together again after an adjustment process. When the co-integration test identifies a single common integrating factor and the LOP is rejected, markets are partially integrated and consist of sub-markets. This is also the case when long run exclusion is rejected. When the co-integration test cannot identify one common integrating factor and when long run exclusion is accepted, some of the goods might be heterogeneous and their markets independent.

The implication of the LOP being in force is, according to Asche, Bremnes and Wessells (1999), that the Generalised Composite Commodity Theorem of Lewbel (1996) holds, and that commodities can be aggregated. Thus, in consistent analyses of supply, demand and trade, the markets should be defined using the above method. Thereby, market integration tests serve as a pre-test to determine the level of aggregation, before undertaking further analyses.

Miljkovic and Paul (2001), however, criticise Asche, Bremnes and Wessells (1999) in their application of the market integration techniques on geographical distinct locations by arguing that they do not address the notion of tradability, implying that market integration is not defined in such a precise manner that it is reasonable to draw policy conclusions. Formulated otherwise and using Gonzáles-Rivera and Helfand (2001), a market consisting of geographically distinct locations will be considered integrated only if there is physical flow of goods between the locations, either directly or indirectly, and if prices in the different locations move together over time. Hence, according to Miljkovic and Paul (2001), Asche, Bremnes and Wessells (1999) do not take into account that it should be possible to trade the good between the different locations. And that is not always the case. The consequence is that the test of the LOP becomes a test for efficiency of the international market instead of a test for market integration. The reason is that transaction costs, albeit large for a perishable product such as fish, are not accounted for explicitly. Asche, Bremnes and Wessells (1999) respond that although non-stationary transaction costs pose a limitation of the methodology, this is not problem on international seafood markets since transactions costs are small. Furthermore, the Gonzáles-Rivera and Helfand (2001) condition for the presence of an integrated market, that there should be a direct or indirect flow of goods between locations, is pointed out by an example in chapter 5. An example of the condition of indirect flow of goods is given, since the LOP is found in force between two countries which do not trade with one another, but which share a third country as a common trade partner.

The market integration methodology is applied on the European seafood markets in a number of studies. Some studies focus on the international integration of seafood markets between countries (Gordon and Hannesson (1996) and Asche, Bremnes and Wessells (1999)), where others test the integration of markets for different fish species and products in single countries in Europe (Gordon, Salvanes and Atkins (1993), Asche, Salvanes and Steen (1997) and Jaffry *et al* (2000)). Finally, the Asche *et al* (2002) study focuses on the integration of markets at different levels of the distribution chain. Common for these articles is that the identified market integration in the early studies is only co-integration and long run exclusion, where later on market integration is also that the LOP is in force.

Gordon and Hannesson (1996) study the integration of fresh and frozen cod markets between the main European cod consumer countries and the US. It is found that that the markets for frozen cod fillets in France, Germany, the UK and the US are integrated since one common integrating factor is identified. The LOP is, however, not tested and it remains unclear whether markets are perfectly or partially integrated. Furthermore, one integrated market is identified for fresh cod between the three European countries, but this market does not include the US. Thus, the frozen cod market remains more closely integrated than the fresh cod market, which is in accordance with *a priori* expectations taking the perishability of fresh cod into account.

In chapter 4 the LOP is also found in force on the first hand market for cod between the largest supplier countries in Europe. One implication is that the part of the potential income of the EU fishermen appearing from the price, rise with the gradual worsening of the North

Sea cod stock. However, due to the integration of the international markets there is an upper limit for the price rise, since imports to the EU rise with the price. Asche, Bremnes and Wessells (1999) examine the international integration between wild caught salmon from the US and farm raised salmon from Norway. The LOP is found in force and salmon from these locations form one integrated international market. Furthermore, the Norwegian salmon price is identified as the market leader. The implication is that consistent supply, demand and trade analyses of the salmon market must depart from a salmon product aggregated from all these locations. An interesting policy implication following from their analysis is that the appearance and fast development of Norwegian salmon farms over the last two decades, has implied that the income potential of American salmon fishers has been pushed downwards to a considerably lower level.

The tests of market integration between fish species include Gordon, Salvanes and Atkins (1993) who test for market integration in the form of identifying one common integrating factor between salmon, cod and turbot on the Paris wholesale market. They find weak evidence of the existence of one common integrating factor between cod and turbot, implying that one market might exist for those two species. They do, however, also find that salmon can be excluded from this market. A policy implication is that markets for wild caught and farmed fish are not integrated, provided that the wild caught fish are not the same species as the farmed. Jaffry *et al* (2000) confirm this conclusion in the analysis of the price interactions between salmon and wild caught species on the Spanish market, since the results suggest that “salmon is at best only a weak substitute for tuna, hake and whiting”. Finally, Asche, Salvanes and Steen (1997) study the integration between EU imports of fresh and frozen salmon and crustaceans, by undertaking long run exclusion tests. None of the products can be excluded and it is concluded that evidence for the existence of one market is present. This is, however, only the weakest form of integration.

The tests of market integration between different levels in the supply chain include the Asche *et al* (2002) study. The LOP is tested and provided that it is in force, prices at different levels in the chain move proportionally to each other over time. The reason is that there is only one variable factor in the intermediaries’ production technology. The implication is that consumer demand can be modelled using derived demand. A proportional relationship is found between the ex-vessel price and the domestic fresh and dried salted cod prices, implying that the domestic demand for fresh and dried salted cod can be modelled as derived demand from the landing market.

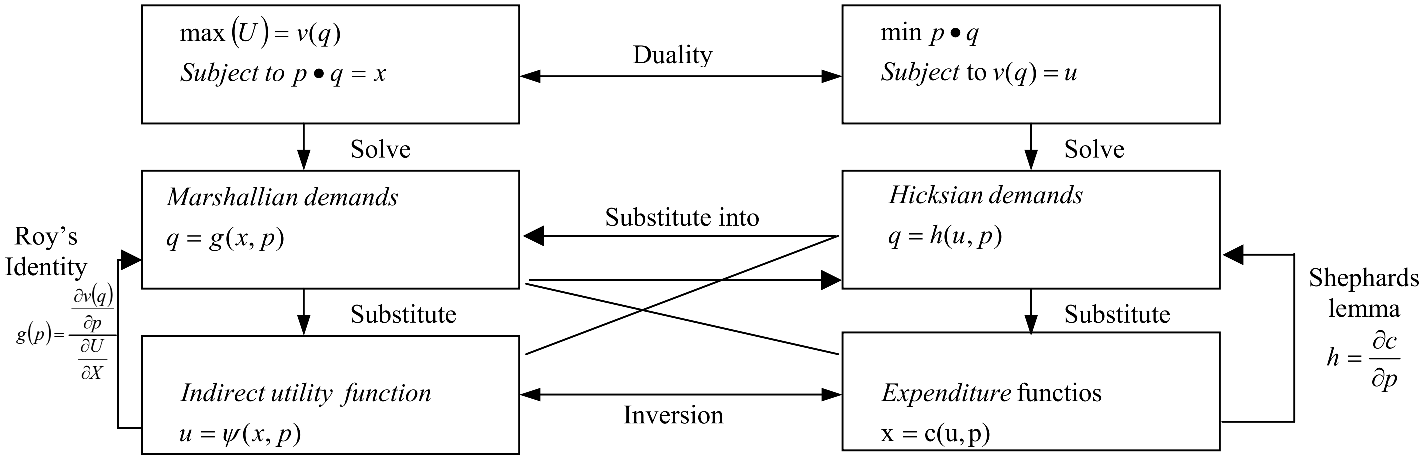
In chapter 5 the integration of markets at different levels in the supply chain is also tested, with first hand herring markets in Denmark and Norway on the one hand and the two countries export markets for different product forms on the other. The LOP is found to be in force between the first hand markets in the two countries and the Norwegian export market for frozen herring in the former Soviet Union and Eastern Europe. The policy implication is that the doubling of the landing price in Denmark in 2001 can, given the stability of the supply and demand in Denmark, be explained by supply and demand on the international market. Hence, the market for the recently introduced individual transferable quotas in the Danish herring fishery will be affected by the volatility of the international herring market.

4. DEMAND

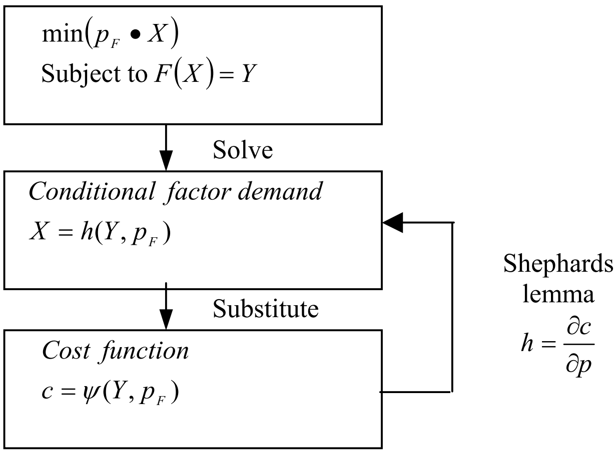
Empirical studies of demand dates back many centuries and it can be argued that empirical demand analysis is the main motivation for the subject of economics. The first known empirical analysis of demand is by the Frenchman Devenant from 1699. Stone (1954) provided an important modern contribution and empirical studies of seafood demand started with Bell (1968) and Nash and Bell (1969). The basis of these studies is traditional neo-classical commodity market analysis where the demand functions are deduced from the maximisation of the consumer utility subject to the budget restriction, assuming well-behaved preferences. Using a Lagrange optimisation, the utility is maximised and the demand function is identified for the rational consumers. The effect of changing demand can then be decomposed into a substitution effect and an income effect, as stated by the Slutsky equation (Slutsky 1915).

In 1980 this approach was criticised for being based on arbitrary preference rankings, as revealed by the choice of the utility function. Therefore, Deaton and Muellbauer (1980a) introduced an alternative. Instead of postulating a specific form of the utility function, they introduce an alternative, which “permits exact aggregation over consumers and represent market demand as if they were outcome of decisions by a rational representative consumer". In this approach cost is minimised given utility, instead of utility being maximised given the budget. These are referred to as Hicksian and Marshallian demand, respectively, and as a whole as "the dual approach". The dual approach is presented in full for final goods in Figure 2.1. Conditional factor demand is also represented, since demand for fish species at the first hand market level on several occasions is derived demand from companies which purchase for further processing. This is for example important in Denmark where the major part of seafood caught or raised on fish farms is used for processing.

FIGURE 2.1 **The dual approach for final goods and factors of production.**



a. Final goods



b. Factors of production/raw material input

Source: Varian (1994); Deaton and Muellbauer (1980a).

Where p is the price of final goods, p_F is factor price, q is quantity, X is expenditure, U is utility and Y is production. For final goods, the Marshallian demand function appears after profit maximisation, and substituting the demand function into the utility function gives the indirect utility function. On the basis of the indirect utility function, Marshallian demand can be found using Roy's identity. The Hicksian demand function appears by cost minimisation and substituting the demand function into the cost minimisation problem yields the expenditure function. On the basis of the expenditure function, Hicksian demand can be found using Shephards lemma. Furthermore, the indirect utility function and the expenditure function can then be found by inversion of each other. The indirect utility function can also be substituted into the Hicksian demand function thereby obtaining the Marshallian demand function. Further, the expenditure function can be substituted into the Marshallian demand function giving the Hicksian demand function.

For factors of production the minimisation of costs gives the conditional factor demand, and substituting this into the cost minimisation problem yields the cost function. This corresponds to cost minimisation for final goods, as shown on the right side of Figure 2.1a. The left side of Figure 2.1a is not reproduced for factors of production, since high production is not an objective in itself for processors, as utility is for the final consumers.

The Hicksian approach departs from a specific form of the expenditure function, which can be tested for theoretical consistency. The demand function is approximated around the optimal point for the true preference structure and the approach rests on the testable adding up, homogeneity and symmetry assumptions. Provided that these assumptions are not rejected in empirical testing, the Hicksian model is theoretically consistent and not, as the Marshallian model, based on an arbitrary preference ranking. Another difference is that the Marshallian as opposed to the Hicksian demand model has global validity (valid for all quantities), implying that they can be used to global welfare analysis.

In empirical modelling two types of demand models have evolved. Ordinary demand models are built on the assumption that causality in the price formation goes from prices to quantities, i.e. prices are exogenous. Inverse demand models start from the opposite assumption where quantities determine prices, given exogenous supply.

The inverse demand model developed from Anderson (1980), who established some theoretical properties of the inverse version of the Marshallian demand model, followed by Barten and Bettendorf (1989) introducing a Hicksian demand model in inverse form, the Rotterdam model. Eales and Unnevehr (1994) outlined another inverse Hicksian demand model, the Almost Ideal Demand System (AIDS). Eales, Durham and Wessels (1997) generalised these models with the introduction of nesting parameters and Jaffry, Pascoe and Robinson (1999) estimated an inverse Marshallian demand system of fish products using co-integration methods of non-stationary variables. Park and Thurman (1999) and Beach and Holt (2001) gave special emphasis to the scale flexibility.

The ordinary demand model can be dated back to Stone (1954) and has been applied on fish products in a number of studies. Recent studies include the Wellman (1992) estimation of the AIDS on US seafood demand, the Burton and Young (1992) use of a dynamic AIDS incorporating systematic demand shifters, and the Asche (1996) estimation of an AIDS for salmon in the EU using differential equations. Furthermore, Moschini (1995) and Asche and Wessels (1997) discuss the price indexes used in the AIDS, Eales, Durham and Wessels (1997) generalise the Hicksian demand systems using nesting parameters, and Eales and Wessels (1999) use this approach to test for separability of meat and fish in Japan. Kaabia and Gil (2001) introduce the use of co-integration to estimate an AIDS with non-stationary data. Definitions of flexibilities and elasticities are shown in Table 2.1.

TABLE 2.1 **Definitions of flexibilities and elasticities.**

Inverse demand	Ordinary demand
Price flexibility is "the percentage change in the price of a good, as demand increases by one percent". Own and cross price flexibilities exist. Provided that the own price flexibility is larger than –1, the price is inflexible and if it is less, the price is flexible. Provided that the cross price flexibility is negative the goods are substitutes, and if it is positive the goods are complements. Price flexibilities might include 1) both the direct quantity induced price effect and the indirect effect caused by changes in purchasing power (uncompensated demand) and 2) the quantity induced price effect (compensated demand).	**Price elasticity** is "the percentage change in the demand for a good, as the price increases by one percent". Own and cross price elasticities exist. Provided that the own price elasticity is less than –1 the price is elastic and if it is larger than –1 the price is inelastic. Provided that the cross price elasticity is positive the goods are substitutes and if it is negative the goods are complements. Price elasticities might include 1) both the direct quantity induced price effect and the indirect effect caused by changes in purchasing power (uncompensated demand) and 2) the quantity induced price effect (compensated demand).
Scale flexibility is "the percentage change in the normalised price of a good, whose buyers' aggregate consumption of goods increases by one percent". Provided that the flexibility is larger than –1 the good is a luxury, and provided that it is less, the good is a necessity.	**Income elasticity** is "the percentage change in the demand for a good, as the buyers′ income increase one percent". If the income elasticity is larger than 1 the good is a luxury, if it is between o and 1 it is a necessity, and if it is less than 0 it is inferior.
Mean size fish price flexibility is "the percentage change in the price of fish on the ex-vessel market, when the average size of landed fish increases by one percent" (Gates (1974)). This flexibility is used to assess economic consequences of changing age composition of the stock, e.g. following changing mesh size regulation.	
Allais coefficient measures the degree of interaction between two goods in relation to a reference pair of goods and forms an alternative to cross price flexibilities (Barten and Bettendorf (1989)).	

Flexibilities and elasticities can be calculated on the basis of parameters estimated from different functional forms of demand systems using econometric methods. In the early studies Ordinary Least Squares (OLS) were generally applied, but today only Vector Auto Regression (VAR) and Seemingly Unrelated Regression (SUR) are applied. VAR is used when data are non-stationary and SUR in the presence of stationarity. Provided that data can be properly differenced, SUR can also be used on non-stationary data. Four examples of commonly used functional forms are presented in Table 2.2 for both inverse and ordinary demand systems and written as simple, static models for closed economies.

TABLE 2.2 **Functional forms of the demand models.**

Model	**Inverse**	**Ordinary**
Marshallian demand		
Linear	$p_i = \alpha_{0+}\alpha_i m + \sum_j \alpha_{ij} q_j$	$q_i = \beta_0 + \beta_i I + \sum_j \beta_{ij} p_j$
Logarithmic	$\ln(p_i) = \alpha_{0+}\alpha_i \ln(m) + \sum_j \alpha_{ij} \ln(q_j)$	$\ln(q_i) = \beta_0 + \beta_i \ln(I) + \sum_j \beta_{ij} \ln(p_j)$
Hicksian demand		
Rotterdam	$w_i \ln\left(\frac{p_i}{m}\right) = \alpha_{0+}\alpha_i \ln(Q) + \sum_j \alpha_{ij} \ln(q_j)$	$w_i = \beta_0 + (\beta_i - w_i)\ln\left(\frac{X}{P}\right)$ $+ \sum_j (\beta_{ij} + w_i(\delta_{ij} - w_j))\ln(p_j)$
	Adding up $\sum_i \alpha_{ij} = 0$, $\sum_i \alpha_i = -1$ Homogeneity $\sum_j \alpha_{ij} = 0$ Symmetry $\alpha_{ij} = \alpha_{ji}$	Adding up $\sum_i \beta_{ij} = 0$, $\sum_i \beta_i = 1$ Homogeneity $\sum_j \beta_{ij} = 0$ Symmetry $\beta_{ij} = \beta_{ji}$
AIDS	$w_i = \alpha_0 + \alpha_i \ln(Q) + \sum_j \alpha_{ij} \ln(q_j)$	$w_i = \beta_0 + \beta_i \ln\left(\frac{X}{P}\right) + \sum_j \beta_{ij} \ln(p_j)$
	Adding up $\sum_i \alpha_{ij} = 0$, $\sum_i \alpha_i = 0$ Homogeneity $\sum_j \alpha_{ij} = 0$ Symmetry $\alpha_{ij} = \alpha_{ji}$	Adding up $\sum_i \beta_{ij} = 0$, $\sum_i \beta_i = 0$ Homogeneity $\sum_j \beta_{ij} = 0$ Symmetry $\beta_{ij} = \beta_{ji}$
Where	p_i = Price of good *i*. q_i = Quantity of good j. m = Revenue. w_i = $\frac{p_i q_i}{m}$ = Market share of good *i*. $\ln(Q)$ = $\sum_j w_j \ln(q_j)$ = Quantity index. α_o = Intercept. α_i = Coefficient of scale effect. α_{ij} = Coefficient of quantity effect.	X = Expenditures. P = $\sum_i w_i \ln(p_i)$ = Price index. β_0 = Intercept. β_i = Coefficient of income effect. β_{ij} = Coefficient of price effect. δ_{ij} = Kroneckers delta.

The functional forms of the inverse and ordinary models, respectively, are written in rank of increasing complexity. In the inverse models the prices are determined by quantities and income and in the ordinary models the quantities depend on prices and scale of consumption. The two first equations are the simplest forms, where variables are given in linear and logarithmic terms. The two other forms are extended with expressions in market shares.

The Marshallian models include the linear form with constant slopes and the logarithmic forms with constant flexibilities and elasticities. Flexibilities and elasticities in the logarithmic model are constants, since they are deduced from a Cobb-Douglas utility function. The model is the most frequently used on seafood markets. The Hicksian models include the Rotterdam and AIDS forms, both with the testable theoretical adding-up, homogeneity and symmetry restrictions. In the inverse Hicksian model, the total quantity of all goods can be computed by use of different quantity indices and can, in a model without savings, be replaced by income. In the ordinary Hicksian model expenditures of all goods in the system divided by a price index represent the scale of consumption in the system. All the functional forms are presented for static models and for closed economies, but can easily be extended to include dynamics and open economy relations.

The choice of functional form in the analysis of specific markets must be based on theoretical consistency and statistical fit. Theoretical consistency can be tested in the Hicksian models, as opposed to the Marshallian models where a specific form of the utility function is postulated. Statistical fit, such as explanation power, relevance of included variables and expected signs, also determine the functional form.

The choice of inverse or ordinary model depends on the market analysed. Wilen (2000) concludes “on fish markets quantity is predetermined at the market level due to the widespread use of quantity regulation in fisheries management”. That is, quantities are determined by factors such bio-economy, weather and fisheries management, no matter what the prices are, implying that the inverse model should be chosen. The price flexibilities obtained from the estimation can then be used to assess the effect of changing fishing quotas on prices. In other parts of the supply chain than on the first hand market, however, the ordinary model might possess more explanatory power than the inverse. The reason is that markets for fish products are international, with a considerable share of the consumption in many countries imported from several different places. Hence the assumption of exogenous supply in the inverse demand models is not reliable.

Systems of seafood demand in Europe have been estimated in more than thirty studies over the last three decades. The simple average of results of studies summarised in Nielsen (1999) is shown in Table 2.3[1].

TABLE 2.3 **Average of estimated flexibilities and elasticities.**

	Inverse demand[1]	**Ordinary demand**[1]
Average of 75 own price flexibilities	-0.30 [-1.00; 0.00]	.
Average of 66 own price elasticities (inverted)	.	-0.94[2] [-4.76; -0.05]
Average of 28 scale flexibilities	-0.90 [-1.79; 0.89]	.
Average of 13 income elasticities (salmon excluded)	.	0.80 [-5.21; 3.12]

Note: 1. Maximum and minimum values given in [].
2. This number is inverted to be comparable to the average flexibility. The average was –1.06 before inversion

Source: Nielsen (1999).

According to the estimations of the inverse demand systems, prices are inflexible. According to the estimated ordinary demand systems, prices are almost unit-elastic. The variance is, however, larger in the ordinary model than in the inverse. Furthermore, according to the inverse model, preferences for fish are almost homothetic (between luxuries and necessities), and according to the ordinary model and excluding salmon, fish are necessary goods. Salmon was until around 1995 generally found to be a luxury good, although the result of Asche, Salvanes and Steen (1997) indicate that this might not be the case any more. The reason for the possible change of salmon from a luxury to a necessary good might be the intensive development of salmon farming. Other fish are generally found necessary, although Young (1984) find that smoked mackerel in the UK is inferior. The prices and sales of luxury goods follow the economic peaks and lows to a larger degree than necessary goods.

It appears that the average reciprocal own price elasticity is more than three times larger than the average own price flexibility, even though the reciprocal own price elasticity theoretically should equal the

[1] It is ignored that the average may depend on several different factors, including e.g. the data period.

own price flexibility. Houck (1966), however, obtained the same result by estimating the two types of models on the same data, and explained it by that the reciprocal value “depends upon the strength of the cross effects of substitution and complementarity”. Huang (1994) also obtained this result and further concluded “by using inverted elasticities to represent flexibilities or vice versa, sizeable measurement errors may be committed”. Therefore, it is important to choose the correct model in practical analyses. The main explanation of the difference is the different degree of substitutability with respect to other goods included in the two models. In the ordinary models the exogenous prices are influenced by several substitutes, which are therefore indirectly included in the models. In the inverse models only sector specific relations influence the exogenous quantities and substitutes are therefore not included in the models.

Another explanation of the differences might be that inverse demand systems generally are estimated on first hand markets, where ordinary demand systems are estimated on import, wholesale and retail markets.

A third explanation of the difference between the own price flexibility and the reciprocal own price elasticity is that several of the above studies are undertaken without including specific knowledge of market structure and integration. The reason is that the market delineation techniques of non-stationary price series developed as late as 1990 and became common practice only some years after. Hence, only in the recent literature it has been possible to depart from specific knowledge of market structures. The consequence is that most of the studies are performed for a few fish species and products in a single country. Thereby, it is not taken into account that markets are integrated, both internationally and between species.

Several economic studies on international trade are based on the Armington (1969) assumption of product heterogeneity. In the presence of market integration, however, products are not heterogenous and the implication is, according to Asche, Bremnes and Wessells (1999) that the Generalised Composite Commodity Theorem of Lewbel (1996) holds, and that commodities as a consequence should be aggregated. This is important, since the aggregation level affect the results. Price flexibilities estimated on smaller parts of larger internationally or inter-species integrated markets will theoretically be smaller than on the whole integrated market. This issue is discussed in chapter 4, where a price flexibility of –0.30 in the presence of international and inter-species integration of the European cod markets would predict a too low price increase following from a potential international coordinated quota reduction. This point is validated on seafood markets internationally or inter-species integrated and are subject to international coordinated quota settings. Even though this is a common situation, the point has according to the author not been raised in the literature before.

The results of the estimated demand systems can further be used as input to welfare analyses, by calculating consumer surplus in Marshallian demand models and compensating variation in Hicksian models. Teisl, Roe and Hicks (2002) analyse whether the dolphin-safe label altered consumer purchases of tuna by estimating an AIDS and identify compensating variations as a partial measure of society's willingness to pay to avoid personal contribution to dolphin mortality in tuna fishing. The point that such a welfare measure may be inappropriate in practical estimations of AIDS systems is raised in chapter 6. The reason is that the AIDS is not suitable for welfare analysis, since it is an approximation around the point of the true preference structure. Thus, the AIDS cannot be used for global welfare analyses. The welfare measure is only partial.

Furthermore, it is argued in chapter 6 that if it should be meaningful to identify consumer surplus or compensating variation, the slope of the demand curve must necessarily be globally negative and the intercept positive. This might not be the situation in several practical estimations of AIDS systems and it is shown not to be the situation in a case study of the Danish seafood market. To the knowledge of the author this issue has not been raised in the literature before.

The implication of the result in chapter 6 is that welfare analyses in general must rely on global negatively sloped demand systems as well as they must have positive intercepts. These requirements are normally fulfilled in linear and logarithmic demand systems. Therefore, the notion that global valid welfare analysis must rely on simple functional forms of the demand system is raised in chapter 6. To the knowledge of the author this notion has not been presented anywhere else in the literature. Based on this a simple linear demand system is estimated for different quality grades of plaice in Denmark in chapter 7 and welfare effects of introducing quality labelling for the final consumers are identified. Based on a hedonic price method, a general applicable theoretical and empirical method is developed to compare the costs and benefits of the hypothetical choice between the total absence of labelling and the presence of a public labelling scheme, which fully informs consumers of the quality and simultaneously allow the producers to differentiate prices between quality grades. It is found that such a labelling scheme should not be introduced for economic reasons. To the knowledge of the author, a method which identifies the total welfare in the form of both producer and consumer surplus on a public labelling scheme of fish quality has not been presented in the literature before.

5. SUPPLY

Studies of supply of fish products have foundations in the theory of exploitation of renewable resources, based on negative externalities in the production. Supply of wild caught fish are distinct from the supply of other goods, where it is possible to react to favourable market conditions by increasing the production. This is not an option in most fisheries, since overexploitation may result. The approach undertaken here focuses on steady state equilibriums, since the fish stocks need time to adjust. Hence, the focus is on the long run with the short run analysis differing considerably. The reason is that the stock is not significantly reduced in the short run. Even though fishermen may be able to switch their fishing to target particular species, the total fishing capacity limits the supply in the short run in most situations. In the extreme, however, it may be possible to catch the total of the stock in the short run, thereby obtaining a high level of supply. Hence, the short run supply curve will be globally increasing and concave, until the supply equals the whole stock. In particular if the stock has schooling nature.

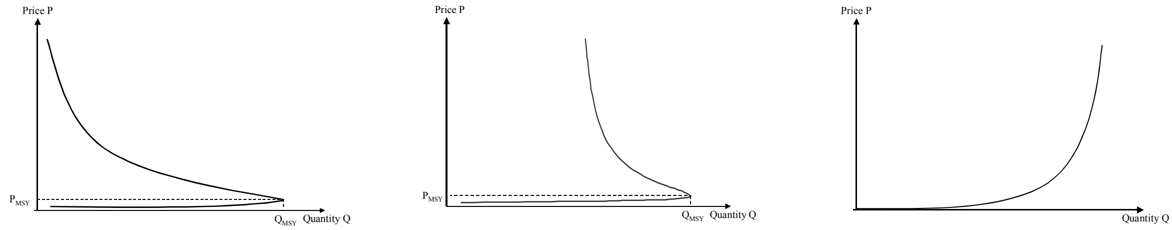
The reason for focusing on the long run is that the fishing industry differs from other industries mainly in the long run. In the short run supply curves in fisheries are globally increasing and similar to other industries. In the long run, over-exploitation may result in lower future production possibilities, as opposed to other industries.

In the following it is implicitly assumed that the discount rate is zero. The reason is that if it were positive, the long run discounted supply curves for all types of supply regimes would, according to Clark (1990), be backward bending at sufficiently high rates.

The studies are based on traditional fisheries economics and in particular the Copes (1970) introduction of the backward bending supply curve of an open access fish stock. This curve is deduced as the average cost curve on the basis of a Schaefer production function. Supply increase until the Maximum Sustainable Yield (MSY), decreases afterwards and approaches zero at infinitive high prices. According to chapter 8 the supply curve might also be deduced on the basis of an age-structured approach based on Beverton and Holt (1957), assuming constant recruitment and taking different fishing mortalities of different year classes into account. The deductions and assumptions are presented in chapter 8 in detail and the supply curve is deduced from the yield per recruit curve assuming that the total cost curve is linear.

According to Clark (1990), the shape of the yield per recruit curve depends on the fishing mortalities and the selectivity appearing from the use of e.g. mesh size regulation. At sufficiently small mesh sizes and large fisheries, the yield per recruit curve is similar to the Schaefer based supply curve. That is, the Schaefer model is a special case of the age-structured approach. At sufficiently large mesh sizes the yield per recruit curve will be increasing in the relevant range. Between the two extremes, the yield per recruit curve remains backward bending, but will approach a positive yield, since the stock cannot be depleted. In chapter 8 it is found that these patterns depend on several factors, but remains valid also for the supply curve of the East Baltic cod fishery. For the East Baltic cod fishery, the shape of the supply curve follows the shape of the yield per recruit curve. Using the East Baltic cod fishery as an example, the shapes of the supply curve under three alternative assumptions on the selectivity is presented in Figure 2.2.

FIGURE 2.2 **Shapes of the supply (average cost) curves**



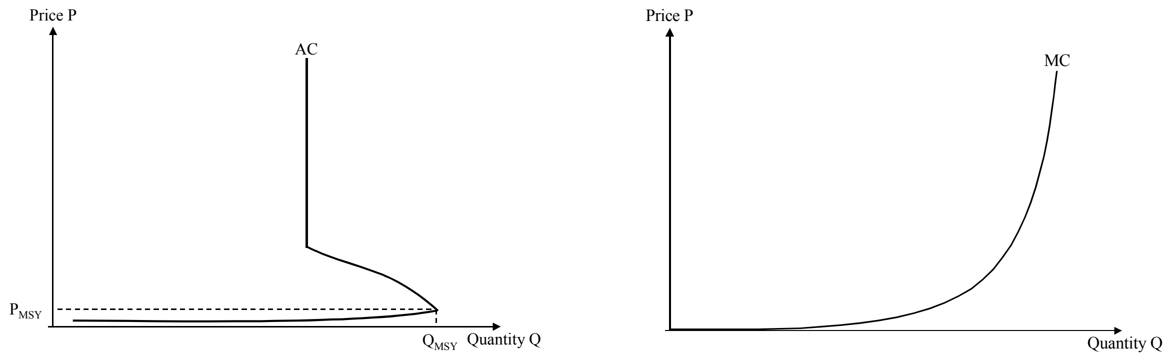
a. Small mesh sizes b. Medium mesh sizes c. Large mesh sizes

For sufficiently small mesh sizes and at large fishing mortalities, the supply curve bends backwards and approaches zero at infinitive high prices, where for larger mesh sizes it approaches a positive quantity. For sufficiently large mesh sizes (mesh sizes constructed to catch fish older than 6 years) the supply curve is increasing in the relevant range. Fishing effort increases with prices and the position of the curves can be shifted with changes in key parameters. If, for example, the recruitment falls or the natural mortality rises the curve will shift inwards, thereby reducing supply at given prices.

It appears that the shape of the supply curve depends on the selectivity and since mesh size regulation is used in most fisheries, the supply curve of the medium mesh size situation might be the most common one. Furthermore, since fishing in several fisheries is on a level causing overexploitation, the common situation is also that fishing is well above the MSY. This implies that even with open access, the supply curve is approximately vertical for high prices. This point is to the knowledge of the author not raised in the literature.

Although the situation with medium mesh sizes may apply in most fisheries, the situations with small and large mesh sizes also apply in some fisheries. In the following, however, focus is on the medium mesh size situation and supply curves in the presence of management are identified. Input and output management is analysed in three alternative schemes; regulated open access, regulated restricted access and optimal management (e.g. individual transferable quotas). Supply curves are shown in Figure 2.3.

FIGURE 2.3 **Supply curves in the presence of fisheries management in the medium mesh size situation**



a. Regulated open and restricted access

b. Optimal management

It appears that the supply curves in regulated open and restricted access are similar. The supply curves follow the open access supply curve until a certain level above MSY and is then given by the quota. The economic optimal way to fix the quota under such a management scheme is to limit the fishing to the Maximum Economic Yield (MEY), which can be shown to be below MSY. Traditionally, however, quota schemes are implemented only after problems in the fishery have been discovered, implying that fishing is well above MSY. The manager can then shift the vertical part of the supply curve to the right by reducing quotas in the short run, thereby giving space for quota increases in the long run. Recovery plans are examples of such a policy.

Hannesson (2001) studies a supply regime for a management scheme between open access and optimal management, referred to as "catch control". A vertical supply curve under such a management scheme is introduced.

The supply curve in optimal management is given by the marginal cost curve and optimal management implies both that the output is maximised subject to the stock constraint and the costs are minimised. The supply curve is globally increasing and will approach a finite positive quantity. Hence, under optimal management the stock cannot be biologically overfished.

All the different types of supply curves have the ability to explain the supply from different fisheries. Selective gears exist in most fisheries. In most developed countries restrictive gears are compulsory, where this may not be the case in some developing countries. Furthermore, all types of management schemes are used. Open access may be the situation in some developing countries, whereas optimal management exists in the form of individual transferable quotas in e.g. the Netherlands, Iceland and New Zealand. Therefore, the supply regime differs between fisheries, but since the majority of the world's fish stocks according to the Food and Agriculture Organisation of the United Nations (2001) are either fully utilised or overexploited, the relevant area of the supply curve for open access fisheries with medium mesh sizes is the vertical part. Regulated open access and regulated restricted access is, however, the situation in most fisheries. In the presence of these management schemes the relevant area is also the vertical part. But the supply curves are deduced for capture fish stocks without interactions with other fish species, for fish stocks owned by a single country and sold in only one product form. In the following, the relaxation of these assumptions is shown to affect the supply curves.

The above supply curves are deduced for a fish stock owned by a single country and do not take into account that several stocks are shared among two or more countries. Provided that no long-term management agreement is in place between the owners, the supply curves must be adjusted, since the fishery of each country make up a negative externality for the others. In chapter 8 (see Figure 8.3), the supply curve of two countries fishing a shared open access fish stock with medium mesh size regulation is deduced for a situation where changes can only happen in one of the two countries (country one). The deduction is made in three steps assuming that the fishery initially is well above the MSY. Firstly, the initial supply curve of country one is identified assuming that fishing changes proportionally in both countries. Thereafter, it is alternatively assumed that fishing only changes in country two, given unchanged fishing in country one. Finally, the terminal supply curve in country one is found, given the new level of this fishing in country two. Provided that fishing in country two rises, the terminal supply curve in country one appears as an inward shift of the initial supply curve.

The initial and terminal supply curves in country one is backward bending. Since initial fishing in the case study of the East Baltic cod fishery is well above the MSY, i.e. the initial supply is placed on the part of the supply curve approaching vertical, the supply curve in country two is increasing for all realistic situations. The reason is that the effect following from the rise in the country's share of the catch exceeds the effect following from the fall in the total catch. The consequence is that even under open access, the supply curve of one country can under special conditions be increasing in the relevant range, implying that the country cannot overexploit the stock by their actions alone.

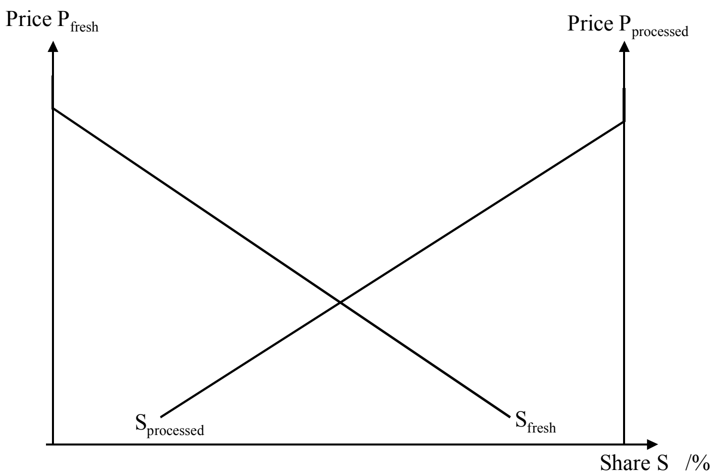
The above supply curves are deduced for a single fish stock, and neither take into account that some fish are predators and some are preys, nor that some species compete for the same feed. Changes in a prey stock affect the supply of a predator stock, since the feed base is changed. For example, increased fisheries on a prey stock result in starvation of the predators. Hence, increased fisheries on a prey imply that the supply curve of the predator stock is shifted inwards. Furthermore, changes in a predator stock affects the prey stock, since the number of prey fish eaten by the predators change. For example, increased fishing on the predator stock results in the survival of more fish and the supply curve shifts outwards. Finally, if two fish species compete for the same feed, a fall in one of the stocks will result in the rise of the other.

The above supply curves are deduced for a capture fish stock. Today, however, a considerable share of the global supply of fish is raised on fish farms. Under such a production regime the supply curve of fish products may still be backward bending. According to Hannesson (2003), the condition is that fish feed is a scarce production factor. Fish feed may form a scarce production factor in fish farming due to overexploitation of industrial fish stocks. The reason is that for most farmed fish species it has only been possible to develop farming techniques using fishmeal as feed. In such a situation, the supply curve will depend on the management of the industrial fish stocks.

Asche and Tveteraas (2000), however, find that international markets for fishmeal are integrated among countries and forms part of a large global oil-meal market. It is further found that fishmeal is a close substitute for soy meal, that fishmeal forms only 4% of the oil-meal market and that aquaculture use 35% of the global supply of fishmeal. Hence, in the short run limitations in supplies of farmed fish is not expected, since substitution away from fishmeal in livestock sectors is possible. This leaves a larger share of fishmeal to aquaculture, probably at higher prices. In the long run when a larger share of the total global supply of fishmeal is used for aquaculture, fishmeal may be a scarce factor for aquaculture, implying that the long run supply curve for farmed fish may depend on the management system in place in the industrial fisheries. Provided that it to a larger extent than today becomes possible to use herbivore feed in aquaculture, feed would not be a scarce factor of production and the long run supply curve of farmed fish would be globally increasing.

The above supply curves are also deduced only for raw materials of fish and do not take into account that the raw material is used for different purposes. One part of the catch may be supplied for fresh consumption where other parts may be supplied in processed form. The supply curves of the fresh and processed forms of a single fish species is presented in Figure 2.4 following Hannesson (2001), assuming that all the raw material of the species is used for these two product forms, and that the total supply of the species remain constant.

FIGURE 2.4 **Supply of fresh and processed fish, given a constant level of raw material**



On the first axis, the shares of raw materials of the two product forms are given and sum to 1 ($S_{processed}+S_{fresh}=1$). The share of fresh fish increases when moving to the left and the share of processed fish rises when moving to the right. Both supply curves are increasing until all the raw materials of the species is used for that product form and are vertical afterwards. When the share of raw materials used for one of the product forms rises, the share of the other falls, since the total supply of raw material remains constant. Therefore, where the supply curves of raw material of fish on most occasions are approximately vertical, the supply curves of different product forms might well be increasing. This implies that changes in the price of one product form also affect the supplies of the other product forms. On this basis, Asche and Hannesson (2002) conclude that "the processing sector and the allocation of fish between product forms seem to be substantially more price responsive than the total supply". The reason is that the total supply is limited by nature, where processors and traders compete for the same raw material.

Systems of supply are identified empirically for fish products in only very few studies. One direction focuses on the steady state supply of raw material of fish species (Frost and Michelsen (2001); Nostbakken and Bjorndal (2002)), a second on the supply from different fleet segments (Squires (1987); Kirkley and Strand (1988); Squires and Kirkley (1991)), and a third on the supply of different product forms (Asche and Hannesson (2002)).

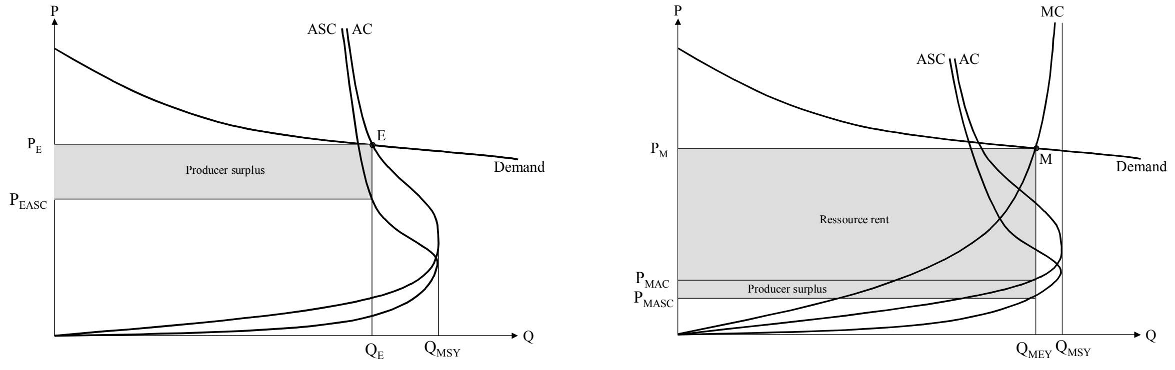
Within the first direction, Frost and Michelsen (2001) calibrate steady state supply curves for cod in the Baltic Sea using an age-structured bio-economic model. The basis is biological data from the International Council for Exploration of the Sea and economic data from landing and account statistics. The supply model is applied for the study on the effects of the introduction of certification for sustainability. Nostbakken and Bjorndal (2002) estimate supply functions for North Sea herring, based on a Schaefer production function. The model is used to discuss the effect of different management schemes on the supply of herring. Furthermore, in chapter 8, the steady state supply curve is calibrated for the East Baltic cod stock using an age-structured bio-economic model. This is done for a shared stock with focus on alternative management schemes. The supply curve is identified as in the medium mesh size situation in Figure 2.2 and is approximately vertical in the relevant region. This implies that the stock with the existing mesh sizes cannot be more biologically overfished, but economic overfishing will still result from increased fishing. The reason is that costs increase with the fishing. Thus, the stock cannot be depleted by increased fishing; supply will remain constant. This point has to the knowledge of the author not been raised in the literature. This result follows from the assumption of constant recruitment in the Beverton-Holt model. The assumption is assessed top be realistic in most situations, since there is normally a considerable overproduction of eggs, of which only a small fraction survives. In the severe overuse case, however, recruitment may fall with increased fishing, implying that a stock can be depleted.

