Application of the Inverse Almost Ideal Demand System to Welfare Analysis[1]

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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 (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.

Key words: Inverse Almost Ideal Demand System, Welfare analysis, Cointegration and Fish.

Table of contents

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 present paper shows some problems, when demand systems are estimated for the purpose of estimating consumer's surplus. The aim of the paper is 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. The demand system used is the inverse almost ideal demand system (IAIDS). It is shown that IAIDS is unsuitable for estimating consumer surplus. Traditionally IAIDS has been used for estimating price flexibilities in the point where a local second order approximation is conducted. However, when 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.[2] The argument that

2 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 sur-

IAIDS is unsuitable for calculating consumers surplus applies to all area. However, we will illustrate the point by estimating demand curves for fish. In estimating demand curves for fish, co-integration is used 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 can not be used for welfare analysis also apples to almost ideal demand systems (AIDS), because AIDS is also a second-order approximation to the true demand system.

Traditionally there has been little differentiation in sea-food product markets. Consumers have 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. For this purpose a market model for fish has to be established for estimating the welfare gains or/and losses of introducing sea-food labels. Here it is natural to depart from IAIDS.

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 ob-

plus. If consumers surplus for a price increase is to be calculated, positive sloped demand functions causes problems.

tained. In the present paper it is shown that IAIDS does not fulfil these conditions.

The paper is organised as follows. In section 2 a brief introduction to IAIDS is given, while an empirical example is presented in section 3. Section 4 concludes the paper.

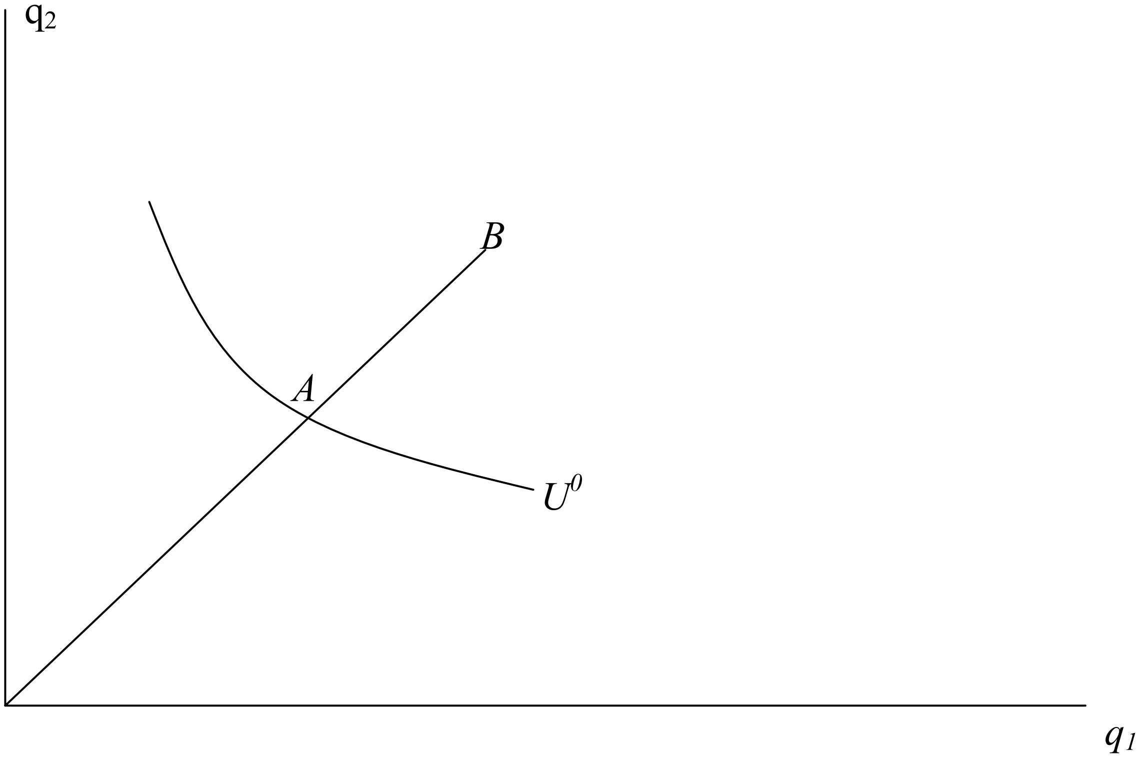
2. IAIDS[3]

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 Unnewehr (1994) suggest IAIDS. In this section the theory behind IAIDS is outlined. To recollect, the point of departure is the assumption about predetermined prices at market level. This is a priori difficult to accept in a market of fish and fish products. Therefore, a dual representation of the cost functions is selected and this representation is known as the distance function, see Deaton (1979). A distance function is sketched in Figure 1.

3 The presentation of IAIDS is, as mentioned in the introduction, brief. Therefore, it is assumed that the reader has prior knowledge of demand systems.

Figure 1: A distance function



In Figure 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 1 $D(U^0, q) = 0B/0A$.

The IAIDS starts by specifying a distance function. 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:

$$\ln D(U,q) = (1-U)\ln a(q) + U \ln b(q) \qquad (1)$$

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

$$ln\, a(q) = \alpha_0 + \sum_{j \neq i} \alpha_j \, ln\, q_j + 0.5 \sum_{i=1}^{n} \sum_{j \neq i} \gamma_{ij} \, ln\, q_i \, ln\, q_j \qquad (2)$$

$$ln\, b(q) = \beta_o \prod_{j \neq i} q_j^{-\beta_j} + ln\, a(q) \qquad (3)$$

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

$$ln\, D(U,q) = \alpha_0 + \sum_{j \neq i} ln\, q_j + 0.5 \sum_{i=1}^{n} \sum_{j \neq i} \gamma_{ij} \, ln\, q_i \, ln\, q_j + U\beta_o \prod_{j \neq i} q_j^{-\beta_j} \qquad (4)$$

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

$$w_i = \alpha_0 + \sum_{j \neq i} \alpha_j \, ln\, q_j + \sum_{j \neq i} \gamma_{ij} \, ln\, q_{ij} - \beta_i U \beta_o \prod_{j \neq i} q_j^{-\beta_j} \qquad (5)$$

where $\gamma_{ij} = 0.5(\gamma_{ij}* + \gamma_{ji}*)$.

Inversion of the distance function at optimum yields the direct utility function:

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

(5) and (6) yields the IAIDS:

$$w_i = \alpha_i + \sum_{j \neq i} ln\, q_j + \beta_i \, ln\, Q \qquad (7)$$

where

$$ln\,Q = \alpha_0 + \sum_{j \neq i} \alpha_j \, ln\,q_j + 0.5 \sum_{i=1}^{n} \sum_{j \neq i} \gamma_{ij} \, ln\,q_i \, ln\,q_j \qquad (8)$$

Eales and Unnewehr (1994) argues that (8) ought to be substituted by a Stone quantity index. If this is done, IAIDS may be written as:

$$w_i = \alpha_i + \sum_{j \neq i} \gamma_{ij} \, ln\,q_j + \beta_i \, ln\,Q \qquad (9)$$

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, (9) causes problems for welfare measurement. The reason for this is that (9) 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 (9). (9) may be written as:

$$w_i = \frac{p_i q_i}{\sum_{i=1}^{n} p_i q_i} = \alpha_i + \sum_{j \neq i} \gamma_{ij} \, ln\,q_{ij} + \beta_i \, ln\,Q \qquad (10)$$

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

$$p_i q_i = \sum_{i=1}^{n} p_i q_i (\alpha_i + \sum_{j \neq i} \gamma_{ij} \, ln\,q_j + \beta_i \, ln\,Q) \qquad (11)$$