Within the second direction, Squires (1987) estimates a multi-product profit function for the New England otter trawl fishery. This is used to identify supply elasticities and roundfish are found to be supply elastic, where flatfish and others are inelastic. Kirkley and Strand (1988) estimate a revenue function for different fleet segments and find that 32 of 42 supply elasticities were inelastic and 19 of these between –0.5 and 0.5. Squires and Kirkley (1991) estimate a revenue function of the US Pacific coast trawl fishery on sablefish, thornyheads, flatfish and rockfish and find the supply elasticities between –0.15 and 0.01. Based on these studies, Asche and Hannesson (2002) note that “most supply elasticities reported for fishermen seem to be low and often very low”. Hence, this direction does not reject the observation that the supply curves are close to vertical, although detailed estimations, which do not include fishing on the whole of a stock, provide limited evidence. Full support for the observation claims that supply elasticities are identified for all vessels fishing on a particular stock, so that stock effects are modelled explicitly.

Within the third direction, Asche and Hannesson (2002) estimate short run supply equations derived from a translog revenue function for different product forms of cod in Canada, Iceland and Norway. It is found that “relative prices are important since they dictate the product form marketed” and that “since cross price elasticities are relatively high, processing industries are competitive”.

The results of the identified supply curves can further be used as input in welfare analyses by calculating producer surplus (inframarginal rent) and resource rent, following Copes (1972). The definition of these concepts is presented graphically in Figure 2.5.

FIGURE 2.5 **Welfare measures.**



Open access Optimal management

In open access E represents the equilibrium where the demand and the supply (average cost) curves intersect. A positive producer surplus exists when fishing vessels are heterogeneous in their economic performance. Thereby, only the “best” vessels, in terms of low use of inputs in relation to output contribute to the producer surplus. The producer surplus is given by the difference between the average cost and the average social cost curves, with the vertical difference between the two given by the remuneration of all other factors than the resource, i.e. capital and labour. Hence, the average social cost curve appears by subtracting the remuneration of all other factors than the resource from the average cost curve.

For fishing at very high levels the average cost and the average social cost curves approach each other and the producer surplus approaches zero. This will also be the case in situations where the alternative value of capital and labour is zero. This might sometimes be the case since the capital base in fisheries is the vessel, which normally cannot be used for anything else. Fishing vessels cost a certain amount to build, but even short time after the value may fall to the salvage value at a mush lower level. Hence, there is a sunk cost. This sunk cost may e.g. in situations with severe overcapacity be close to the new value, implying that the salvage value is close to zero. The alternative value of labour might also sometimes be close to zero, if the labour force is immobile between sectors and areas. This might in particular be the case where fisheries are located in remote areas with few alternative employment opportunities. In the very long run, however, when fleets have to be renewed and when new generations should take over, the alternative value of capital and labour is positive. The resource rent in open access is zero, since increased earning is used for inefficient investments.

In optimal management, the marginal cost curve represents the supply curve and M represents the equilibrium. The producer surplus is defined equivalently, but due to that fishing is below MSY, the difference between the two are found on the increasing part of the two curves. The resource rent is defined as the difference between marginal and average cost at the increasing part of the curve. Hence, in optimal management welfare consists of both producer surplus and resource rent where only the producer surplus exists under open access.

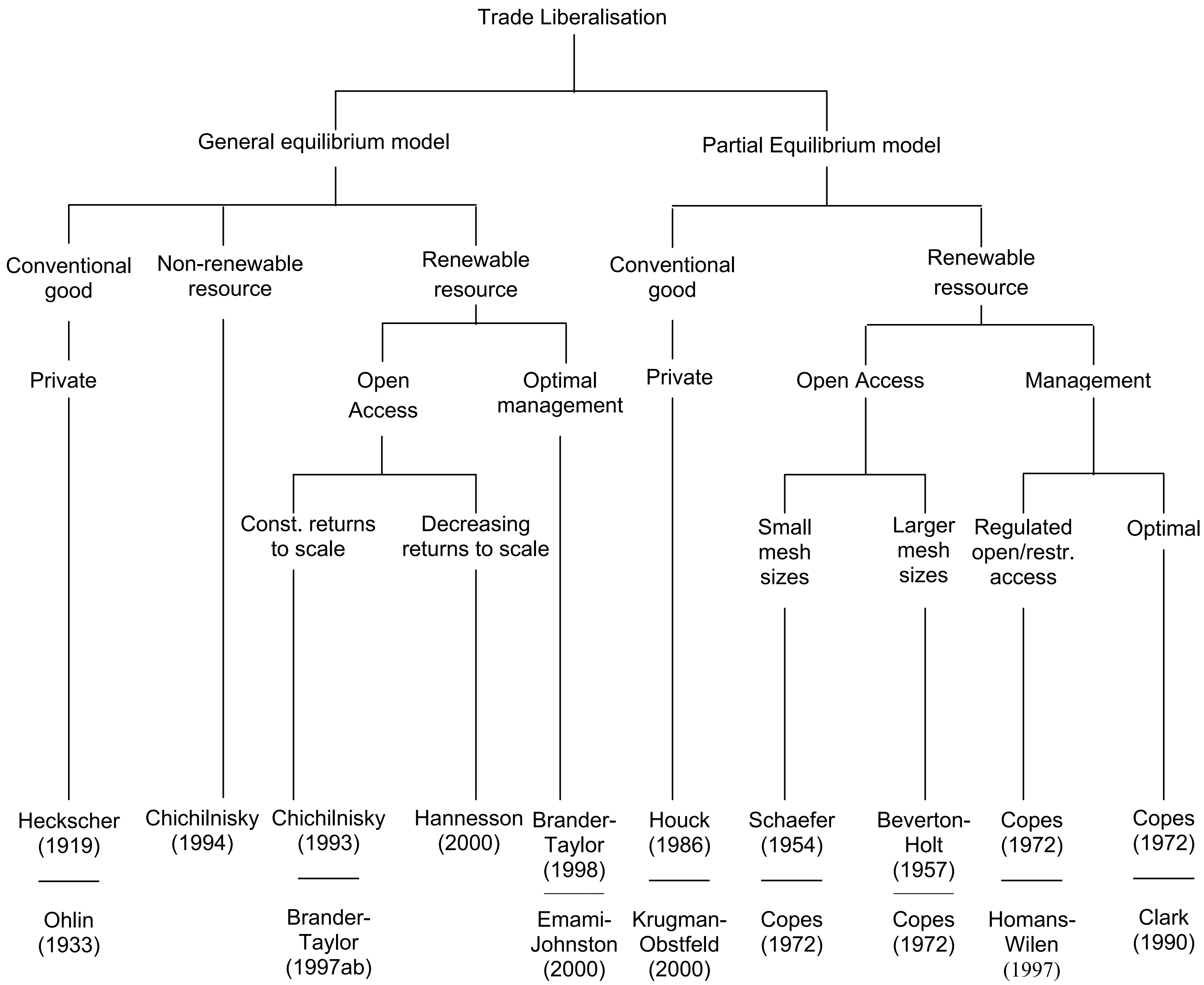
Based on this approach, an empirical supply model is calibrated in chapter 8 for East Baltic cod based on an age-structured bio-economic model. This model is used to identify the steady state welfare effects of liberalising trade. To the knowledge of the author, neither has such an empirical model been developed in the literature before based on an age-structured bio-economic model, nor has it been used for welfare analysis. Furthermore, no models are known to identify the steady state welfare effects on sectors in the economy.

6. TRADE

The Neoclassical theoretical tradition applied to international economics is developed on the basis of a traditional understanding of trade as inter-industrial, in which the exchange of excess goods occurs between different industries. Today, according to the European Commission (1999) and discussed by the Danish Economic Council (2001), however, the majority of all trade is intra-industrial, in which trade with relatively similar goods occurs due to increasing returns to scale and product differentiation. The presence of this situation form challenges in the analysis of trade liberalisation, since traditional theory, which predicts trade based on differences in resource endowment, is therefore inadequate. This situation render attention in general, but may also render attention for seafood trade, due to increasing returns to scale in parts of the distribution chain. Increasing returns to scale are in particular present in processing companies, which might partly be explained by the presence of large international supermarket chains demanding large lots in their purchase. Furthermore, product differentiation is present in seafood trade, due to the existence of the many fish species and product forms on the world market. Hence, intra-industrial trade theory is clearly relevant in explaining trade in fish products. On the other hand, trade in fish products is a classical example of the inter-industrial type, since countries are very differently endowed with fish resources. In the following, therefore, focus is chosen to be only on inter-industrial trade theory, since the interaction between trade policies, sustainability and fisheries management is the central concern.

Studies of trade liberalisation of international seafood markets are based on the literature on traditional international economics. In this literature, trade liberalisation is analysed given that all markets in the economy are in equilibrium. Hence, the basis is the general equilibrium model. This model is reviewed below followed by the introduction of a partial equilibrium model inspired by resource economics, which to the knowledge of the author is presented in the literature for the first time. Subsequently, a synthesis of the effects of trade liberalisation is drawn and empirical studies reviewed. Based on the two models, the theoretical basis for identifying welfare effects of liberalising international seafood trade is presented in Figure 2.6.

FIGURE 2.6 **The contribution of international trade theory and resource economics in explaining welfare effects of liberalising international seafood trade.**



The different versions of the models are reviewed below. The focus is on the analysis of trade liberalisation modelled as the removal of tariffs, but the analysis also applies for reductions in other trade measures that opens up or increases trade. These include for example import quotas, countervailing duties, price mechanisms and sanitary and hygiene requirements.

The general equilibrium model

The economic literature that treats trade policies and liberalisation has developed over time. Traditionally, liberalisation of international trade is analysed on the basis of the Ricardian theoretical tradition applied to international economics. Within this tradition, fish is regarded as a conventional good and the presence of international trade is explained by differences in technology. Everybody can specialise in productions where they possess a comparative advantage.

The Heckscher-Ohlin theory (Heckscher (1919); Ohlin (1933)) followed, explaining the appearance of comparative advantages due to differences in factor endowment and use, not due to differences in technology. Based on the premises that goods differ in their factor requirement (described by the factor intensity) and countries differ in their factor endowment (described by the factor abundance), the simple idea is that *"a country has a comparative advantage in those goods that use its abundant factors intensively"*. It follows that a country with large fish stocks has a comparative advantage in the sale of fish products, as fish products are produced intensively on the basis of fish resources.

It further follows that at least two goods, two production factors and two countries necessarily must be included in the model in order to allow analysis. Sometimes, however, analysis is made for one country taking other countries into account only indirectly. Including the rest of the world through the international price relationship, which typically is exogenously given, does that. On this basis, a general equilibrium model where all markets are in equilibrium at the same time is needed. Such a model consists of several parts. The interactions of factor and good markets can be built on the Stolper-Samuelson theorem focusing on prices and on the Rybczynski theorem focusing on quantities. Substitution relations can be built on knowledge obtained from demand, supply and market integration studies, thereby giving the model a microeconomic foundation. Substitution relations must, however, also fulfil the elasticity rules of Marshall (1920).

The Stolper-Samuelson theorem describes how changes in final good prices affect factor reward. It states "an increase in the relative price of a good raises the real reward of the factor used intensively in the production of the good and reduces the real reward of the other factor" (Stolper and Samuelson 1941). The relevance of this theorem lies in that it can explain how some groups or sectors gain from the opening of trade. Workers have, for example, an incentive to seek protection from imports of labour intensive goods, since otherwise domestic wages will fall.

The Rybczynski theorem describes how changes in factor endowment affect production. It states that “when the coefficients of production are given and factor supplies are fully employed, an expansion of the endowment of one factor of production raises the output of the good that uses the expanded factor intensively and reduces the output of the other good” (Rybczynski 1955). The relevance of this theorem lies in that it can explain why some countries’ level of trade is high, where others’ are low. The reason is that differences in factor endowment drive trade. That is, the larger the difference in factor endowments is between two countries, the more will the two countries trade with one another.

The elasticity rules of Marschall (1920) describe what determine the elasticity of factor demand. Following Layard and Walters (1978), which cite Marschall (1920), state that: “within an industry, the elasticity of demand for a factor varies directly with” 1) the elasticity of demand for the product the factor produces, 2) the share of the factor in the cost of production, 3) the elasticity of supply for the other factor and 4) the elasticity of substitution between the factor in question and the other factor. Rules 1-2 state that the elasticity of factor demand increases both with the elasticity of the good it produces and with the share of the factor in the cost of production. However, it only increases with the share of the factor in the cost of production when the price elasticity of demand for the product the factor produces, is larger than the elasticity of substitution between the two factors. Rule 3 describes the relationship between demand of a factor and the supply of the other, and rule 4 considers substitution relations between factors.

Using the above framework, trade liberalisation can be analysed in the Heckscher-Ohlin model. It is clear that a global social optimum can only be reached in the case of free trade. Small countries, which are price takers on the world market, also face a situation where the social optimum can only be reached in the case of free trade. Large countries, however, can affect their terms of trade and thereby reach a social optimum only through the active use of trade policies, provided that there is no retaliation from other countries. These results are referred to as the conventional opinion.

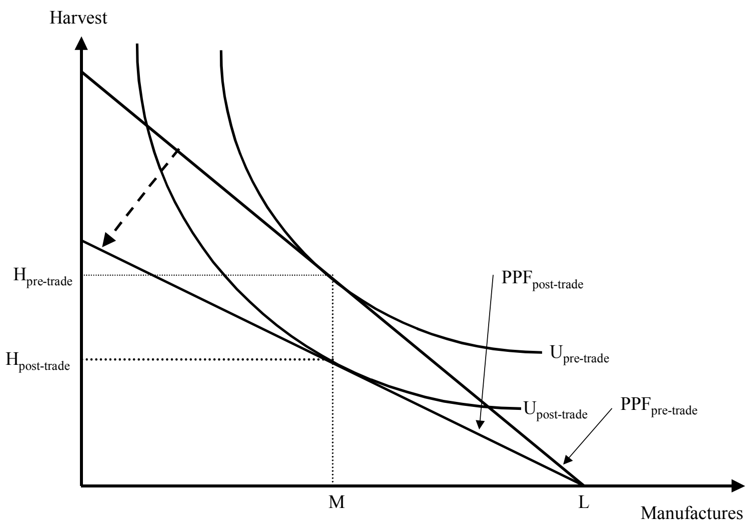
From the conventional opinion a direction has evolved which links trade theory and the exploitation of renewable resources. This direction originates in Bhagwati (1958) who finds that economic growth can cause reduced welfare under certain conditions. One recent example relates to renewable resources, where continued growth and rising incomes globally tend to increase purchasing power, causing pressure on the renewable resources. This phenomenon, which is referred to as immiserising growth, is related to international economics in that "economic expansion increases output which, however, might lead to a sufficient deterioration in the terms of trade to offset the beneficial effect of expansion and reduce the real income of the growing economy".

Along the same direction, Chichilnisky (1993, 1994) explains trade between two otherwise identical countries on the basis of differences in property rights of renewable and non-renewable resources. The exporting country may not necessarily be abundant in the resource, but since it has weak property rights it possesses an "apparent comparative advantage" and sell cheaper than the importing country with strong property rights. The reason is that they do not account for replacement costs of the resource. This implies that the price does not reveal the full cost of extraction and the producers will over-exploit the resource. If alternatively the price reveals the real value of both production and replacement costs, over-exploitation will not result.

Within the same theoretical basis, one direction studies the link between tropical deforestation and timber trade. The focus is on the potential use of trade policies of timber to limit tropical deforestation. Barbier and Rauscher (1994) use a dynamic model of a renewable resource, where timber is extracted for purposes of export and domestic consumption. It is found that "trade interventions that seek to affect the terms of trade against the export of tropical timber products are in the long run a second best policy option for influencing the deforestation process". Furthermore, Barbier and Schulz (1997) emphasise the role of trade in relation to biodiversity and habitat conversion using a bio-economic model of wild-resource exploitation. It is found that "the inclusion of habitat conversion and biodiversity value yields significantly different outcomes than a basic bio-economic model".

Brander and Taylor (1997ab, 1998) show in three seminal papers that advantages with free trade in renewable resources, that are not managed optimally, exist only under certain conditions and for certain types of countries. Brander and Taylor (1997a) study the effect of the introduction of trade in a small diversified exporter country of fish with an open access fish stock. A model with two goods, produced with constant returns to scale on the basis of two production factors is used. The two goods are a fish product and a numeraire representing all other products, and the two production factors are a fish stock and labour, with the fish stock being a specific factor for the fish product and labour a factor, which is mobile between the two sectors. Welfare is measured as "steady state utility" on the basis of a Cobb-Douglas utility function and with steady state amounting to the long run bionomic equilibrium. Utility is maximised subject to the production possibility frontier (PPF) for a steady state stock where natural growth equals harvest. In the small diversified exporter country the trade liberalisation is followed by a rise in the price of fish and an upward shift on the supply curve in Figure 2.2a will take place. Hence, the production possibility frontier is shifted inwards, as shown in Figure 2.7.

FIGURE 2.7 **Pre and post trade steady state equilibrium in the small exporter country**.

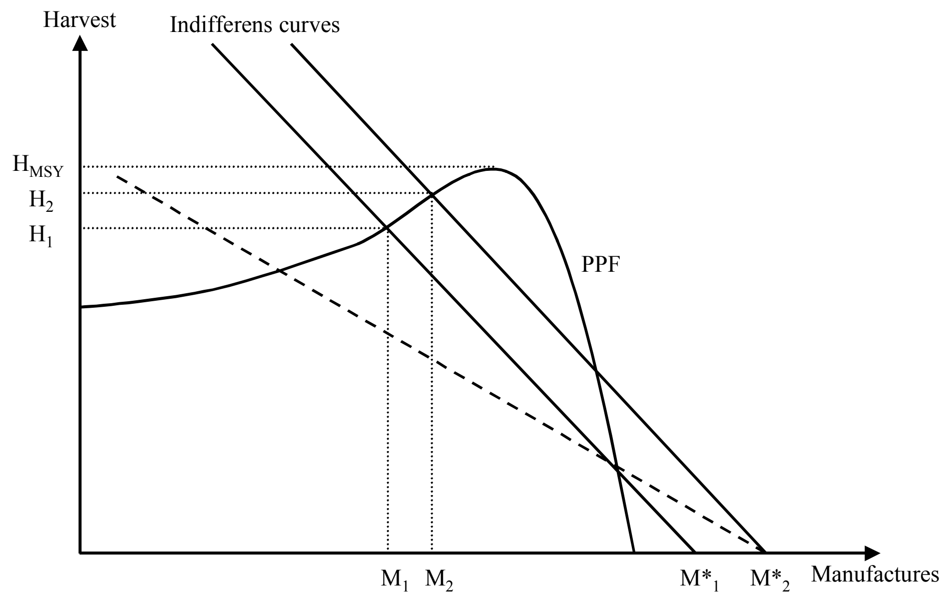


Brander and Taylor (1997a).

The steady state equilibrium shifts from (M, $H_{pre\text{-}trade}$), where the indifference curve is tangent with the production possibility frontier, to (M, $H_{post\text{-}trade}$) at a lower utility level. The new steady state equilibrium appears after an adjustment process from a temporary non-sustainable Ricardian equilibrium. In this process the production possibility frontier pivots inwards. Thereby, trade liberalisation results in a welfare loss in the diversified small exporter country.

Hannesson (2000) modifies the analysis of Brander and Taylor (1997a), since he replaces their assumption on constant returns to scale in manufacturing with decreasing returns to scale. Thereby a "humped" PPF with a harvest peak at MSY is obtained as shown in Figure 2.8.

FIGURE 2.8 **Pre and post trade steady state equilibrium in the small exporter country with decreasing returns to scale in manufacturing.**



Source: Hannesson (2000).

The PPF is deduced on the basis of the backward bending supply curve in Figure 2.2. It can be shown that the hump-shaped form in Figure 2.8 appears. The PPF is decreasing to the right of the hump, but positively sloped to the left. The hump appears as one moves to the left since more labour is used inefficiently for overexploitation. Given that optimal management existed, the PPF would be negatively sloped all along, as for conventional goods.

Based on this, a welfare analysis is performed by introducing utility in the model. It is assumed that *M* and *H* are perfect substitutes, implying that the indifference curves are linear. The indifference curves are negatively sloped and the numerical value of the slope is the relative price between *M* and *H*. The line drawn in Figure 2.8 reveals the relative price in the autarky equilibrium and the equilibrium point is the left intersection between the PPF and the indifference curve. At that equilibrium point the open access renewable resource is exploited above MSY, which is the traditional result.

Liberalising trade will now result in a price increase in the renewable resource. This implies that the relative price on *H* in relation to *M* rises and the line pivots. Now the utility level can be measured in terms of the original indifference curve intersection with the *M*-axis, which can be done due to the perfect substitution assumption, and a higher utility level is reached. Finally, the prices will adjust to the world market prices, and the initial indifference curve will make a parallel move to the right as shown. The result is that a trade liberalisation in the renewable resource based good implies that a higher level of welfare is obtained at higher production levels of both goods. The result contrasts the Brander and Taylor (1997a) result, the reason being that decreasing returns to scale and perfect substitution is assumed here.

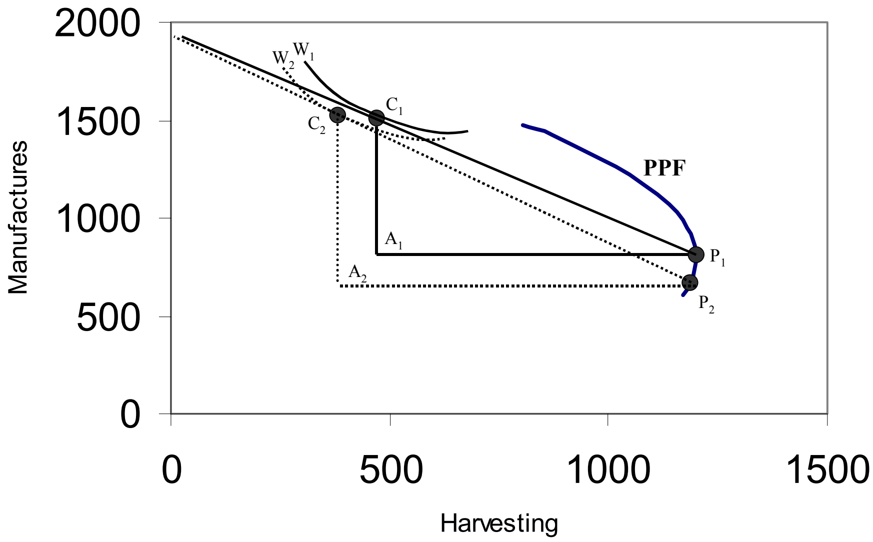
Brander and Taylor (1998) use a similar approach in a two-country model where both countries are diversified and have open access fish stocks. They find that the resource importer gains from trade and that the resource exporter suffers a decline in steady state utility. Hence, it is found that "tariffs imposed by the resource importer country always benefit the resource exporter, and may be Pareto improving".

Furthermore, Brander and Taylor (1997b) find in a two-country model of trade between a consumer country with an open access renewable resource and a conservationist country with a well-managed renewable resource, that trade liberalisation will cause net-export of the consumer country to rise in the short run and steady state utility to fall in the mild-overuse case in the long run. In the severe overuse case, however, both countries will experience gains from trade liberalisation.

Emami and Johnston (2000) show in a two-country, two-good model that import tariffs on a renewable natural resource with incomplete property rights might reduce losses in steady state utility in both countries, caused by weak resource management in one of the two countries.

Finally, Bernard (1998) proposes a computable general equilibrium model in the analysis of specific fisheries. This model includes a conventional numeraire good, as well as a renewable resource. The focus is on the interactions between the seafood market and all other commodity markets in the economy. Two computable models are introduced, one dealing with open access and one with optimal management. The open access model of Bernard (1998) is used in a hypothetical numerical example in the appendix to analyse the effect of removing a tariff on a renewable resource in a small country exporting the renewable resource. The model is used together with the technical implementation in the Excel spreadsheet using the Problem Solver, according to Jorgensen (2003). The removal of the tariff is assumed to increase the domestic price on the harvesting goods by 10%. Based on that model and with the numbers presented in the appendix, the effects of removing a tariff in a small exporter country is shown in Figure 2.9.

FIGURE 2.9 **Effects of removing a tariff in a small exporter country with open access.**



From the Figure the hump-shaped production possibility frontier, following from open access in the exploitation of the renewable resource, appears together with two trade triangles. These trade triangles show production and consumption before and after the trade liberalisation. The prices are normalised to one in the initial situation in order to show changes and the slope of the production possibility frontier depicts the international relative price between the harvesting and manufacturing goods. The relative price is exogenous due to the small country assumption. In the initial situation production of *H* and *M* is 1,200 and 800, respectively, where the consumption is 500 and 1,500. Hence, export of the harvesting goods as well as import of the manufacturing good, is 700. In the terminal situation appearing after the 10% price increase on the harvesting good, the production of *H* and *M* is 1,191 and 697, respectively, where the consumption is 456 and 1,506. Export of *H* is then 735 and import of *M* 808. The initial and terminal situations are depicted by triangles $A_1C_1P_1$ and $A_2C_2P_2$.

On this basis it is found that the trade liberalisation implies that the production of both goods fall. Furthermore, with the iso-welfare contour (W_1 and W_2) drawn in the Figure, which can be deduced from individual well-behaved preferences, welfare falls as a result of the trade liberalisation. In the present numerical example with the well-behaved preferences, the small exporter country loses from the removal of the tariff, since production of *H* and *M*, respectively, is reduced by 0.7% and 12.8%.

This numerical model can be used to study the effects of trade liberalisation in hypothetical situations, which can be fitted to depict "real world" fisheries. This would in particular be relevant when studying the interactions between the fisheries and the other sectors in the economy. For example one could study how the harvesting good is affected indirectly by a trade liberalisation in all other goods (i.e. in the manufacturing good). The model is, however, not well suited for taking fisheries management, mesh size regulation, shared stocks and multi-species environmental relations into account. And these may be decisive for whether trade liberalisation results in welfare gains or losses. Therefore, a partial equilibrium approach is introduced in the next section focusing explicitly on the modelling of these items.

The partial equilibrium model

The supply functions of the previous section are integrated with the basic tariff analysis for two countries, according to Houck (1986) and used by Francois and Hall (1997) and Krugman and Obstfeld (2000). This is combined with the welfare concepts of Copes (1972) and a new analytical framework for analysing the welfare effects of seafood trade liberalisation is developed. This is referred to as the partial equilibrium model. Although it is partial it gives important information, since a broad welfare concept is applied. Welfare in this model includes consumer surplus, producer surplus (infra-marginal rent), resource rent and tariff revenue, implying that the welfare effects of trade liberalisation can be allocated among sectors in the economy.

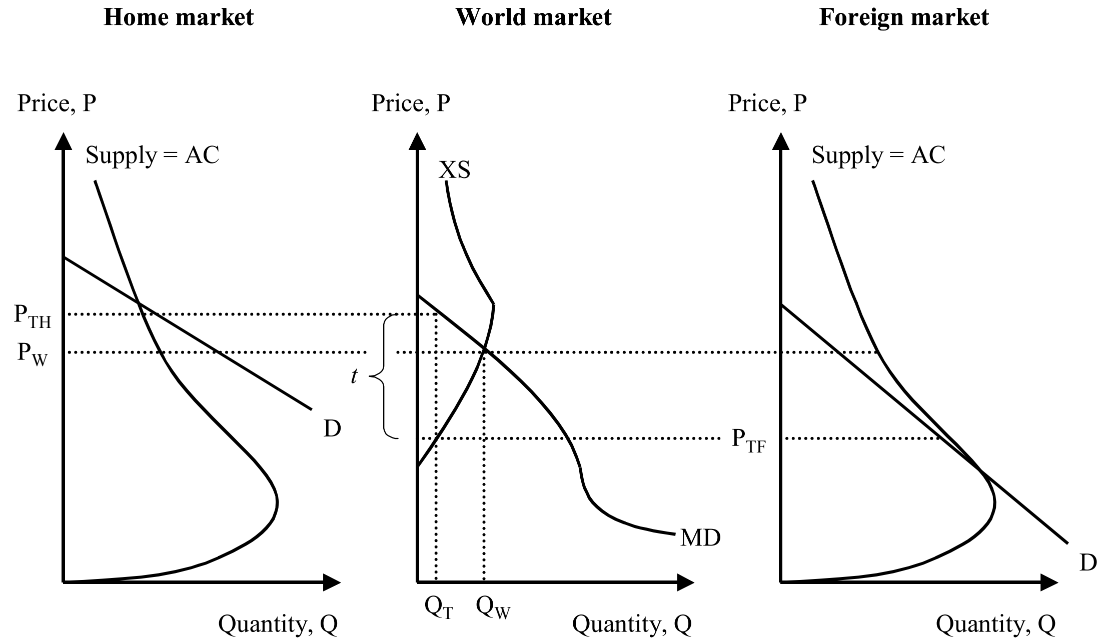
Furthermore, it is possible to identify welfare effects of trade liberalisation under management systems between pure open access and optimal management in a consistent way. These management systems include mesh size regulation, regulated open access and regulated restricted access. This is important since most fisheries today are managed by some of these regimes. To the knowledge of the author such an integrated approach for trade liberalisation in a renewable resource is presented in the literature for the first time.

The analytical framework consists of an initial situation where two countries (home as the importer and foreign as the exporter) own an open access fish stock which both over-exploit. The two countries trade with one another and home uses an import tariff. The effect of removing this tariff is analysed for one of the countries, considering the other country as the rest of the world. This framework is applied as the basis here, whereas Houck (1986) perform their analysis for a conventional good.

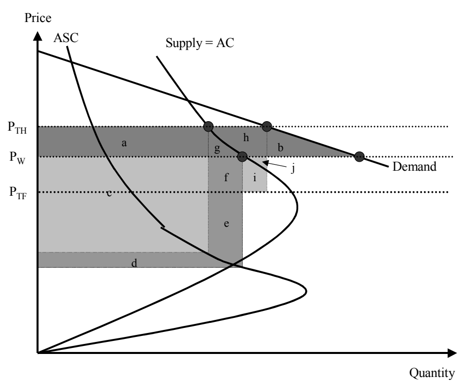
The analysis departs from two open access fish stocks fished with small mesh sizes, based on the situation in Figure 2.2a. Subsequently larger mesh sizes, the presence of different management schemes, shared ownership of resources, predator-prey relations, aquaculture and processing are introduced. The price and quantity effects of removing the tariff are presented in Figure 2.10a and welfare effects in Figure 2.10b and 2.10c. The supply curves in Figure 2.10b and 2.10c are identical to the curves in the left and right hand diagrams of Figure 2.10a, respectively.

FIGURE 2.10 **Effects of removing a tariff with open access.**

a) Price and quantity effects



b) Welfare effects in home



c) Welfare effects in foreign

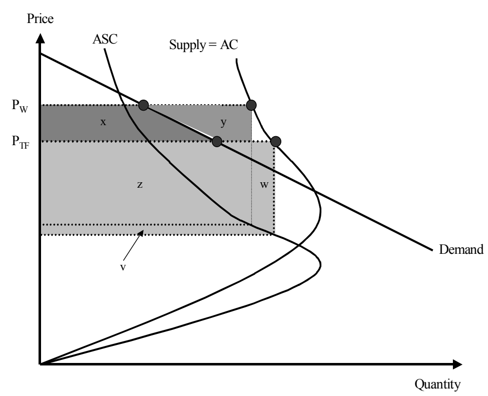


Figure 2.10a consists of three diagrams, one of the home market, one of the world market and one of the foreign market. Supply curves on both markets are for the small mesh size situation of Figure 2.2a, but the analysis of the medium and large mesh size situations can easily be performed by replacing the supply curve by the ones in Figure 2.2b and 2.2c. Supply and demand on the world market appears as excess supply

from the foreign market and excess demand from the home market. At the world market, the initial import tariff used in home is shown together with the corresponding price in home (P_{TH}) and foreign (P_{TF}). Moreover, the free trade price (P_W) is shown and it appears that removing the tariff implies that the tariff wedge at the world market between prices at the home and the foreign market disappears and drives international trade up from Q_T to Q_W. Subsequently, trade liberalisation will in the model always be followed by a fall in the price in the importer country and a price rise in the exporter country.

Based on this framework, the welfare effect of removing the tariff is outlined in Figure 2.10b and 2.10c in home and foreign and summarised in Table 2.4.

TABLE 2.4 **Welfare effects of liberalising trade in an open access fish stock.**

	Importer country	**Exporter country**
Change in consumer surplus	(a + b + g + h)	- (x)
Change in producer surplus	+ (d + e + f) – (a)	+ (x + y) – (v + w)
Tariff revenue	- (f + g + h + i + j)	.
Change in welfare	(b + d + e) – (i + j)	+ (y) – (v + w)

The welfare effect of trade liberalisation in the importer country is generally indeterminate. The consumer surplus rises the tariff revenue disappears and the producer surplus is indeterminate. In the small importer case where the country does not possess power on the world market, $P_W = P_{TF}$, implying that the terms of trade effect (f + i + j) is zero. The tariff is then measured by the difference between P_{TH} and P_W (g + h) and the welfare change becomes (b + d + e + f). Thereby, the welfare effect of trade liberalisation in a small importing country with an open access fish stock is positive. On the foreign market, the welfare effect of trade liberalisation is also ambiguous. The consumer surplus falls and the producer surplus is indeterminate. If y > (v + w) welfare will rise, otherwise welfare will fall. In two situations the total welfare effect is negative. When the alternative value of labour and capital is zero and when vessels are homogeneous, the producer surplus is zero and the total welfare effect negative.

The welfare analysis of the medium mesh size supply regime is analogous. The change in consumer surplus and the disappearance of tariff revenue is the same. The change in producer surplus is, however, zero when the price approaches infinitive. In the exporter country the total welfare effect is given by the fall in the consumer surplus. In the importer country the total effect remain indeterminate, since consumer surplus still rises and tariff revenue still disappears.

When optimal management instead of open access exists the supply curves in Figure 2.10 are to be replaced by the globally increasing supply curve in Figure 2.3b. Furthermore, the welfare analysis includes the concept of resource rent. Undertaking such an analysis it can be shown that trade liberalisation results in a welfare gain in an exporter country. This can also be shown to be the case for a small importer country, but for a large importer country the effect remains indeterminate.

When regulated open access exists, i.e. the fishery is output not input regulated, the fishery will be characterised by entry and exit of vessels until the resource rent is zero (Homans and Wilen (1997)). Furthermore, the change in the producer surplus in the exporter country is zero, since the increased turnover following from increased price is used for totally inefficient investments. Therefore, the fall in the consumer surplus creates a welfare reduction. In the analysis of the importer country the supply regime in Figure 2.10 is to be replaced by the one in Figure 2.3a. The welfare effects then depend on whether the initial and terminal situations are on the vertical part of the supply curve. In that case, the total welfare effect of the price fall is determined by the strength of the increased consumer surplus meet by the disappearing tariff revenue. In the case where the price falls to the increasing part of the supply curve, the changes are followed by increased producer surplus. Hence, in both situations the total welfare effect is indeterminate.

Regulated restricted access is when both input and output regulation exists. Regulated restricted access may or may not secure optimal economic management, dependent on the use of management measures. If a quota is fixed at the maximum economic yield and input is limited to the minimum necessary to fish the quota, the management is optimal. The welfare effects of trade liberalisation then follow from the above. If, on the other hand, overcapacity is initially present and if the quota initially is fixed at a high level, neither the input nor the output regulation works optimally. In such a situation, a welfare gain results from trade liberalisation in an exporter country. The reason is that increased turnover following from the price rise will increase profit and thereby producer surplus. The rise in producer surplus offsets the fall in consumer surplus. In an importer country a trade liberalisation results in a fall in the producer surplus, a rise in the consumer surplus and the disappearance of the tariff revenue. Hence, the total welfare effect is indeterminate.

The above results are obtained for two countries, which each own their separate stock. The welfare effects of trade liberalisation for two countries (a large importer and a small exporter country) fishing a shared open access fish stock is analysed in chapter 8. The total welfare is reduced in both countries. In the small exporter country the consumer surplus falls due to the increased price. The producer surplus is also reduced since the increased turnover is used for totally inefficient investments and since the opportunity cost of fishing becomes larger with increased fishing. In the large importer country the producer surplus falls, due to the externality, and the tariff revenue disappears.

The above results are also obtained assuming the absence of environmental interactions between fish species. Schulz (1997) finds that relations between species as well as the management system in place, and the economic importance of each species, in a complex way are decisive for the effects of trade sanctions and liberalisation. This follows from that the harvest of one species affects the stock and harvest of others. Schulz (1997) considers several situations, one being a predator-prey relationship between two open access species both harvested above the maximum sustainable yield and being of economic importance for an exporter country (of both species). In that situation, trade liberalisation in the good produced on the basis of the predator species implies that the price of the predator good rises and that steady state harvest and the predator stock falls. Thereby, either the prey stock or the prey steady state harvest rises. Whether a total gain or loss results depends on which effect dominates.

Furthermore, the above results are obtained for a capture fish product. For a farm raised fish product the effects of trade liberalisation depend on whether fishmeal is an abundant or scarce factor. If it is abundant the supply curve is globally increasing and the welfare effects of trade liberalisation follows from conventional opinion. If it is scarce the supply curve is backward bending and the welfare effect depends on the management system in the industrial fisheries. The reason is that it is impossible to substitute fishmeal as feed in aquaculture.

Finally, the above results assume that fish products are traded only in one product form. Typically, fish products are sold in several different forms. Provided that raw material and processed products are subject to different tariffs, there are welfare effects of trade liberalisation originating from relocation of value added activities. Typically, tariffs on processed products are larger than on raw materials, since the importer country can then simultaneously protect the domestic processing industry from foreign competition on the market for processed products and allow the industry to import cheap raw material. The situation is referred to as tariff escalation and is of relevance here, since welfare creating value added activities in the processing sector should be added to the above analysis. Trade liberalisation will affect the localisation of these welfare creating value added activities through the relative price on processed products between importer and exporter countries. The reason is that liberalising trade implies that the price in the exporter in relation to the importer country rises, which on the margin causes relocation from the importer to the exporter country. Trade liberalisation will also affect the product mix since unprocessed products become relatively cheaper than processed.

Synthesis

The structure of the general equilibrium models of Heckscher-Ohlin and Brander-Taylor are similar. The models include the whole economy and two goods are produced on the basis of two factors of production. The difference is, however, that in the Brander-Taylor model one good is a renewable resource and one a conventional, where both goods are conventional in the Heckscher-Ohlin model. Furthermore, the renewable resource is produced with open access, implying that it can be over-exploited. Hence, the Brander-Taylor model is a long run model, where there is no specific focus on time in the Heckscher-Ohlin model. Provided that the renewable resource is optimally managed, the two models are similar.

The Brander-Taylor and the partial equilibrium models face a different structure and focus, and can therefore be used supplementary. Where the Brander-Taylor model includes the whole economy and focuses explicitly on the interactions between factor and good markets, the partial equilibrium model only focuses on the renewable resource. Hence, other parts of the economy, affecting the renewable resource, are modelled exogenously. Nevertheless, the partial equilibrium model possesses advantages over the Brander-Taylor model in more senses. Firstly, the welfare can be allocated among consumers, producers, resource rent and the government, where the welfare concept of the Brander-Taylor model focuses on steady state utility and thereby solely on consumers. Hence, the producer surplus is ignored, amounting to the implicit assumption of homogeneity of producers. Secondly, management can be built in the partial equilibrium model on a detailed level. This is important since commonly used management regimes worldwide, such as regulated open and restricted access as well as mesh size regulation, might be decisive for the welfare effects of trade liberalisation. Furthermore, the model may be designed to take shared stock and predator-prey relations into account. The Brander-Taylor model may also be extended to include such measures, but to the knowledge of the author this has not been done to date.

Based on the Heckscher-Ohlin model, conventional opinion states that liberalising trade and moving to free trade improves global welfare, as well as improving welfare in small countries. It also states that large countries only through the active use of their trade policies can maximise their welfare. This opinion is obtained for conventional goods, but might also hold in some situations for goods with production externalities, such as fish. However, there are several exceptions following from the welfare analyses of both models. In the Brander-Taylor model it is found that exporter countries with overexploited open access fish stocks with constant returns to scale in the production of other goods lose steady state utility from trade liberalisation. Furthermore, small fish importing countries with under exploited open access fish stocks lose steady state utility from trade liberalisation.

From the partial equilibrium model, it is not possible to draw unambiguous theoretical conclusions on the welfare effects of trade liberalisation. Whether trade liberalisation results in welfare gains or losses depend on several factors, the main ones summarised as:

1. The country's status as importer or exporter.

2. The input-output regulation in place and the use of it.
3. Mesh size regulation.
4. The state of the fish stock.
5. The size of the country on the world seafood market.

These factors are of decisive importance in determining the welfare effects. For example, Food and Agriculture Organisation of the United Nations (2001) assess that the majority of global fish stocks are either fully exploited, overexploited, or close to extinction. This implies that perverse effects of trade liberalisation are likely to happen. On the other hand, mesh size regulation is compulsory in most countries worldwide. Interpreted together with the overexploited state of most global stocks, supplies are determined on the vertical part in Figure 2.2b. Thereby, further biological overexploitation is almost impossible, although further economic overexploitation can result. The reason is that totally inefficient investments in fishing capacity can rise. The existence of regulated open or restricted access in most fisheries support this result, although regulated restricted access in some fisheries might be applied optimally. If that is the case conventional opinion applies. But the management of several fish stocks might not be effective, since Hannesson (1996) summarises the management situation for the North Atlantic cod in one word: "mismanagement".

Other than the five factors, such as returns to scale in the non-fish sector, the presence of homogeneity or heterogeneity in the economic performance of fishermen and the alternative value of capital and labour is also relevant. In addition the analyses above are performed only in two-country models for fleets fishing on one species solely owned by the single country, and for trade in only one product form. Thereby, aspects such as competition between different exporter countries, shared stocks, multi-species fisheries, environmental multi-species relations and localisation of value added activities are ignored. This does not mean that trade liberalisation through such factors does not affect welfare. Trade liberalisation will e.g. affect welfare when fish products are traded as both raw material and processed products subject to different tariffs, since welfare originating from value added activities might then be relocated.

Given this framework, the main conclusion arising is that welfare effects of trade liberalisation are case specific and thus, the question of welfare effects remains empirical. Therefore, the identification of welfare effects of seafood trade liberalisation must be based on empirical studies, which are therefore reviewed.

Empirical analyses of liberalising international seafood trade are limited. One study focuses on the effects of removing tariff barriers on fish products between all members of the Asian Pacific Economic Council (Hartmann, Klijn and Cox (2000)), two others on the effects of antidumping duties on an integrated global salmon market (Anderson and Fong (1997); Asche (1997, 2001)), others focus on the effects of tariffs on EU import of fish products (Guillotreau and Péridy (2000); Péridy, Guillotreau and Bernard (2000)), and finally the analysis of chapter 8 identifies welfare effects of removing tariffs on East Baltic cod products, as a consequence of the EU enlargement.

Hartmann, Klijn and Cox (2000) use a traditional partial equilibrium model to identify the welfare effects of removing tariffs on seafood trade in the Asian-Pacific area. Consumer and producer surplus is identified considering fish products as private goods. The welfare effects of a total removal of the tariff barriers appear to be small, but due to tariff escalation the effect is larger on processed than on unprocessed products. It is further concluded, "it is likely that non-tariff barriers have influenced trade to a much greater degree than have tariff barriers". Since the fish products are treated as a private good, the welfare effect due to that "the removal of the tariff barriers will place greater pressures on existing fish stocks, unless sustainable management regimes are implemented", is neglected.

Anderson and Fong (1997) examine the Norway-US salmon dispute on dumping and Asche (2001) uses market integration studies to identify one integrated world market for salmon. Asche (2001) further argues that the antidumping measures imposed on imports of Norwegian salmon to the US, to protect the domestic producers, are inefficient. The reason is that although US import from Norway will fall, other suppliers on the world market will take over the Norwegian position. Hence, it is argued "the trade disputes is closely related to who is going to benefit of the productivity gains in the industry – producers by high profit or consumers by low prices". Asche (1997) also argues that "the disputes are also related to who is going to survive in the industry, those who have the best productivity or those located inside the main markets".

Guillotreau and Péridy (2000) and Péridy, Guillotreau and Bernard (2000) estimate an import function for fish imported to the EU on the basis of panel data. Determinant of the EU import of fish products include tariff barriers, price, exchange rates and distances between countries. However, where price, exchange rates and distances between countries are influential, tariff protection has little effect on imports. The effect from tariff protection is, due to tariff escalation, larger for processed than for unprocessed products. Welfare effects are not identified in the study, but may also be small.

In chapter 8, a quantitative supply model for the East Baltic cod fishery is introduced and used to study the effects of the tariff removal on imports into the EU from Poland, following from the EU enlargement. To the knowledge of the author, a model simultaneously quantifying the welfare effects of liberalising seafood trade and explicitly taking the link to sustainability and fisheries management into account, is presented in the literature for the first time. Assuming open access and simultaneous use of mesh size regulation, a welfare reduction follows, but this reduction is almost solely related to economic over-exploitation more than to biological over-exploitation.

Poland is negatively affected through a fall in consumer surplus. The producer surplus is unaffected, since the increased profit is used for totally inefficient investments. The EU is affected through the externality in the fishery of the shared stock. This implies that the producer surplus falls. The tariff revenue also falls, due to the removal of the tariffs. The consumer surplus remains unaffected, since falling domestic catches are assumed replaced by other sources and, therefore, the total welfare fall. Alternatively assuming the presence of regulated open access implies that the result still applies. The welfare rise following from a hypothetical change from regulated open access to optimal management is, however, twenty times larger than the welfare reduction of trade liberalisation.

On this basis it is concluded that fisheries management remains the first best policy to achieve welfare from fish stocks, where trade liberalisation remains the second best. The two policies must, however, be coordinated. Or as formulated by Schulz (1996) "trade policy is a too general measure for the management of living resources, and may implicate important economic distortions to the ecological system”. Contrary to this view, Stone (1997) assesses that the use of trade laws to limit fisheries subsidies and thereby overcapacity globally “should be more aggressively used in the campaign to reduce the pressure on stocks”. Furthermore, Stone (1997) concludes, “the elimination or confinement of these subsidies would not, in themselves, heal the world fisheries. But it would relieve national budgets of perverse expenditures, ease the task of fisheries managers, remove distortions to trade, help foster a larger, more valuable catch in the long run, and protect the environment”. Between these views, Emami and Johnston (2000) conclude that the World Trade Organisation “should not always insist on free trade, rather they must pay careful attention to the particular relationships between trade conditions and natural resource policies among trading nations”. Hence, no agreement on the use of trade measures for resource conservation purposes exists in the literature. On the other hand there is no doubt that liberalising seafood trade affects resources and welfare. But the conclusion here points to that the effect is more on welfare than on the resource.

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Appendix

A basic CGE-model with a natural ressource, spreadsheet version

Base parameters	
alpha	0,67
beta	0,50
gamma	2,00
lambda	1,89
teta	0,25
Inst. Growth (v)	2400
Carrying cap. (S)	2,00

Derived paramters	
Unit factor req.:	
aKH	0,72
aLH	0,37
aKM	0,49
aLM	0,51

Exogenous		Endogenous				Equations			
			Terminal	Initial	Change (%)		Terminal	Initial	Change (%)
PHW_	1,1	QH	1.191	1.200	-0,7	ConsH	456	500	-8,7
PMW_	1,0	QM	697	800	-12,8	ConsM	1.506	1.500	0,4
e	1,0	CH	456	500	-8,7	FDemKH	858	800	7,2
K_	1.200	CM	1.506	1.500	0,4	FDemLH	445	400	11,2
L_	800	XH	735	700	5,0	FDemKM	342	400	-14,4
		MM	808	700	15,5	FDemLM	355	400	-11,2
		PH	1,1	1	10,0	PriceH	1,1	1	10,0
		PM	1,0	1	0,0	PriceM	1,0	1	0,0
		r	1,0	1	1,9	ClearH	735	700	5,0
		w	1,0	1	-1,8	ClearM	808	700	15,5
		Y	2.008	2.000	0,4	ClearK	1.200	1.200	0,0
		KH	858	800	7,2	ClearL	800	800	0,0
		KM	342	400	-14,4	Income	2.008	2.000	0,4
		LH	445	400	11,2	SOH	1,1	1	10,0
		LM	355	400	-11,2	SOM	1,0	1	0,0
		G	1,0	1	0,0	ExtBal	735	700	5,0
		S	0,9	1	-8,5	StockG	1.191	1.200	-0,7

Sources. Calculations based on the model specified by Bernard (1998) and the technical implementation in Excel using
'"Problem Solver" by Jorgensen (2003).

CHAPTER 3

The use of tariff measures on seafood products in OECD countries

Published in OECD (2003), *Liberalising Fisheries Markets – Scope and effects*, Paris, pp. 80-92.

1. Introduction

The purpose of this paper is to present an overview of the information gathered for the OECD Committee of Fisheries' Study on Market Liberalisation. The paper seeks to assess the extent of use of tariff measures among OECD countries and to identify key issues arising from the use of these measures. The basis is information supplied by the OECD member countries in the Committee. In addition, a number of studies and web sites have been consulted. The paper only assesses the use of tariff measures, but the full study also assesses the use of other policies, which limit free trade internationally. These include import quotas, countervailing duties, price mechanisms, licensing arrangements, export measures, government financial transfers, sanitary and hygiene requirements, technical import requirements, access to ports, investment restrictions, and services restrictions. Assessments of these measures are available in OECD (2003), Liberalising Fisheries Markets – Scope and Effects.

2. The present tariff situation

Following the Uruguay Round (UR), which culminated with the Marrakech Agreement (1994) members of the WTO commenced the reduction of their tariff rates from the pre-UR level to the agreed level

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This paper is identical to the authors contribution to the published study ”Liberalising Fisheries Markets – Scope and Effects”, Paris, pp. 80-92, undertaken for the OECD Committee of Fisheries under the 2001-02 programme of work. The paper was prepared during a stay at the Fisheries Division of the Directorate of Food, Agriculture and Fisheries in the OECD in Paris in the winter 2001-02. The author wish to thank the OECD and in particular Carl Christian Schmidt for obtaining the opportunity of working with such a timely policy relevant topic. The author also thanks Carl Christian Schmidt for valuable comments on earlier drafts of this paper.

of tariff bindings. This process of tariff reductions was to have been finalised by year 2000 according to the UR Agreement implementation schedule. For fish and fish products the average across-the-board Most Favoured Nation (MFN) bound tariff rate applied by developed countries was reduced from 6.1% to 4.5%, or by 26%[1]. The reductions in tariff levels for fish and fish products were somewhat lower than for other industrial products (which ended with an average reduction of 40%). In addition the reductions covered a wide range of possibilities; some rates were not reduced at all while others were reduced to zero or eliminated.

Table 3.1 provides an overview of the reductions agreed to during the Uruguay Round by showing the relative distribution of imports by tariff level (bound tariffs), pre- and post-Round. It is noted that the relative share of trade taking place at lower rates of duty has increased with the full implementation of the Uruguay Round results. Although there are differences among the countries, a comparison pre- and post-UR of the distribution of tariff lines clearly shows that the number of tariff lines in the lower bands has increased.

[1] See GATT, The Results of the Uruguay Round of Multilateral Trade Negotiations. Overview of the Results, Geneva, November 1994.

Table 3.1 **Tariff Profiles for Fish, Developed Economies, by Origin, US$ '000 Million.**

Product category	**Total import value**	**Percentage of imports**[1]											
		Duty-free[2]		**0.1-5%**		**5.1-10%**		**10.1-15%**		**15.1-35%**		**Over 35%**	
		Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Fish & fish Pro-ducts													
All sources	18 527	21	24	42	44	18	21	12	8	7	3	0	0
Developing economies	10 621	19	20	45	45	13	20	14	10	9	5	0	0

1) Figures exclude tariff lines for which duties are not available in *ad valorem* terms since these lines cannot be distributed by duty ranges.
2) Figures refer to tariff lines which were duty free prior to the Uruguay Round, including those that were fully bound, partially bound or unbound.

Source: GATT "The Results of the Uruguay Round of Multilateral Trade Negotiations", Geneva November 1994

3. Tariff information

In building the present inventory of tariff measures a peculiarity became an obvious obstacle to the work. WTO members are not obliged to notify, to the WTO, the tariff rates actually used, although several do. For some OECD countries this is a cause of concern as the actual used tariff rates can be very different from the MFN tariff rates they are obliged to notify. Whilst this situation renders an inventory exercise difficult it is likely to be a serious concern for exporters and importers who lack instant knowledge of the likely rate of duty by which their trade will be assessed.

However, some OECD countries have set up web sites that provide tariff information on a real time basis. This concerns in particular:

- The European Union - the market access database[2] (http://mkaccdb.eu.int/) provides information on applied tariffs, sectoral trade barriers, WTO bound tariffs, import formalities. It also includes a GATS Info-Point, a statistical database and studies and the EU Commission's Directorate for Customs and Direct Taxation "TARIC" database[3] includes MFN and preferential tariff rates, tariff quota fill and other information relevant for traders and policy makers.
- The United States (http://www.usitc.gov/taffairs.htm) provides the US tariff schedule.
- Canada's online tariff database for 2002 "Tariff Wizard" is available at http://207.61.56.166/services/t,wiz2002/twiz2002e.cfm
- Also the Asia Pacific Economic Co-operation (APEC) Tariff Database provides tariff schedules, concessions, prohibitions for APEC Member countries at http://www.apectariff.org/
- And the Inter-American Development Bank provides tariffs and trade schedules for the Free Trade Area of the Americas at http://198.186.239.122/.

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[2] Access to the Sectoral and Trade Barriers Database is free. However, information under the Exporters Guide, Applied Tariffs, and WTO Bound Tariffs is restricted users in the 15 Member States of the European Union.

[3] See http://www.europa.eu.int/comm/taxation_customs/dds/en/tarhome.htm.

Tariff information has been received from several OECD countries and this information has been used as the starting point for the analysis. Additional tariff information from already published sources (basically on tariff schedules in APEC countries) has also been used. Thus detailed information on tariff schedules on the most detailed level from eleven OECD countries (out of sixteen[4]) has been made available. Insofar as trade figures are concerned, the OECD International Trade Statistics Database and the Eurostat Comext Database has been consulted. Finally, the WTO tariff information submitted to the Study has been used to verify the information from OECD countries.

4. Harmonised system

All OECD countries base their tariff nomenclature on the international Harmonised System (HS) administered by the World Customs Organisation (WCO). 177 countries (153 of which are WCO members) use the HS as the basis for customs classification and for trade statistics purposes. According to the WCO (see http://www.wcoomd.org) 98 % of all merchandise trade is based on the HS system. The WCO's primary function is to ensure uniform interpretation of the HS coding system, a process that is carried out through its Harmonised Systems Committee. Amendments and updating to the HS are carried out every four to six years on the proposal of the WCO's HS Committee with the last update taking place in 2002.

Due to the way the Harmonised System (HS) is constructed (defined by the WCO to the sixth digit level) and modified and the multitude of fish species and fish products traded, some species and products thereof do not have a code in the HS (and hence a specific tariff line). Such products are generally lumped together in the category, "other" which often attracts a higher tariff rate. This has been a cause for concern by some OECD countries whose fish species are only slowly entering the international market for fish and fish products. As the HS only undergoes substantial changes every four to six years (see above), some countries' fisheries may be at a disadvantage. This issue is likely to become more prevalent in the future as traditional fish stocks become over-exploited and new fish species enter international trade. Also to ensure the proper function of trade information systems (see below) it is

[4] The EU is considered as one country.

of importance for the surveillance of international trade flows that HS codes actually exist for single species of fish and products thereof. An international effort to ensure this may be required. In this regard it is worth noting that with tariff reductions more attention may be given to measures taken by regional fisheries organisations including the surveillance of trade flows and hence more detailed trade information may be warranted. However it should be recalled that the more detailed the HS becomes the more resource intensive it will be to administer the system. Checks on imports and their conformity to declaration by importer/exporter involve considerable expertise (including on biology and taxonomy) and follow-up procedures for the final destination and use of the imports may be administratively expensive.

5. Tariff bindings

The binding of tariffs ensures that tariffs are not raised above the bound level and ensures a stable trading environment as it "disallows" countries to change the tariff rate to above the bound level. According to a Study by UNCTAD[5] all tariff lines of the United States, Norway, Canada and the European Union are bound. The level of binding remains an issue for Japan, Korea, Poland and Turkey, where some tariff-lines remain unbound, although Japan has not raised its bound rates.

6. Tariff averages

Tariff averages can be based either solely on the MFN tariff rates or on actual applied tariff rates[6]. Tariff averages can be calculated as simple averages and as trade weighted averages. Below, two types of tariff averages are calculated; 1) simple averages of the MFN tariff rates and 2) trade weighted averages of the applied tariff rates. Simple tariff

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[5] See Shirotori, UNCTAD, *Fishery Sector: The Post Uruguay Round Trade Environment,* (1997).

[6] The MFN (Most Favoured Nation) tariff rate is the maximum rate of duty that can be used. The MFN rate can be either bound or unbound. The bound rate of duty applied from 1 January 2000 as agreed upon in the Uruguay Round. The applied rate of duty is the one actually applied on import and is normally lower than the MFN rate.

averages and trade-weighted averages are, however, not straightforward to interpret.

A simple tariff average (where the sum of all tariffs across the product selection has been divided with the number of tariff lines/products) disguises the possibility that a country could have most of its trade in the products that are levied zero tariff rates. As such the simple average tends to overstate the real tariff level. This may be a particular problem in fisheries with relatively low tariffs and a relatively higher level of trade in raw materials (HS 03) accompanied by high tariff rates and relatively lower levels of trade for processed products (HS 16).

Trade weighted tariff averages are weighted according to the traded value of the product in question or measured as total tariff revenue divided with total value of trade. Trade weighted averages tend to underestimate the real protection as the lower tariff lines are usually the ones with the highest value of trade.

The trade-weighted averages of applied tariff rates and simple average of MFN rates are presented in Table 3.2. Fish products are defined as all products included in the HS-group 03 "Unprocessed and semi-processed fish and seafood", 1604 "Processed fish products" and 1605 "Processed crustaceans, mussels etc."[7].

[7] Almost all fish and seafood products are covered. However, due to lack of comparable data a few products remain unaccounted for. These are fish waste (051191), seaweed (121220), fish liver oil (150410), fishoil 150420), fishmeal (230120) and fish soluble (230910).

Table 3.2 **Trade weighted average of applied tariff rates and simple average of MFN rates on imports of fish and fish products to OECD countries (% and USD million[1]).**

	Aus	Can	EU[2]	Ice	Jap	Kor	Mex	NZ	Nor	Pol	USA	All	RO[3]	RW
Tariff average (%):														
Trade weighted	0.4	0.5	4.2[4]	0.1	4.0	12.7	11.2	0.7	0.0	9.3	0.2	3.1	-	-
Simple (MFN)	0.0	1.5	12.1	1.4	5.9	16.9	19.3	0.7	0.0	18.4	2.4	7.0	-	-
Import value	458	1,134	8,888	63	12,576	538	84	42	483	328	8 524	33,118	573	9,424

Notes:

1. Tariff data covers the year 2000 for the EU, Iceland, Norway and Poland and 2001 for the remaining countries. Tariff averages are calculated using trade values in 1998 as trade weights.
2. The calculation includes only extra EU trade.
3. Rest OECD includes the sum of the import value in Czech Republic, Slovak Republic, Turkey, Hungary and Switzerland.
4. Estimates by the European Commission suggest a trade weighted tariff average on EU imports of fish and fish products of 3.7%, where the Secretariat in their calculations obtain a trade weighted tariff average on 4.2%. The difference is possible due to the underlying data and the assumptions made on the use of tariff quotas and on the treatment of countries with special arrangements.

Source: OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

Tariff averages for imports into the eleven OECD countries are 3.1% and 7.0%, respectively for the trade weighted average of the applied tariff rates and for the simple average of the MFN rate. The tariff revenue collected by OECD countries amounts to USD 1 billion[8]. Moreover, it appears that the lowest tariff average is present in Norway as all tariff lines have zero rates[9]. Tariff averages are also low in Iceland, Australia, New Zealand, Canada and in the US.

Korea, Mexico and Poland exhibit the highest tariff averages, both measured as the trade weighted average of the applied tariff rates and as

[8] Calculated as 3.1% of the USD 33 118 million.

[9] However, this is only because the HS-groups 03, 1604 and 1605 are considered. Within the fish oil group (1504) a MFN tariff rate of 170% is reported by Norway and within the fishmeal group (2301) a MFN tariff rate of 283% is reported. Tariffs are applied for animal feed purposes.

the simple average of the MFN rates. The weighted applied tariff averages in Japan and in the EU are both at the same level of around 4%. However, the simple average of the MFN rates is considerably higher in the EU than in Japan, mainly due to the extensive use by the EU of tariff quotas and suspensions for imports of raw materials and preferential agreements.

Table 3.3 presents tariff averages of fish products together with tariff averages on a selection of other food products. The tariff averages for fish products are trade weighted where the tariff averages for other products are weighted with domestic production, implying that the figures are not directly comparable. Moreover, it is underlined that the tariff averages calculated for fish products cover year 2000, where the tariff averages on the other products cover 1996. Nonetheless, the figures give a rough indication of the level of protection provided by tariffs on fish products related to other food products.

Table 3.3 **Weighted tariff averages, selected OECD countries and product groups (%).**

	EU	USA	ICE	JAP	CAN	AUS	NOR	NZ
Fisheries (2000)	4.2	0.2	0.1	4.0	0.5	0.4	0.0	0.7
Agriculture products (1996)[1/2]	10.7	7.9	2.1	5.0	5.5	0.5	60.3	1.7
Food, beverages and tobacco (1996) [1/2]	32.5	15.9	10.6	18.9	57.4	3.3	135.1	5.2
Total all products	7.7	5.2	5.2	3.4	12.1	4.2	22.3	51

	MEX	TUR	AUT	FIN	SWE	KOR
Fisheries (2000)	11.2	n.a.	n.a.	n.a.	n.a.	12.7
Agriculture products (1996)[1/2]	14.7	9.1	7.0	4.2	1.3	n.a
Food, beverages and tobacco (1996) [1/2]	43.6	82.3	14.7	11.9	1.0	n.a
Total all products	18.0	10.6	8.8	5.2	3.0	n.a.

Notes:

1. The average tariff rates of these products are weighted with domestic production, where the tariff average for fisheries is weighted with imports.
2. The groups "agriculture products" and "food, beverages and tobacco" can be considered as unprocessed and processed foodstuff respectively.
3. Figures for Austria, Finland and Sweden refer to 1993.

Source: OECD, Indicators of Tariff and Non-tariff Trade Barriers, Paris, (1997)

From Table 3.3, it appears that the weighted tariff averages on fish products in the countries for which data are available are lower than on both imports of unprocessed and processed foodstuffs. The extreme is Norway with very high tariffs on foodstuffs and other imported goods, but without tariffs on fish.

Despite a low overall level of protection, tariffs on some specific fish species are significant and markets for these species therefore heavily affected. In other words, liberalising trade by reducing tariff barriers would be felt on markets with relatively large tariff averages but less so on markets with relatively low tariff averages. This is for example important in assessing whether tariff rate reductions gives supply responses, as supply responses are connected to fisheries management, which again is related to fish species. Table 3.4 highlights this by showing tariff and trade data for selected fish species.

Table 3.4 **Tariff averages and trade values for the eleven OECD countries, by species.**

Species[1]	Tariff average /%		Trade value /USD Million		
	Trade-weighted (applied)	Simple (MFN)	Import	Export	Trade balance
Trout	3.6	5.6	258	157	101
Salmon	2.4	6.2	2 147	1 873	274
Expensive flatfish	1.5	5.8	226	220	6
Cheap flatfish	3.8	5.6	169	121	48
Cod	1.8	6.2	1 158	964	194
Fillets (all species)	2.1	5.8	4 980	2 583	2 397
Tuna	4.5	9.4	3 658	992	2 666
Herring	6.2	6.7	194	386	-192
Sardines and anchovies	3.8	7.9	286	189	97
Mackerel	4.4	7.9	398	449	-51
Lobster	1.4	8.0	1 002	971	31
Shrimps	1.9	8.2	8 693	1 398	7 295
Crabs	3.2	8.9	1 360	458	902
Bi-valves	5.4	8.7	1 921	1 166	755
Cuttlefish	4.6	5.4	1 410	295	1 115
Other	4.2	6.5	5 258	2 993	2 265
Total	3.1	7.0	33 118	15 214	17 904

Note: Species defined according to OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris, where tariff and trade data are also further detailed

Source: OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

Table 3.4 shows that the largest trade weighted tariff averages are on herring (6.2%) and bi-valves (5.4%) and the lowest are on lobster (1.4%), expensive flatfish (1.5%) and shrimp (1.9%). All the remaining rates are within the interval 2-5%. The interval of the simple averages of the MFN rates is also within a limited interval (5-10%). As the tariff averages on imports of the selection of fish species to the eleven OECD countries do not differ significantly it is not possible to identify particular markets for fish species where the impacts of liberalising trade by reducing tariff rates are more pronounced than others.

As trade weighted averages underestimate the real protection, the distribution of imports according to tariff treatment is reported in Table 3.5.

Table 3.5 **Distribution of imports (based on value) according to tariff treatment (%).**

	Aus	Can	EU	Ice	Jap	Kor	Mex	NZ	Nor	Pol	USA	All
Imports:												
- With zero rates	92	87	46	99	0	0	43	62	100	34	89	42
- Under preferential rates (rate > 0)	0	10	24	0	18	0	0	19	0	29	0	14
- With MFN rates applied (rate > 0)	8	3	30	1	82	100	57	19	0	37	11	44

Source: Calculations based on data in the document, *Inventory of tariffs and trade data* available in OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

From Table 3.5, it appears that 42% is imported without tariffs, 14% on preferential rates and 44% on MFN rates. However there are considerable differences among countries.

7. Tariff quotas and tariff suspensions

A tariff quota is an allocation of a given amount of imports to which a lower than normal rate of tariff is imposed. Tariff quotas may be opened on an autonomous[10] basis while a few tariff quotas are GATT/WTO bound and have been negotiated in the context of a multilateral trade negotiation. Tariff suspensions are the unilateral lowering of the normal tariff rate and may be applied throughout the year or for a given period of time.

Tariff quotas or tariff suspensions are used in the European Union and Korea (in Korea this is known as an "Elastic Tariff System"). Tariff quotas or suspensions are opened to complement domestic shortfalls in landings with a view to better manage the supply situation for unprocessed products which serve as a basis for activities in the processing sector.

In the case of the European Union, the tariff quotas for herring, cod and silver hake are GATT bound (and therefore not subject to change without re-negotiation) whilst others are opened on a unilateral basis;

[10] Voluntarily opened by a country.

the tariff quotas can be used by any exporter on an *erga omnes* basis. The quotas cover, in particular, cod (25 000 tons), herring (34 000 tons) and cold water shrimp (12 000 tons) destined for further processing. The European Union also operates a series of tariff suspensions — some of which are permanent (*e.g.* frozen tuna for further processing), some are opened on a yearly basis and others are opened to cover shortfall during certain periods of the year.

Korea applies the "Elastic Tariff System" on some products chosen annually. In 2000 (and 1999) the elastic tariff system included 14 fish and fish products including live eels (30 % in lieu of 10 %) and sea bream (70 % in lieu of 10 %), frozen croaker (70% in lieu of 10), frozen Alaska Pollack (30 % in lieu of 10 %), shrimp (35 % in lieu of 20 %), squid (40 % in lieu of 10%) and seasoned squid (25 % in lieu of 20 %). Tariffs are adjusted to compensate for the negative impact of import liberalisation following import liberalisation of fish imports on 1st July 1997. In essence tariffs are increased according to the domestic supply situation and import possibilities and fixed annually. These “elastic tariffs” are unbound. However, they have been marginally bound and the number of products covered has been reduced in recent years.

The United States applies a tariff quota on canned tuna not packed in oil. The tariff quota is based on the previous year's domestic pack (production) of canned tuna not packed in oil. Up to a ceiling of 20% of the previous year domestic pack imports are assessed at a tariff rate of 6% increasing to 12.5% for imports above the ceiling.

The fill rates (*i.e.* the level at which the quota or suspension is used) is a useful indicator in evaluating the trade impact of tariff quotas and (time limited) suspensions. For example, if exporters/importers are fully utilising the possibility for cheaper imports offered by the tariff quota/suspension, an extension of the quota/suspension offer to cover additional quantities will expand trade and thus constitute a move towards further liberalising trade. However, while it may be argued that the opening of tariff quotas and tariff suspensions is a move towards trade liberalisation, it should be noted that for the exporters at least three issues arise in their application. First, a tariff quota or a time limited tariff suspension may give rise to uncertainty — in particular when the quota is close to being filled. Second, once opened, the trade in the product that benefits from the tariff quota/suspension may become important and a discontinuation of the measures will therefore have more impact. Finally, tariff quotas and suspensions may give rise to trade diversion towards the products benefiting from the measure.

8. Preferential tariff arrangements

Basically there are two types of preferential access arrangements; Autonomous preferential agreements like the GSP scheme and bi/pluri-lateral preferential reciprocal arrangements.

Autonomous preferential agreements

Most OECD countries apply preferential tariff treatment to developing countries - either under the General System of Preferences[11] (GSP schemes) or under particular preferential arrangements (*e.g.* the European Union-ACP[12] agreement - the so-called "Cotonou Partnership" Agreement covering 71 ACP countries). Ultimately, the intention is to move towards a free trade area[13].

Bilateral and multilateral preferential reciprocal arrangements

The European Union offers preferential access to fish and fish products from Greenland and the Faeroe Islands (Danish territories), to Norway (as a compensation for lost trade opportunities when Sweden and Finland became members of the European Union), and to members of the European Economic Area (EEA agreement[14]). The European Union also operates a series of arrangements with countries in transition and Mediterranean countries that (for some products) open either tariff quotas or suspensions.

On the few product lines that carry a tariff, New Zealand offers preferential tariff treatment to Australia and Canada, developing

[11] Detailed information on the GSP schemes can be found on http://www.unctad.org/gsp/Default.asp Presently, Australia, Canada, EU, Japan, Norway, Poland, Slovak Republic, Switzerland, USA and New Zealand applies a GSP scheme.

[12] ACP denotes Asian, Caribbean and Pacific.

[13] The preferential arrangements of the eleven OECD countries is summarised in OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris, pp. 128-9.

[14] The EEA Agreement extends the single market of the European Union to three (out of the four) EFTA countries; namely, Norway, Iceland and Liechtenstein.

countries, and to the South Pacific island countries, which receive duty-free access under the South Pacific Regional Trade and Economic Co-operation Agreement (SPARTECA).

Under the North American Free Trade Area (NAFTA) agreement, fish and fish products can be traded tariff free between three OECD countries; *i.e.* Canada, United States and Mexico.

Canada applies preferential tariff treatment to Commonwealth countries in the Caribbean and to Chile under the Canada-Chile Free Trade Agreement. The United States applies tariff free trade in its trade with Israel.

The European Free Trade Association (EFTA), whose membership includes the OECD countries Switzerland, Norway, Iceland as well as Lichtenstein, has free trade agreements with nineteen countries, ongoing negotiations with four, and exploratory talks and declarations on co-operation with nine other countries/organisations. The elements of the EFTA free trade agreements with non EU-countries are in principle similar to the trade regime prevailing among the EFTA States themselves providing for free trade in industrial products, processed agricultural goods, as well as fish and other marine products. In the last few years the negotiated agreements also comprise among other elements areas such as services and investment, rules of competition, protection of intellectual property rights.

Poland offers free or preferential access on imports for several fish products imported from Eastern European and the Baltic countries, as well as from EFTA countries. Iceland offers free access on imports from European countries.

The wide use of preferential arrangements implies that exporters to OECD countries are treated differently and this gives rise to competitive advantages for some countries.

9. Rules of origin

The use of preferential tariff treatment may give rise to issues of rules of origin. This might be the case where a domestic processing industry (dependent on imported raw material) competes on the home market with a foreign fish processing industry (also dependent on imported raw materials), where tariff rates on raw materials differ. In this situation the domestic industry faces a disadvantage in relation to the foreign industry[15]. This is a problem for fish and fish products that are traded in both raw, semi-processed and processed forms but are caught by a multitude of vessels in many parts of the world.

The only way of determining origin is through a chain of custody verification, the costs of which may be high[16]. Tuna caught by developed countries and subsequently transhipped and landed in a developing country for processing (e.g. canning) is a case where rules of origin and the extent of transformation may give rise to problems. However, it should also be noted that a chain of custody is needed to ensure traceability of these products and that traceability is gradually becoming a *sine qua non* in international trade in fish and fish products. Traceability through chain of custody verification is required, *inter alia,* for compliance with sanitary and health regulations, for labelling purposes and for the implementation of conservation measures (e.g. "Tuna Tracking System"). See also under 2.e. Licensing arrangements and trade information systems.

10. Tariff peaks

There are a number of tariff peaks *i.e.* very high tariff rates, defined as tariff lines with an MFN tariff rate at or above 15%. The number of tariff peaks for fish products in HS-groups 03, 1604 and 1605 are provided in Table 3.6.

[15] The absence of an international recognised system capable of securing traceability through the trade and distribution channels makes rules of origin difficult to enforce.

[16] In particular for developing countries costs associated with chain of custody verification may be prohibitively high.

Table 3.6 **Tariff peaks measured as tariff lines with MFN tariff rates >15%.**

	Aus	Can	EU	Ice	Jap	Kor	Mex	NZ	Nor	Pol	USA
Tariff peaks (MFN rate)											
- Total number of tariff lines at or above 15%	0	0	128	0	10	225	106	0	0	270	6
- of which processed products i.e. 1604 and 1605			29		0	64	19			45	4
- Total number of tariff lines	101	117	394	101	285	322	113	137	101	386	175

Source: Inventory of tariffs and trade data available in OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

Table 3.6 shows that only six OECD countries have MFN tariff rates at or above 15%. The largest number of tariff peaks relative to the number of tariff lines is present in Korea, Mexico and Poland. In the EU, 128 of 394 tariff lines are at or larger than 15%. The US and the EU tariff rates on canned tuna are also high, respectively 35% and 24%. In Korea a number of products carry a general 20% tariff. However, adjustment tariffs in Korea were used on a small number of products, lifts tariff peaks to 80 % (e.g. frozen croaker). In Norway, tariff rates on fish for consumption are zero. However, the MFN tariff rate on fishmeal used in animal feed is 283%.

The limited number of extreme tariff peaks suggests that protection provided by tariffs is at a relatively low level in most OECD countries. However, they also show that there is room for further trade liberalisation, as some specific products are still subject to high tariffs. Moreover, it is possible that some of these tariffs are sufficient to deter imports. This will depend however on the value of the product, the level of domestic production and the availability of substitutes.

11. Tariff escalation

Tariff escalation exists when, during subsequent processing stages, the applied tariffs increases thus resulting in a higher effective protection (a tariff rate exceeding a calculated rate that compensates for yield losses and value added from a change in processing stage) for the processed products and hence the processing industry. This produces a bias towards the importation of raw material. Trade weighted tariff averages on processed and unprocessed imports are shown in Table 3.7[17].

Table 3.7 **Trade weighted tariff averages for eleven OECD countries total imports, separated by processing stages.**

	HS-codes	Aus	Can	EU	Ice	Jap	Kor	Mex	NZ	Nor	Pol	USA	All
All /%		**0.4**	**0.5**	**4.2**	**0.1**	**4.0**	**12.7**	**11.2**	**0.7**	**0.0**	**9.3**	**0.2**	**3.1**
- Unprocessed	0301-0303/0306-0307	0.0	0.1	2.9	0.0	3.5	12.4	10.2	0.0	0.0	8.2	0.0	2.5
- Fillets	0304	0.0	0.0	2.3	0.0	3.9	10.0	16.7	0.0	0.0	7.9	0.0	2.1
- Smoked, salted etc.	0305	0.0	0.0	2.0	0.0	1.4	20.0	14.4	0.0	0.0	12.7	0.6	1.5
- Processed	1604-1605	1.2	1.8	10.4	5.2	7.0	20.0	9.0	1.0	0.0	21.8	0.9	6.3

Source: OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

Trade weighted tariff average on imports of processed products to the eleven OECD countries for which data are available is 6.3%, where it is only 2.5% for unprocessed and less for semi-processed products (fillets, smoked and salted products). Hence, tariff escalation is present. Moreover, it appears that this situation is present in all the countries, except Mexico. The situation is most noticeable in Poland, Korea, the EU and Japan. In Japan and Korea, tariff escalation does not depend pronouncedly on fish species, whereas in Poland and the EU it does. In Poland, tariff escalation is pronounced on herring and mackerel as well as on salmon. In the EU, tariff escalation is largest for tuna, shrimp, salmon, herring and mackerel. An extreme example is for example fishmeal and oil in Norway (not covered in Table 3.7), which applies a tariff rate of 170% on fish oil and 283% on fishmeal for feed purposes compared to a zero rate on raw material.

[17] Tariff escalation is identified by comparing the nominal tariff rates on processed and unprocessed products. However, the nominal tariff rates are calculated on the basis of the value of the final product, not on the basis of value-added. To identify this the effective rate of protection should be calculated. The effective rate of protection (=ERP) is formally defined as $ERP = \frac{V_P - V_{FT}}{V_{FT}}$, where V_P is value added at the present level of protection provided by tariffs and V_{FT} is value added at free trade.

In Table 3.8, trade weighted tariff averages on exports from all the eleven OECD countries to all the other eleven OECD countries (i.e. “intra –OECD trade”) are shown.

Table 3.8 **Trade weighted tariff averages for intra-OECD fish trade, by processing stage.**

	Aus	Can	EU	Ice	Jap	Kor	Mex	NZ	Nor	Pol	USA	All
All /%	4.4	3.4	7.1	4.1	2.2	6.9	0.4	2.7	2.9	1.3	4.1	3.7
- Unprocessed	4.2	3.9	7.2	3.4	1.9	5.6	0.4	3.7	3.1	2.0	3.9	3.8
- Fillets	2.4	0.1	5.4	1.5	0.8	5.6	0.1	1.2	2.0	0.0	4.7	2.2
- Smoked, salted etc.	8.3	8.2	6.0	0.4	1.3	8.6	0.2	7.6	1.0	8.1	4.0	2.5
- Processed	9.6	2.6	8.4	16.3	4.5	10.8	0.3	4.2	9.5	0.4	3.6	7.2
Export value to OECD /USD Million	380	2 197	622	1 211	233	1 040	608	497	2 950	183	2 152	12 067
Share of total export exported to OECD /%	51	97	34	99	33	85	99	77	84	88	95	79

Source: OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

The trade weighted tariff average on “intra-OECD trade” is 3.7% for a total value of trade of USD 12 billion, corresponding to a total tariff revenue paid on USD 450 million.

Meanwhile the tariffs applied differ considerably among countries. As was the case for total OECD imports, tariff escalation does also exist in intra OECD trade, as the trade weighted tariff average of processed products is 7.2%, only 3.8% for unprocessed and less for semi-processed products. The figures show that the processing sectors in Iceland, Norway, Australia and Korea are likely to be hit hardest by the present tariff structure as they face tariff escalation in their principal export markets i.e. the EU, the USA and Japan. In particular products of salmon (smoked), tuna (canned) and shrimps (preserved) in all the three major import markets show evidence of this problem.

In Table 3.9, trade weighted tariff averages are given for exports from developing countries (DEV) and least developed countries (LDC) to the eleven OECD countries.

Table 3.9 **Trade weighted tariff averages for developing countries exports to OECD countries, by processing stage**

	LDC	DEV	All other
All /%	2.5	2.9	3.2
- Unprocessed	2.5	2.5	2.5
- Fillets	2.8	2.5	2.0
- Semi-processed	0.5	1.9	1.4
- Processed	1.7	4.3	8.0
Total value in USD Million	437	10 689	21 992

Source: OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

From the Table it appears that the trade weighted tariff average on exports from developing countries to the eleven OECD countries is 2.5% and 2.9%, respectively from least developed and other developing countries. Compared with the trade weighted tariff average on exports from all other countries to the OECD of 3.2%, the difference is due to the preferential access of developing countries to markets in most OECD countries. Moreover, it also appears that the trade weighted tariff averages on processed products are lower for developing countries, where this is not the case for other products. Therefore, preferential access to the OECD markets is mainly granted for processed products. Of the total OECD imports, one-third originates from developing countries and 25% of this is processed products[18].

12. Implications of reducing tariff barriers

In capture fisheries, trade can only be expanded through the implementation of proper fisheries management systems that balance resources with fishing capacities. However, market measures may be

[18] Which can be compared with 15% on products originating in non-developing countries.

helpful to correcting price and information signals. Several studies have been published on this issue[19].

[19] Recent studies in this area include: Hartmann, J., N. Klijn and A. Cox (2000), *Seafood Trade in the APEC Region*, Research Report no. 3 from the Australian Bureau of Agricultural and Resource Economics; Guillotreau, P. and N. Péridy (2000), Trade barriers and European imports of seafood products: a quantitative assessment, *Marine Policy*, 24, 431-37; Heiberg, I. (1996), Implications of possible trade political penalties against Norwegian fish export (in Norwegian), Report from the NFR-project Marine resources and Trade Policy Norwegian School of Fisheries Science, University of Tromso; Stendal, D. (2000), Does liberalisation of fish trade cause increased pressure on fish stocks? Assessed in the light of the present fisheries management regime and the importance of aquaculture for fish supply (in Norwegian), note from SINTEF Fishery and Aquaculture.

Table 3.10 **Actual and potential tariff revenue collected from imports and effects of reductions in the MFN tariff rates on tariff revenue (USD million and percentage).**

	Tariff average[3]		Tariff revenue[1] / USD mio.		Approximated effects of reducing MFN rates on tariff revenue collected[2]					
	Simple	Trade weighted	Ac-tual	Poten-tial	25% reduction	50% reduction	75% reduction	80% reduction	90% reduction	100% reduction
Australia	0.0	0.4	2	2	22	48	74	79	90	100
Canada	1.5	0.5	5	12	0	0	44	55	78	100
EU	12.1	4.2	373	1,466	0	0	2	22	60	100
Iceland	1.4	0.1	<1	<1	0	0	51	61	80	100
Japan	5.9	4.0	508	544	20	46	73	79	89	100
Korea	16.9	12.7	69	69	25	50	75	80	90	100
Mexico	19.3	11.2	9	16	0	16	57	66	83	100
New Zealand	0.7	0.7	<1	<1	0	32	66	73	87	100
Norway	0.0	0.0	0	0	-	-	-	-	-	100
Poland	18.4	9.3	31	52	0	5	58	66	83	100
USA	2.4	0.2	16	101	0	0	0	0	36	100
All	7.0	3.1	1,015	2,264	0	0	44	55	78	100

Notes: 1) Actual tariff revenue is calculated as the trade weighted tariff averages multiplied by import values, both shown in Table 3.1. Potential tariff revenue is calculated as the MFN tariff rates multiplied by total import values on a detailed level (on the 8-digit HS-level for the EU and on the 6-digit level for all other countries).
2) These figures are calculated by comparing actual and potential tariff revenue.
3) For details see Table 3.2.

Source: Calculations based on data in *Inventory of tariffs and trade data* available in OECD (2003), Liberalising Fisheries Markets – Scope and Effects, Paris.

The traditional process of liberalising trade and reducing tariff barriers is through multilateral WTO trade negotiations; firstly by agreeing on binding the tariff rates at certain levels and then by agreeing on reducing the bound tariff rates. As have been shown above, however, several fish products are traded at tariff rates lower than the bound rates. Hence, reducing the MFN tariff rates[20] by a certain percentage will not imply that the tariff revenue collected will fall by the same percentage. Table 3.10 provides actual tariff revenue today and potential revenue following reductions in MFN rates. The effects of reducing the MFN rates on potential tariff revenue are also shown. This is an approximation only, as the calculated figures centres around revenue rather than on rates[21].

Table 3.10 shows that USD 2 264 billion would have been collected in tariff revenue totally from the eleven OECD countries if preferential arrangements, temporary tariff reductions, tariff quotas and tariff suspensions did not exist i.e. if the maximum tariff protection as given by the MFN rates were applied. This compares with the USD 1 billion collected today. It implies that MFN tariff rates should be reduced considerably if the intention is to reduce actual protection. On average across the countries for which data are available, the MFN rates should be reduced by 78% to reduce tariff revenue by 50%. However, the effects differ and are only important among countries with significant tariff revenues, mainly Japan and the EU. In Japan the effects of reducing MFN tariff rates would be apparent even at small reductions, as the difference between actual and potential tariff revenue is small. This is not the case in the EU. Reducing the EU MFN tariff rates would have a limited effect on actual protection. For example, given the assumptions, reducing the MFN tariff rates by three-fourths of the present level would only reduce tariff revenue by 2%.

These observations are based on the assumptions that reducing tariff rates does not affect the level of trade and that potential tariff revenue is reduced before actual tariff revenue.

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[20] MFN rates are identical to bound rate in all countries except Japan. In Japan unbound MFN rates remain.

[21] Preferably, effects of reducing MFN tariff rates on potential tariff revenues should be identified. Hence, the figures given above overestimate the effects.