(11) may be written as:

$$p_i q_i (1 - (\alpha_i + \sum_{j \neq i} ln\,q_{ij} + \beta_i \, ln\,Q)) = \sum_{j \neq i} p_j q_j (\alpha_i + \sum_{j \neq i} \gamma_{ij} \, ln\,q_{ij} + \beta_i \, ln\,Q) \qquad (12)$$

Solving (12) for p_i yields, the demand curve:

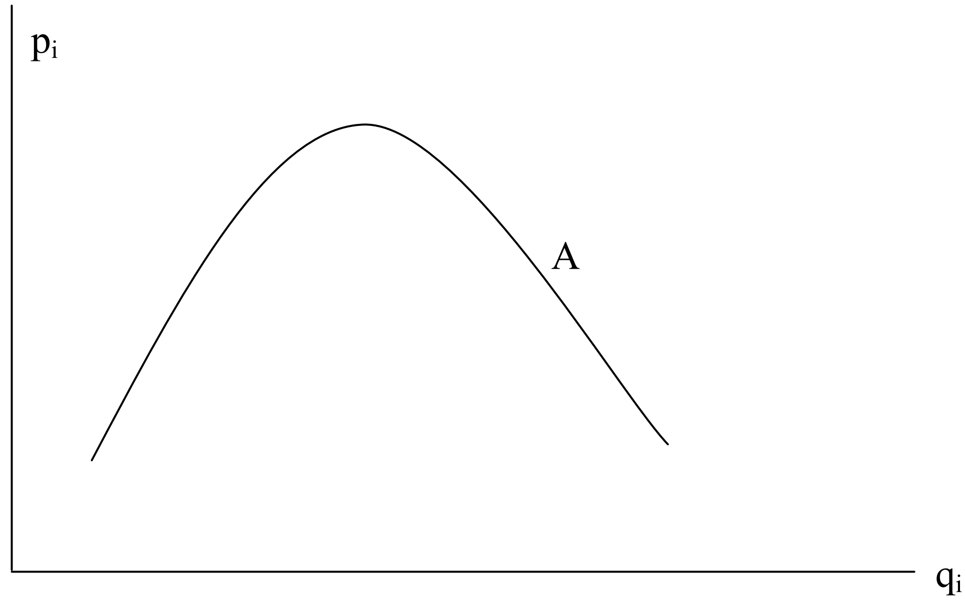
$$p_i = \frac{\sum_{j \neq i} p_j q_j (\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q)}{q_i (1 - (\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q))} \tag{13}$$

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

$$\frac{\partial p}{\partial q_i} = -.\frac{(\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q)}{(q_i)^2 (1 - (\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q))} \tag{14}$$

To interpretate (14) note that if $\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q > 1$, $1 - (\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q) < 0$ and therefore, the slope of the demand function is positive. Contrary, if $0 < \alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q < 1$, $1 - (\alpha_i + \sum_{j \neq i} \gamma_{ij} \ln q_{ij} + \beta_i \ln Q) < 0$ and the slope of the demand function is negative. Thus it is impossible on theoretical grounds a priori to determine the slope of the demand curve. This point is illustrated in Figure 2.

Figure 2: The demand curve in IAIDS



In Figure 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 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 2 is unsuitable for 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 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. In the next section this point is illustrated empirically in the case of fisheries.

3. Empirical estimations

The purpose of this section is to illustrate the theoretical finding, that IAIDS is not well suited for 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 section 3.4. discuss' whether consumer surplus can 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

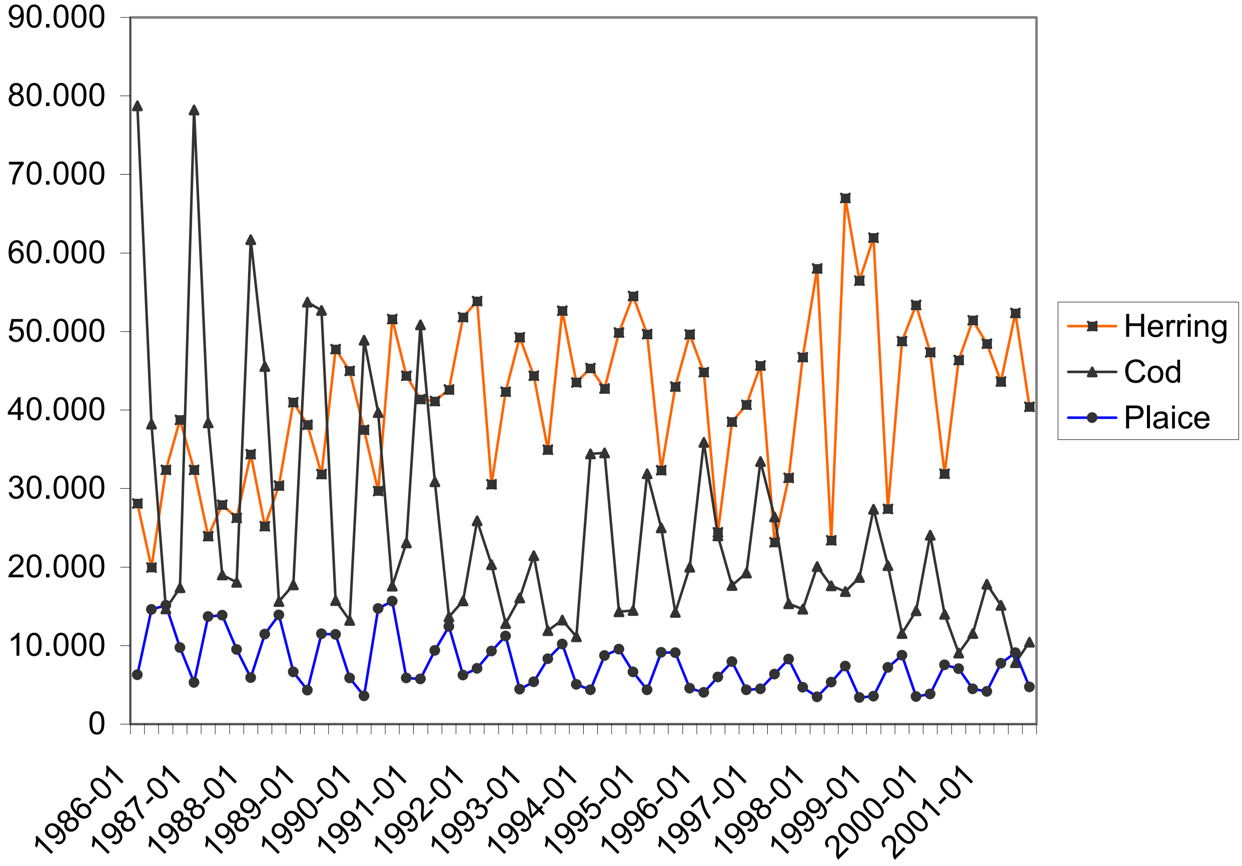
Time series on landed fish in Denmark are available for different fish species at first-hand market level from the Danish Directorate of Fisheries. Measured in value of landings, cod, herring and plaice are the most important fish species for human consumption and these species are, therefore, included 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 1.

Table 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 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 3.

Figure 3: The composition of the landings (tonnes)



From Figure 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 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.[4] 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.[5] 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 decisions 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 Unnewehr (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 (9), 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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4 A time series is non-stationary if it follows a trend.

5 In a VAR model the non-stationarity problem is solved because the model is based on a predefined 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:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-1} + \mu + \varepsilon_t \tag{15}$$

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 can not 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 (9) 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 2.

Table 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 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 3.