CHAPTER 4

Price formation and market integration on the European first-hand market for whitefish

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Abstract. Total Allowable catches (TACs) for whitefish in European Union (EU) waters have been reduced each year for the past five years, thereby reducing fleet revenue. During the same period prices increased, partly offsetting the reductions in income. However, price changes depend on the structure of the market within which they are formed and, therefore, this paper examines the structure of the European first-hand market for whitefish. A Vector Auto Regressive (VAR) model in Error Correction form (ECM) is used to analyse landing prices among the main fishing nations, using co-integration tests and tests for the Law of One Price (LOP) to determine the degree of market integration. A partially integrated European first-hand market for whitefish is identified and as a part of this a perfectly spatially integrated cod market. The existence of this relatively loose market integration is explained by the presence of rigidities on the supply side. The implications are discussed in relation to reductions in the EU whitefish TACs and quotas and to the market policies applied.

Keywords. Price formation, market integration, co-integration, Law of One Price, first-hand market for whitefish.

Introduction

The purpose of this paper is to contribute to the understanding of the price formation process through a market integration analysis of the European first-hand whitefish market. When supply changes, as it did recently, and you wish to know the effects of this change, you need to know what to compare with *i.e.* you need to have an adequate perception of what the total volume of the relevant market is. Is it a local specialized market or is it a global market for homogenous standard products? The market integration analysis is a suitable tool for revealing the adequate delimitation of the relevant markets. The understanding of the role of market integration in the price formation process then allows for an assessment of the effects of changing fisheries management (e.g. stock conservation policies) on prices and thereby on the income of fishermen. This is an issue of high applicability, since the EU Commission has proposed a moratorium on cod fishing in the North Sea for 2003. Moreover, increased knowledge of market integration allows for assessments of the effectiveness of regional market policies. The subject is analysed within the multivariate co-integration framework by identifying market integration, sizes and boundaries of markets, and then uses the obtained information to illustrate implications for the price formation process.

The issue is important on a resource constrained capture fish market, such as the European first-hand whitefish market. Several authors have found that prices were inflexible in relation to changes in landed quantities[1]. Whether price changes are great or small will have an effect on the quantities demanded by consumers and on the income of fishermen. However, since these studies usually cover only single countries, they may have underestimated price flexibilities in the presence of market integration between countries. If markets are integrated and an internationally coordinated quota reduction is undertaken, prices might well be more flexible than the literature indicates, implying that quota reductions are followed by larger price increases than might be expected on the basis of studies of single markets. Where markets are not integrated, prices would remain inflexible and increases would be relatively small. In the quota setting process in the Northeast Atlantic Ocean, the International Council for Exploration of the Sea (ICES) is also of importance, since it through the Advisory Council of Fisheries Management provide advises to all

[1] Prices are inflexible when the own-price flexibility (defined as the percentage change in the price of a good as demand increases by one percent) in an inverse demand system is negative and less than one in magnitude, implying that, for example, a 10% reduction in quantities will lead to an increase in the price that is less than 10%. The authors include Ioannidis and Whitmarsh (1987), Barten and Bettendorf (1989), Burton (1992) and Millán (1998), who all find that European first-hand whitefish prices are inflexible.

countries fishing in the area. The issue is of particular current interest in relation to the gradually worsening condition of several of the main European whitefish stocks, together with reduced quotas and declining domestic supply, as shown for the period 1997-2002 in Table 4.1.

Table 4.1 **European Union TACs for selected whitefish, 1,000 tonnes**

Species	Sea	1997	1998	1999	2000	2001	2002
Cod	North Sea[1]	103	125	120	74	41	41
Cod	Baltic Sea	70	87	77	64	66	46
Haddock	North East Atlantic	84	85	70	61	48	82
Hake	North Sea[1]	60	59	55	42	23	27
Saithe	North Sea[1]/Baltic Sea	55	47	53	42	43	66
Total		372	402	375	283	221	262

Note 1: North Sea includes Kattegat and Skagerrak.
Source: European Commission.

The numbers clearly demonstrate that during the period 1998-2002 dramatic changes have occurred in the TACs of the selected fisheries. In 2002 quotas were 65% of the levels prevailing in 1998. Moreover, for cod in the North Sea, the quota in 2002 is only one-third of the quota in 1998, and on the basis of the continued worsening of the stock, scientists from the International Council for the Exploration of the Sea (ICES) proposed a moratorium on cod fishing in the North Sea for 2003. It is to be presumed that these measures will cause prices to rise, although to what extent will depend heavily on the size of the market within which they are being formed. Hence, one hypothesis of this paper is that, in the literature, price flexibilities estimated for the European first-hand markets for whitefish underestimate price increases that follow internationally coordinated quota reductions, since the markets are integrated.

Market integration is also interesting in relation to regional market policies, since their regional effectiveness depends on the degree of market integration. If market integration is absent these policies are potentially effective, since price levels may respond. On the other hand, such policies are ineffective if market integration is tight, since price levels can then only be affected marginally. Thus, the second hypothesis is that European market policies are ineffective since first-hand markets for whitefish are internationally integrated.

Finally, market integration is of importance from a theoretical point of view, since the correct specification and calibration of economic management models require a good understanding of the size and linkages in the relevant markets. Price formation has traditionally been studied empirically in the Neo-classical tradition by estimating demand and supply systems, based on implicit assumptions on market sizes and boundaries, as revealed by the choice of goods included in analyses. Goods included are to some extent part of the market, where goods excluded are implicitly assumed not to be part of the market. The new econometric methods made available over the last decade, such as the co-integration analysis of non-stationary time series and the emergence of tests for the LOP, however, provide suitable tools for assessing these implicit assumptions. This allows us to obtain consistent pictures of market integration, and thereby market structures, before analysing price formation processes.

In the economic literature, several articles identify market sizes by testing the Law of One Price on European Union import markets for whitefish. The main conclusions obtained from the literature, which include Gordon and Hannesson (1996), Asche, Salvanes and Steen (1997), Guillotreau (1998), Asche, Gordon and Hannesson (2002), and which use foreign trade data, are:

- The markets for whitefish are integrated between EU countries in all cases examined.
- The cod market is strongly integrated with the markets for all other whitefish.
- The markets of other whitefish species are also integrated, but the integration is looser than for cod. Hence, the studies indicate that cod is a price leader.
- The markets for fresh cod in the UK, France and Germany are not integrated with the market in the US. The market for frozen cod fillets, however, in the three EU countries are weakly integrated with the US market.

Based on these surveys, market integration is found both between countries and between species in EU import markets, which, given perfect market conditions, would predict that the first-hand markets would also be integrated. However, this will not necessarily be the case. Previous research deals with the markets for partly processed products, or products close to final consumption, whereas this paper deals with the market for raw materials. Markets for whitefish might consist of many sub-markets and signals might therefore not be transferred perfectly between these markets. Moreover, Asche and Hannesson (2002) and Asche *et al* (2002) study price transmission and relationships between prices at different market levels. Proportional relationships between ex-vessel prices and domestic fresh and dried salted cod prices are found in Norway. However, a proportional relationship between ex-vessel prices and the export price of frozen fillets could not be found. Other articles identify market sizes in EU landing markets for whitefish. Clay and Fofana (1999), for example, find that the quayside price formation process of different whitefish species in the UK are integrated and the LOP is in force.

The author is not aware of any articles identifying the sizes and boundaries of landings markets for whitefish between countries and, therefore, this paper will explore this further. Given the results of previous research, knowing that the majority of total European whitefish catches are consumed within Europe and knowing that considerable trade takes place within Europe, some level of market integration is expected on the first-hand European market for whitefish, with the closest integration expected between the cod markets. Whitefish includes cod as well as haddock, hake and saithe.

Methods

A market, according to Stigler (1969), is defined as "the area within which the price is determined, allowances being made for transport costs". Based on this definition, this paper uses econometric tests to determine market sizes and boundaries, thereby enabling the identification of integrated markets. The implication is, according to Asche, Bremnes and Wessells (1999, 2001) that the Generalised Composite Commodity Theorem of Lewbel (1996) holds, and that commodities as a consequence can be aggregated[2]. Co-integration tests and tests of the LOP are undertaken in order to determine market boundaries and sizes. When the co-integration test identify a single integrating factor which is common to all the price series and the test of

[2] For a deeper discussion see Asche, Bremnes and Wessells (1999, 2001) and Miljkovic and Paul (2001).

the LOP shows that the LOP is in force, the goods analysed are homogeneous[3], relative prices are constant and markets are perfectly integrated. When the co-integration test identify a single common integrating factor and the LOP is rejected, the markets are partially integrated, since markets, according to Stigler and Sherwin (1985), they can "show every level of interdependence from absolute homogeneity to complete independence – the continuity of the conventional criteria of cross-elasticities of demand and supply are enough to suggest that". Thus, goods may be neither perfect substitutes nor absolute independent. If markets are partially integrated the goods will be partial substitutes. Where the co-integration test cannot identify one common integrating factor, some of the goods might be heterogeneous and their markets independent. As a consequence, subsystems for which a single common integrating factor exists should be sought by excluding price series from the tests one-by-one until a subsystem with a single common integrating factor is identified. The price series thus excluded are then not part of the integrated market. Hence, the test of the LOP is used to identify market inter-dependence, while the co-integration test is used to identify market boundaries.

The LOP is tested between prices of the same species landed in different countries and between different species landed in different countries in a multivariate co-integration framework. The LOP in the basic simple bivariate form is, according to Stigler (1969), tested by estimating Equation 1:

$$\ln(\boldsymbol{p}_{1,t}) = \boldsymbol{B} + \boldsymbol{A}\ln(\boldsymbol{p}_{1,t}) + \varepsilon_t \qquad (1)$$

where the price of good one ($\boldsymbol{p}_{1,t}$) and the price of good two ($\boldsymbol{p}_{2,t}$) are of two different products, for example cod landed in Norway and cod landed in the UK and where A=1 implies that the law of one price is in force. This simple bivariate form of the LOP can easily be extended to a multivariate form by adding extra products, e.g. $\boldsymbol{C}\ln(\boldsymbol{p}_{3,t})$, and then testing jointly whether $\boldsymbol{A} + \boldsymbol{C} = 1$. However, the regression is only valid

[3] In the sense that prices of two goods follow each other over time.

for stationary data series[4]. For non-stationary data series, co-integration analysis must be used, since regressing data series integrated of different orders may cause spurious correlations between them. Therefore, one has to confirm that data series are integrated (in the econometric sense) of the same order, determining whether the individual data series are stationary, I(1) or I(2).

Based on an I(1) nature of the price series, the Johansen co-integration rank procedure is used and a Vector Auto Regressive (VAR) model in Error Correction form is formulated following Asche, Bremnes and Wessells (1999), as given in Equation 2:

$$\Delta \boldsymbol{X}_t = \Gamma_1 \Delta \boldsymbol{X}_{t-1} + \ldots + \Gamma_{k-1} \Delta \boldsymbol{X}_{t-k+1} + \Pi \boldsymbol{X}_{t-1} + \mu + \delta \boldsymbol{t} + \Psi \boldsymbol{D}_t + \varepsilon_t \quad (2)$$

where $\Delta \boldsymbol{X}_t$ is the differenced price series, $\Delta \boldsymbol{X}_{t-k}$ is the price series differenced between the present period and period *k*, $\boldsymbol{X}_{t-1}$ is a price series in a basic period, *t* is a trend and $\boldsymbol{D}_t$ is a vector of other deterministic components, such as seasonal dummies and dummies for outliers. $\Gamma_1 \ldots \Gamma_{k-1}$, Π, μ, δ and Ψ are all parameters. The matrix Π is the long-run solution to the VAR model and contains the possible co-integrating relations. The rank of Π determines the number of stationary linear combinations of the variables in $\boldsymbol{X}_t$. If the rank equals the number of variables, all the price series are stationary and if the rank is 0, none of the price series are stationary. If the rank is less than the number of variables minus one but larger than zero, it is not possible to identify the exact nature of stationarity and the LOP cannot be tested. However, if the rank is exactly the number of variables minus one, a single integrating factor which is common to all the price series exists and Π can be decomposed into $\alpha\beta'$, where α contains the adjustment coefficients and β the co-integrating vectors. In that case the LOP can

[4] A data series is stationary if it moves randomly around a constant mean over time (that is, mean and variance are independent of time) and is non-stationary if it follows a trend. A stationary data series is said to be integrated of degree zero (i.e. I(0)). A non-stationary data series is said to be integrated of degree one (i.e. I(1)) if its first differences (the difference between two periods) move randomly around a constant mean over time and integrated of a higher order (i.e. I(z)) where $z \geq 2$, if it follows a trend.

be tested. The Johansen test is used in this framework to test for the number of co-integrating vectors, using the Trace Test. In this test, the null hypothesis is that there are up to a given number of co-integrating vectors, whereas the alternative hypothesis is that there is exactly one more co-integrating vector. However, since the asymptotic distribution of the test for the co-integration rank changes, depending on the assumptions regarding the constant term (μ) and the parameters for the trend term (δ), the co-integration rank test must be undertaken based on assumptions about these terms. Tests are undertaken in this paper on the basis of three alternative assumptions; that the constant term is unrestricted, that the constant term is restricted to the co-integration space and that the trend term is restricted to the co-integration space. Critical values for the tests based on the three alternative assumptions are known from Johansen (1996).

Based on the chosen rank (larger than zero), the LOP is tested using Likelihood Ratio tests of restrictions imposed on β. In a bi-variate set-up, X_t contains two price series (as in Equation 1). If these price series are co-integrated, the rank is one and a test of $\beta' = [1, -1]'$ is the test of the LOP. In a multivariate set-up, and assuming that the rank is the number of variables minus one, a test of the LOP is a test of whether the columns in the β matrix sum to zero[5]. This implies that the price series are pair wise co-integrated and thereby follow a common trend. The tests of the LOP are undertaken without any identification problems in all cases in this paper, due to the fact that the rank condition of Johansen and Juselius (1994) will always be fulfilled.

Only multivariate and not bivariate tests are performed here, partly as the issues by nature are multivariate and partly as it has recently been demonstrated, according to Gonzáles-Rivera and Helfand (2001), that bivariate models are "inadequate for capturing the spatial dynamics of

[5] In that case, and given a rank of the number of variables minus one, the β matrix in a multivariate test with four data series becomes:

$$\beta' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}$$

Testing whether the LOP holds is now a test of whether imposing the restriction on β' makes $\beta' X_t$ stationary.

price adjustments". The software package used for estimation is CATS in RATS, following Hansen and Juselius (1994).

Data

Data covering the EU were sought using the New Cronos Database, supplied web-based by EUROSTAT. However, data from Sweden were only available after 1995, so data from the Swedish Board of Fisheries were used instead. The Norwegian Directorate of Fisheries and the Icelandic Ministry of Fisheries provided landings from Norway and Iceland. However, whereas the EUROSTAT database includes all landings in each country, the other sources only include landings made in the home country by domestic fishermen. For Sweden and Iceland this is not a problem, since less than 5% of total landings are by foreign fishermen. For Norway, however, 20-25% of total cod landings are made by foreign fishermen (mainly Russian) and data on these landings are only available on an annual basis. Data summary statistics are given in Table 4.2.

Table 4.2 **Summary statistics**

	Data series				Quantity /average tonnes live weight per month[1]			
	Start	End	No.	Missing	Cod	Haddock	Hake	Saithe
Belgium	92.01	00.12	108	0	260	30	4	6
Denmark	92.01	00.10	106	2	**7.731**	506	133	**1.614**
Germany	92.01	99.07	91	17	1.448	129	1	1.132
Greece	92.01	96.12	75	33	0	0	398	0
Spain	92.01	00.12	108	0	672	33	**8.077**	41
France	98.01	01.01	37	71	1.100	344	566	1.554
Ireland	92.01	97.12	72	36	372	281	175	165
Italy	92.01	00.08	104	4	0	0	**2.062**	0
Netherlands	92.01	00.07	103	5	1.377	41	12	8
Portugal	92.01	00.06	102	6	423	0	0	0
Sweden	94.01	00.12	84	24	**2.913**	86	3	129
UK	94.01	00.08	104	4	**5.740**	**6.652**	364	**1.167**
Norway	92.01	00.12	108	0	**25.845**	**5.730**	66	**16.030**
Iceland	92.01	00.12	108	0	**14.544**	**2.650**	0	**3.148**
Total					62.425	16.482	11.861	24.994

Note: 1. Bold indicates that these landings are selected for further analysis.
Sources: EUROSTAT New Cronos Database (EU, Sweden excluded), the Swedish Board of Fisheries, the Norwegian Directorate of Fisheries and the Icelandic Ministry of Fisheries.

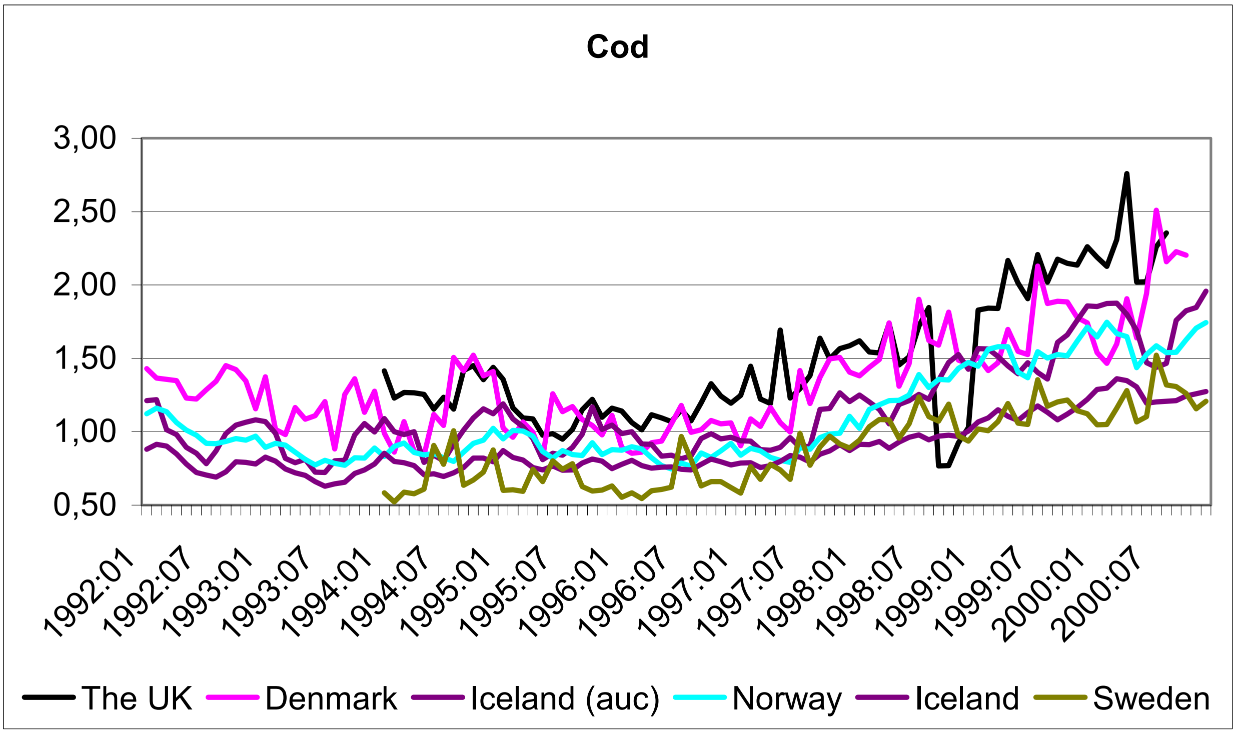
In Table 4.2 the data series and the landed quantities are presented. The time series are chosen for the period January 1992 to December 2000, but for most countries there are some missing observations at the beginning or end of the period. These observations are excluded from further analysis. Landings are made in several different forms (whole fish, gutted, headed and gutted, filleted etc.) and, as a consequence, the landed quantities are calculated in live weight using biological conversion factors used by the national authorities for quota control. The choice of supply sources selected for further analysis is partly based on their importance and partly on the length of the available time series. For cod Norway, Iceland, Denmark, the UK and Sweden are selected for further analysis, for haddock Norway, the UK and Iceland, for hake Spain, and Italy, and for saithe Norway, Iceland, Denmark and the UK.

Landings of whitefish are sold either at fish auctions or directly to fish processors, with direct landings being either on contracts, or to processors that own (or is vertically integrated with) the fishing vessels. The degree of market integration within each market level is determined by several factors. One is that first-hand sale within vertically integrated firms does not necessarily reveal the real market value, implying that spatial market integration might not exist between first-hand markets. Another factor is that markets for frozen imported whitefish are found to be more closely integrated internationally than markets for fresh whitefish, than found by other authors, implying that first-hand markets are closer integrated when the markets are dominated by direct landings and signals from second and third-hand sale are perfectly transmitted to first-hand sale. On this basis it is not *a priori* given whether markets dominated by auction sale are tighter integrated than markets dominated by direct landings. Nonetheless, the expected existence of several sub-markets for cod in Europe might imply that signals from second and third-hand sales are not perfectly transmitted to first-hand sale. Further, since first-hand sale within vertically integrated firms does not always reveal the real market value this also implies that first-hand markets dominated by auction sale might be closer integrated.

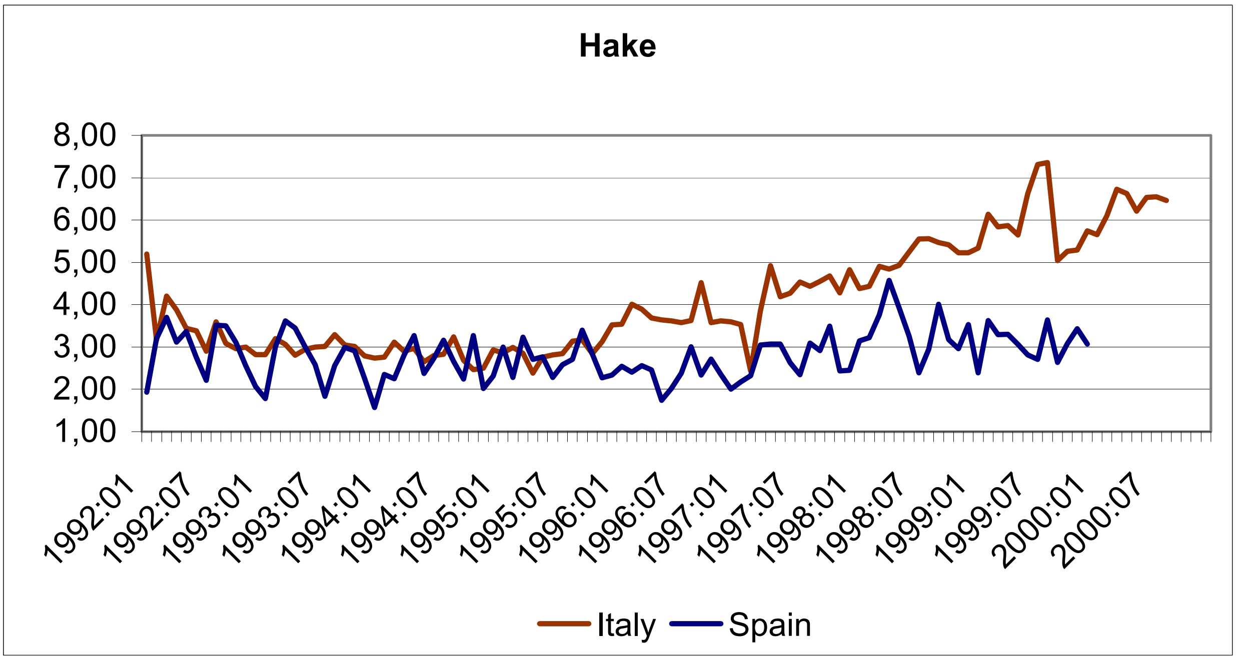
The patterns of sale vary according to country, with Denmark and Iceland representing two extremes. In Denmark the overwhelming majority of landings are sold at fish auctions but in Iceland approximately two-thirds of whitefish are sold directly to processors who often own the fishing vessels[6]. The situation in countries, such as Sweden, Norway and the UK is close to that in Denmark, whereas in Spain it is closer to the situation in Iceland. On this basis it would have been interesting to examine detailed data for auctions and direct sales in Iceland and Spain, but it was only possible to obtain data for Iceland. By value, the market share of auction sales of cod and saithe was around one-third of total Icelandic landings over the entire period, while the share for haddock increased from 50% in 1992 to 80% in 2000. This was because total Icelandic haddock catches fell, but sales on auction markets in absolute terms remained largely unchanged.

Price series in nominal terms of the whitefish species from the selected supply sources are shown graphically over the entire time period in euros per kilo live weight in Figure 4.1.

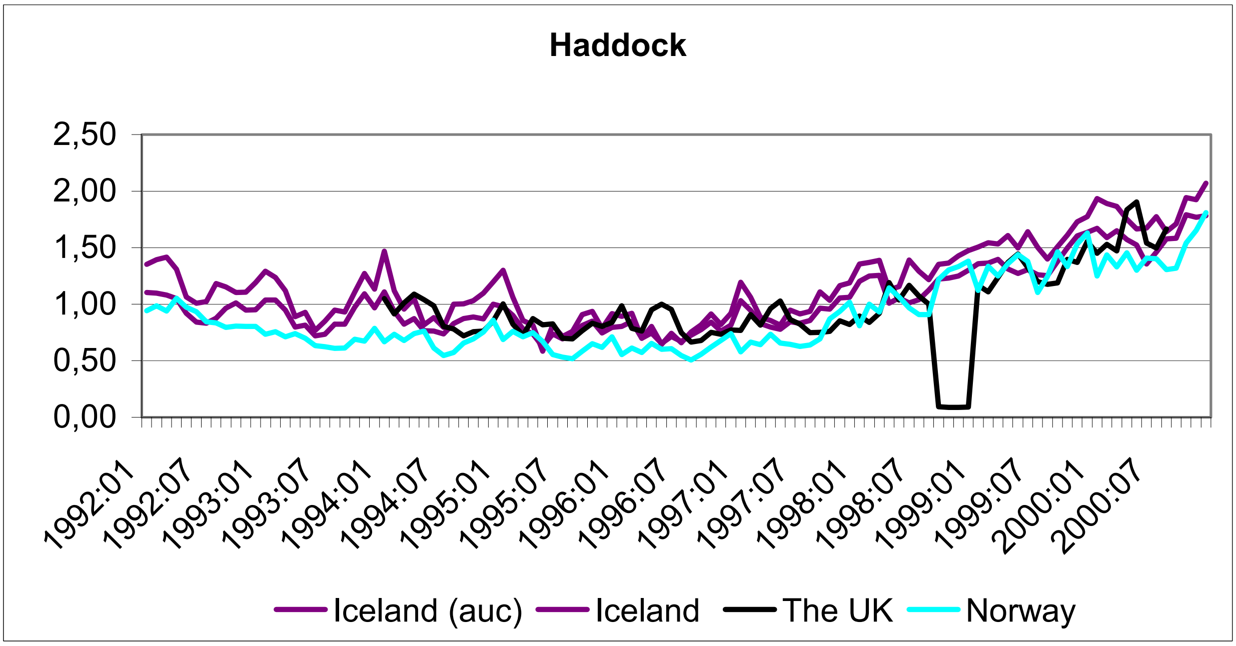
Figure 4.1
Monthly landing prices of whitefish in Europe, Euros per kilo live weight



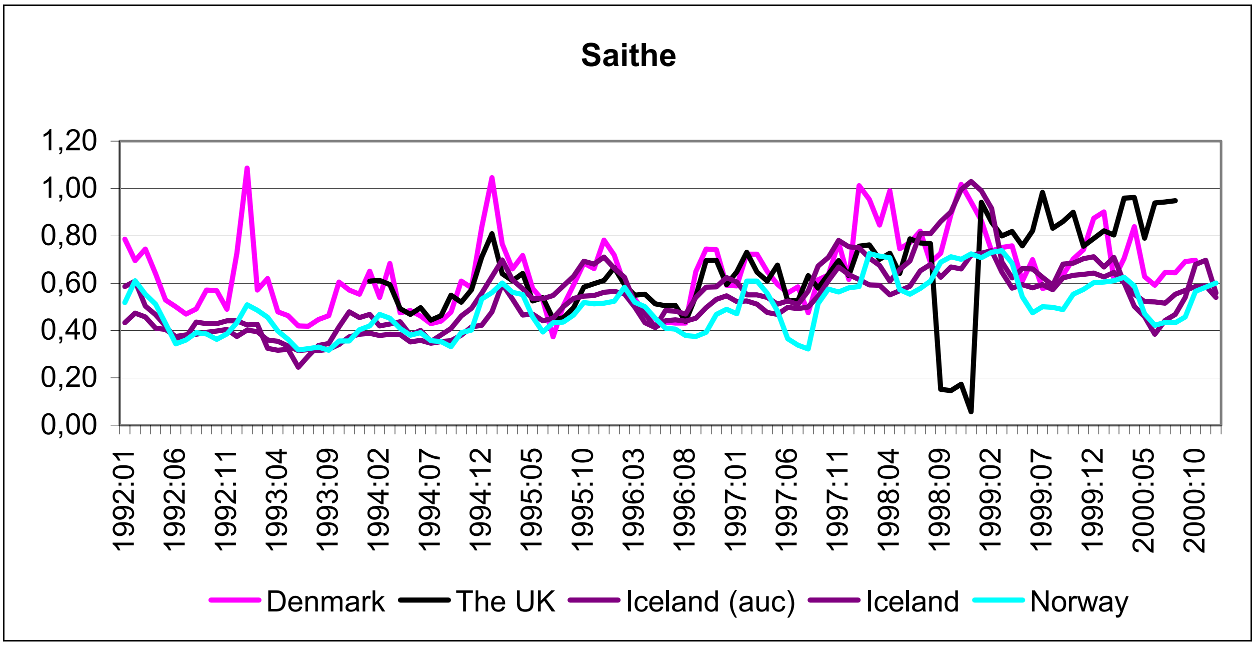
[6] Processors in Iceland might not only own the fishing vessels, but also the fishing right (Individual Transferable Quotas).



Hake
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
1992:01
1992:07
1993:01
1993:07
1994:01
1994:07
1995:01
1995:07
1996:01
1996:07
1997:01
1997:07
1998:01
1998:07
1999:01
1999:07
2000:01
2000:07
Italy
Spain



Haddock
2,50
2,00
1,50
1,00
0,50
0,00
1992:01
1992:07
1993:01
1993:07
1994:01
1994:07
1995:01
1995:07
1996:01
1996:07
1997:01
1997:07
1998:01
1998:07
1999:01
1999:07
2000:01
2000:07
Iceland (auc)
Iceland
The UK
Norway



From Figure 4.1 it appears that hake (*merluccius merluccius*) is the most expensive species, followed by cod (*gadus morhua*) and haddock (*melanogrammus aeglefinus*). Saithe (*pollachius virens*) is a cheaper species. Moreover it appears that prices vary by country for the same species. There can be many reasons for this. If prices are not formed on the same market there are no obvious grounds for prices to be the same. However, if prices in different countries are formed on the same market, implying that prices follow the same development over time, differences in price levels can still be present. Several factors can explain this. First the conversion process is important. There are two conversions that may each introduce differences: a) the conversion from the price of landed fish to the price of live weight and b) the conversion from national currencies to Euros. These are not price differences themselves, but errors arising from arithmetic mechanism used to produce a common unit account for comparing prices. Secondly, and more fundamentally, variations in quality and size can explain the difference. This might be the case for the different price levels between species, as for example hake is considerably more expensive than the other species. Moreover, the large price difference between cod in the UK and in Sweden can be explained by quality differences, since Swedish cod mainly originates from the Baltic Sea, whereas the UK cod originates from the North Sea and the waters surrounding the British Isles. The reason is that the North Sea cod is tastier with firmer flesh and the Baltic Sea cod has a larger head, unfit for human consumption. The North Sea cod is the thus more expensive. Differences in processing costs between larger and smaller fish may also play an important role. Processing smaller fish is more costly as it is more labour intensive. Finally, differences in transportation costs can explain differences. This is confirmed by the observation that prices of all species originating in Norway and Iceland are generally lower than the corresponding prices in the EU, since transportation costs of supplies from Iceland or Norway, mainly exported to the EU market, are larger than for domestic EU supplies. From Figure 4.1 it further appears that prices of cod, haddock and saithe landed in the different countries seem to follow each other in looser or closer relations over the entire time period, whereas this seems not to be the case for hake. Hence, markets for cod, haddock and saithe might be integrated across borders, whereas this may not necessarily be the case for hake. Moreover, it appears that the UK prices decreased considerable in the period 98:09-98:11 for cod and 98:09-98:12 for haddock and saithe, as the UK fishermen ran out of quota[7]. Finally, it appears as expected that prices of whitefish landed for auction in Iceland are greater than prices for total landings of whitefish.

Results

The presence of unit roots was tested for with Augmented Dickey-Fuller tests in order to ensure that all the data series were integrated of the same order. Two versions of the Augmented Dickey-Fuller test were used. Both include a constant in the regression. One excludes a deterministic trend and one includes it. Moreover, tests were undertaken in both levels and differences in the logarithms of the price series in nominal terms[8]. The optimal number of lags in the regressions was

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[7] This implies that dummies for outliers must be introduced in the estimations. For the cod price series, a dummy equal to one in 98:09, 98:10 and 98:11 and equal to zero in all other periods is introduced and for the haddock and saithe price series, a dummy equal to one in 98:09, 98:10, 98:11 and 98:12 and equal to zero in all other periods is introduced.

[8] Analyses can be carried out both in nominal and real prices. According to traditional Neo-classical theory “money is an illusion” implying that analysis of economic values should be undertaken in real terms, since the values of goods are then measured in terms of the values in relation to other physical goods. On the

chosen according to the Schwarz Criteria and test results are presented in Table 4.3.

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other hand, testing for market integration and finding closer relationship between prices in nominal terms than between prices in real terms is not easily explained on the basis of traditional theory. Moreover, it is not always possible to identify a suitable deflator in practice, in particular not when analysing market integration between countries, which trade with one another. Furthermore, if applied it is preferable to use the same deflator for all price series, since it removes all the other economic effects on exchange rates relating to international trade, monetary policy, interest rates, etc. Therefore, an analysis might be undertaken in both nominal and real prices. In the literature, both types of analyses exist, with Gonzáles-Rivera and Helfand (2001) being an example of an analysis of prices in real terms when analysing the spatial delineation of the Brazilian rice market. Asche, Bremnes and Wessells (1999) is an example of an analysis of prices in nominal terms when analysing the world salmon market.

Table 4.3 Unit root (ADF) tests[1]

	H_0 of non-stationarity in price levels		H_0 of non-stationarity in differenced prices	
	ADF without trend	ADF with trend	ADF without trend	ADF with trend
Cod:				
Denmark	0.36 (8)	-1.80 (8)	-2.34 (12)	-7.61 (7)**
Sweden	-0.20 (12)	-2.08 (12	-2.87 (11)*	-2.91 (11)
UK	-2.22 (0)	-3.76 (0)	-9.96 (0)**	-9.93 (0)**
Norway	-0.28 (0)	-2.40 (1)	-12.16 (0)**	-12.58 (0)**
Iceland (total)	0.86 (6)	-3.46 (1)*	-8.01 (5)**	-8.34 (5)**
Iceland (auction)	0.82 (7)	-1.53 (7)	-8.56 (6)**	-8.92 (6)**
Haddock:				
UK	-2.66 (4)	-2.80 (4)	-4.96 (7)**	-5.02 (7)**
Norway	-0.44 (12)	-1.95 (12)	-1.95 (11)	-2.27 (11)
Iceland (total)	-1.01 (0)	-2.52 (0)	-10.73 (0)**	-7.20 (8)**
Iceland (auction)	0.17 (12)	-1.50 (12)	-1.88 (12)	-2.53 (12)
Hake:				
Italy	-0.50 (2)	-3.68 (2)*	-10.26(1)**	-10.42 (1)**
Spain	-1.84 (5)	-2.22 (5)	10.95 (4)**	-10.99 (4)**
Saithe:				
Denmark	-1.27 (12)	-2.92 (12)	-3.61 (12)**	-3.58 (12)**
UK	-2.71 (0)[2]	-3.49 (4)*	-5.89 (4)**	-5.86 (4)**
Norway	-1.39 (12)	-5.49 (2)**	-2.68 (12)	-2.68 (12)
Iceland (total)	-1.90 (1)	-3.73 (1)*	-7.79 (0)**	-7.75 (0)**
Iceland (auction)	-1.66 (5)	-3.58 (2)*	-6.52 (6)**	-6.53 (6)**

Note 1. Critical values are known from MacKinnon (1991) and are with constant but without trend –3.43/-2.86/-2.57 respectively at 99%, 95% and 90% levels and are with constant and trend –3.96/-3.41 /-3.13 respectively at 99%, 95% and 90% levels. Number of lags is shown in parentheses. **/* = significance at 1 and 5 percent levels.

2. The test is undertaken without the outlier observations in 98:09, 98:10, 98:11 and 98:12.

From Table 4.3 it appears that the null hypotheses of unit roots in price levels without trends are all accepted at the 5% level. Moreover, the null hypotheses of unit roots in price levels with trends are accepted at the 1% level for all the price series, except for saithe in Norway. It further appears that the null hypotheses of a unit root in the differenced price series are all rejected at the 5% level, except for the differenced price series for cod in Denmark, haddock in Norway and Iceland (only auction prices) and saithe in Norway. However, at the 10% level the null hypothesis of a unit root in the differenced price series of saithe in Norway is rejected, and the test with a null hypothesis of a unit root in the differenced price with trend for cod in Denmark is also rejected. Contrary, the test with a null hypothesis of a unit root in the differenced price with trend for haddock in Norway and Iceland (auctions) was accepted, implying that potential I(2) remains. As a consequence, further analysis was not carried out for haddock in Norway and for auction prices in Iceland, but only for all the other price series, by maintaining the hypothesis that all these are I(1)[9].

Based on the I(1) nature of selected price series, co-integration tests as well as tests for the LOP were undertaken between different countries for each of the four species. The countries were selected on the basis of Table 4.2 and tests were undertaken using a strategy starting with 12 lags (one year) to search for a model without any misspecification problems and with a rank of the number of variables minus one. The misspecification tests included autocorrelation, normality and autoregressive conditional heteroscedasticity (ARCH) tests and conclusions on the presence and absence of misspecification problems are obtained at the 5% significance level[10]. The analysis was carried out by removing lags, by including and excluding 11 centred seasonal dummies as well as dummies for outliers, and by running regressions with the three alternative assumptions on the deterministic terms; that the constant term was unrestricted, that the constant term was restricted to the co-integration space, and that the trend term was restricted to the co-integration space. When a model with a rank of the number of variables minus one without misspecification was found, it was chosen and the LOP was tested. If such a model could not be found, price series were excluded on a one-by-one basis and the search was repeated until

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[9] In order to eliminate potential I(2), data was deflated using the Consumer Price Index for the whole EU, since the majority of whitefish landed in all the countries is consumed within the EU. Results, however, remained unchanged. Thereafter, all haddock price series were deflated using the Consumer Price Index for the UK, since the UK is the leading market for haddock. Again, results remained unchanged and the two price series were excluded from further analysis.

[10] The tests used are the multivariate LM test for first and fourth order autocorrelation in the residuals, a multivariate test of normality of the Shenton-Bowman type (Doornik and Hansen 1994) and univariate LM tests for autoregressive conditional heteroscedasticity with degrees of freedom = number of lags. The results of the misspecification tests are not reported, only mentioned in the text.

such a model was found or only one price series remained. Because of the special position in the Icelandic landings market, the tests were carried out for average prices on total Icelandic landings. However, if a rank of the number of variables minus one without misspecification problems could not be found or if the LOP was rejected, tests on auction prices alone were undertaken. After the co-integration tests and tests of the LOP between countries for each of the whitefish species, co-integration tests and tests of the LOP were carried out between species, where the largest supplier country for each species was included. Test results are reported only where a rank of the number of variables minus one without misspecification could be found and only for the largest number of price series included. That is, results for tests with a reduced number of price series included are reported only if higher degrees of market integration were found. Test results are shown in Table 4.4.

Table 4.4A **Multivariate Johansen Tests and Tests for the LOP - Prices of Whitefish in Europe**

Price series[1]	Model[2]	Multivariate Johansen Tests Eigenvalues				
		1	2	3	4	5
Cod						
Den/Ice/Nor/Swe/UK	RC/D/10	0.86	0.46	0.27	0.18	0.12
Den/Ice/Nor/Swe/UK	RT/10	0.74	0.68	0.48	0.37	0.12
Saithe						
Den/Ice[3]/Nor/UK	UC/SC/12	0.61	0.38	0.19	0.03	.
Ice[4]/Nor/UK	UC/SC/D/12	0.81	0.28	0.01	.	.
Ice[4]/Nor/UK	RT/SC/12	0.77	0.31	0.15	.	.
Inter-species						
Cod Nor/Had UK/Hak Spa/Sai Nor	UC/SC/12	0.56	0.39	0.31	0.03	.
Cod Nor/Had UK/Hak Spa/Sai Nor	RT/D/11	0.93	0.28	0.24	0.11	.

Table 4.4B **Multivariate Johansen Tests and Tests for the LOP - Prices of Whitefish in Europe**

	Multivariate Johansen Tests Trace test[5]					LOP Tests	
	p=0	p<=1	p<=2	p<=3	p<=4	LR	p
Cod							
Den/Ice/Nor/Swe/UK	225.42**	87.08**	43.74**	22.12*	8.64	6.88	0.14
Den/Ice/Nor/Swe/UK	272.42**	163.60**	85.63**	40.69**	9.20	37.97	<0.01
Saithe							
Den/Ice[3]/Nor/UK	112.98**	48.79**	16.19*	1.84	.	21.08	<0.01
Ice[4]/Nor/UK	134.48**	23.10**	0.58	.	.	41.07	<0.01
Ice[4]/Nor/UK	133.97**	35.43**	10.83	.	.	80.31	<0.01
Inter-species							
Cod Nor/Had UK/Hak Spa/Sai Nor	116.69**	61.03**	27.07**	1.93	.	13.61	<0.01
Cod Nor/Had UK/Hak Spa/Sai Nor	233.77**	49.85**	27.13*	8.38	.	12.48	0.01

Notes:
1. Den = Denmark, Ice = Iceland, Nor = Norway, Swe = Sweden, UK = the UK, Spa = Spain, Had = haddock, Hak = hake and Sai = saithe. All tests results reported in the Table are based on the period 1994.01-2000.08, corresponding to 80 observations.
2. C = model with an unrestricted constant, RC = model with a constant restricted to the co-integration space, RT = model with a trend restricted to the co-integration space, SC = seasonal corrected by introducing 11 centred seasonal dummies and D = dummy introduced to correct for outlier observations. The numbers measure the lags at which the estimations are undertaken.
3. Includes only landings sold at auctions.
4. Includes total landings.
5. **/* = significance at 1 and 5 percent levels, according to critical values known from Johansen (1996).

The results reported in Table 4.4 are based on the test procedure described above and each line represents a separate test. Results are only reported for cod, saithe and between species, since it was only possible to obtain a rank of the number of variables minus one without misspecification for these groups of price series. Since tests were also carried out for haddock and saithe, test results are described below for cod, haddock, hake, saithe and between species.

The tests for co-integration and for the LOP between prices of cod landed in Norway, Iceland, Denmark, the UK and Sweden identify a common integrating factor (the rank is 4 in the model with 5 price series). The test of the LOP is accepted for a model with a constant restricted to the co-integration space. Hence, the LOP is in force on the European cod market and cod landed in the different countries are nearly perfect substitutes for each other. For haddock, tests were only made between the price series of total landings of haddock in Iceland and the UK, since it, according to Table 4.3, could not be rejected that the price series of landings in Norway and the price series of landings sold at auctions in Iceland are I(2). In the co-integration test it was not possible to identify a common integrating factor (i.e. to obtain a rank of one without misspecification problems), implying that the two haddock markets might not be integrated. For hake, the co-integration test could not identify a common integrating factor between landings in Spain and Italy, and markets are not integrated. On the saithe market, co-integration tests were first undertaken between the price series of total landings in Norway, Iceland, Denmark and the UK without being able to identify a common integrating factor. Therefore, direct landings for further processing in Iceland were excluded and the test was repeated including only landings sold at auctions from Iceland. In that case it was possible to identify a common integrating factor (of rank 3), but the test of the LOP was rejected. Alternatively, the test on the price series of total landings in all countries was repeated by removing price series on a one-by-one basis. In the case where the Danish price series was excluded a rank of 2 was found, both in a model with an unrestricted constant and with a restricted trend. However, in both cases the LOP was rejected. That is, co-integration was found between the price series, but the LOP was rejected, implying that the first-hand European saithe market are partially, but not perfectly, integrated. The European market for whitefish as a whole consists of all the species examined and market integration was tested between the largest supplier countries of each of the four species. The co-integration tests identified a common integrating factor between cod and saithe landed in Norway, haddock landed in the UK and hake landed in Spain, both in a model with an unrestricted constant and in a model with a restricted trend. The tests of the LOP were rejected in both models, implying that the first-hand markets for whitefish in Europe are partially integrated.

Discussion

In this paper the size and boundaries of the first-hand European market for whitefish were identified between markets in different countries using multivariate market delineation methods. It was generally found that co-integration tests in most cases identified common integrating factors, but that the tests of the LOP were rejected. These results imply that partial integration exists on the European markets for whitefish, although exceptions were also present. The LOP was found in force between all the cod markets but no common integrating factor was identified between the hake markets. The results confirm the expectation from other authors studying import markets that the cod market would be the most strongly integrated and that the saithe market would be more loosely integrated. Moreover, the expectation of the existence of one integrated European market for whitefish was also confirmed, with the integration being loose. For haddock, results are ambiguous owing to the possible presence of I(2).

The implications of these findings are two-fold, covering economic modelling and policy issues. These are discussed in this section. Before this, however, methods and results are qualified in order to assess the reliability of the applied methods and the validity of the results obtained.

A potential problem with the analysis lies in the time series used. There are only a relatively small number of observations available. Moreover, the fact that the data are monthly can invalidate the results, since the long-run variation may simply not be reflected in the data. Another potential problem lies in that the European market might form part of a globally integrated whitefish market. Given that this is the case, the European market interacts with whitefish markets elsewhere and integration should be examined not only in the European market, but also in the world market. Therefore, the results should be interpreted with due caution, although the problems encountered do not give sufficient reason to reject the results in general.

The implications for economic modelling are numerous and suggest that co-integration between price series and the LOP should be tested before traditional estimation and analysis of demand are carried out. The advantage of such a procedure is that knowledge of market sizes and boundaries is obtained and the determination of price elasticities can be based on a more reliable and consistent statistical basis, as opposed to using the usual assumption of product heterogeneity (Armington 1969). This assumption can be replaced by one of homogeneity among the products where the LOP is in force since the products can be considered as one and the same, and their quantities and values aggregated.

A possible interpretation of the implications for econometric estimation and equilibrium of using market delineation methods is shown in Table 4.5.

Table 4.5 **Implications of the presence and absence of market integration**

Test results	Market integration	Modelling Action
LOP accepted	Perfect	Aggregate variables
A common integrating factor identified and the LOP rejected	Partial	Model variables with substitution elasticities
A common integrating factor not identified	None	Exclude variables

The policy implications of the finding that the European markets for whitefish are partially integrated between countries, combined with the knowledge that prices within the single country according to the literature review in Nielsen (1999) are inflexible, indicate that decreased North Sea and Baltic Sea whitefish quotas, as implemented over the past 3-4 years, will have caused prices to rise. Moreover, these price increases might be higher than those that might be predicted from the economic literature (where estimations are made for a single country). However, the finding also implies that the supply from the large fisheries in Norway and Iceland will serve as a stabilising factor for EU whitefish prices. Therefore, on balance, the EU policy of reducing quotas in the North Sea and the Baltic Sea may be expected to cause moderate increases in whitefish prices.

This result can be clarified by a simple worked example (with randomly chosen numbers), following Nielsen (2000). Based on Neo-classical theory and assuming exogenous supply, an inverse demand system can illustrate how quantities affect prices in the absence of integration and in the presence of perfect integration.

Let us formulate a double logarithmic inverse demand system with spatially separated markets.

$$\ln(\boldsymbol{p}_i) = \alpha_{0+}\alpha_{\boldsymbol{m}} \ln(\boldsymbol{m}) + \alpha_i \ln(\boldsymbol{q}_i) + \alpha_j \ln(\boldsymbol{q}_j) \tag{3}$$

where p_i = price of the good on market *i*, *m* = income, q_i = quantity of the good on market *i*, q_j = quantity of the good on market *j*, *i* = the local market, *j* = the large market and α are the intercept and coefficient for scale and quantity effects. Thus, the price of the good on market *i* is a function of income and own and cross-quantities.

The own price flexibility describes the effect changing quantities have on prices. Where the price of the good analysed is formed on its own separate market, the own-price flexibility of the local market (f_p) is the first derivative in relation to quantity, as shown in Equation 4. When the price is formed within a perfectly integrated market, and given that quantities in the different parts of the market is independent (i.e. vary randomly in relation to each other over time), the own-price effect on the total market can be calculated using Equation 5, taking into account the share the analysed good provides of the whole integrated market. Given that quantities on different parts of the perfectly integrated market are inter-dependent (i.e. follow each other over time), the price flexibility for the local market also applies for the total market, since every change in the quantity on the local market also takes place in the total market[11]. Subsequently, the own-price flexibility follows from Equation 4.

$$\boldsymbol{f}_p = \frac{\hat{\boldsymbol{P}}_i}{\hat{\boldsymbol{q}}_i} \tag{4}$$

[11] The reason for the method on perfectly integrated markets being different, dependent on whether quantities are independent or inter-dependent, is that price flexibilities known from the literature are estimated for markets in single countries and used here for international cross-country markets. That is, a *ceteris paribus* assumption is implicitly made on relationships with other countries in the studies where price flexibilities are estimated. This assumption does not affect the results when quantities are inter-dependent, since quantities follow each other over time. However, it does affect results when quantities are independent, since they then vary randomly in relation to each other.

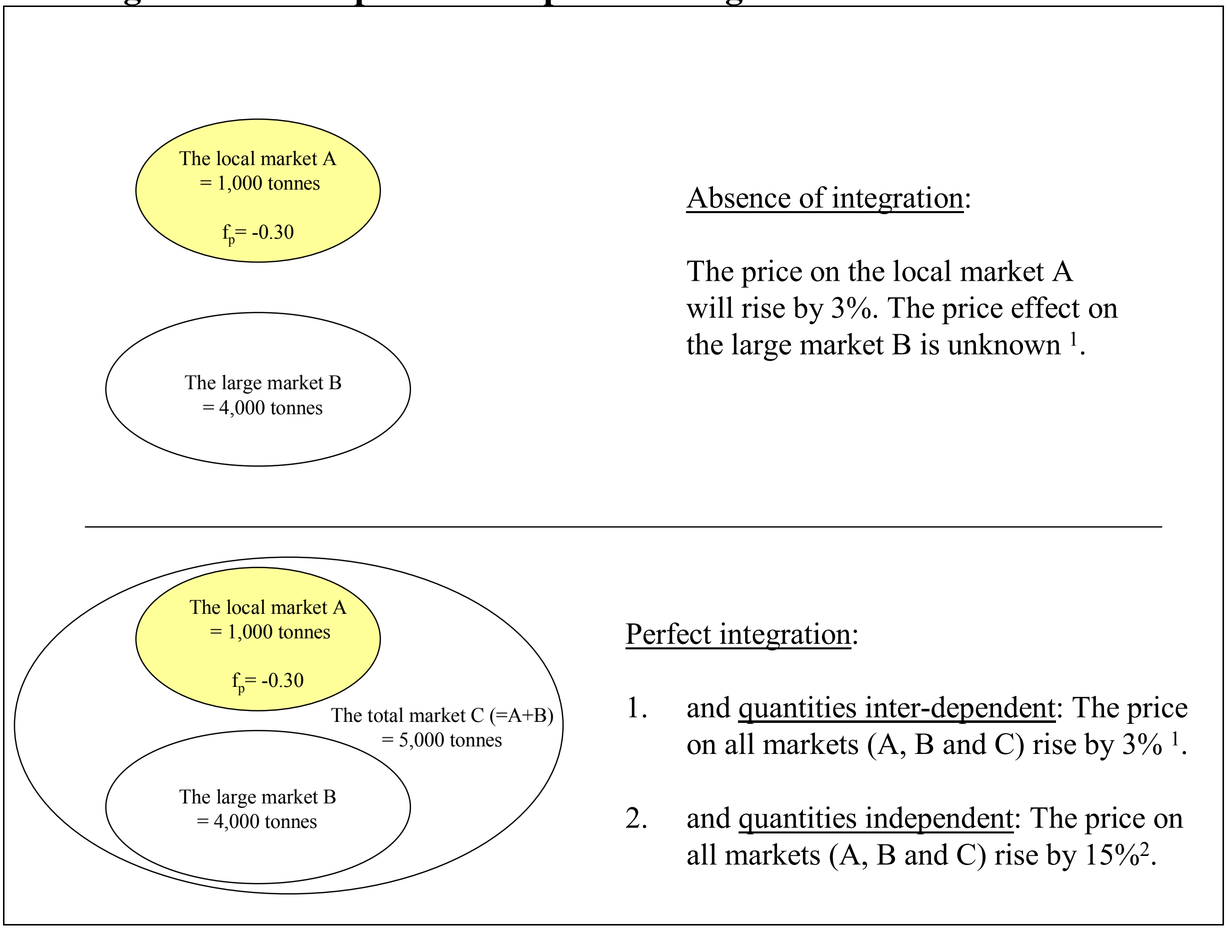
$$\hat{P}_i = f_p \frac{\hat{q}_i}{w_i} \qquad (5)$$

where $\hat{P}_i$ = the change in price of good *i*, caused by the change in the quantity of good *i*, $\hat{q}_i$ = the change in the quantity of good i and w_i = market share of good *i*.

Using this system with numbers by assuming the existence of a price flexibility of –0.30 on the local market[12], the effect of an internationally coordinated quota reduction, defined as a 10% decrease in the quantity on the total market, is illustrated in Figure 4.2 in the absence of integration and in the presence of perfect integration.

[12] According to the literature review in Nielsen (1999), a price flexibility of this size for whitefish is not unrealistic.

Figure 4.2 **The effects of a 10% reduction in the quantity on the total market, assuming absence and presence of perfect integration.**



Note: 1. The price rise is calculated as -10%*-0.30 = +3%.
2. The price rise is calculated in two steps. Firstly, the price flexibility on the total market is identified on the basis of the price flexibility on the local market, knowing that a 10% reduction in the quantity on the local market implies that the price on the total market increases by 3%. As a 10% or 100 tonnes decrease on the local market equals a 2% decrease on the total market, the price flexibility on the total market is 3%/2%=-1.5. Secondly, the effect of a 10% reduction in the quantity on the total market is calculated as –10%*-1.5 = +15%.

In the example in Figure 4.2, the effect of an internationally coordinated quota reduction (a 10% fall in the quantity on the total market) in the absence of integration, *ceteris paribus*, is a price rise of 3% on the local market A. The effect on the large market B is unknown. In the presence of perfect integration and given that quantities are inter-dependent, the price will rise by 3% on all markets. Given that quantities are independent the price will rise by 15% on all markets. Thereby, the only situation wherein a price rise of 15% will result is when markets are perfectly integrated and quantities are independent.

Owing to the presence of partial integration on the European market for whitefish, integration is neither perfect nor absent, and the price effect might be found between the two extremes. Moreover, fisheries management including quotas is an important factor in determining whether quantities on the European whitefish market are independent or inter-dependent. Whitefish are mainly caught in four separate seas (the Barents Sea, the North Sea, the Baltic Sea and Icelandic waters), where the state of the stocks does not affect one another and where fisheries management is separate. This would indicate that quantities from each of these stocks are independent. Moreover, catches of different species of whitefish do not necessarily follow each other over time, implying that quantities are independent. Contrary, the existence of international management plans for some stocks, including for North Sea cod between the EU and Norway, and for Barents Sea cod between Norway and Russia, implies that catches in the single countries from each of these stock may follow each other over time and be inter-dependent. Therefore, quantities on the European whitefish market might neither be independent nor inter-dependent, but rather somewhere in between. Thus, the presence of a dependency between quantities, which is neither perfect nor absent, as well as the presence of market integration which is neither perfect nor absent, both indicate that the price effect might be found between the two extremes. Subsequently, the effect of an internationally coordinated quota reduction is moderate increases in whitefish prices.

The finding of only partial integration in this paper modifies the results obtained by other authors, who as discussed in Section 1, found only perfect integration. The results confirm that the European markets for whitefish are generally integrated and that the cod markets are the most strongly integrated. However, they contradict the findings of other authors in that the LOP is not in force between species, implying that market integration appears looser on the first-hand market than on the second and third-hand markets for frozen products. However, whereas the results obtained by other authors are based on European import prices, the results in this paper are based on landing prices. The use of foreign trade data, as opposed to landing data, implies that locally induced price variation caused by, for example, mobility limitations due to infrastructure and logistical problems, is not taken into account. Moreover, the presence of rigidities on the first-hand supply side caused by, among other things, fisheries management (quotas, days at sea, etc.), results in less flexibility in fishermen's behaviour, as compared to processors and intermediate traders.

These results raise the issue of the effectiveness of the market policies used in Europe. In the EU, the market policy is managed directly and through regional Producer Organisations (POs). POs operate withdrawal prices to stabilise internal EU landings prices. Trade rules use reference prices to prevent dumping of fish on EU markets by controlling prices of fish originating from outside the EU. In Norway, fishermen's associations negotiate minimum prices for each fishing year, which usually depend on prices the previous year. Asche, Gordon and Hannesson (forthcoming) found evidence of a robust French market for imported whitefish and, based on this finding, argue that in the case of France, the market for whitefish leaves no scope for regional associations to influence prices of whitefish. In other words, in the case of France the EU market policy is largely ineffective. However, given the results here showing that the European first-hand markets for whitefish, including the Norwegian markets, are generally integrated, their conclusion applies also to Norway. Hence, the Norwegian minimum price scheme is shown also to be largely ineffective. On the other hand, despite the conclusion that the EU and Norwegian market policies are largely ineffective, the finding of partial integration in European markets for whitefish implies that there is greater scope for affecting prices through the policies than if there were perfect integration.

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CHAPTER 5

International market integration and demand: An analysis of the Norwegian and Danish herring market

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Abstract.
This paper provides a method where pre-tests for international market integration are used to identify market structures before estimating demand systems. The method is applied to the analysis of the European herring market. A Vector Auto Regressive model in Error Correction form is used to identify co-integration vectors between price series and, based on this, to test for the Law of One Price. The Law of One Price is in force between the landing markets for herring in the two largest global supplier countries, Norway and Denmark. Therefore, an inverse demand function is estimated for the combined Norwegian and Danish market. The results are used in the interpretation of the increase in the prices of herring on the Danish ex-vessel market in 2001, given the stability of the Danish market. The implication is that even though Denmark did not export to the main Norwegian export markets in the former Soviet Union and Eastern Europe, the Danish landing price is influenced by the situation there.

Key words: Co-integration, herring, inverse demand, law of one price, market integration, weak exogeneity.

1. Introduction

The purpose of this article is to contribute to the understanding of the price formation through market integration and demand analysis of a first hand seafood market. The paper discusses the relevant tools and a procedure is set up for revealing the adequate delimitation of seafood markets, which are often internationally integrated. The focus is on the European herring market and the question raised is why the prices on the Danish ex-vessel market increased from 2000 to 2001? Is it supply and demand in Denmark or is it the derived effects from other parts of an internationally integrated market? The analysis includes both Denmark and Norway, and since Norway is the world largest supplier of herring and Denmark the largest processor, the analysis covers a large part of the world herring market. This is emphasised by the fact that the majority of the Norwegian supply is exported to the main markets in the former Soviet Union and Eastern Europe. The understanding of the price formation process then allows for an assessment of the effects of changing fisheries management (e.g. stock conservation policies) on prices and thereby on the income of fishermen. This is an issue of high applicability, since such an understanding allows for an assessment of how the fishermen are affected by changing conditions on the export markets. Market integration analysis is a suitable tool for revealing the adequate delimitation of the relevant markets and demand analysis for identifying the effect appearing from changing quantities.

The issue of international integration of markets is important in studying the price formation process in a country. Whether markets are integrated or not will have an effect on the price formation. If markets are separate, the domestic price will be determined by domestic supply and demand. However, if markets are integrated, the domestic price will be determined by supply and demand on the whole international market, of which domestic supply and demand forms only a fraction. One hypothesis in this paper is that first-hand markets are integrated between the two largest supplier countries, Norway and Denmark. Provided that markets are actually integrated, the landing price in Denmark will be determined by supply and demand on the whole international market. The development in the quotas, as the main determinant of supply on the whole European market, is shown in Table 1.

TABLE 5.1 **Herring quotas in Europe, 1,000 tonnes.**

	2000	2001
Norwegian Sea	1,252	852
North Sea etc.	345	370
Baltic sea	490	380
Other	84	72
Total	2,171	1,674

It appears that the total quotas in 2001 fell from 2.171 to 1.674 million tonnes, i.e. by 23%. As a consequence, the supplies also decline and the hypothesis is that reduced supplies explain a part of the price rise on the Danish first-hand market. This is examined by estimating an inverse demand system, i.e. where the causality goes from quantities to prices, given exogenous supply. The demand on parts of the international market also changed considerably in 2001, due to increased purchasing power in the former Soviet Union and Eastern Europe. However, where the supplies changed drastically from one year to another, the change in demand in 2001 is part of a longer and more steady development, due to the gradual economic improvement and thereby increasing incomes in these countries after the opening of markets following the fall of the Berlin wall. Hence, another hypothesis is that the Danish first-hand price is determined by changing demand in the former Soviet Union and Eastern Europe. This is expected to be the case since Norway as the main supplier nation on the international market exports mostly unprocessed products to these countries, but without any export from Denmark to these countries.

Linked analysis of international market integration and demand is also of importance from a theoretical point of view, since consistent aggregation of goods included in demand analyses is necessary to provide reliable results, when international markets are integrated. Otherwise, important parts of the international market are left out of the analysis corresponding to an unrealistic *ceteris paribus* assumption, which makes results unreliable. The new econometric methods made available over the last decade, such as the co-integration analysis of non-stationary time series and the emergence of tests for the Law of One Price (LOP), provide suitable tools for obtaining consistent pictures of market integration, and thereby market structures, before analysing demand.

In the economic literature, studies of the European herring market are few and include only the Nilsson (1998) study of the emerging herring market in the former Soviet Union and the Food and Agriculture Organisation of the United Nations (2000) study on the world market for herring. Several articles do, however, identify demand for other fish species, including Ioannidis and Whitmarsh (1987), Barten and Bettendorf (1989), Burton (1992) and Eales, Durham and Wessells

(1997). Whereas these studies estimate demand systems in Seemingly Unrelated Regression (SUR) models, Jaffry, Pascoe and Robinson (1999) estimate a demand system in a Vector Auto Regressive (VAR) model, since their data series are non-stationary. Moreover, several articles examine the integration on other fish markets. Articles examining market integration between fish species and fish products include Guillotreau (1998) and Asche, Gordon and Hannesson (forthcoming), where studies of international market integration include Gordon and Hannesson (1996) and Nielsen (forthcoming). Furthermore, Asche *et al* (2002) find that "when there is only one variable factor in the intermediaries' production technology, prices at different levels in the value chain will move proportionally to each other over time" and that "derived demand elasticities contain information about consumer elasticities". Finally, Asche, Bremnes and Wessells (1999) link the relationships between prices with product aggregation and it is found that "when markets are well integrated, a single aggregate quantity and price for the good in question can be constructed".

This paper presents an empirical extension to the Asche Bremnes and Wessells (1999) approach by undertaking both market integration and demand analyses simultaneously, using the results from market integration tests to construct a single aggregate quantity and price for herring in two countries, to be included in the estimation of an inverse demand system. That is, the purpose is to estimate an inverse demand function based on consistent aggregation of goods included. The approach is new in that no other studies are known to use the same data for both pre-test for market integration and for the subsequent estimation of inverse demand systems. The approach is also new in that it is based on a VAR model of non-stationary time series for both market integration and demand analysis. Due to the possible presence of a structural break in the data appearing from the large price rise from one year to the next, all estimations are performed for the period before 2001.

2. Methods

A market is, according to Stigler (1969), defined as "the area within which the price is determined, allowances being made for quality differences and transport costs". Based on this definition, the basic idea in this paper is that econometric tests should be used as a pre-test to determine market sizes before estimating demand systems. Thereby, through the identification of perfectly integrated markets, it becomes possible to aggregate these commodities in the estimation of demand systems. The reason is that the Composite Commodity Theorem by Lewbel (1996) holds.

Co-integration tests and tests of the LOP are undertaken in order to determine whether prices move together over time and thereby determine market sizes. Provided that the co-integration test identifies one (and only one) integrating factor which is common to all the price series, and that the test of the LOP shows that the LOP is in force, the analysed goods are homogeneous in the sense that prices of two goods follow each other over time, relative prices are constant and markets are perfectly integrated.

The LOP in the basic simple bivariate form is, according to Stigler, tested by estimating (1).

$$\ln\left(\boldsymbol{p}_t^1\right) = \boldsymbol{B} + \boldsymbol{A}\ln\left(\boldsymbol{p}_t^2\right) + \varepsilon_t \tag{1}$$

where the price of good one ($\boldsymbol{p}_t^1$) and two ($\boldsymbol{p}_t^2$) are of two different products. Testing whether $A=1$ is now a test of the LOP. This simple bivariate form of the LOP can easily be extended to a multivariate form by adding extra products, e.g. $\boldsymbol{C}\ln\left(\boldsymbol{p}_t^3\right)$, and then test jointly whether $\boldsymbol{A}+\boldsymbol{C}=1$. The regression is, however, only valid for stationary price series. For non-stationary data series, co-integration analysis must be used, as regressing price series integrated of different orders may cause spurious correlations. Therefore, one has to confirm that the price series are integrated of the same order, i.e. are I(1).

Based on an I(1) nature of the price series, the Johansen co-integration rank procedure is used and a VAR model in Error Correction (ECM) form is formulated following Asche Bremnes and Wessells (1999), as given in (2).

$$\Delta\boldsymbol{X}_t = \Gamma_1\Delta\boldsymbol{X}_{t-1} + \ldots + \Gamma_{k-1}\Delta\boldsymbol{X}_{t-k+1} + \Pi\boldsymbol{X}_{t-1} + \delta\boldsymbol{t} + \Psi\boldsymbol{D}_t + \varepsilon_t \tag{2}$$

where Δx_t is the differenced price series, Δx_{t-k} is the price series differenced between the present period and period k, x_{t-1} is a price series in a basic period, t is a trend and D_t is other deterministic components, such as seasonal dummies. $\Gamma_1 ... \Gamma_{k-1}$, Π, δ and Ψ are all parameters. The ECM form in (2) then explains changes in a price series by price changes in relation to former periods and by price levels in a base period, thereby taking account of the non-stationarity of the price series. The matrix Π is the long-run solution to the VAR model and contains the possible co-integrating relations. The rank of Π determines the number of stationary linear combinations of the variables in x_t and Π can be decomposed into $\alpha\beta'$, where α contains the adjustment coefficients and β the co-integrating vector.

Provided that the rank equals the number of variables minus one, one common integrating factor exists and the LOP can be tested using Likelihood Ratio tests of restrictions imposed on β. In a bi-variate set-up, x_t contains two price series. If these price series co-integrate, the rank is one and a test of $\beta' = [1, -1]'$ is the test of the LOP. In a multivariate set-up, and assuming that the rank is the number of variables minus one, a test of the LOP is a test of whether the columns in the β matrix sum to zero. This implies that the price series are pair wise co-integrated and thereby follow a common trend.

Tests of weak exogeneity of price series can identify causal relationships, thereby allowing the identification of market leaders. Given a rank of the number of variables minus one and accepting the test of weak exogeneity of a given price series, implies that the price series drive the others without being affected by them. Thereby, the price series can be considered as the market leader. Weak exogeneity is tested using Likelihood Ratio tests of restrictions imposed as zero rows in α, since this implies that the equation for Δx_t does not contain information about the long run parameter. The test is performed without maintaining the restrictions on β.

In order to identify the effects that changes in supplies have on the prices on the international market, a simple inverse double logarithmic demand function with only one good included is estimated, assuming exogenous supply. This is done for the whole international market, provided that the LOP was found to be in force. Through this estimation the price flexibility appears, defined as the percentage change in the price of a good, as the quantity demanded increases by one percent. Thereby knowledge of the effects of changing supplies on prices internationally is obtained. The inverse version is selected since in the case of fisheries it is quantity that is predetermined at the market level due to the widespread use of quantity regulation. The double logarithmic form follows from a Cobb-Douglas utility function and is selected since the price flexibility is constant. The model is given in (3):

$$\ln(\boldsymbol{P_t}) = \boldsymbol{a} + \boldsymbol{b} * \ln(\boldsymbol{Q_t}) \tag{3}$$

where P_t is the average price on the international market and Q_t the total quantity on the same market. This regression equation is, however, only valid for stationary data series. For data series integrated of degree one, co-integration analysis must be used. Thus, the data series must be tested for the presence of unit roots in order to confirm that the data are I(1). Based on the I(1) nature of the data series, the Johansen co-integration rank procedure must be used again. The regression equation remains as in (2), except that x_t now includes the average price as well as the total quantity on the total market, and except for that the deterministic trend is replaced by a constant. Given a rank of one, the demand function can be exactly identified, Π decomposed into $\alpha\beta'$, where β is the co-integration vector. Normalising the price series around minus 1 identifies the demand system as $\beta' \boldsymbol{X}_t = \begin{bmatrix} -1 & \boldsymbol{b} & \boldsymbol{a} \end{bmatrix} \begin{bmatrix} \boldsymbol{P} \\ \boldsymbol{Q} \\ 1 \end{bmatrix}$.

3. Data

Data on landings of herring in Denmark and Norway were obtained from the Directorate of Fisheries in the two countries. The data are monthly, cover the period January 1992 to September 2000 and include both landings of domestic and foreign fishermen. The period is chosen to avoid 2001 and the end of 2000, since a structural change occurred with price increases. The Danish Directorate of Fisheries and the Norwegian Seafood Export Council provided data on export of herring products. Data summary statistics are shown in Table 2 with values and prices in nominal terms.

TABLE 5.2. **Data summary statistics, yearly avr, 1,000 tonnes, Million kr and kr/kilo[1].**

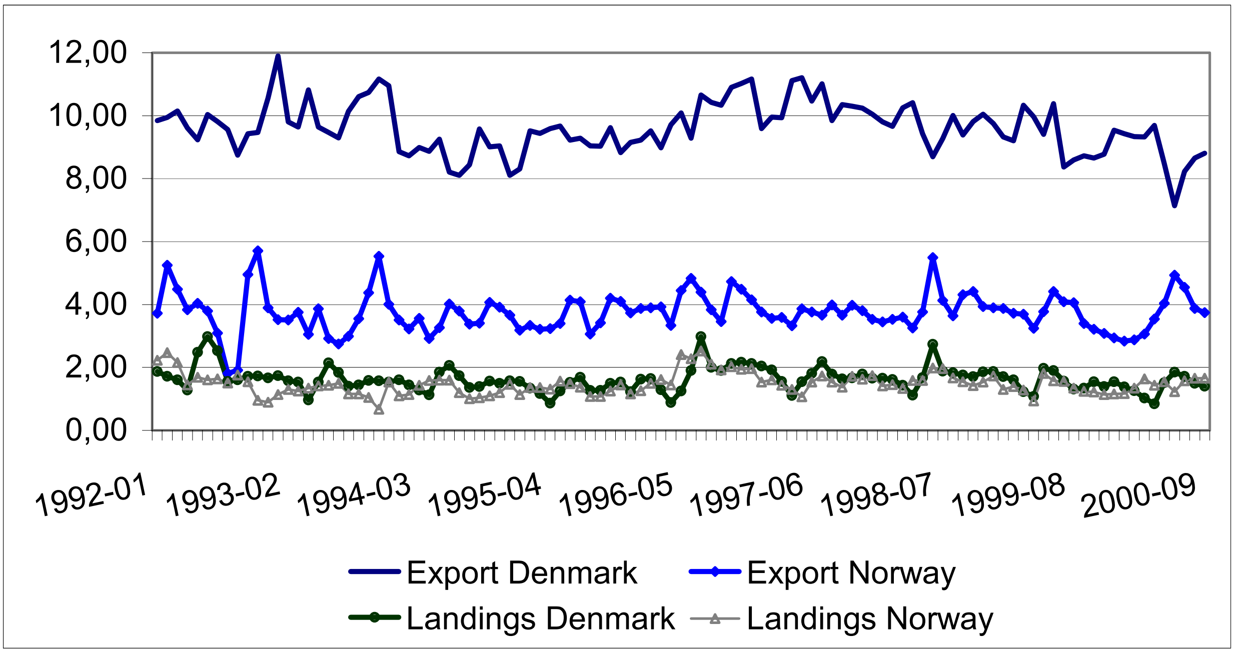
	Denmark			Norway		
	Quantity	Value	Price	Quantity	Value	Price
Landings	260	419	1.61	686	976	1.42
Export						
Fresh whole	35	96	2.79	99	229	2.32
Frozen whole	5	27	5.33	212	786	3.72
Fresh fillets	27	140	4.88	11	59	5.56
Frozen fillets	2	15	7.66	72	396	5.48
Minced meat	8	42	5.19	.	.	.
Smoked	0	3	24.70	1	11	16.07
Salted	9	78	8.86	9	45	5.07
Processed	.	.	.	7	70	10.45
Pickled in jars	4	70	17.68	.	.	.
Soured	**20**	**192**	**9.45**	.	.	.
Total	111	664	5.95	410	1,597	3.90

Note: 1. Data period is from January 1992 to September 2000.

It appears that the landings in Norway are 2.5 times larger than in Denmark and that the Danish export is more widespread than the Norwegian, with Norway exporting frozen herring products and with Denmark exporting mainly processed products. This reveals that the level of value added is larger in Denmark than in Norway. Furthermore, Norway is the world-leading exporter of frozen herring products, whereas Denmark is the leading processor and leading exporter of processed herring. In Denmark, a considerable home market for pickled herring in jars also exists. Denmark exports to other EU countries, mainly Germany, which obtains the majority of its herring import from Denmark. Norway exports mainly to the former Soviet Union and Eastern European countries. These countries are supplied mainly by Norway but also Iceland. Besides that, the countries are partly self-supplying. The trade between Norway and these countries is relatively new, emerging in the nineties as a result of the post-Berlin wall opening of markets combined with the subsequent increase in purchasing power. The opening of markets followed the improvement of the atlanto-scandic herring stock in the Norwegian Sea, which also occurred in the nineties, and made it possible for Norwegian suppliers to meet the increased demand.

Price series in nominal terms of landings in the two countries as well as price series of the most important herring export item in each country, soured from Denmark and frozen from Norway, are selected for further analysis and shown in Figure 1.

FIGURE 5.1. **Monthly landing and export prices of selected herring products in Denmark and Norway, Dkr. per kg.**



It appears that the prices rise with degree of processing in both countries. It remains, however, unclear whether upward or downward trends, if any, are present in the period. Thus, whether the price series are non-stationary or stationary must be determined by testing for unit roots.

3. Results

The price series (in natural logarithm[1]) selected in Figure 1 to be included in the further analysis were tested for the presence of unit roots in order to ensure that all the price series were integrated of the same order. This was done using the Augmented Dickey-Fuller test with 9 lags and a constant and a trend included in the regression. Tests were

[1] All estimations undertaken below are performed with the data series in natural logarithm.

undertaken for both levels and differences. The test statistics for the price series for levels are –3.02 for the Danish landings, -3.14 for the Norwegian landings, -1.59 for the Danish export and –2.74 for the Norwegian export. The corresponding test statistics for first differences are –6.04, –5.11, –5.09 and –6.38, respectively. Thereby, none of the null hypotheses of unit roots for levels are rejected and the null hypotheses of unit roots for first differences are all rejected at the 1% level, using critical values known from MacKinnon (1991). Thus, the hypothesis of I(1) is maintained.

Based on the I(1) nature of the price series, co-integration tests, tests for the LOP and weak exogeneity were undertaken. Tests were undertaken using a strategy starting with all the four price series included and starting with 9 lags to search for a model without any misspecification problems and with a rank of the number of variables minus one.

The misspecification tests included autocorrelation, normality and autoregressive conditional heteroscedasticity (ARCH) tests and conclusions on the presence and absence of misspecification problems were obtained at the 1% level. The analysis was carried out by removing lags and by in- and excluding 11 centred seasonal dummies. When a model with a rank of the number of variables minus one without misspecification was found, it was chosen and the LOP and weak exogeneity was tested. If such a model could not be found, price series were excluded on a one-by-one basis and the search was repeated until such a model was found. In the test with all the four price series included it was not possible to identify one common integrating factor. Excluding the price series of Norwegian export of frozen herring did not help to identify it either. However, when excluding the price series of Danish export of soured herring, one common integrating factor was identified and test results are reported in Table 3.

TABLE 5.3 **Multivariate Johansen test of the price series and test of the LOP.**

Model	H_0: rank=p	Eigenvalues	Trace test[1]	$C_{95\%}$
Period = 1992.01-2000.09	p=0	0.32	64.33*	42.20
Lags = 9	p<=1	0.17	27.15*	25.47
11 seasonal dummies	p<=2	0.09	9.30	12.39
105 observations				

Note: 1. * denotes significance at the 5% level (Johansen 1996).

It appears that the rank is two at the 5% level in the model with the three price series included, as required. The model was estimated without misspecification problems at the 1% level. The test of the LOP is accepted with a Likelihood Ratio test statistic at 2.64, corresponding to p=0.27. Hence, the LOP is in force and prices of herring landed in Denmark and Norway and the Norwegian export prices of frozen herring follow each other over time. This implies that one market for raw material exists across the two countries and that prices on the raw material market (the landing market) develop similarly to the price of the low processed frozen herring export from Norway.

The market for raw material and the market for Norwegian export of frozen herring do not seem to be integrated with the export market for the Danish export of soured herring. Thereby, a situation remains, where the Danish landing price interacts closer with Norwegian export prices than with Danish export prices. The result might, however, not be surprising taking into account the flexibility of fishermen from the two countries to unload in the country they prefer. Several factors may play a role in the decision of the single fisherman of where to unload, including the price of the fish and transportation costs from the fishing ground to the port. That is, the fishermen might, when they are still at sea, obtain information of where the price is good before they take the decision of where to go. This information might be either from physical (auction) markets or from quotations, and might be what ties the landing prices of herring in Denmark and Norway together. Moreover, the result might not be surprising taking into account that the Norwegian herring export is less processed than the Danish, as revealed by the price difference between export from the two countries. Costs of other input factors than herring, where prices probably vary independently, make up a larger share of the processing costs in Denmark.

The test of weak exogeneity is clearly accepted for the Norwegian landing price with LR=1.63 and p=0.44, but rejected for the other price series. Thus, the Norwegian landing price is the price leader. This result may not be surprising, since Norway is the largest market for raw material and presuming that the development on the market is mainly determined from the supply side. Demand conditions on the export markets for Norwegian frozen herring in mainly the former Soviet

Union countries and Eastern Europe, will also determine prices on the landing markets in Norway and Denmark.

Since the LOP was shown to be in force in a test where both the Danish and the Norwegian landing prices were included, the two data series can be aggregated. This was done by summing quantities as well as values in the two countries at given points in time. The aggregated price and quantity series are then included in the estimation of a simple inverse demand system and the test of the LOP is used as a pre-test to identify the market size, before estimating demand systems.

Again, it is necessary to confirm that the two data series are integrated of the same order. This is tested using the Augmented Dickey-Fuller test now with 12 lags and only a constant included in the regression. The test statistic for the price series for levels is –2.16 and for the quantity series –3.41. For first differences the test statistics are –3.05 and –4.27. Hence, none of the null hypotheses of unit roots for levels are rejected at the 1% level. The null hypothesis of unit roots in first differences is rejected at the 1% level for the quantity series. For the price series this is only the case at the 5% level. Accepting this level, the hypotheses of I(1) are maintained.

Based on the I(1) nature of the data, the demand function is estimated with 12 lags included, since quotas are annual[2]. The estimation was performed without misspecification problems at the 1% level and results of the rank test are presented in Table 4.

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[2] Tests of market integration in the VAR model were undertaken as a search procedure with 2-12 lags and with an unrestricted constant, a constant restricted to the co-integration space and a trend restricted to the co-integration space. The model with the tightest market integration without misspecification and with unit root tests not rejecting the presence of I(1) was chosen. That was with 9 lags and a trend restricted to the co-integration space. Correspondingly, the Augmented Dickey-Fuller tests were performed with 9 lags and a constant and a trend. The inverse demand system was estimated in the VAR model with 12 lags, since fishing quotas are fixed for a year. The model was also estimated with a constant restricted to the co-integration space, since a constant is included in an inverse demand system. Again, the Augmented Dickey-Fuller tests were performed with 12 lags and a constant.

TABLE 5.4. **Johansen test with average price and quantity included.**

Model	H_0: rank=p	Eigenvalues	Trace test	$C_{95\%}$
Period = 1992.01-2000.09	p=0	0.15	23.12*	19.99
Lags = 12	p<=1	0.08	7.55	9.13
11 seasonal dummies				
105 observations				

The rank is one at the 5% level and, based on this rank, $\beta' X_t = [-1 \quad -0.42 \quad 6.50] \begin{bmatrix} P \\ Q \\ 1 \end{bmatrix}$. That is, the price flexibility on the total landing market for herring in Denmark and Norway is –0.42, implying that a 10% reduction in quantities, e.g. following a reduction, gives a price rise of 4.2%. It does not matter whether the quantity reduction takes place in Denmark or Norway, since the effect on the prices in the two countries is the same. The estimation result is in accordance with *a priori* expectations, since the price flexibility is between zero and minus one. The magnitude of the price flexibility is relatively close to results obtained for other fish products, e.g. in Barten and Bettendorf (1989) and in Eales, Durham and Wessells (1997), with estimates in the range of –0.09 to –0.52.

The implication of the price flexibility of –0.42 on herring landed in Norway and Denmark is that since quantities of herring landed in the two countries totally decreased by 23% in 2001 due to quota reductions, the prices are *ex post* forecasted to rise by 10% solely due to the change in supply in Denmark and Norway. Thereby, decreased landings in the two countries alone can explain 10% of the 80% price increase in 2001.

The cause of the remainder of the price increase remains a matter of speculation. It is possible that it could be driven from both the supply and the demand side. On the supply side, falling catches of herring in other herring supplier nations might explain parts of the price rise, provided that the markets are integrated. Provided that this is the case, falling catches in the Russian Pacific Ocean herring fishery as well as falling catches of herring by vessels from Iceland, Russia and Sweden in the Norwegian Sea might explain part of the remaining price increase. Total global catches of herring were 2.8 million tonnes in 2000 (Food and Agriculture Organisation of the United Nations 2001), of which Norway and Denmark accounted for 42%. Other important supplier countries were Russia, Iceland and Sweden accounting for a 35%.

Global supply fell 17% in 2001 after decreases in all the 5 largest supplier countries. Another explanation might be that, provided that herring and Alaskan Pollack are substitutes, the Russian catches of Alaskan Pollack in the Pacific Ocean were approximately halved in 2001. On the demand side increased purchasing power in the former Soviet Union and Eastern European countries might contribute to explain the price rise, since prices of Norwegian export of frozen whole herring to these countries was found to be formed within the same market as the landing prices in Denmark and Norway. Uncertain information on the final market in the former Soviet Union and Eastern Europe among the Norwegian exporters might also have caused Norwegian exporters to overestimate the potential of the market, thereby giving an upward shift in demand and prices. This might be probable since prices of herring in 2003 fell 28% with a largely unchanged international supply, thereby "normalising " the market.

4. Discussion

In this paper it has been demonstrated how tests of market integration can be used systematically and consistently to obtain knowledge before estimating demand systems. It has also been demonstrated that the knowledge obtained from the market integration tests can sometimes be counterintuitive on how international markets work. This is demonstrated by the 80% price rise in 2001 on herring landed in Denmark, which appeared without large falls in the landed quantities in Denmark and given relative stable conditions on the export market. The rise in the Danish landing price might be explained by the developments on other parts of the European herring market, which is found integrated between countries. Thus, the price rise in Denmark is explained by the reduced quotas in the herring fishery in the Norwegian Sea and by improved conditions on the Norwegian export markets in the former Soviet Union and Eastern Europe. Thereby, due to changing conditions in Norway, the Former Soviet Union and Eastern Europe, the Danish prices were able to increase considerable, even though Danish export to these countries was largely non-existent. Thus, leaving an important part of the international market out of analysis corresponds to an unrealistic *ceteris paribus* assumption, which makes results unreliable.

The result underlines the importance of including knowledge of international market integration in analyses of demand of products traded across borders. Undertaking fish demand analysis for single countries will in several and presumably most cases be misleading, since fish markets today are international and cannot be analysed consistently ignoring that fact. The result also applies for markets for other food items with mainly one variable factor in the intermediaries production technology and traded at internationally integrated markets. Furthermore, the result implies that European prices of raw material of herring reveal information on derived consumer demand. Hence, consumer demand can be modelled as derived demand for raw materials.

In the paper it has also been demonstrated how the VAR models can be used as a basis for the estimation of demand systems when data are non-stationary, following e.g. Jaffry, Pascoe and Robinson (1999). Most existing demand studies, including Ioannidis and Whitmarsh (1987), Barten and Bettendorf (1989), Burton (1992) and Eales, Durham and Wessells (1997), use SUR models. In cases where time series data are non-stationary, VAR models provide a structured framework of estimation as an alternative to SUR models. SUR models can still be applied, but only if data are properly differenced.

The results are important for the newly introduced individual transferable quota scheme in Denmark (Regulation 958, Danish Ministry of Food, Agriculture and Fisheries 2002), since the development in the determinants of the price of herring give indications of how the individual quota market can be expected to develop. It is expected that the volatility of the landing market resulting from the price rise also cause volatility on the market for the individual quotas. This will cause uncertainty of the real value of the individual quota during the implementation period. Furthermore, the value of the individual quota will be determined by supply and demand factors on the whole European market. Hence, important determinants of the individual quota price are the expected future supply from the large herring stock in the Norwegian Sea, expected development in purchasing power on the Norwegian export market in the former Soviet Union and Eastern Europe, and expected supply of substitutes in those countries. Thus, volatility on the market for the individual quotas is related to the development in these factors and whether to introduce individual transferable quotas is thus a decision under uncertainty.

The analysis was capable of explaining 10% of an 80% price rise, but an extension of the model within the same framework, by the inclusion of further variables in the estimation of the inverse demand system, might increase the explanatory power. Firstly, even though Denmark and Norway are the main European herring supplier countries, other supplier countries are also important and should be included. These are Iceland, Russia and Sweden fishing in the North Atlantic Ocean, and Russia fishing in the North Pacific Ocean. None of these were included in the analysis due to data limitations. Secondly, potential substitutes on the market, such as Alaskan Pollack in Russia, should be included. Furthermore, income effects should be included in the model emphasising the importance of increasing income in the former Soviet Union and Eastern Europe. Finally, exchange rate fluctuations should be included in the analysis, since they contribute to the price formation process at international markets. The analyses were undertaken in Danish kroner, thereby ignoring that the Norwegian currency was strong at the end of the period and that the Russian currency was devalued in 1998.

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CHAPTER 6

Application of the Inverse Almost Ideal Demand System to Welfare Analysis

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Submitted to *Marine Resource Economics*.

Abstract. This paper presents the theoretical properties of the Inverse Almost Ideal Demand System and applies the system on time series data for cod, herring and plaice in Denmark. The suitability of the Inverse Almost Ideal Demand System when applied to welfare analysis is discussed. The properties of the demand system show that - since the demand system is a second-order approximation to the true system - it does not have global applicability for welfare measurement. It may, therefore, not satisfy the conditions for calculation of consumer surplus (negative slope and positive point of intersection with the price-axis). The demand system is neither suitable for global welfare analysis and, therefore, nor for relative welfare analysis. It is, however, under certain conditions and using the appropriate calculation method, suitable for marginal welfare analysis of small policy changes. The theoretical point is illustrated by an empirical example of the Danish fish market. Using a vector auto regressive model in error correction form to overcome the problem of non-stationarity of data, the Inverse Almost Ideal Demand System is estimated. For cod the intercept is negative and for herring and plaice the slope of the demand function is positive in the data interval investigated. Thus, the estimated demand system is not suitable for welfare analysis.

Key words: Inverse Almost Ideal Demand System, Welfare analysis, Co-integration and Fish.

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1. Introduction

The valuation of environmental goods has theoretically had a dual development. Two distinct schools, stated preferences and revealed preferences, can be precipitated (Tietenberg (2002) and Braden and Kolstad (1991)). These two schools have very different theoretical points of origin. The most common valuation method of especially environmental damages of non-market goods builds on stated preferences, where hypothetical bids of individuals are facilitating the valuation of non-market good carried out through questionnaeres. The most well known stated preference method is contingent valuation (Mitchell and Carson (1989) and Toivonen *et al* (2001)). Revealed preferences, on the other hand, is based on observed market behaviour (Bockstael and McConnel (1999)). An example of revealed preference methods is the hedonic method (embedded preferences), where the value of a property is embedded as in the normal consumer good and elicited through the marked behaviour of consumers. For both distinct schools a common denominator is the estimation of consumer's surplus in order to obtain an estimate for the welfare gain or loss of changes in non-market natural resources.

The background of the present paper is the desire to develop a revealed preference model suitable for estimating the indirect benefit of fish purchase, credence parameters as quality, which might be internalised though labelling and environmental properties tied to fish caught. Only through the development of such a model existent data can be applied as an alternative to the more expensive stated preference methods. The model can be based on several different demand systems. Commonly used are either based on a postulated utility function, like the Cobb-Douglas utility function, or based on knowledge of the true preference structure in the optimal point, like in the Inverse Almost Ideal Demand System (IAIDS). The demand system applied in the present paper is the IAIDS. The inverse version where the causality goes from quantities to prices is chosen since quantity regulations are widely used in fisheries management. In the literature, the IAIDS have been used to identify market structures (Eales and Unnevehr (1994) and Eales *et al* (1997)), where the use of the IAIDS for welfare analysis, and thereby for valuation of environmental and non-market goods, have been more sparse. Teisl *et al* (2002) do, however, use the ordinary version of the AIDS for welfare analysis.

The aim of the paper is to discuss the suitability of the IAIDS for theoretical and empirical welfare analysis, including the identification of conditions under which the system is suitable for welfare analysis. It is shown that IAIDS is unsuitable for estimating global welfare in the form of total consumer surplus, since when the IAIDS is extended to welfare analysis, the adding-up restriction and the fact that the demand system is based on a second-order approximation to the true demand system, gives the result that the demand curves may have a positive slope.[1] This is illustrated by estimating demand curves for fish using co-integration because data are non-stationary. The use of co-integration to estimate parameters in IAIDS is a new research area and, therefore, this paper also contributes to the debate about estimating IAIDS systems. The argument that IAIDS cannot be used for welfare analysis also applies to ordinary almost ideal demand systems (AIDS), where prices determine quantities, because the ordinary AIDS is also a second-order approximation of the true demand system.

A true demand system in unrestricted form gets very complicated as a very high number of equations are involved. Therefore, a true demand system is almost impossible to estimate. To cope with these problems, the traditional method has been to approximate the true demand system with a second-order approximation and to make restrictions on the parameters in connection with the econometric estimation (Deaton and Muellbauer (1980a) and (1980b)). This is exactly the procedure in the IAIDS. Welfare analysis in its basic form has to satisfy special requirements with regard to the demand system. To estimate consumer's surplus, a positive intercept and a global negative slope must be obtained. In the present paper it is shown that IAIDS does not fulfil these conditions.

Knowledge of the suitability of the IAIDS for welfare analysis is important, since only through such knowledge a revealed preference model can be developed. And only through the development of such a

[1] The normal procedure used when consumers surplus is calculated is to estimate a demand function and then take the integral of the estimated demand function in order to find consumers surplus. If consumers surplus for a price increase is to be calculated, positive sloped demand functions can cause problems

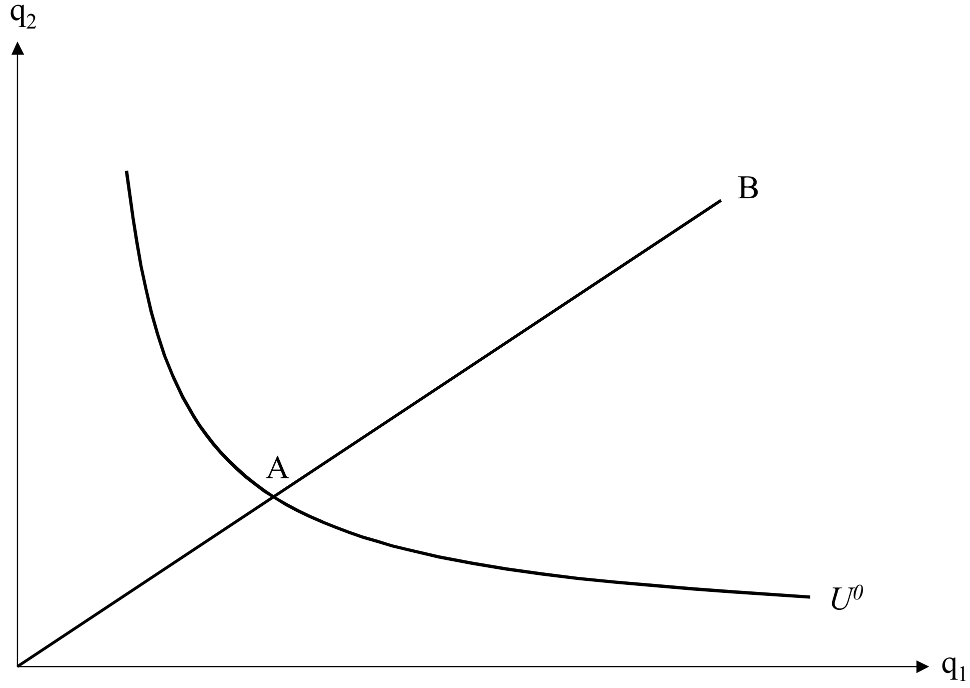
model, seafood markets where there traditionally has been little differentiation can be analysed. Consumers have traditionally largely been unable to exercise choice as to neither the location nor the state of the fishery their seafood came from. Furthermore, it has not been possible to exercise choice regarding how the fish was caught because of lack of eco-labelling of fish. If credence parameters are introduced by establishing standards for quality or eco-labelling, this development calls for rational considerations as to whether the welfare gains of consumers exceed the marginal cost of production and a cost incurred running a labelling scheme. In that context, development of the present market model of fish may potentially be important.

The paper is organised as follows. In section 2 IAIDS is introduced, while an empirical example is presented in section 3. Section 4 concludes the paper.

2. IAIDS

The Almost Ideal Demand System (AIDS) (Deaton and Muellbauer (1980a) and (1980b)) has enjoyed great popularity in applied demand analysis. There are several advantages of this demand system. First, it is derived from a specific cost function and thus corresponds to a well defined preference structure. Second, a property of AIDS is a consistent aggregation from micro to market level. Third, non-linear Engel curves are possible. Finally, the preferences can be thought of as a local second-order approximation of an unknown true preference structure. Although AIDS has worked well in many applications, a critical assumption is that prices are predetermined at the market level. In the case of fisheries it is the quantity that is predetermined at market level due to the widespread application of quantitative regulations (Wilen (2000)). To analyse such cases Eales and Unnevehr (1994) suggest IAIDS. In this section the theory behind IAIDS is outlined. Again following Eales and Unnevehr (1994) and Deaton (1979), a distance function function, also known as the direct cost unction, is introduced as a representation of preferences, which measure what the consumers have to give up of one good to achieve another good. The distance function is sketched in Figure 6.1.

Figure 6.1: **A distance function**



In Figure 6.1, q_1 is the quantity consumed of good *1* while q_2 is the quantity consumed of good *2*. U^0 is a pre-selected utility level. The distance function, $D(U^0, q)$, is defined as the amount by which all quantities must be changed proportionally to obtain a given utility level. Thus, in Figure 6.1 $D(U^0, q) = 0B/0A$.

The IAIDS starts by specifying a distance function representing the preferences of consumers. The distance function must possess the following properties:

1. It is linear homogeneous, concave and non-decreasing in quantities (Diewert (1982)).
2. It is decreasing in utility (Diewert (1982)).
3. Differentiation with respect to quantities at optimum yields the compensated inverse demand function.

Following the specification of the cost function in Deaton and Muellbauer (1980b), a logarithmic distance function may be specified as:

$$\ln D(U,q) = (1-U)\ln a(q) + U \ln b(q) \tag{1}$$

lna(q) and *lnb(q)* may also be specified in a way analogous to Deaton and Muellbauer (1980b):

$$\ln a(q) = \alpha_o + \sum_{j=1}^{n} \alpha_j \ln q_j + 0.5 \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_j^* \ln q_k \ln q_j \tag{2}$$

$$\ln b(q) = \beta_o \prod_j q_j^{-\beta_j} + \ln a(q) \tag{3}$$

Inserting (2) and (3) in (1) yields:

$$\ln D(U,q) = \sum_{j=1}^{n} \alpha_j \ln q_j + 0.5 \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_{kj}^* \ln q_k \ln q_j + U\beta_o \prod_j q_j^{-\beta_j} \tag{4}$$

By differentiating with respect to q_i the budget shares, w_i, may be found:

$$w_i = \alpha_{i+} \sum_{j=1}^{n} \gamma_{ij} \ln q_j - \beta_i U \beta_o \prod_j q_j^{-\beta_j} \tag{5}$$

where $\gamma_{ij} = 0.5(\gamma_{ij}^* + \gamma_{ji}^*)$.
Inversion of the distance function at optimum yields the direct utility function:

$$U(q) = \frac{\ln a(q)}{\ln b(q) - \ln a(q)} \tag{6}$$

(5) and (6) yields the IAIDS:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_j + \beta_i \ln a(q) \quad (7)$$

where $\ln a(q)$ is given in (2). Eales and Unnevehr (1994) argues that $\ln a(q)$ ought to be substituted by a Stone quantity index. If this is done, IAIDS may be written as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_j + \beta_i \ln Q \quad (8)$$

where Q is the Stone quantity index. Some authors have argued that Q ought to be substituted with other indices (Buse (1994)). However, irrespectively of which index is used, (8) causes problems for welfare measurement. The reason for this is that (8) is a second-order approximation to the true demand system even if other indices than the Stone index is used.

However, a problem arises with (8). (8) may be written as:

$$w_i = \frac{p_i q_i}{\sum_{j=1}^{n} p_j q_j} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_j + \beta_i \ln Q \quad (9)$$

Multiplying both sides with $\sum_{i=1}^{n} p_i q_i$ yields:

$$p_i q_i = \sum_{j=1}^{n} p_j q_j (\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_j + \beta_i \ln Q) \quad (10)$$

(10) may be written as:

$$p_i q_i \left[1 - (\alpha_i + \sum_{j=1}^{n} \ln q_j + \beta_i \ln Q) \right] = \sum_{j \neq i} p_j q_j (\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_i + \beta_i \ln Q) \quad (11)$$

Solving (11) for p_i yields, the demand curve:

$$p_i = \frac{\sum_{j \neq i} p_j q_j (\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_j + \beta_i \ln Q)}{q_i \left[1 - (\alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln q_j + \beta_i \ln Q) \right]} \tag{12}$$

Using (8), (12) can be rewritten as:

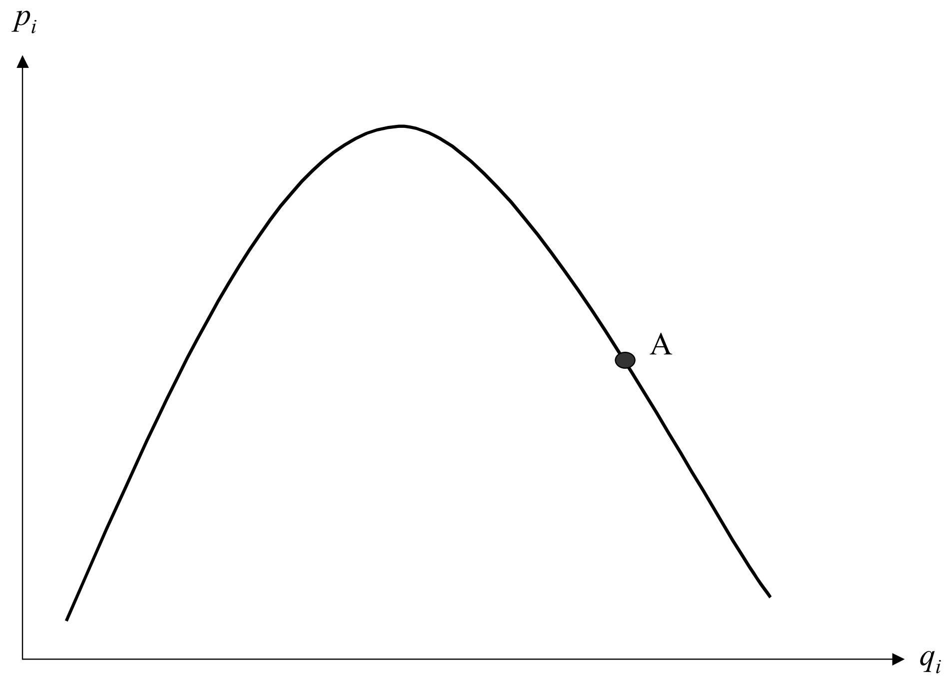
$$p_i = \frac{\sum_{j \neq i} p_j q_j w_i}{q_i (1 - w_i)} \tag{13}$$

Differentiating (13) with respect to q_i yields the slope of the demand function:

$$\frac{\partial p_i}{\partial q_i} = - \frac{\sum_{j \neq i} p_j q_j (\gamma_{ii} - w_i (1 - w_i))}{q_i^2 (1 - w_i)^2} \tag{14}$$

To interpret (14) note that if $\gamma_{ii} > w_i(1 - w_i)$, $\frac{\partial p_i}{\partial q_i} < 0$ and the slope of the demand curve is negative. Contrary, if $\gamma_{ii} < w_i(1 - w_i)$, $\frac{\partial p_i}{\partial q_i} > 0$ and the slope of the demand curve is positive. Thus it is impossible on theoretical grounds a priori to determine the slope of the demand curve. This point is illustrated in Figure 6.2.

Figure 6.2: **The demand function in IAIDS**



In Figure 6.2 the local approximation point is A. Around A, a second-order approximation to the true demand system is conducted. This means that the demand function is approximated with a parable as drawn in Figure 6.2. A parable has a positive slope on some parts and a negative slope on other parts. This point is illustrated in (14). It is clear that the demand function in Figure 6.2 is unsuitable for global welfare analysis. To repeat, the distance function is based on a second-order approximation around the optimal point only. The implication of this is that IAIDS is well suited for calculating the flexibility in a point. But when the analysis is extended to calculating consumer surplus the extrapolation is done in this specific point. Therefore, the demand curve, due to the configuration of the demand system, may have a positive slope.

Since the IAIDS is not suitable for welfare analysis, it follows that it is also unsuitable for relative welfare analysis. The system may, however, provided that the slopes are negative in the approximation point, be used to calculate marginal welfare changes around the optimal point. Welfare changes following from small policy changes under this condition can potentially be determined by calculating the integer under the demand curve or by extrapolating from the price flexibility in the optimal point. Calculating the integer may, however, give spurious results, provided that the marginal change is sufficient large to cross the peak of the parable formed demand curve shown in Figure 2. Hence, the only secure method for calculating marginal welfare changes is extrapolation, following Teisl *et al* (2002). In the next section these points are illustrated empirically in the case of fisheries.

3. Empirical estimations

The purpose of this section is to illustrate the theoretical finding, that IAIDS have shortcomings in welfare analysis, with an empirical example. The fish market in Denmark is selected because harvest of fish is subject to quantitative regulation. Therefore, the natural choice of model specification is the IAIDS where quantities are pre-determined.

In section 3.1 the data from which the estimations are performed is presented, while section 3.2 develop an estimation methodology. The results of the estimations are presented in section 3.3 and in section 3.4 it is discussed whether consumer surplus could be calculated in the empirical example. The purpose of section 3.1-3.3 is to obtain estimates for the parameters in the theoretically IAIDS model. These parameters are then used to calculate the slope of the demand function in section 3.4.

3.1 Data

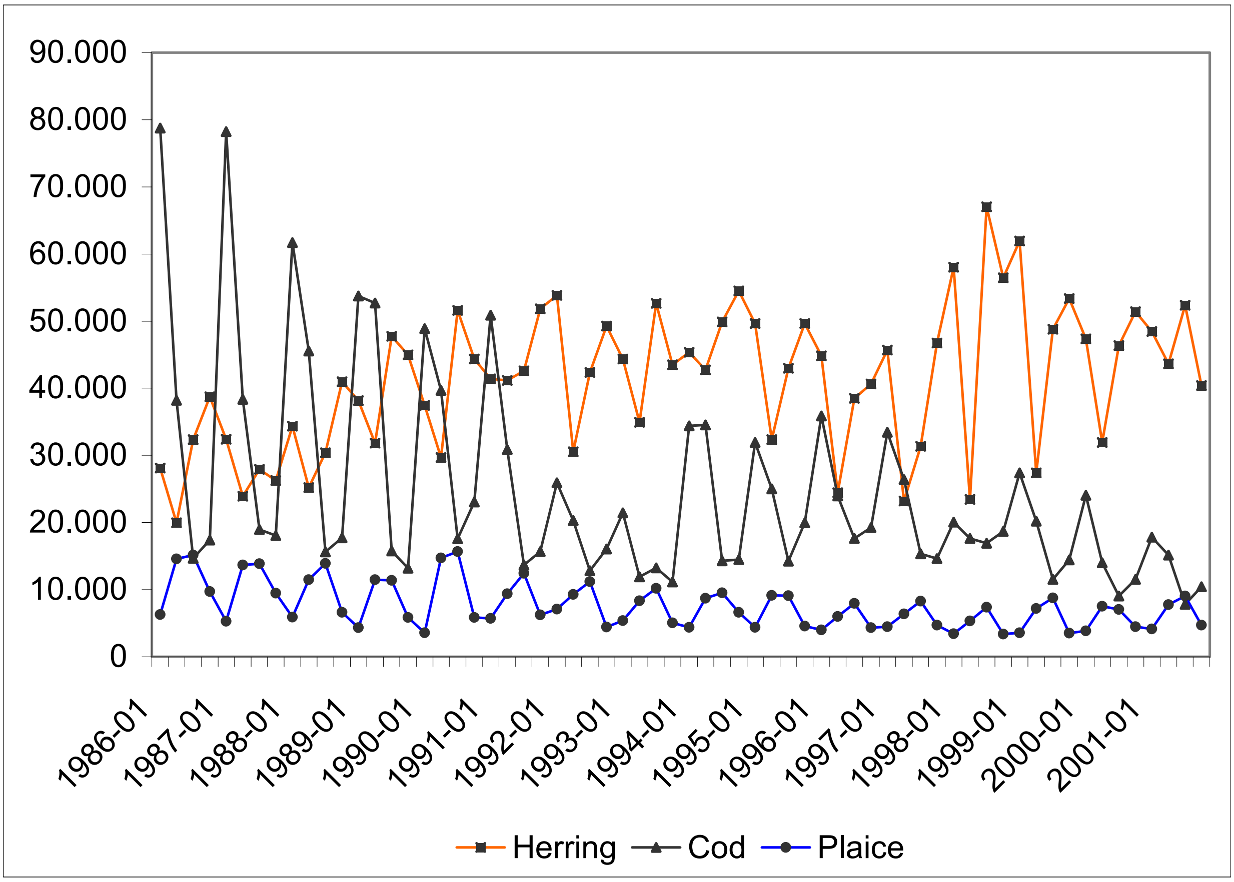
Time series on landed fish in Denmark are available for different fish species at first-hand market level from the Danish Directorate of Fisheries. Measured in value of landings, cod, herring and plaice are the most important fish species for human consumption and these species are, therefore, included in the analysis. Cod, herring and plaice account for two-thirds of the total fish landing value in 2001 and a time series is available of these species quarterly for the period 1986-2001. Summary statistics for the three species are presented in Table 6.1.

Table 6.1: **Data summary statistics, averages**

	Quantity /1,000 tonnes	Price /dkr per kilo	Market share /%
Plaice	7,619	5.48	0.19
Cod	24,747	5.50	0.60
Herring	41,180	1.39	0.21

From Table 6.1 it appears that cod is the most important species covering 60% of the market, while the two other species are of almost equal importance. Moreover, it also appears that the average prices of cod and plaice are on the same level, while the price on herring is lower. The development in landed quantities is shown in Figure 6.3.

Figure 6.3: **The composition of landings (tonnes)**



From Figure 6.3 it is seen that the landed quantities of cod, herring and plaice do not follow the same pattern over time. Landings of cod decrease from a high level due to over-exploitation of the cod stock while the herring landings increase due to a gradual improvement in the herring stocks. Landings of plaice are relative constant, although weekly decreasing.

3.2 Estimation methodology

From the description in Figure 6.1, it appears that the quantities of cod, herring and plaice followed either a downward or upward trend. Therefore, the data for quantities are probably non-stationary.[2] Based on this fact and knowing that the time series for prices generally are non-stationary, estimation of IAIDS must be undertaken using Vector Auto Regressive (VAR) models. The reason for this is that traditional Seemingly Unrelated Regression (SUR) models might result in spurious correlations. [3]Consequently, a VAR model is used for estimations.

Moreover, since only three fish species are included in the analysis, weak separability of parameters are implicitly assumed. The reason is that consumer choices can be considered a multistage decision process wherein the choice of fish species is the last decision.

The methodology is developed on the basis of the existing literature where IAIDS is estimated (Eales and Unnevehr (1994) and Eales et al (1997). However, because only a few estimations of IAIDS are known and because these estimations are based on SUR models, the methodology is also based on the existing literature where AIDS systems is estimated. SUR models is applied to estimate AIDS in, for example, Deaton and Muellbauer (1980b), Hayes et al (1990) and Eales et al (1997), while VAR models is used in Lind (2002) and Kaabia and Gil (2001). In this section the methodology for using co-integration to estimate AIDS models is reviewed. However before that it is necessary to secure that all data are non-stationary and integrated of the same order (e.g. I(1))

Based on the I(1) nature of the data, the estimation of the IAIDS, as presented in (8), is performed in the following two steps. First, the number of co-integrated relationship is determined using the procedure in Johansen (1988). Second, exact identifications and over-identification restrictions is introduced to ensure theoretical consistency.

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[2] A time series is non-stationary if it follows a trend.

[3] In a VAR model the non-stationarity problem is solved because the model is based on a pre-defined preference structure where all variables are endogenous, with exogenous variables being of the same lags. However, the model is due to this structure only applicable in the estimation of systems with small number of variables

The procedure in Johansen (1988) is based on the following VAR model:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-1} + \mu + \varepsilon_t \qquad (15)$$

where: X_t is a column vector made up by the market shares of the products included in the analysis, the natural logarithm of the quantities of these products and the Stone index.
$\prod$ is the long run solution to the VAR model and contains the possible co-integrating relations.

The rank of $\prod$ determines the number of stationary linear combinations of the variables in X_t. If the rank equals the number of variables which is $2n + 1$, where n is the number of products, all variables are I(0) (stationary). Contrary, if the rank is zero, none of the variables are stationary. If the rank is less than $n – 1$, it is not possible to identify the exact nature of stationarity and IAIDS cannot be estimated. However, if the rank is exactly $n – 1$, $\prod$ can be decomposed into $\alpha\beta'$, where β contains the co-integrating vectors. This implies that IAIDS can be identified by imposing restrictions. If the rank is between n and $2n + 1$, the same procedure can be used, but now the restrictions remove over-identification.

From (15) it appears that the constant is restricted to the co-integration space. The Johansen test can be used to test for the number of co-integrating vectors. In this test, the null hypothesis is that there are up to a given number of co-integrating vectors, whereas the alternative hypothesis is that there is exactly one more co-integrating vector.

Based on the chosen rank the exact identification restrictions and the over-identification restrictions can be imposed and tested using the Likehood Ratio test of restrictions imposed on β.

Following Pesaran and Shin (1999) the exact identification restrictions, given the rank $n – 1$, is the removal of other market shares from the two co-integration vectors as well as normalisation. The exact identification restriction in the case that is analysed in this paper is:

$$\beta' X_t = \begin{bmatrix} -1 & 0 & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} & \beta_{17} \\ 0 & -1 & \beta_{23} & \beta_{24} & \beta_{25} & \beta_{26} & \beta_{27} \end{bmatrix} \begin{bmatrix} w_p \\ w_h \\ ln\, q_p \\ ln\, q_h \\ ln\, q_c \\ ln\, Q \\ 1 \end{bmatrix} \tag{16}$$

Following Kaabia and Gil (2000), the exact identification restrictions, given a rank of n or more, is the removal of other market shares from the two first co-integration vectors as well as normalisation. In addition, zero restrictions are imposed on all market shares and the Stone index in the third co-integrating vector, in order to remove interference in the system from this co-integrating vector. Thereby, the exact identification restrictions are:

$$\beta' X_t = \begin{bmatrix} -1 & 0 & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} & \beta_{17} \\ 0 & -1 & \beta_{23} & \beta_{24} & \beta_{25} & \beta_{26} & \beta_{27} \\ 0 & 0 & 1 & \beta_{34} & \beta_{35} & \beta_{36} & \beta_{37} \end{bmatrix} \begin{bmatrix} w_p \\ w_h \\ ln\, q_p \\ ln\, q_h \\ ln\, q_c \\ ln\, Q \\ 1 \end{bmatrix} \tag{17}$$

Provided that the rank is larger than or equal to n but less that $2n - 1$, the β vector would consist of one more co-integration vector for each rank and the forth and fifth row in β would be the last row in (17).

(16) and (17) are, however, only exact identification restrictions, which has to be imposed together with the over-identification restrictions which are introduced to ensure theoretical consistency of the IAIDS model. The over-identification restrictions are:

Adding up $\sum_i \alpha_i = 1 \; \sum_i \gamma_{ij} = 0$ (18)

Homogeneity $\sum_j \gamma_{ij} = 0$ (19)

Symmetry $\gamma_{ij} = \gamma_{ji}$ (20)

The three restrictions implies that (8) represents a system of inverse demand functions which add up to total expenditures (18), are homogeneous of the degree of zero in quantities (19) and have symmetric cross effects (20).

Testing whether a model with both exact identification and over-identification form a better model than a model without both restrictions, can be performed by examining whether imposing the restrictions make βX_t stationary.

3.3 Results

Based on the above methodology, tests for non-stationarity is undertaken, the Johansen co-integration rank test is performed and the IAIDS is estimated with the restrictions imposed, given the rank determined. Tests for non-stationarity are performed in order to secure that all data series are integrated of the same order. Two tests are performed, one excluding and one including a trend. Moreover, tests are performed in both levels and differences. Test results are presented in Table 6.2.

Table 6.2: **Unit root tests in real terms**

	H_0 of non-stationarity in price levels[1]		H_0 of non-stationarity in price differences[1]	
	ADF without trend	ADF with trend	ADF without trend	ADF with trend
Quantity				
Herring	-1.90 (3)	-1.87 (3)	-15.08 (2)	-15.02 (2)
Plaice	-1.93 (3)	-1.52 (3)	-20.62 (2)	-20.88 (2)
Cod	-1.07 (4)	-2.28 (4)	-5.27 (3)	-5.23 (3)
Share				
Herring	-1.52 (4)	-2.67 (4)	-3.38 (3)	-3.44 (3)
Plaice	-2.59 (4)	-3.38 (4)	-5.35 (3)	-5.30 (3)
Cod	-1.96 (4)	-2.25 (4)	-4.16 (3)	-4.18 (3)
Stone Index	-1.85 (4)	-2.95 (4)	-5.53 (3)	-5.50 (3)

Note 1. Critical values are known from MacKinnon (1991) and are with constant but without trend –3.43/-2.86/-2.57 respectively at 99%, 95% and 90% levels and are with constant and trend –3.96/-3.41/-3.13 respectively at 99%, 95% and 90% levels.

In Table 6.2 the results of the Dickey-Fuller tests with lags chosen according to the AIC criteria in real terms are reported. As shown, all data series are non-stationary, but stationary in first differences. It also appears that the null hypothesis of a constant and a trend in the data are accepted in levels and rejected in first differences. Thereby, all data series appear I(1) and further analysis can be performed.

Based on the result that all variables with critical values are I(1), the estimation of IAIDS is undertaken as a search procedure. First, models with the constant restricted to the co-integration space and without misspecification problems are identified among eighteen models. The eighteen models have two, three and four lags, with and without three centred seasonal dummies and w_h, w_p and w_c included. Misspecification tests for autocorrelation, normality and autoregressive conditional heteroscedasticity are performed. In eight of the eighteen models no sign of misspecification on a five percent level appear, increasing to eleven when accepting a three percent level. For the eleven models, the Johansen test is used to determine the number of co-integrating relations, which in all cases are found to be two or three as required for further IAIDS estimation.

Among the eleven models the model that gives the most reasonable price and scale flexibilities is chosen. The first criteria requires the compensated own price flexibility to be negative. The second criteria express the scale flexibility in the range of zero to minus one. None of the models were reasonable in relation to both criteria. Therefore, the model with reasonable own price flexibilities was chosen. The result of the Johansen test for the chosen model is presented in Table 6.3.

Table 6.3: **Multivariate Johansen Test - market shares of plaice and herring, quantities of plaice, herring and cod and Stones Index**

Model	H_0: rank=p	Eigenvalues	Trace Test	$C_{90\%}$
Period = 1986.1-2001.4	p=0	0.52	117.68*	97.17
Lag = 4	p<=1	0.47	74.07***	71.66
64 observations	p<=2	0.21	36.27	49.92
	p<=3	0.17	22.30	31.88
	p<=4	0.13	11.03	17.79
	p<=5	0.04	2.49	7.50

Note: */*** = significance at 1 and 10 percent levels, respectively.

From Table 6.3 it is seen that the rank is two at a 10 % level. On the basis of two co-integration relations, the exact identification and over-identification restrictions (16) and (18)-(20) are imposed. The parameters of the β vector are:

$$\beta' X_t = \begin{bmatrix} -1 & 0 & 0.126 & -0.029 & -0.097 & 0.292 & 0.324 \\ 0 & -1 & -0.029 & -0.120 & 0.150 & 1.038 & 2.535 \end{bmatrix} \quad (21)$$

The first row is the parameter estimates for plaice, while the second row is the parameter estimates for herring. Based on symmetry, homogeneity and adding-up the parameters for cod may be found. However, for the purpose of highlighting whether IAIDS can be used for welfare estimation it is sufficient to calculate the intercept. Based on adding-up the intercept for the cod demand function is – 1.859.

In the next section the estimated parameters are used to show whether IAIDS can be used for calculating consumer surplus.

3.4 Welfare measurement.

The usefulness of IAIDS for welfare measurement is analysed in this section. For the cod market IAIDS cannot be used for measuring consumer surplus because the intercept is negative. Thus, as a consequence of adding-up IAIDS may be unsuitable for measuring welfare.

For the herring and plaice market, the slope of the demand curve can be calculated by (14)[4]. In calculating the slope of the demand function for herring and plaice, it is chosen to insert actual values for the Stone Index and the quantities for other species. If consumer surplus is going to be calculated in a given year, actual values for the involved variables must be inserted in the estimated demand function (21). In calculating the slope of the demand function for plaice, the first row in (21) is used, while the second row in (21) is used when the slope is calculated for herring. It is chosen to present the slopes as a function of the quantities. By presenting the results in this way, the original demand curve can be analysed. The slope of the demand function for plaice is shown in Figure 6.4, while Figure 6.5 presents the slope of the demand function for herring.

[4] An alternative is to draw the actual demand curve. However, the actual demand curve is already drawn in Figure 2, so it is chosen to calculate the slopes.

Figure 6.4: **The slope of the demand curve for plaice**

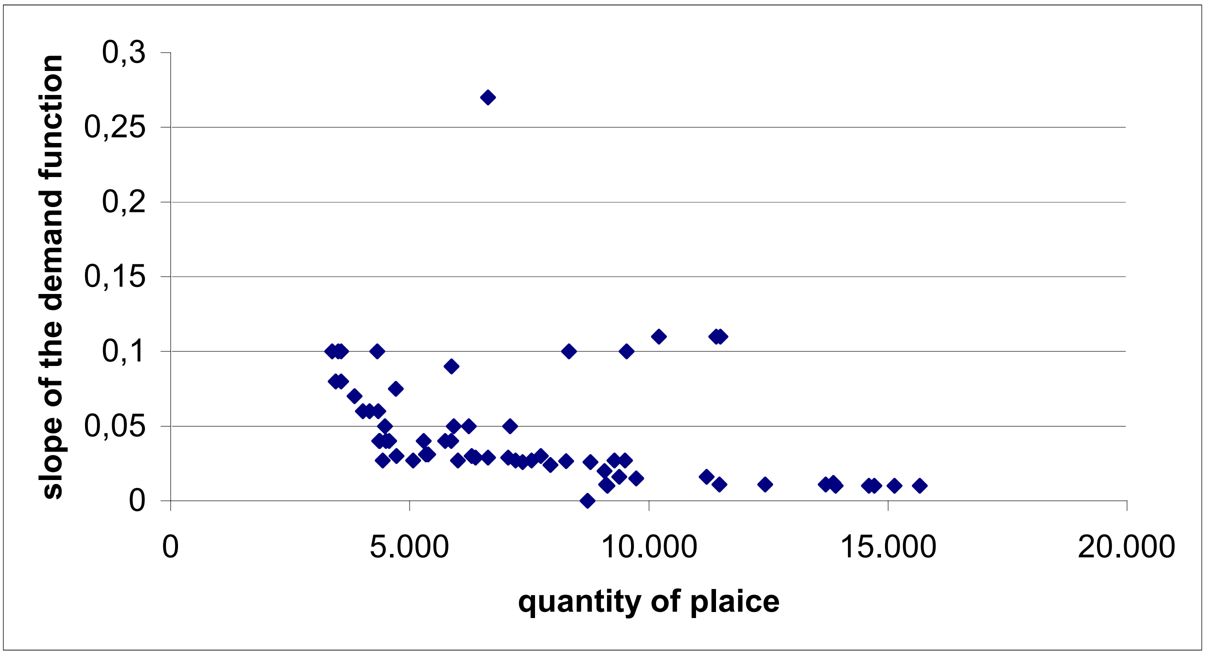
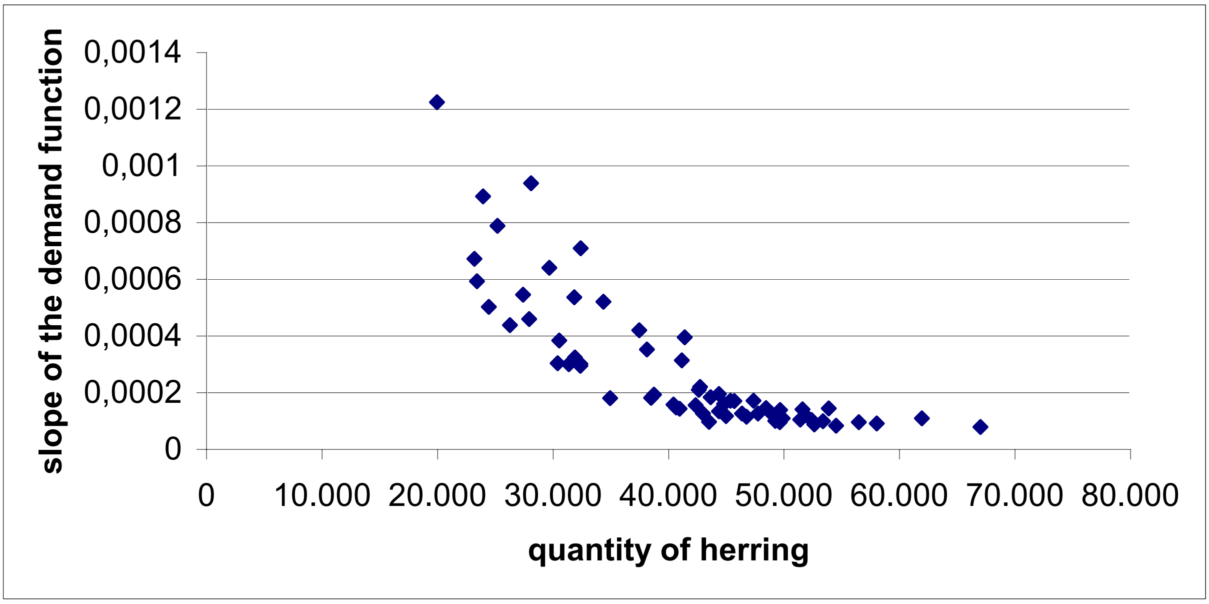


Figure 6.5: **The slope of the demand curve for herring**



From Figure 6.4 and 6.5 it is seen that the slopes of the demand functions follow exactly the same pattern for plaice and herring. The slopes are positive and decreasing in quantities. The implication of a positive slope is that IAIDS is not well suited for calculating consumer surplus. Calculating welfare on a demand curve with a positive slope simply gives no meaning.

In section 2 it was mentioned that the true demand curve was locally approximated with a second-order equation. This implies, as sketched in Figure 6.2, that a parable represents the demand function and this fact explains the decreasing slope. An implication of this is that negative price flexibilities may be obtained even if the demand function has a positive slope. This would occur if the local approximation point (the point where the flexibilities are calculated) lies in the negative sloped part of the parable. However, despite this fact, the conclusion is that IAIDS is not well suited for welfare measurement where the demand curve has a positive slope.

4. Conclusion

In this paper it has been analysed whether IAIDS can be used for measuring welfare in the form of consumer surplus. An IAIDS has been estimated for three species of fish (cod, plaice and herring) and it has been shown that in calculating welfare of the present goods, IAIDS is not well suited. For one species a negative intercept is obtained, while a positive slope of the demand curve is obtained for the two other species.

The empirical results confirm that one should be careful in using the IAIDS for welfare analysis, but the results are not sufficient reason to abandon the use of IAIDS for welfare analysis generally. Due to the parable formed demand curve, the IAIDS is not suitable for global welfare analysis. Furthermore, the IAIDS is not suitable for relative welfare analysis, since global welfare cannot be determined. Moreover, welfare analysis cannot be made for positively sloped demand curves, but provided that the slopes are negative, welfare analysis might be possible under certain circumstances. Given the negative slopes of the demand curves, welfare analysis is possible marginally around the optimal point. Welfare can then potentially be determined either by calculating the integer below the demand curve or by extrapolation of price flexibilities from the optimal point. Calculating the integer may, however, give spurious results, provided that the marginal change is sufficient large to cross the peak of the parable formed demand curve shown in Figure 2. Hence, the only secure method for calculating marginal welfare changes is extrapolation, following Teisl *et al* (2002). On this basis, the IAIDS possess several shortcomings in welfare analysis, but can be used marginally to assess small policy changes under certain conditions.

Despite the shortcomings of the IAIDS for welfare measurement, IAIDS remain valid to identify market structures by calculating flexibilities. The reason is that IAIDS is a local second-order approximation to the true demand curve. When flexibilities are calculated, the analysis is restricted to the local approximation point, which is in the area where the demand curve has a negative slope.

Traditionally, IAIDS has been estimated with SUR models. However, a new development in the AIDS literature is to use co-integration to estimate demand parameters. Co-integration departs from an assumption that the involved variables are non-stationary and with co-integration it is possible to test the theoretical restrictions. In this paper co-integration is used, which makes the paper a novel contribution to the estimation of IAIDS systems.

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CHAPTER 7

A Cost-Benefit Analysis of a Public Labelling Scheme of Fish Quality

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Abstract. The purpose of this paper is to introduce a new method capable of evaluating the economic welfare for quality graded fish products using the hedonic price method for plaice in Denmark. Today no labelling scheme exists for the final consumers of different qualities of fish. A scheme does only exist at the first hand market. On this basis, a general applicable theoretical and empirical method is developed to compare the costs and benefits of the hypothetical choice between the total absence of labelling and the presence of a public labelling scheme, which fully inform consumers on the quality and simultaneously allow the producers to differentiate prices between quality grades. Under certain assumptions it is shown that the economic welfare associated with a public labelling scheme is at minimum 263,000 euro. Sensitivity analysis shows that this result is robust. The policy implication is that a public labelling scheme should not be implemented as the demand and cost functions have low elasticities, implying that the welfare gain is low.

Key words: Co-integration, fish quality, hedonic pricing, public labelling scheme, welfare.

JEL classifications: L11, Q21, Q22.

1. Introduction

The objective of the present paper is to introduce a new method for calculating the economic value of fish quality, thereby being able to evaluate the economic rational for implementing a public labelling scheme for fish quality in the retail market for plaice in Denmark. The rationale is evaluated by comparing the welfare of total absence of labelling with the welfare in the presence of a full public labelling scheme, where perfect information prevail and where producers differentiate prices accordingly. The economic welfare is calculated both with and without labelling, thereby identifying the rise in welfare associated with the introduction of labelling. This is done under two alternative assumptions on the reaction of the market. In the first case it is assumed that the price adjustment in the market remains unchanged despite the introduction of the public labelling scheme while the second case establishes a market reaction which leads to a social optimum. Thereby, a lower and an upper limit of the welfare associated with a public labelling scheme appears. Price differentiation is assumed possible only with labelling, with prices being higher for higher quality fish. Without labelling fish of all qualities are sold at the same price. The hypothesis of the paper is that the benefit of the introduction of a public labelling scheme of plaice quality is small, since demand for fish generally is inflexible to changing quantities (Nielsen (1999)). This is further underlined by the relative insignificance of supply of one country to the total market. Provided that this is the case, the costs might be larger than the benefit and the scheme should not be implemented for rational economic reasons.

The empirical analysis departs from the first-hand market for plaice in Denmark, where the European Council Directive (no. 2406 of 1996) on the common marketing standards for fish products is in force. According to this, quality grading of fish in all landing markets in the EU is obligatory. Welfare is defined as consumer and producer surplus, with and without labelling, and since the present data are quality differentiated, consumers are through intermediate purchasers *per se* able to judge quality and the market is informed. Hence, the available quality differentiated data represent a situation where labelling is present. There is, however, no comparable data available representing a situation without labelling, i.e. data from a non-informed markets is not available. Therefore, it is assumed throughout the paper that the average demand function of the informed market serves as an approximation for the demand function on the non-informed market[1]. Furthermore, the present quality differentiation of the first-hand market serves as an approximation of the welfare premium at the retail market. Welfare appears from estimating demand and cost functions. The demand functions for consistently aggregated plaice products are identified using co-integration, since data are non-stationary. The cost functions are identified using a simple calculation procedure. Comparing the welfare with and without a public labelling scheme identifies the welfare effects of the potential introduction of a full scheme.

The welfare calculations are based on prices in the first-hand market, implying that these are the prices the consumers pay. Hence, an implicit assumption is that trade of plaice in Denmark takes place directly between the fishermen and the final consumers or, alternatively, that a fixed mark-up in the intermediate trade equal to costs prevail in the trade. Both assumptions have a similar outcome for the economic argument and imply that fishermen earn the producer surplus, while the final consumers earn the consumer surplus. In reality, a whole supply chain is present when plaice is traded in Denmark. When the fish is caught it is most often sold through the auction system. A part of the catch of plaice is exported as fresh and chilled plaice primarily to the European market. A large part goes to fish processing factories from which it reaches the market mostly through Danish and European supermarket chains. For each supply chain in this business procedure a market exist and, thereby, a consumer and producer surplus is earned. Therefore, the calculated welfare does not include the consumer and producer surplus earned in the remaining part of the supply chain.

The issue of quality is important in fish markets, since consumers cannot necessarily distinguish quality of plaice. Although it might be possible for some consumers to distinguish quality of fresh plaice before purchase, for example through the smell, the look of the eyes and the consistency of the flesh, it is generally presumed that only some consumers have this ability. Furthermore, it is more difficult for

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[1] Better data of the non-informed market would be desirable, but have not been available. The implication is that the validity of the empirical results rests on the assumption that the average demand function of the informed market can represent the demand function of the non-informed market.

consumers to distinguish quality of processed products, such as fillets and breaded fillets, before purchase. It might be possible to distinguish the quality of these product forms during consumption, but even then it might not be the case for several consumers. Contrary, it can be argued that since fish purchase in most instances is a repeated game, the purchase of bad quality would simply lead the consumer not to abstain from further purchase but to change supplier. In other words, it is assumed that the demand function is unchanged by the experience of bad quality. This implies that consumers might be able to judge the quality during consumption. Therefore, it remains uncertain whether consumers in general actually can distinguish the quality of plaice, but since the majority of plaice landed in Denmark are sold in processed forms it is assumed throughout this paper that consumers cannot distinguish. The ability of consumers to judge quality might be decisive for whether the introduction of a public labelling scheme is relevant. If they cannot distinguish the quality, the introduction of labelling solves a potential information problem, but if they have the ability to distinguish the quality, the scheme can be considered unnecessary. However, despite their possible ability to distinguish, consumers might be interested in the introduction of the scheme, since it implies that they can be perfectly certain on the quality. Such certainty might be important for consumers due to the utility of eating fish, but also as a signal of high food safety.

The implication of consumers being unable to judge quality is that an imperfect information problem arises. This situation has similarities with the problem discussed by Akerlof (1970) in the market for lemons. In this market the producers cheat the consumers by pretending that a good of low quality has high quality. Thereby, the producers increase their profit. In this paper an imperfect information approach similar to Akerlof (1970) is used. In the case without labelling it is assumed that an expected demand curve exist. This expected demand curve is calculated from the demand curves of different qualities using probabilities for the different quality levels. Now one, and only one, price is used to calculate the expected quantity of fish that is consumed. One price for fish exists because of imperfect information. A public labelling scheme meets this information problem and distributes the fish of high quality to the consumers who prefer them. Furthermore, it can support the producers by allowing them to differentiate prices.

The issue is also interesting in relation to the choice between public and private labelling schemes in that a compulsory public labelling scheme is normally introduced for the benefits it brings to society. Contrary, it can be argued that a private labelling scheme is launched if it is profitable for the companies participating and the companies voluntarily joining the scheme. This type of labelling does not necessarily lead to the maximisation of total welfare. Instead, private labelling is meant to differentiate the market so as to differentiate the prices and transfer consumer surplus into producer surplus. Hence, if labelling shall be introduced according to a cost-benefit criteria, the welfare should necessarily include both consumer and producer surpluses and the gain to society must be higher than the costs associated with developing, monitoring and controlling the scheme. In the Nordic countries labelling schemes are most often introduced, monitored and controlled by the public.

In the economic literature, economics of information with regard to consumption have developed over several years, starting at least from Nelson (1970), who introduced "search costs" attributable to the time and energy spend by the consumer to determine and obtain the products with the desired quality. Based on the Lancaster (1971) theory of characteristics, Nelson (1974) distinguish between search and experience characteristics of goods, where consumers can determine the properties, including quality, of a search characteristics before they buy the good, while the properties of experience characteristics are only appearing during consumption. Darni and Karni (1973) further introduce the credence characteristics, where consumers cannot determine the properties of the good at all, not even after they have consumed it. According to Caswell (1998), labelling of fish has the effect of transforming the experience and credence characteristics into search characteristics, thereby increasing welfare.

Another direction in the literature is the principal-agent approach, which is developed as a recent solution to the problems of imperfect information (Varian (1992)). This approach applies a solution of a tax/subsidy mechanism to correct the market failure that arises with imperfect information. An alternative to the principal-agent approach is labelling in the situation where imperfect and asymmetric information exists in the consumer market. The producers know the quality of the fish products whereas the consumer is uninformed and the labelling solution to this asymmetry is studied in this paper.

A few studies also identify consumers of labelling empirically. Wessels *et al.* (1999) and Pickering *et al.* (2001) estimate consumer willingness to pay for seafood labelling using stated preference methods. By focusing on consumer willingness to pay the production side of the economy is ignored. This paper applies the revealed preference method of hedonic pricing to measure consumer benefit of the quality property contrary to Wessels *et al.* (1999) and Pickering *et al.* (2001). The authors are not aware of the existence of any articles identifying the total welfare of labelling of fish products including both consumer and producers surplus. Neither are the authors aware of articles modelling market reactions on the introduction of labelling which leads to the social optimum, nor of articles using co-integration in the estimation of the demand system as the basis for welfare analysis.

The paper is outlined as follows. In section 2 a theoretical model for calculating the economic welfare of a public labelling program is presented, while demand and cost functions are estimated in section 3. Section 4 presents the results of the cost-benefit analysis and section 5 discuss´ the results and the implications of the findings.

2. Theory

In this section the theory behind calculating the economic value of fish quality is sketched. Within the theory of valuing the benefits of environmental goods two traditions, stated and revealed preferences, exist. Stated preference methods include contingent valuation (Mitchell and Carson (1981)) and the idea behind this method is to ask consumers to state their preferences for a non-market good using direct survey methods. Revealed preference methods include the travel cost method (McConnell (1985)) and the hedonic price method (Harrison and Rubenfeld (1978)). Travel cost methods are based on the fact that private resources are sacrificed in order to consume an environmental good. This is used to estimate a demand curve. The idea behind the hedonic method is that differences in the level of an environmental good are reflected in the price of a private good. In this paper, the hedonic price method is used, because differences in the level of fish quality are assumed reflected in the price of fish.

In the introduction it was mentioned that the purpose of the paper was to evaluate whether a public labelling scheme of fish should be implemented. Therefore, a model for the market of fish with and without a public labelling scheme is necessary. First, a model for the fish market with a public labelling scheme is introduced. Assume that trade of fish takes place directly between consumers and fishermen and three qualities of fish, s_1, s_2 and s_3, exist, where *1* express the highest quality and *3* the lowest quality. s_i for $i = 1,2$ *and* 3 is assumed to be a discrete variable. With a public labelling scheme different prices for different qualities can exist. Therefore, three different demand functions are postulated: $P_1 = f_1(q_1, s_1)$, $P_2 = f_2(q_2, s_2)$ and $P_3 = f_3(q_3, s_3)$ where P_i for i = *1, 2 and 3* is the price and q_i for $i = 1, 2$ *and* 3 is the quantity[2]. For each quality of fish a cost function, $C_i(q_i)$ for $i = 1,2$ *and* 3, is also assumed to exist. The cost function measures the opportunity cost of catching fish. A regulatory authority (society) maximises the net benefit of the fishing activity. This net benefit can be defined as:

$$Max \int_0^{q_1} f_1(q_1,s_1)dq_1 + \int_0^{q_2} f_2(q_2,s_2)dq_2 + \int_0^{q_3} f_3(q_3,s_3)dq_3 - C_1(q_1) - C_2(q_2) - C_3(q_3) \quad (1)$$

s.t.

$$q_1 + q_2 + q_3 \leq K \quad (2)$$

where *K* is a quota. (2) is a quota restriction expressing that the sum of catches of all qualities must not exceed the quota.

Assuming a binding quota restriction, the first-order conditions are:

$$f_1(q_1,s_1) - MC_1 - \lambda = 0 \quad (3)$$

$$f_2(q_2,s_2) - MC_2 - \lambda = 0 \quad (4)$$

[2] In the theoretical model, it is assumed that the price of one quality only depends on the consumed quantity of that quality grade. In reality, fish of various qualities are substituted and in the empirical model such substitution is included. However, the possibility of substitution between qualities does not change the theoretical argument and therefore this possibility is excluded, although cross-price effects can also easily be included in the theoretical model.

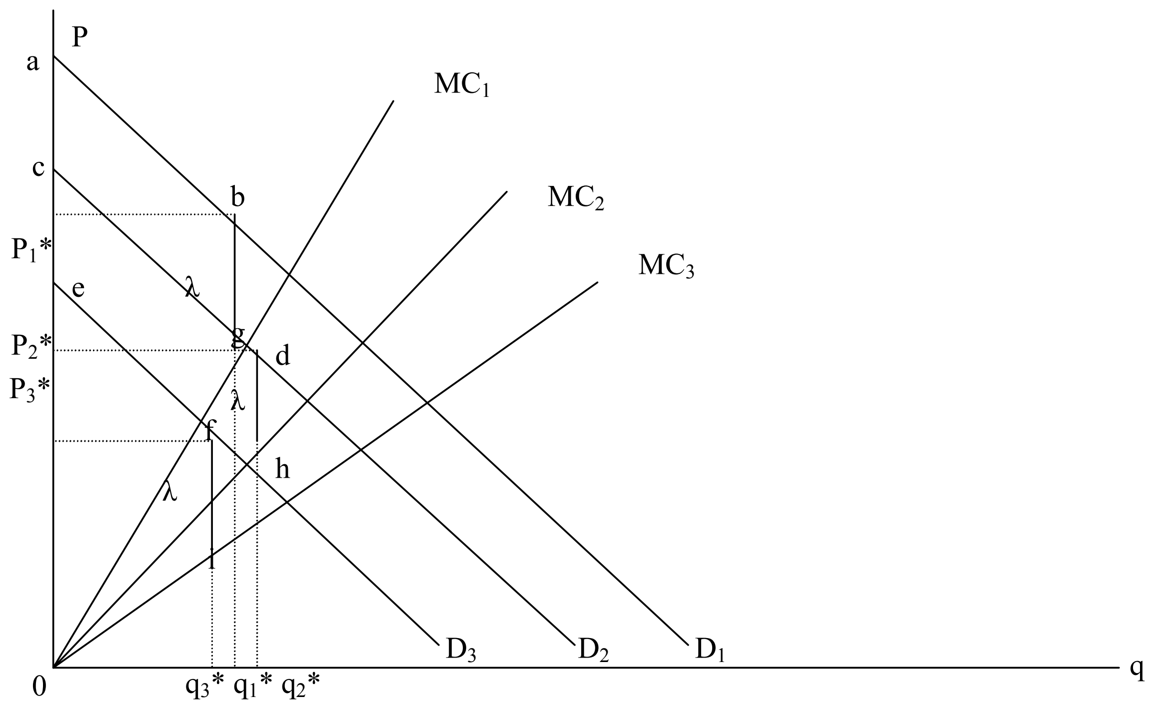
$$f_3(q_3, s_3) - MC_3 - \lambda = 0 \quad (5)$$

where MC_i for $i = 1,2$ *and* 3 is the marginal cost and λ is a positive Lagrange multiplier included due to the quota restriction. Because *1* express the highest quality and *3* the lowest quality a natural assumption is that $MC_1 > MC_2 > MC_3$. Because λ is the same for all three qualities this implies that $P_1 > P_2 > P_3$.

λ is the shadow price of the quota restriction and measures the loss in welfare of catching fish of one quality due to lost catch opportunities of other qualities. In this way λ captures the social cost of an externality, which can be labelled the quota externality. The quota externality arises because catches of fish of one quality implies a cost in terms of decreased catch possibilities of other qualities. When the quota is set in an economic optimal way the quota externality is exactly equal to what is commonly referred to as the stock externality (Clark (1991)).

The social optimal solution is illustrated in Figure 1.

Figure 1. **The social optimal solution with labelling**



Because λ is equal for all qualities, it is social optimal to select quantities such that $P_1 - MC_1 = P_2 - MC_2 = P_3 - MC_3$. Thus, the implication is that the social optimum occurs where prices are equal to a common mark-up over marginal cost. The mark-up over marginal cost reflects the cost of the quota externality (stock externality).

The difference between the price and marginal cost must be equal to λ for all qualities. Therefore, q_1^*, q_2^* *and* q_3^* is the social optimal quantity of fish of quality *1, 2 and 3* and P_1^*, P_2^* *and* P_3^* is the optimal prices. The total consumer surplus for all three qualities is $abP_1^* + cdP_2^* + efP_3^*$ while $P_1^*bg0 + P_2^*dh0 + P_3^*fi0$ is the total producer surplus. The total welfare, assuming that a labelling scheme induces optimal quantities, is the sum of producer and consumer surplus. However, there is no guarantee that the market will secure q_1^*, q_2^* *and* q_3^* and the total welfare calculated in Figure 1 is, therefore, an upper estimate of the welfare. A lower estimate must, therefore, also be established. In Table I the actual prices of various qualities, P_1', P_2' *and* P_3', is reported. The quantities of different qualities, q_1', q_2' *and* q_3', assuming actual prices may now be found from the equations $P_1'=f_1(q_1', s_1)$, $P_2'=f_2(q_2', s_2)$ *and* $P_3'= f_3(q_3', s_3)$[1]. In addition, the marginal costs may be found by solving $MC_1'=MC_1(q_1')$, $MC_2'= MC_2'(q_2')$ *and* $MC_3'= MC_3'(q_3')$. By using P_i', q_i' *and* MC_i' for $i =1, 2$ *and* 3, consumer and producer surplus and, thereby, welfare, can be calculated assuming current prices. This can be considered as a lower estimate for the welfare achieved by a public labelling program, because an implicit assumption is that no market reaction occurs.

Now turn to the case without labelling. Consumers cannot distinguish between various qualities of fish and, therefore, one price exists in the market for fish. Assume that a probability, π_i *for* $i = 1, 2$ *and* 3 exist for consuming a fish of quality i. Now an expected market demand function can be defined as $P = m(q)$, where P is the common price and q is the aggregated output. In addition, an industry cost function can be defined as $C = C(q)$. Turn now to societies maximisation problem without labelling which can be written as:

$$Max\left(\int_0^q m(q)dq - C(q) \right) \quad (6)$$

s.t.

$$q < K \quad (7)$$

In the case of a binding quota restriction, it follows that:

$$q^* = K \tag{8}$$

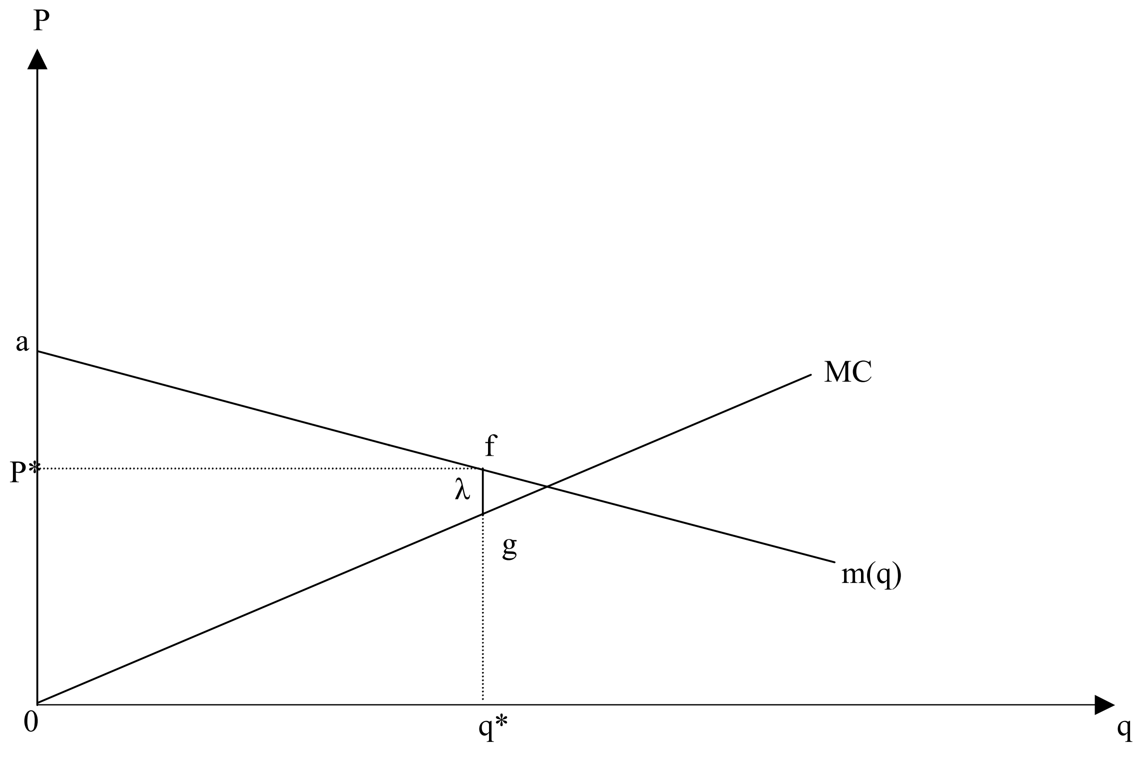
(8) express that the quantity caught is equal to the quota.

The first order condition of the maximisation problem is:

$$m(q) - MC - \lambda = 0 \tag{9}$$

λ is the positive shadow price for the quota restriction, not necessarily equal to λ in equations 3-5. λ expresses that fish caught by one fisherman has an opportunity cost in terms of lost fishing opportunities for other fishermen. In this instance, λ is again a measure of the quota externality. Because $\lambda > 0$, $P > MC$ and for the society it is again optimal to select quantities such that the prices are larger than the marginal cost. The difference between price and marginal cost reflects the quota externality and, thereby, the stock externality if the quota is set in an economic optimal way.

Figure 2. **illustrates the solution**.



In Figure 2 the optimal quantity is q^* and this optimal quantity is equal to the quota. P^* is the optimal price and the price is larger than the marginal cost reflecting the quota externality. The total producer surplus is P^*fg0, while P^*af is the consumers surplus. The sum of producer and consumer surplus is the total welfare.

As in the case of labelling the welfare sketched in Figure 2 is an upper bound for total welfare because optimal quantities are assumed. A lower bound is obtained by using the current average price, P', in Table I. Now the quantities are found by the equation $P' = m(q')$ and the marginal costs by the equation $MC' = MC(q')$. On basis of P', q' and MC' a lower bound for consumer and producer surplus and, thereby, welfare can be calculated.

Irrespectively of whether current or optimal prices are used the net benefit of a public labelling program may be found. Let WUL be the economic welfare without labelling and WL the net benefit with labelling. Now $NB = WL - WUL$ is the net benefit of a public labelling program. Assume, further, that a cost of PC of implementing a public labelling program is induced to society. If $NB > PC$ the labelling program shall be implemented, while the program shall not be implemented if $PC > NB$. Such calculations will be performed in section 4 for plaice in Denmark

3. Empirical estimations

In this section, the demand and cost functions are identified for plaice traded in the Danish market. Before that, however, data is examined.

Data on plaice landings in Denmark were obtained from the Danish Directorate of Fisheries. The data are monthly, cover the period January 1993 to December 1998 and includes both landings of domestic and foreign fishermen. The data are sorted into quality extra (E-quality), A-quality, B-quality and not admitted, in accordance with the Council Regulation (1996) laying down the common marketing standards for certain fishery products. The quality differentiation is defined for freshness and includes the colour of the skin and skin mocus, the look of the eye, gills and peritoneum (in gutted fish), the smell of gills and abdominal cavities and the consistency of the flesh.

The data are available in volume, value and average price for different quality grades. The average prices are in fixed prices corrected using the consumer price index. Data summary statistics are presented in Table I as yearly averages.

Table I. **Data summary statistics, yearly average, 1993-98**

	Quantity /tonnes	Price /euro per kilo
Plaice:		
Grade E	7,104	1.86
Grade A	16,728	1.68
Grade B	24	1.08
Not admitted	**2,172**	**0.40**
Total	26,028	1.62

Table I shows that 92% of total landings in the 72 periods (months) are graded as E, A and B-fish. It, further, appears that two-third is graded as A-fish and that the average price increases with the level of quality as expected. The average price of the not admitted fish, however, shows huge fluctuations over time. The reason is that this grade is used as a residual where fish incorrectly graded are entered. Due to the presence of this situation, the not admitted fish are excluded from further analysis. Furthermore, the total landings of approximately 26,000 tonnes correspond to the quota, assuming perfect quota utilisation. Finally, it appears that the prices of E and A fish are relatively similar, while B-fish are cheaper.

The methodology used to identify demand functions starts with the estimation of a simple average inverse linear demand function, where the inverse form is selected since in the case of fisheries it is, according to Wilen (2000), quantity that is predetermined at the market level due to the widespread use of quantity regulation. The linear form is selected since it might be globally decreasing and have a positive intercept, implying that it is possible to calculate the consumer surplus[3]. The average demand function of all sales in the situation with an informed market is selected as an approximation for the demand function in a hypothetical situation with a non-informed market.

[3] This is not the case in an Inverse Almost Ideal Demand system, since it is based on a second order approximation around the optimal point of the true preference structure (see Jensen, Nielsen and Roth (2003)).

The regression equation for the demand function $P = m(q) = \gamma_o - \gamma_1 q$ is, however, only valid for stationary data series. A data series is stationary if it moves randomly around a constant mean over time and non-stationary if it follows a trend. A non-stationary data series is integrated of degree one, i.e. I(1), if its first differences moves randomly around a constant mean over time. For an I(1) data series the Johansen co-integration rank procedure must, therefore, be used. Hence, since all data were tested for the presence of unit roots using Augmented Dickey-Fuller tests found to be I(1), co-integration must be used. A traditional vector auto regressive model in error correction form with the constant restricted to the co-integration space and the parameter estimates unrestricted is used following e.g. Jaffry, Pascoe and Robinson (1999).

Based on the estimated average demand function, individual demand functions can be identified, provided that the prices of the different quality grades are formed within the same market. This follows from the Composite Commodity Theorem of Lewbel (1996), which states that if two or more price series can be described by the same common factor, the relative prices remain fixed and prices will move together over time. Thus, a composite commodity can be constructed. It is, however, a "reverse" use, since in a situation where the theorem is in force, the average demand function is disaggregated into three individual demand functions. This is done knowing that the individual demand curves are parallel to the average demand curve, since a price change in one of the commodities affects the quantity of the commodity in the same direction and scale. Therefore, the individual demand curves are calculated given the knowledge that they are parallel to the average demand curve with the distance between them given by the difference in average prices.

It follows that it must be tested whether the prices of the different quality grades are formed within the same market. This is done using the Stigler (1969) definition of a market as "the area within which the price is determined, allowances being made for quality differences". The basis is the traditional test of the Law of One Price (LOP) for I(1) data, where trending prices must move perfectly together over time in order to be formed within the same market. Asche, Bremnes and Wessells (1999) provide with their model the point of departure, with the only difference being that the present estimation is with a trend term restricted to the co-integration space. The reason is that the quality which caused price differences are then also allowed to be non-stationary. Provided that the co-integration test identifies one (and only one) integrating factor which is common to all the price series and that the test of the LOP shows that the LOP is in force, prices follow each other over time and, thus, the individual demand curves are parallel to the average demand curve.

The average demand function was estimated without misspecification problems for a model with 8 lags and eleven centred seasonal dummies included. The misspecification tests included autocorrelation, normality and autoregressive conditional heteroscedasticity tests and conclusions on the absence of misspecification problems are obtained at the 5% significance level. The result of the Johansen test is reported in Table II.

Table II. **Johansen test with average price and quantity included**

Model	H_0: rank=p	Eigenvalues	Trace test[1]	$C_{95\%}$
Period = 93.01-98.12	P=0	0.18	19.87***	19.99
Lags = 8	p<=1	0.10	6.91	9.13
11 seasonal dummies				
72 observations				

Note: 1. */*** = Significant at the 1 and 10 percent levels, according to critical values known from Johansen (1996).

It appears that a rank of one is obtained at the 10% level as required, implying that the function can be exact identified. The average demand function for plaice landed in Denmark is identified as
$p = 15.8 - 0.0000011 * q$.

Given that prices of the different quality grades of plaice are formed within the same market, the individual demand functions of the different quality grades can be identified. In order to ensure that the different quality grades are formed within the same market, co-integration tests and tests of the LOP must be performed. This was done for a model with 8 lags, with a trend restricted to the co-integration space and with eleven centred seasonal dummies included. Again, the model was estimated without misspecification problems. The results appear in Table III.

Table III. **Multivariate Johansen test of the price series and test of the LOP**

Model	H_0: rank=p	Eigenvalues	Trace test[1]	$C_{95\%}$
Period = 93.01-98.12	P=0	0.34	49.55*	42.20
Lags = 8	p<=1	0.22	23.42***	25.47
11 seasonal dummies	p<=2	0.11	7.42	12.39
72 observations				

Table III shows that a rank of two was found on the 10% level between the price series for the three quality grades of plaice. The Likelihood Ratio test statistics is 7.14 and accepting a p-value of 3%, the test of the LOP was also accepted. This implies that the LOP is in force and prices of the different quality grades of plaice move together over time. Thus, prices are formed within the same perfectly integrated market and the individual demand functions can be identified. This is done knowing that the slopes are the same as the slope of the average demand function and with the differences in intercepts of the individual demand functions given by the differences between average prices. Thereby, the three individual demand functions are given by:

$$p_E = 17.6 - 0.0000011 * q_E \qquad (10)$$

$$p_A = 16.2 - 0.0000011 * q_A \qquad (11)$$

$$p_B = 11.8 - 0.0000011 * q_B \qquad (12)$$

The estimated demand curves have, as expected, a very low elasticity.

In order to calculate the expected market demand curve, some probabilities for the various quality levels are necessary. Assume that the output shares are an estimate for these probabilities. In this case the expected demand function is given by the average demand function:

$$p = 15.8 - 0.0000011 * q \qquad (13)$$

(13) has a very low elasticity.

The methodology used to identify the cost functions is based on that the costs reflect opportunity costs. This implies that the costs of an activity are the benefit loss of using the resources in an alternative way. However, assuming perfect competition in the economy the opportunity cost of fishing is exactly the costs associated with the fishing activity. This implies that the account statistics in Anon (1998) can be used to calculate the economic costs associated with fishing plaice of various qualities in Denmark. However, because account statistics are only available for five years it is impossible to estimate a cost function using econometric methods. Therefore, a method in Jensen (2002) is applied to determine a cost function. The idea in this method is to calculate a cost parameter based on information on total costs and catches of each quality.

First, it is necessary to calculate economic costs from the account statistics. The idea is to take the total expenditures for all species harvested minus depreciations. Then, assuming that the skipper has an alternative employment opportunity equal to the wage rate for employment in the fishing sector, the cost of the skipper is added to the total costs. Taking the share of plaice of the total revenue and multiplying with the total cost of all species gives the total cost of plaice. Then, total cost of various qualities of plaice is found by multiplying the total cost of plaice by the share of the quality category of output. Now the following cost functions are assumed:

$$TC_E = eq_E^{\,2} \qquad (14)$$

$$TC_A = fq_A^{\,2} \qquad (15)$$

$$TC_B = gq_B^{\,2} \qquad (16)$$

Calculation shows that $e = 0.0000064$, $f = 0.0000018$ *and* $g = 0.00000099$ and the hypothesis that $MC_E > MC_A > MC_B$ is confirmed[4]. The parameter estimates show that marginal cost functions is inelastic.

The total cost function for all plaice for the case without labelling is correspondingly established, but now on the basis of aggregated costs and the aggregated catches of all plaice. This market cost function is assumed given by:

$$TC = hq^2 \qquad (17)$$

Where $h = 0.00000018$. Again the marginal cost function is inelastic.

[4] The background data on the calculation of the parameters in (14)-(16) are available from the corresponding author on request.

4. The net benefit of a public labelling program

The economic welfare associated with implementing a public labelling scheme is calculated in this section on the basis of the parameters estimated in section 3, using the models of section two[5].

With regard to social optimal prices and quantities with labelling, it turns out that the actual price for grade *E and A* is too small. It would be more beneficial to society to supply less of grade *E and A* and, thereby, increase the price of these two grades. With regard to grade *B* the price is too high and the quantity supplied is too small. In the case without labelling the social optimal price is larger than the actual average price. In the case of labelling λ = 0.72 euro per kilo indicate that prices are considerably higher than the marginal costs, while λ = 0,44 euro per kilo without labelling. The values of λ in the case without labelling explain why the optimal price is larger than the actual price.

With respect to the lower bound (actual prices), the quantities calculated are larger than the actual quantities and equal to the quota.

The calculated welfare is reported in Table IV.

Table IV. **Social welfare, euro per year**

		Consumers surplus	Producers surplus	Total Welfare	Welfare gain
Upper bound					
	With labelling	359,000	275,000	634,000	301,000
	Without labelling	206,000	127,000	333,000	
Lower bound					
	With labelling	264,000	240,000	504,000	263,000
	Without labelling	150,000	91,000	241,000	

The welfare gain obtained by introducing a public labelling program is 301,000 euro when optimal values are used and 263,000 euro when actual values are used. The difference between these numbers is not large and it is reasonable to assume that the real welfare gain lies between these numbers. Taking the lower bound as a point of departure, the distribution of the welfare gain is 114,000 euro to consumers and

[5] The equations for the social optimal quantities, prices and marginal costs as well as for the calculation of consumer and producer surpluses are derived on the based of the model in section two. These derivations are not reported, but available from the corresponding author on request.

149,000 euro to producers. Thus, even though both groups gain from the introduction of the public labelling scheme, the gain of producers are largest with a 165% increase compared to the producer surplus without labelling. The rise of consumer surplus compared to without labelling is 75%. However, the total welfare gain only represent 0.6% gain on total turn-over of 42 million euro.

The results may be sensible to variations in the estimated parameters. Therefore, sensitivity analyses are performed. The slopes and the intercepts of the demand function for all the three quality grades as well as for the cost parameter are varied by *+/- 20%* in both the upper and lower bound. The results are not reported, but shows that when the intercepts of the demand functions are varied by +/- 20%, the welfare gains does not change with more than 6% in any of the cases. Varying the slope of the demand functions yields changes not larger than 3% and varying the cost parameter change the welfare gains by not more than 12%. Hence, the total benefit remains approximately unchanged with varying parameters when a public labelling program is considered. The welfare gains are at minimum 263,000 euro. Instigating a public labelling scheme at a cost less than the welfare gain is hardly possible and this leads to the conclusion that such a program should not be implemented. The low welfare gain appears because the cost and demand functions are inelastic.

5. Discussion

In this paper it has been shown that a public labelling scheme for plaice in the retail market of Denmark yield a benefit to society at a minimum of 263,000 euro per year. If the cost of introducing, monitoring and controlling this scheme is less than this benefit, it was found that the scheme would be a net welfare gain to society. Furthermore, it was shown that both producers and consumers would gain. The gain in producer surplus causes a market reaction induced by price differentiation. The consumer surplus increase as the consumers who prefers high quality actually also obtains this quality. The gain of producers was, however, larger than for consumers. All results were robust to changes in the parameter estimates.

The minimum benefit of 263,000 euro of introducing a public labelling scheme represents more than a doubling of welfare compared to the market situation without labelling. Compared to the gross turnover in the market of 42 million euro, however, the gain represents only 0.6%. Hence, even though the relative increase in welfare following the introduction of labelling is large, the absolute welfare both before and after the introduction of labelling as well as the welfare compared to gross turnover are small, due to inelastic supply and demand. The hypothesis of the paper is then confirmed. Therefore, despite that information on the costs of the introduction of the public labelling scheme is not available it is highly unlikely that a public labelling scheme can be set up at such low costs. This implies that a public labelling scheme according to economic arguments should not be set up.

The argument that some consumers, as opposed to the a priori assumption in the paper, might be able to distinguish quality, points in the same direction. The reason is that the introduction of a public labelling scheme might then be unnecessary for consumers. For producers, however, the option of price differentiation introduced with the labelling scheme will still result in the welfare gain. Therefore, the total welfare gain will be given only by the producer surplus and is therefore less than the gain in the case where consumers are assumed unable to judge quality. The consequence is again that a public labelling scheme, according to the cost-benefit argument, should not be set up.

The benefit of the 263,000 euro is, however, for at least three reasons a lower estimate of the true benefit. First, as explained in the theoretical section, the estimate is obtained by inserting actual prices in the demand function. Thereby, it is assumed that no market reaction to a public labelling scheme will occur. If a market reaction takes place welfare will increase. Second, behind the calculation of economic welfare is an implicit assumption that the market interactions between consumers and producers take place at the landing level. Thus, fish is directly transferred from the fisherman to the final consumer. However, the fish is traded though a supply-chain before the product reaches the final consumers and this supply chain also earns a producer and consumer surplus. Third, if a public labelling scheme is introduced for plaice it is most likely introduced for other species too. Thus, consumer and producer surplus is earned in the market for those species unless a fixed mark-up in the intermediate trade equal to costs prevail in the market.

However, with respect to the public cost of labelling there are economics of scope implying that this result does not preclude an economic rational labelling scheme for the total Danish fish market.

The hedonic price method is adopted in calculating the welfare gain. This method rests on an assumption that price differentials established in the market for plaice in Denmark at first-hand-sales reveals consumer preferences. These prices reflect a non-optimal market situation because consumers have imperfect information about the quality of fish. Furthermore, a very simple linear demand system is estimated. There are two reasons for this choice. First, in order to calculate welfare, demand curves with a globally negative slope and positive intercept must be required (Jensen, Nielsen and Roth (2003)). Second, the calculation of welfare in the case of labelling is complicated even with a simple linear demand system.

An implication of the theoretical analysis is that welfare optimal prices must be higher than marginal costs with a factor that captures the value of the quota externality (stock externality). The present market allocation of the quota on different quality grades differ from the optimal allocation between different quality grades. In the actual market fishermen maximises profit and the fishery is characterised by regulated open-access (Homans and Wilen (1997)) where average revenue is set equal to average cost on the margin. Above, it was mentioned that the optimal allocation should reflect the stock externality and that the difference between price and marginal cost is equal to the value of this externality.

The results have some practical implication. The structure in determining the quality of fish in the supply chain is that fishermen a priori catch fish of excellent quality. The quality of fish is preliminary determined by how the fish is treated by the fishermen after they are harvested. Therefore, it is reasonable to operate with a cost function for each quality grade and such a cost function is analysed in this paper. In the estimation section it is shown that fish of different qualities are traded on perfectly integrated markets. In other words, the fish is traded in a market, where prices move together over time. The implication of this is that the only difference between the different quality graded demand functions is the reservation price. On the producers side of the economy a high quality implies higher marginal costs and, thus, higher price. Therefore, there is a trade-off between price, marginal costs and quality. Despite this trade-off total profit is higher for high quality because of higher willingness to pay. However, with labelling the producers will be willing to supply all quality grades of fish and will supply them until the marginal profit is equal for all quality grades. Even if a labelling scheme is introduced there are still market imperfections. Producers will still maximise profit and a stock externality remain. So despite the fact that labelling secures a welfare gain, it does not secure a welfare optimum. However, it is easy to secure a welfare optimal allocation of fish of different grades. A labelling scheme can be combined with an individual transferable quota system (ITQs). If the total quota is fixed and this total quota reflects the value of the stock externality this quota can be distributed to fishermen as ITQs. Trade among fishermen with ITQs will now occur until the marginal profit is equal between vessels and equal to the stock externality. In addition trade of ITQs among fishermen and the allocation of ITQs between grades within individual vessels will secure that the marginal profit is equal between grades.

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CHAPTER 8

Trade liberalisation, resource sustainability and welfare: The case of East Baltic cod

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Abstract.
Recent research has warned that liberalising trade in capture fish products originating from inefficiently managed fisheries might cause over-exploitation, reduced fish stocks and thereby a reduced steady-state of welfare. This paper qualifies the warning in a case study of the East Baltic cod market by developing an age-structured bio-economic supply model combined with basic theory of trade between two countries. Welfare effects of trade liberalisation are identified taking fishing quotas, input limitations, mesh-size regulations and shared ownership of stocks into account. It is shown that even though liberalising trade in products supplied by such a fishery might cause steady-state welfare reductions in the supplier countries, these welfare reductions are small compared to the welfare gains from a hypothetical change to optimal management. Hence, the introduction of better fisheries management is much more important than trying to meet potential negative consequences of trade liberalisation, since even small improvements in fisheries management may offset the negative effects of trade liberalisation. The consequence is that the argument that warns against trade liberalisation in certain situations gains less validity, and conventional wisdom following from the Neo-classical theoretical tradition regains validity in several and probably most fish markets globally.

Keywords: EU enlargement, trade liberalisation, fisheries management, shared stock, backward-bending supply, welfare.

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1. Introduction

The purpose of this paper is to identify the welfare effect of liberalising trade between two trading partners sharing ownership of a managed fish stock. Furthermore, the purpose is to construct an empirical model for welfare analysis of the enlargement of the European Union (EU) for the case of the East Baltic cod (*Gadus Morhua*) fishery. When trade between old and new EU countries is fully liberalised is total welfare increased or decreased? Who gains and who loses? Is it the consumers, the fishermen or the governments and are they in the new or the old member countries? Moreover, if the East Baltic Sea, which will be almost surrounded by EU countries, is used proactively by the new single management authority how will that affect welfare? Identifying the welfare effects allows an assessment of how the enlargement should be treated to ensure that all sectors in each country benefit fully. This is an especially pertinent issue, since the trade policy works as a tax, which constrains catches in exporter countries and subsidises the fisheries sector in the importer countries. Thus, the trade policy serves indirectly and unintentionally as a second best fisheries management tool.

The issue is important since a liberalisation of trade will cause overexploitation in exporter countries, if fisheries management is inefficient. The reason is that the price of the fish increases, causing an increment to the incentive to "race for fish" where the increased turnover following from the price increase is used for inefficient investment in fishing vessels. This limits the future catch potential. A consequence might be extinction of the fish stock. In importer countries the opposite effects result, since competition from foreign producers disappears, thereby reducing the pressure on the fish stock of the importer country. In the case of the cod stock in the East Baltic Sea, however, the issue is not that simple, since the stock is shared among new (exporting) EU member countries and old (importing). The shared stock is then affected in opposite directions by the different developments in the new and old member countries and the total effect on the stock and thereby on welfare is not *a priori* known. The effect depends on, for example, the management system in place and the market structure. If the effects in the exporter country offset those in the importer and fisheries management is inefficient, this requires action.

Thus the first hypothesis in this paper is that since the present management scheme is inefficiently used, the stock and welfare effect from trade liberalisation will be negative because the exporter country is a price-taker on the world market.

A welfare analysis is also interesting since with the enlargement of the EU the East Baltic Sea will be almost surrounded by EU countries. Thus, the EU Commission is the sole owner and manager of the stock. Hence, the potential for better fisheries management arises and if this potential is used and optimal management introduced, welfare gains will appear. The second hypothesis therefore is that such potential welfare gains will be large and will far exceed the size of the effects following from trade liberalisation. Even small improvements in fisheries management may offset possible negative effects of trade liberalisation.

In the economic literature, many authors have considered the issue of why trade arises. The history of general trade theory starts with Ricardo (1821) and Smith (1937) explaining the presence of international trade by the international division of labour and with specialisation resulting from differences in technology. The Hechcher-Ohlin model followed, which explains the appearance of international trade by differences not in technology but in factor endowments. It is demonstrated that a global social optimum can only be reached in the case of free trade. Furthermore, small countries also face a situation where the social optimum can only be reached with free trade, whereas large countries can affect their terms-of-trade and thereby reach a social optimum only in the presence of restrictive trade policies, provided there is no retaliation from other countries. The theory of trade in renewable resources develops in a general equilibrium framework from Chichilnisky (1993), via Brander and Taylor (1997ab, 1998) to Hannesson (2000) and Emami and Johnston (2000). Brander and Taylor show in three seminal papers that advantages with free trade in renewable resources, which are not managed optimally, exist only under certain conditions and for certain types of country. The reason is that overexploitation might follow from the opening of trade.

A parallel development in bio-economic supply modelling appears with Schulz (1996, 1997), based on the backward-bending supply curve introduced by Copes (1970). Furthermore, quantitative supply models of fish stocks are introduced by Frost and Michelsen (2001) and Bjorndal and Nostbakken (2002). These articles, however, identify harvest and stock effects, but not those on welfare.

In the literature, the welfare effects of trade liberalisation are generally found to be case specific and dependent on a country's status as importer or exporter, the fisheries management system, the state of the fish stocks, and the size of the country in the world market. In this case study of the East Baltic cod fishery the general equilibrium theory of Brander and Taylor (1997a) predicts that the small exporter country with an overexploited open access fish stock would lose welfare from trade liberalisation. The large importer country would remain unaffected, since the price in that country is unchanged. This may, however, not necessarily be the result, since both input and output management exist, minimum mesh-sizes are compulsory and the stock is shared between countries. These factors are not taken into account in Brander and Taylor (1997a) and their inclusion may change the results. The presence of management will change the results as the supply curve become vertical in the relevant range, given by the quota. The presence of compulsory mesh-size regulation will affect the results, in particular for longer-lived fish species, since if fishing on younger age groups is avoided the tendency for the supply curve to bend backward is very small. There, the problem of overexploitation is less severe and the risk of extinction of the stock small. Hence, overexploitation becomes an economic more than a stock problem. The existence of shared ownership might affect the results through negative externalities, If management is inappropriate. Hence, the third hypothesis of this paper is that the welfare effects of liberalising fish trade are small in cases where the fish stocks are overexploited and subject to quotas, input limitations and compulsory mesh-size regulation. Since several fisheries globally are subject to these measures and since the majority of fish stocks globally are exploited at or above the maximum sustainable yield (FAO 2001), this finding may be of relevance in the majority of the world's fisheries.

In this paper the welfare effects of trade liberalisation for different sectors in the economy are thus identified in a case study of the East Baltic cod fishery using an age-structured bio-economic model combined with basic theory of trade between two countries. The welfare concepts of Copes (1972) are used. The model further departs from regulated open access and analyses the welfare effects of two countries, following an exogenous price increase in only one of the countries sharing ownership of the stock. The author is not aware of any former articles identifying quantitatively the welfare effects of liberalising fish trade, which take any of these factors into account.

2. Methodology

In this section a model capable of identifying welfare effects of trade liberalisation empirically for a small exporter country sharing ownership of a fish stock with an importer country is developed under alternative fisheries management schemes. The model appears in a partial equilibrium setup by combining a bio-economic supply model with traditional trade theory.

Following Clark (1990), the standard age-structured bio-economic model of Beverton and Holt (1957) of a fish population is applied. This model is used instead of the Schaefer (1954) model, since it allows different fishing mortalities for year classes. This makes it possible to take the wide use of technical fish stock conservation measures, such as minimum mesh-sizes, into account. The recruitment R, which is the number of fish entering the fishery, is assumed constant over time and the number of fish dead at time t is assumed given by (1).

$$\frac{dN}{dt} = -(M+F)N, \; N(0)=R \qquad (1)$$

where M is the natural mortality and F is the fishing mortality. The weight of one fish $w(t)$ at the age t is given by the von Bertalanffy weight function $w(t)=a(1-be^{-vt})^3$, where a, b and v are positive constants. The total biomass B_t of one year class is then identified as $B_t=N(t)w(t)$. Based on Clark (1990), it is assumed that all year classes are in equilibrium, are identical and that the natural mortality is constant over time.

On this basis and following Hilborn and Walters (1992) a discrete bio-economic model, which is applied to the empirical identification of supply curves, is developed[1]. The biomass and the landings H of year class t, both measured in weight, are functions of the fishing mortality level L^1.

$$B_t = \sum_{i=1}^{20} B_{i,t-1} * e^{-(M_i + L*F_i)} \qquad (2)$$

$$H_t = \sum_{i=1}^{20} B_{i,t} * \frac{(L*F_i)*\left(1-e^{(M_i+L*F_i)}\right)}{(M_i + L*F_i)} \qquad (3)$$

where $B_{0,t}=R$ and i relates to age classes. The fishing mortality level L is assumed to be a function of fishing effort E.
where z is a measure of the differences in the catch efficiency between fishermen. (4) is introduced to take into account that the last fisherman joining the fishery is less efficient than the first. Thus, the catch efficiency decreases with fishing effort. It is further assumed that the total cost C is a linear function of the fishing mortality level L.

$$C = c*E,\ c>0 \qquad (5)$$

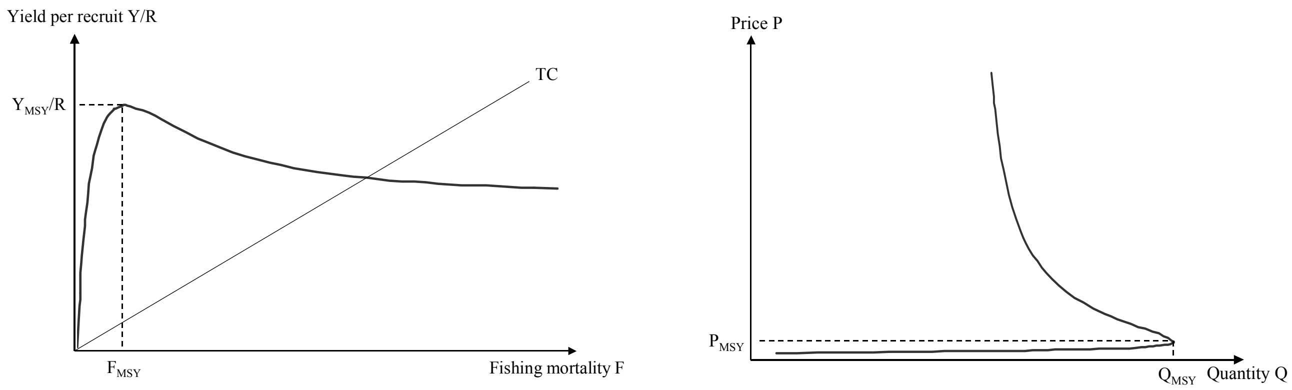
where c is the parameter of the cost function and the fishing effort and fishing mortality levels are proportional. Market equilibrium is determined where the price is equal to the average cost, which is the usual equilibrium condition in fisheries.

$$P = \frac{C}{H} \qquad (6)$$

This equilibrium rule is for an open access fishery in which the long-run profit of fishermen by definition is zero and yield per recruit equals total costs. Fishing mortality is assumed at an initial level of one. This normalisation relates policy changes in the fishery to the basic equilibrium and is achieved by fixing the parameter c of the total cost curves[1].

In this model the yield per recruit and the supply curves are alike, since the total costs are linearly increasing in L. If only large mesh-sizes are allowed, the yield per recruit curve and hence the supply curve retains a positive gradient. If, alternatively mesh-sizes are small the two curves are backward bending and if they are very small, the curves will approach zero. With medium mesh-sizes, however, the two curves approach a positive value. For illustration, the shapes of the curves for the east Baltic cod stock in open access are shown in Figure 8.1, for the values and parameters presented in the case study in the next section.

FIGURE 8.1 **Curve shapes.**



I. Yield per recruit and total cost curves

II. Open access supply curve

It appears that with the existing compulsory mesh-sizes, designed to catch two-year-old fish and older, the curves become backward bending. The turning point is known as the Maximum Sustainable Yield (MSY). Fishing at an effort level greater than that associated with the MSY is characterised as biological overexploitation. If the mesh-sizes are sufficiently large (for this case designed to catch only fish of an age of 7 years and older) both curves will show a positive gradient in the relevant range. In contrast to a curve derived from a Schaefer function, it will therefore not converge against zero with increasing price. The reason is, that the present age-structured model assumes unchanged recruitment. This implies that it is impossible to extinguish the fish stock.

The supply function for an optimally managed fish stock is the marginal cost function, since the management system can be used actively to prevent overexploitation and to minimise costs. It can be shown that the Maximum Economic Yield (MEY) is reached at a level below MSY and that the marginal cost function is monotonously increasing, just as a supply function for a conventional good[1].

The supply functions for stocks managed between MEY and open access equilibria, such as regulated open and restricted access[1] are identical, since the only difference appears between the costs of fishing when the quota is taken. Such supply curves are identical to the one shown in Figure 8.1 for all levels of the price *p* until a certain value above MSY, where input and output management is reached. Thereafter, the fixed quota determines supply.

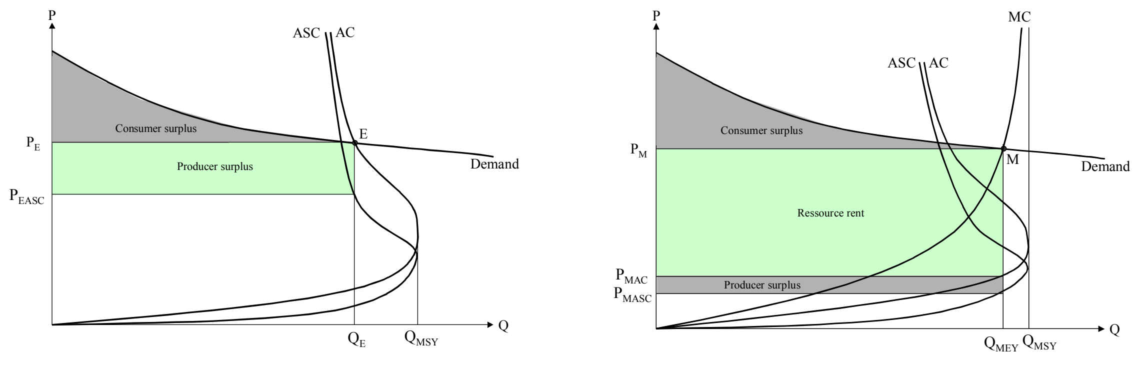
The inverse demand function of a fish product can be deduced as the aggregate of what single consumers are willing to pay. Assuming a Cobb-Douglas utility function, the inverse demand function is given by (7).

$$\ln(p) = a_1 + \varepsilon * \ln(q) \qquad (7)$$

where p is the price consumers are willing to pay, q the quantity demanded, ε the price flexibility and a_1 the intercept. The double-logarithmic form of the demand curve corresponds to constant price flexibilities.

Based on the supply and demand functions and following Copes (1972) welfare measures of a capture fish stock are defined in Figure 8.2.

FIGURE 8.2 **Welfare measures of renewable resources.**



I. Open access

II. Optimal economic management

The equilibrium between demand and supply in open access (the bionomic equilibrium) is where the supply (average cost) and demand curves intersect, at *E* in Figure 8.2.I, and even though the resource rent is zero, the existence of the fishery still results in positive economic benefits. This benefit consists of the consumer surplus (shown as the shaded triangle in Figure 8.2.I) and the producer surplus (the shaded rectangle). The consumer surplus is traditionally defined as the difference between the amount consumers are willing to pay and the amount they actually pay. For conventional goods (that is, those without externalities in production), producer surplus is defined as the difference between the minimum amount for which a producer is willing to sell and the amount for which he actually sells. Following Copes (1972), however, distinction is made for a fishery between resource rent and producer surplus; the first representing the factor rent of the resource and the latter representing other factor rents (such as of capital, labour and skill).

The condition for the existence of a positive producer surplus in an open access fishery is that fishing vessels are heterogeneous, implying that vessels vary in their economic performance. Hence, only the "better" vessels contribute to the producer surplus. Using this understanding of the producer surplus, an average social cost (ASC) curve is obtained by subtracting the average producer surplus from the average cost curve. The curve is shown in Figure 8.2.I and measures the average opportunity cost per unit of output for labour and capital. The ASC curve is always lower than the AC curve and for fishing mortalities above MSY the two curves approach each other. This implies that the producer surplus approaches zero. The form of the social cost (SC) function in (8) is chosen to reflect these ideas:

$$SC = \frac{E^2}{\frac{E}{c} + \frac{D}{E}}, \quad D = \frac{YE^2}{c(1-Y)} \qquad (8)$$

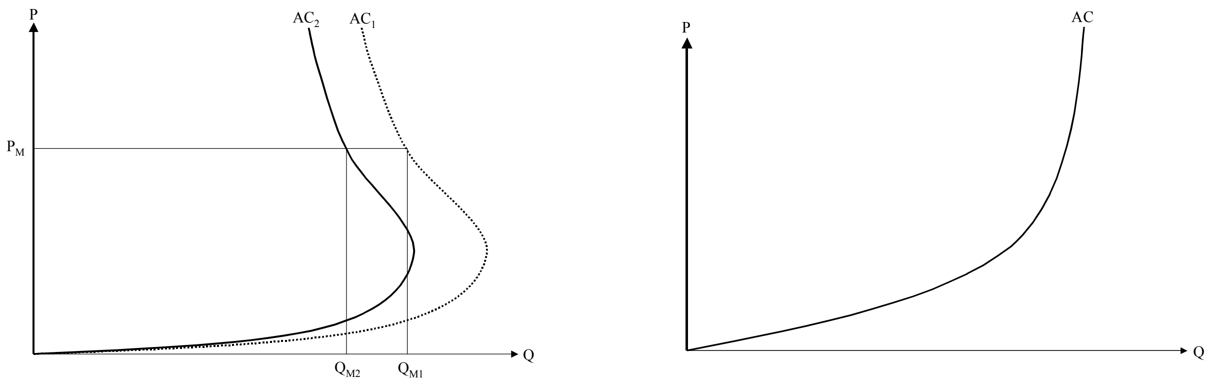
where Y represents the initial share of total (private) costs that the remuneration of capital and labour enjoy.

The economic optimum in the presence of management at MEY is shown where the supply (now the marginal cost) and demand curves intersect at M in Figure 8.2.II. At the optimum, the consumer and producer surpluses have the same definition as in the open access situation. To these welfare components, however, is added the resource rent, the area between the average and marginal cost curves in Figure 8.2.II, again following Copes (1972).

Under regulated open and restricted access, the supply curves become vertical when the price, p, exceeds a given level. Under regulated open access the producer surplus appears as the product of the quota and the difference between the prices given by the average cost and the average social cost curves. Thus, the producer surpluses in regulated open access and in pure open access, at the quantity of output given by the quota, are equal. The reason is that the shape of the average social cost curve will be similar to that of the average cost curve, which is backward bending until the quota is reached and vertical thereafter. Under regulated restricted access the producer surplus appears as the product of the quota and the difference between the equilibrium price and the price given by the average social cost curve. The producer surplus under regulated restricted access is always larger than under both pure open and regulated open access, since in these situations other input factors than the resource, for example, capital and labour, are used inefficiently. Based on the supply curves developed above, the supply curves of two countries sharing ownership of a fish stock can now be deduced under open access. Assuming that the price changes only in Country 2, the supply curve may be identified in three steps. First, the initial supply curve in Country 1 is identified, given the initial allocation of fishing between countries. Then, the supply curve in Country 2 is identified assuming that changes in fishing mortalities only appear in Country 2. Finally, the terminal supply curve of Country 1 is found given the terminal allocation of fishing after the changes in Country 2.

On this basis, the open access supply curve in Country 1 is seen as a parallel inward shift of the supply curve in Figure 8.1.II according to that country's share of the total catch. The open access supply curve of Country 2 may be found starting from the initial equilibrium point on the total supply curve, which gives the initial price and quantity. The fishing mortality in that country is now changed upwards and downwards and the new total fishing mortality as well as the new total catch found. Country 2's share of the total catch is proportionate to its share of the new total fishing mortality. The corresponding price is the average cost of producing that quantity in Country 2. Assuming that the stock is exploited at fishing mortalities sufficiently above the MSY and that changes in fishing mortalities only appear in that country, the supply curve can be shown to be rising in the relevant range. Finally, the terminal supply curve in Country 1 is identified as a shift of the initial supply curve, determined by the changed share of the total fishing mortality. The three curves are shown in Figure 8.3.

FIGURE 8.3 **Open access supply curves of two countries sharing ownership of a fish stock.**



I. Country one

II. Country two

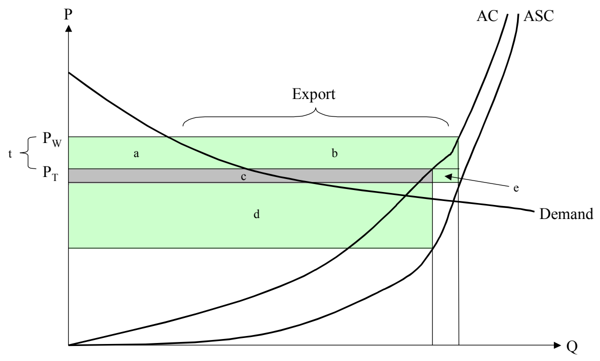
In the diagram on the left the initial (dotted) and terminal (solid) open access supply curves appear for a situation where the fishing mortality is increased in Country 2. In the right diagram, the open access supply curve for Country 2 appears. The supply curves with optimal management are not shown, since it is known that these will always have an upward gradient. The supply curves in regulated open and restricted access will in Country 1 be as discussed above. In Country 2 the supply curve in such situations is upward-sloping until the quota level , and then vertical.

Since the analysis now includes more than one country, the model must be disaggregated further. The biological values remain unchanged, but the economic values and the parameters must be identified for each country. Thus, $L_{Total} = \Sigma L_k = 1$, where L_k is the contribution of Country *k* to the total fishing mortality level L_{Total}, normalised to one. Furthermore, the cost parameter *c* is given by $c_{Total} = \Sigma c_k$, with c_k representing the contribution of Country *k*. The relative values of c_k are determined by each country's share of the total costs, λ_k with $\lambda_{Total} = \Sigma \lambda_k = 1$. This structure allows different cost levels among countries. Finally, ε and *Y* are permitted to vary by country. This implies that demand and social costs (such as wages) can differ.

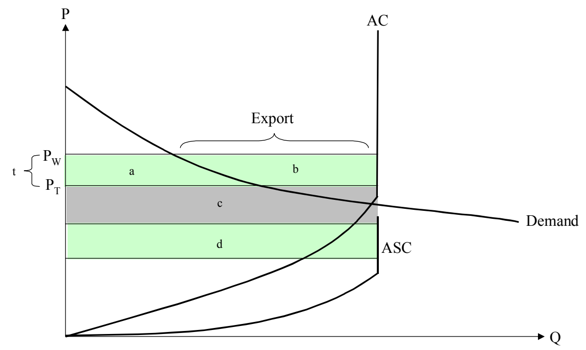
Based on the supply curves identified, the welfare effects of a price increase in Country 2, for example, caused by a trade liberalisation for that country in its export to Country 1, may be studied. The bonds that tie the two countries together are the externality from Country 2 borne by Country 1 originating from increased fishing and Country 2's role as an exporter to Country 1. Assuming that Country 2 is unable to influence the price in Country 1, since the terms of trade effect is assumed neglected, the effect is that the price in Country 2 will increase by exactly the level caused by the trade liberalisation; that is, the tariff rate removed. In Country 1 there is no price effect, but in the open access case the domestic fishery is reduced, due to the negative stock effect. Furthermore, imports from Country 2 are increased and since the price is unchanged it is implicitly assumed that the gap is filled by increased domestic production from other sources than the fishery analysed. This suggests that the fishery analysed contributes only marginally to the total supply of the homogenous fish product in Country 1. In the presence of management neither the price nor the stock is affected. In that case the only thing that happens is that imports from Country 2 together with increased domestic production from other sources replaces domestic production.

The welfare effects of trade liberalisation in Country 2, the small exporter country, are sketched in Figure 8.4 for the alternative management systems, assuming that input management is introduced at the time the catches reach the level determined by the quota.

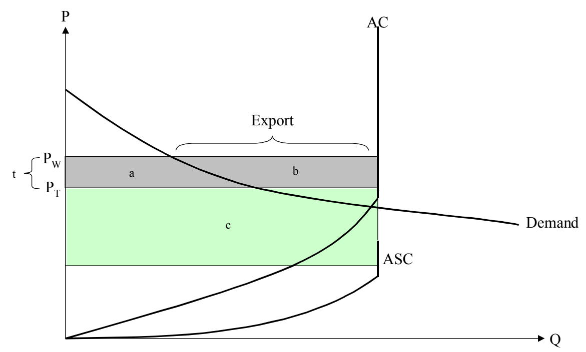
FIGURE 8.4 **Welfare effects of trade liberalisation in the small exporter country**



I. Open access



II. Regulated open access

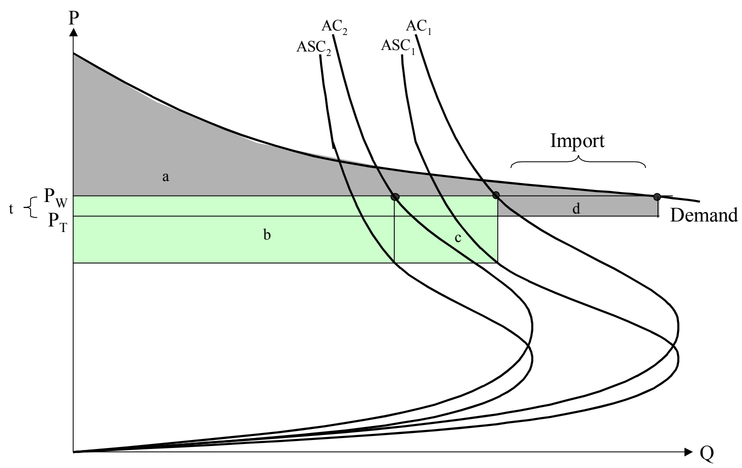


III. Regulated restricted access

The trade liberalisation is introduced in the Figure as removal of a tariff *t*, thereby increasing the price from P_T (with the tariff) to the "world" market price P_W. Under all three alternative management systems, the removal of the tariff causes a price rise in the exporter country, increases exports (shown by the horizontal bracket marking the difference between supply and demand in equilibrium) and reduces the consumer surplus (area a). In open access the change in the producer surplus is indeterminate (since area a+b+e might or might not be larger than d). In regulated open access it is zero (since it is given by the producer surplus in open access at the given level of quantity implying that area c+d=a+b+c). In regulated restricted access it is positive (area a+b>0). Since the resource rent under these management systems is either zero or by definition included in the producer surplus, the total welfare effect is indeterminate in open access (b+e–d), negative in regulated open access (–a) and positive in regulated restricted access (b). These results are as expected, except under regulated open access. The reason for the welfare loss under that management regime is that the price rise causes increased but completely inefficient investment, since its cost exactly outweighs the increased turnover. Owing to the presence of a quota, it is not possible to increase catches. In open access, the country will increase its share of the total fishing effort, giving rise to increased catches in that country, provided that the negative stock effect is not engaged. In regulated restricted access, the increased price implies rising profits, producer surplus and welfare.

The welfare effects under open access in Country 2, the large importer country, are shown in Figure 8.5.

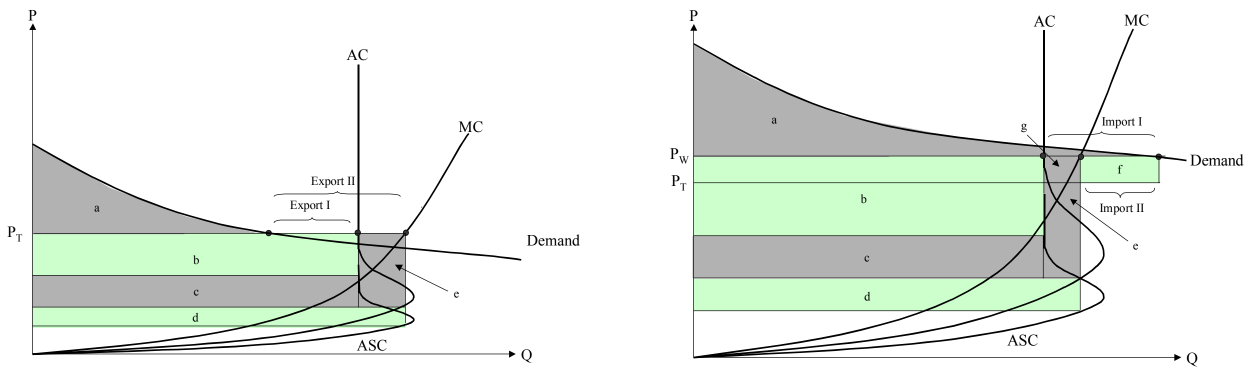
FIGURE 8.5 **Welfare effects of trade liberalisation in the large importer country with an open access shared stock.**



Welfare is affected through the negative externality which appears from the increased use of the shared stock by the other country and through the disappearance of the tariff revenue on imports. The removal of the tariff shifts the supply curve inwards, due to the negative externality. This causes the tariff revenue (area d) to disappear and imports to increase. Assuming that the remuneration of capital and labour obtains a fixed share of turnover, the producer surplus falls (from area b+c to b). The consumer surplus remains unchanged (area a) and hence the total welfare effect is negative. In the presence of management (both initially and terminally) the only welfare effect is that the tariff revenue disappears. Neither a price change nor a stock effect exists, since the country possesses an unchanged share of the catch. Thus, no matter which management system is present the welfare effect in the large importer country is negative.

The case where a hypothetical change from regulated open access to optimal management of a shared stock is introduced is sketched in Figure 8.6 for the exporter and importer countries.

FIGURE 8.6 **Welfare effects of a hypothetical shift in fisheries management from regulated open access to optimal management.**



I. Exporter

II. Importer

It is assumed that the change of management system is implemented without the trade liberalisation and that the fishery supplies only a fraction of an integrated world market (corresponding to constant price). Furthermore, since the stock is shared and each country assumed to obtain a fixed share, the supply curves under regulated open access in the two countries are alike. The curves follow the backward bending average cost curve until a certain price above MSY and are then vertical. Thus, for country one the curve remains unchanged, but for Country 2 the curve changes from an upward gradient. The reason is that given constant prices, only proportional changes can happen in catches from the two countries. In optimal management the marginal cost curve represents the supply curve and it appears that at the unchanged price (P_W in the importer country and P_T in the exporter), supply in both countries increases. Thus, exports from the exporter country increase. In the importer country imports decrease, since the country becomes more self-sufficient. At the unchanged price the effect is oversupply in both countries, implying that Country 2 must export also to other countries. The consumer surplus obtained from such exports to elsewhere are not included in the analysis.

It appears from Figure 8.6.I that the welfare change in the exporter country is given by the indeterminate change in producer surplus (d-b) and the new resource rent (b+c+e). Comparing the sum of the new resource rent and the terminal producer surplus with the initial producer surplus does, however, result in an unambiguous gain (c+d+e). Since the domestic consumer surplus remains unchanged, the total welfare effect is, as expected, positive.

The welfare effects in the importer country appear in Figure 8.6.II. The situation is the same as for the exporter country, since the change in producer surplus is indeterminate (d-b) and the new resource rent appears (b+c+e). Comparing these also gives a gain (c+d+e). The tariff revenue in the importer country is, however, reduced (from f+g to f, that is, by g). This implies that since the consumer surplus is unchanged, the total welfare effect is always positive.

3. Case study of the East Baltic cod fishery

In this section the model is applied to a case study of the east Baltic cod fishery. The fishery takes place in the Baltic Sea east of the island of Bornholm. Several countries are active in the fishery with the EU (mainly Sweden and Denmark) and Poland being the largest. The total catch was 91,000 tonnes in 2001, representing a landing value of approximately €115 million. The EU catch is used for domestic consumption, while the Polish is mainly exported as frozen fillets to the EU.

The case study is based on assumptions of biological values, economic values and parameters. The biological values are available from the International Council for Exploration of the Sea (ICES) and the economic values from various sources, as shown in Table 8.1.

TABLE 8.1 **Assumed values and parameters.**

		Total	Unit	Year classes								
				0	1	2	3	4	5	6	7	8+
	Values[1]:											
EX	Export (from Poland to EU)	15,000	Tonnes									
t_0	Trade weighted tariffs	8.3	%									
P_{EU}	Price – EU	1.41	€/kg.									
P_{Poland}	Price – Poland	1.10	€/kg.									
V_{EU}	Factor remuneration share – EU	50	%									
V_{Poland}	Factor remuneration share – Poland	35	%									
R	Recruitment	217	Million									
M	Natural mortality	0.2										
t	Cohorts and years	20										
F	Fishing mortality			0	0	0.06	0.19	0.89	1.05	1.27	1.29	1.21
N	Initial population		Million	217	178	146	122	63	22	4	1	0
W	Weight per individual		kg.	0.12	0.24	0.49	0.63	0.89	1.28	2.10	3.37	5.98
	Parameters:											
L_{Total}	Fishing mort. level – Total	1.00										
L_{EU}	Fishing mort. level – EU	0.43										
L_{Poland}	Fishing mort. level – Poland	0.35										
λ_{Total}	Cost share – Total	1.00										
λ_{EU}	Cost share – EU	0.49										
λ_{Poland}	Cost share – Poland	0.35										
z	Diff. in catch efficiency	0.68										
ε_{EU}	Price flexibility – EU	-0.23										
ε_{Poland}	Price flexibility – Poland	-0.16										

Note:1. Biological values represent an average of 1997-2001 and economic values are from 2001.

Source: Biological values known from ICES (2003ab), tariffs from OECD (2003), trade and landing prices from Eurostat (2003ab) and account statistics from Danish Research Institute of Food Economics (2002).

Exports of cod from Poland to the EU are taken from the Eurostat foreign trade statistics and the average trade-weighted tariff is calculated on the basis of OECD figures (OECD 2003). Prices are derived from landings statistics, and the share of total costs formed by the remuneration of capital and labour are derived from data held by the Danish Research Institute of Food Economics (2002).

Recruitment to the fish stock is assumed constant over time and includes 217 million individuals annually. This is also the size of the initial population for year class zero, which falls subsequently. The fishing mortality is given for twenty different year classes. It increases with age until year 6, after which it remains stable. This implies that the population almost entirely consists of fish younger than 8 years of age. The fishing mortality for fish until year 2 is zero owing to the presence of mesh-size regulation (minimum 130 mm[1]). For year classes 2-6 the fishing mortality increases gradually, since the selectivity is not knife-edge. The fishing mortality level is distributed across the countries on the basis of the countries' shares of the total catch. The total catch is distributed among countries by fixed shares of the total quota[1].

The initial distribution of costs is identified on the basis of their share of the total catch, corrected for differences in labour costs. The parameter for differences in the catch efficiency of fishermen is approximated from efficiency scores estimated with data envelopment analysis, according to Lindebo *et al* (2002). Since no such analysis is performed for the East Baltic cod fishery, the parameter is approximated on the basis of a survey of the cod fishery in the North Sea. The price flexibilities are chosen on the basis of studies summarised in Nielsen (1999).

Based on these, only the parameter, c, of the cost function is missing. The reason is, that it is determined endogenously by claiming that yield per recruit is equal to total costs per recruit with the initial fishing mortality level of unity.

Knowing that Polish exports to the EU amount to less than 2% of the consumption of cod products in the EU (Norwegian and Icelandic exports are the largest supply sources), the assumption that Poland cannot affect the “world” market price may realistically be well accounted for. This implies that terms of trade effects are absent and that products from other sources can be substituted for EU imports from

Poland. On this basis, the welfare effect of EU enlargement on the East Baltic cod market is analysed. This is done in the model with three countries included, but focusing on Poland and the EU, since Poland exports to the EU. It is assumed that the only policy that changes is that all tariffs disappear. This implies that the price of Polish exports to the EU will increase with the average trade-weighted tariff of 8.3%. Further, assuming that the increased export price pulls the Polish domestic price up by the same amount, the price difference between Poland and the EU will be reduced by 8.3%.

Welfare effects are identified for different sectors in each country. In Poland consumers obtain the consumer surplus and fishermen the producer surplus. A potential resource rent can be allocated to either the fishermen or the government, depending on how management is introduced. In the EU, consumer countries of cod obtain the consumer surplus. These include Germany and France. Fishermen in Sweden and Denmark obtain the producer surplus. The potential resource rent is obtained by either these fishermen or by the government in the two countries. Again, it is a decision to be made by the management authority. Finally, the European Union body obtains the tariff revenue.

The base year is 2001, in which the gradual tariff reduction had not started yet, and welfare effects are identified in the short run in 2004 and in the long run in 2021. 2004 is chosen since it is the first year without tariffs and 2021 since it offers a situation in which the system has moved to a new equilibrium.

Since it was shown in section two that welfare effects of liberalising trade in a capture fish product depends on the management system in place, a welfare analysis of EU enlargement on East Baltic cod trade must begin with a brief critical review of the present management system. A system is used where all the countries surrounding the Baltic Sea decide once a year on the total allowable catch (TAC) in the International Baltic Sea Fisheries Commission. Subsequently, this TAC is allocated to the single countries with a share, which has been fixed for the last five years. Simultaneously, some of the countries use input management, such as capacity limitations. Therefore, the management systems can neither be characterised as optimal management nor pure open access. The management systems might rather be characterised as regulated open or restricted access. However, ICES (2003b) has questioned the effectiveness of the management system, since it has assessed unreported catches at an average 11% above TAC over the years 1997-2001. This is in particular the case in years where the TAC is close to being 100% utilised. Furthermore, while the level of the spawning stock biomass has been outside safe biological limits in recent years, TACs have been fixed at levels above ICES recommendations. Thus, the management system has not been applied in a way that secures sustainability. Therefore, even though regulated restricted access exists, it might be more realistic to analyse welfare in an open access situation. Hence, welfare analysis is performed assuming the presence of different management systems.

On this basis the welfare effects of a landing price increase on 8.3% in Poland are studied under the following management scenarios:

1. Regulated open access.
2. Regulated restricted access.
3. Open access.

Furthermore, a fourth scenario is studied where the management is changed from regulated open access to optimal management, without liberalising trade. Scenario 1 and 2 are studied assuming that they secure the current level of catches, but under two alternative assumptions on the input management. Scenario 3 takes the incentive of increased prices to increase illegal catches into account and scenario 4 analyses the hypothetical situation where the current management system is replaced by an optimal management system, for example, individual transferable quotas, by the EU.

The model is solved for different prices and the open access supply curve for Poland becomes upward-sloping. For the EU, the supply curve remains backward bending. The long- and short-run welfare effects are identified, for the four scenarios, in Table 8.2.

TABLE 8.2 **Welfare effects from cod from the East Baltic Sea of the EU enlargement and from a hypothetical change from regulated open access to optimal management, Million Euro[1].**

	Scenarios							
	1. Regulated open access		2. Regulated restricted access		3. Open access		4 Hypothetical change to opt. man.	
	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
Poland								
Consumer surplus	-0.9	-1.0	-0.9	-1.0	-0.9	-1.0	0	0
Producer surplus	0	0	+2.7	+2.9	+0.3	+0.4	-3.0	-7.5
Resource rent[2]	.	.	.	.	0	0	+20.2	+40.0
Total	-0.9	-1.0	+1.8	+1.9	-0.6	-0.6	+17.2	+32.5
The EU								
Consumer surplus	0	0	0	0	0	0	0	0
Producer surplus	0	0	0	0	-0.7	-0.7	-12.6	-20.1
Resource rent[2]	.	.	.	.	0	0	+31.8	+64.0
Tariff revenue	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4	-0.4	-1.5
Total	-1.4	-1.4	-1.4	-1.4	-2.1	-2.1	+18.8	+42.4

Notes:
1. The initial landing values in the EU and Poland are 49.8 and 29.9 million euro, respectively.
2. The resource rent is not necessarily zero in the missing (.) cases, but, if present, included in the producer surplus.

If regulated open access is maintained both Poland and the EU lose from the tariff removal following the EU enlargement. In the EU the tariff revenue from imports of cod from Poland disappears and in Poland the consumer surplus falls because the price increase drives exports up causing fewer consumption opportunities in Poland. Under regulated restricted access the same effects result, except that a further positive producer surplus appears in Poland. This is because the price increase is converted into pure profit whereas in regulated open access the price increase is wholly wasted in inefficient investment in extra factor inputs.

It might, however, neither be reasonable to characterise the management system as regulated open access nor regulated restricted access. The reason is that some, but not all, inputs are subject to limitations. The use of fishing vessels is e.g. constrained by investment limitations. The input management is, however, not fully efficient, since other inputs including labour are not limited. Thus, the management system falls in between the two, implying that the effects of the trade liberalisation will also be in between. With total losses and gains not larger than €1.9 million under any of the management systems, the welfare effects are rather small, not exceeding 7% of the total landings value.

The characterisation of the management system as either regulated open access or regulated restricted access implicitly assumes that the increased incentive to fish illegally, in the case where prices increase, has no impact. If it did, the management system can be characterised instead as absent, that is, as open access. In open access Polish consumers still lose, but now the fishermen gain. The reason is, that the price increase will raise activity in their fishery and hence their catch, since the Polish fishermen obtain a larger share of the total stock. In the EU the disappearance of the tariff revenue remains, but now a loss of producer surplus is also seen. This is due to the negative externality from increased Polish fishing. Even when the potential for increased illegal fishing is taken into account, the total loss remains, however, negligible.

The welfare effects are identified in the three situations in the long-run where a new equilibrium after 20 years is assumed to have been reach following the trade liberalisation. The welfare effect in 2004 is also identified and it appears that 90% of the effect has already been felt after the three years.

In the hypothetical situation where a new single fishery manager takes advantage of the situation whereby the Baltic Sea, with the EU enlargement, is almost surrounded by EU countries[1] and introduces optimal management, both the EU and Poland gain. Given that regulated open access initially exists, the increase compared to current value of landings is 85% and 109% respectively. This gain appears in the form of resource rent, which goes to either the fishermen or the government. The gain from the resource rent is, however, counter-balanced by a decline in tariff revenue in the EU, due to the decrease in imports. A fall in the producer surplus is also observed in both countries, but interpreting producer surplus and resource rent as one, it becomes clear that this can be offset by a reallocation of welfare. Thus, the change in management regime increases the welfare of all sectors and is Pareto-improving. Moreover, the gain is a conservative estimate, since the consumer surplus appearing between new trade partners is not included in the analysis. In this hypothetical situation it is further clear that it takes several years to change to optimal management, since only half of the full effect is obtained after the three years.

4. Discussion

In this paper the welfare effects of the EU enlargement in 2004 have been identified for different sectors in different countries that are active on the market for East Baltic cod products, using an age-structured bio-economic model combined with basic trade theory. One effect is the relaxation of trade barriers, since all tariffs disappear. Another potential effect is that the Baltic Sea, with the enlargement, will be almost entirely surrounded by EU countries, implying that only a single fisheries manager will remain, creating the potential for the introduction of better fisheries management.

Assuming the presence of regulated open or restricted access to the fishery, it was as expected found that the welfare effect of trade liberalisation was small for all sectors in all countries. The explanation is that fisheries management in the form of quotas, input limitations and mesh-size regulations are taken into account. Even assuming open access, the welfare effects remain small. It was, however, against expectations, found that the producer surplus in Poland under open access increased (by €0.4 million), although the fall in the consumer surplus was large enough to maintain the total welfare reduction. But a sufficiently large price increase would have caused an increase in the total welfare. Such a result would have contradicted Brander and Taylor (1997a), who found that the small exporter country of a renewable resource always loses from trade liberalisation. The present result follows from the more realistic inclusion of mesh-size regulations and shared ownership. Whether the results remain valid also for other fisheries depend on whether the supply curves of the small exporter countries continue to be increasing. This may or may not be the case, dependent of e.g. the share the fishermen from such countries possess of the total catches. If improved fisheries management results from the enlargement, welfare gains would as expected be large and exceed the welfare effects following from trade liberalisations. In the case of east Baltic cod the welfare effect of the hypothetical change to optimal management is approximately twenty times larger than the effect of trade liberalisation.

The implications of these findings are two-fold, covering trade modelling and policy issues. The implications for trade modelling suggests that conclusions obtained without taking quotas, input management and mesh-sizes into account might not be valid. Neither the sign nor the size of the welfare effect might be as predicted by the Brander and Taylor theoretical approach. Welfare effects might in several and probably most fisheries be very small, as shown for the East Baltic cod stock. The direction of the welfare effects based on the age-structured approach used in this paper confirm the direction of the welfare effects following from for example, Brander and Taylor (1997ab, 1998) only under certain and in several cases unrealistic assumptions. The Brander and Taylor (1997ab, 1998) result does not hold for overexploited fish stocks with realistic mesh-sizes, since the supply curve will be approximately vertical. Thus, the neo-classical theory regains its position in the explanation of why trade in fish arises. Furthermore, in trade modelling it must be taken into account that the ownership of several fish stocks, including the East Baltic cod, is shared among countries. If this is not accounted for, stock externalities are ignored and welfare effects identified might be of the wrong direction.

The partial equilibrium approach applied consists of a supply model based on an age-structured bio-economic model combined with basic trade theory. This approach rests on an assumption of constant recruitment. This assumption has been made because, although recruitment fluctuates from year to year, biologists have not been able to identify a unique relationship between spawning stock size and recruitment (as explained in the Nordic Council of Ministers (2000)). Changed recruitment will, however, affect welfare. Furthermore, the results rest on the assumption that cod is traded directly between fishermen and final consumers, since prices at first-hand sales are the price that consumers pay. This implies that fishermen earn the producer surplus, while the final consumers earn the consumer surplus. In reality, a whole supply chain is present and welfare is earned at each market level. Therefore, for example the option of relocation of welfare-creating processing of fish following trade liberalisation, is ignored. Hence, the welfare calculated should be interpreted with due caution and only as the lower estimate.

The policy implication of the finding, that the welfare effects of trade liberalisation are small compared to the welfare gains from a hypothetical change to optimal management, indicates that the new sole fishery manager in the area should aim at introducing better fisheries management. This is much more important than trying to meet potential negative consequences of trade liberalisation, since even small improvements in fisheries management may offset the negative effects of trade liberalisation. The welfare effects of reducing non-tariff measures, such as quantitative restrictions, anti-dumping duties and price controls, could also be included in the analysis, since they can be shown to be equivalent to a tariff. This was not done, but the finding of relative inelastic supply predicts that the effects of the reduction of these measures may also be small.

The finding of small welfare effects of fish trade liberalisation in the present case follows from the inclusion of constant recruitment and age groups as well as fisheries management in the analysis and because the stock was exploited at a fishing mortality level approaching a vertical supply curve. Since these conditions are realistic for several and probably most global fish stocks the present result might also hold for these fisheries. This implies, that the conclusion of Brander and Taylor (1998) that "while we are convinced that none of our results is sufficient reason to abandon ongoing trade liberalisation around the world, we are equally convinced that trade liberalisation is a two-edged sword for a country with a comparative advantage in renewable resources and weak property rights in these sectors" should be modified for fish trade. Along the same line, the conclusion of Emami and Johnston (2000) that for example, "the World Trade Organisation should not always insist on free trade, rather they must pay careful attention to the particular relationships between trade conditions and natural resource policies among trading nations" should also be modified for fish trade. The reason is that even though the conclusions are not directly wrong, they can be seen to be less valid, since the most commonly used fisheries management systems globally are regulated open and restricted access. Most fisheries are subject to mesh-size regulations and most fish stocks globally are overexploited (FAO 2001). Hence, the argument that warns against trade liberalisation in certain situations maybe held less valid and conventional wisdom following from the neo-classical theoretical tradition is strengthened in several and probably most fisheries globally. Brander and Taylor (1997ab, 1998) and Emami and Johnston (2000) are not sufficient reason to abandon the ongoing trade liberalisation.

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