Table 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 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 and tested simultaneously. The LR test statistics was 56.93, clearly rejecting the restrictions. The test was also undertaken excluding the symmetry restriction. Now the LR test statistics was 27.65, again rejecting the restrictions. Therefore, the data does not support the restrictions. Eales and Unnewehr (1994) and Eales et al (1997) have also imposed the restrictions in IAIDS, but not tested these restrictions. In estimating AIDS, Hayes et al (1990), Lind (2000) and Kaabia and Gil (2001) have tested and accepted homogeneity and symmetry. However, despite the fact that homogeneity and symmetry is rejected in this paper, the assumptions are maintained due to their theoretical properties. Otherwise, the IAIDS system would not be meaningful.

The parameters of the β vector are:

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

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.

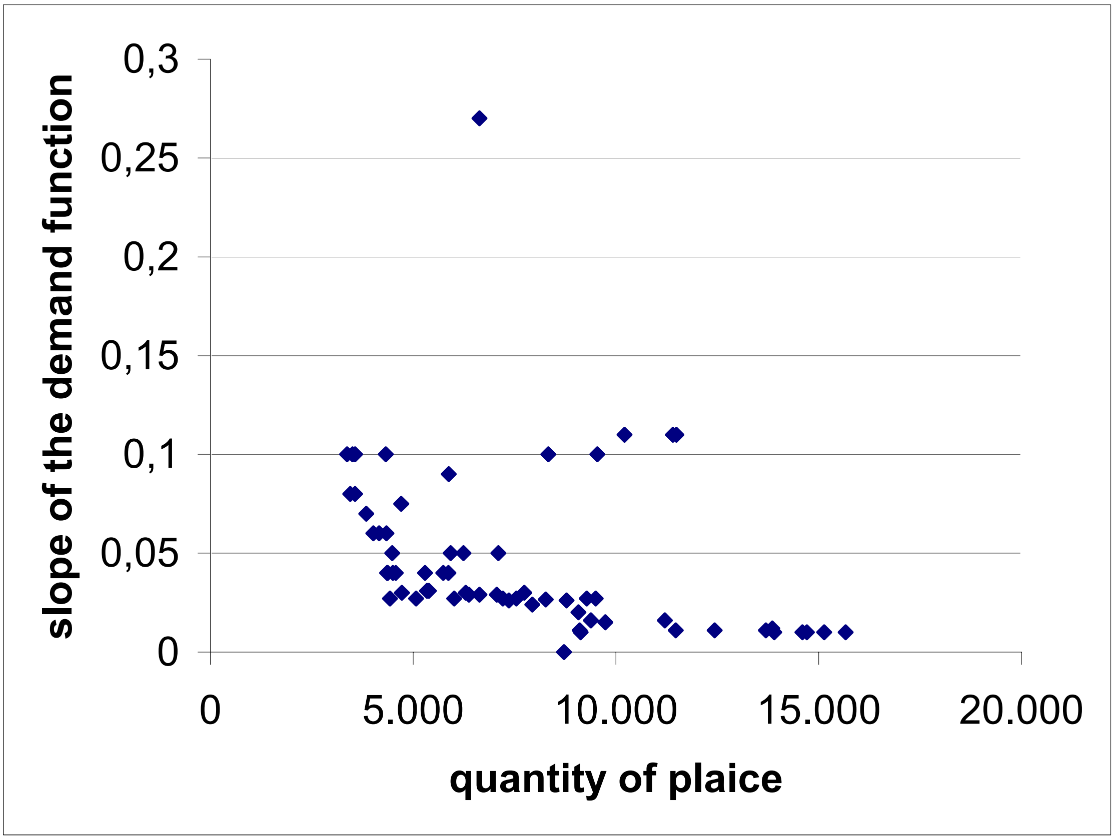
In the next section the estimated parameters are used to show whether IAIDS can be used for calculating consumer surplus.

3.4. Welfare measurement

The usefulness of IAIDS for welfare measurement is analysed in this section. For the cod market IAIDS can not 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.

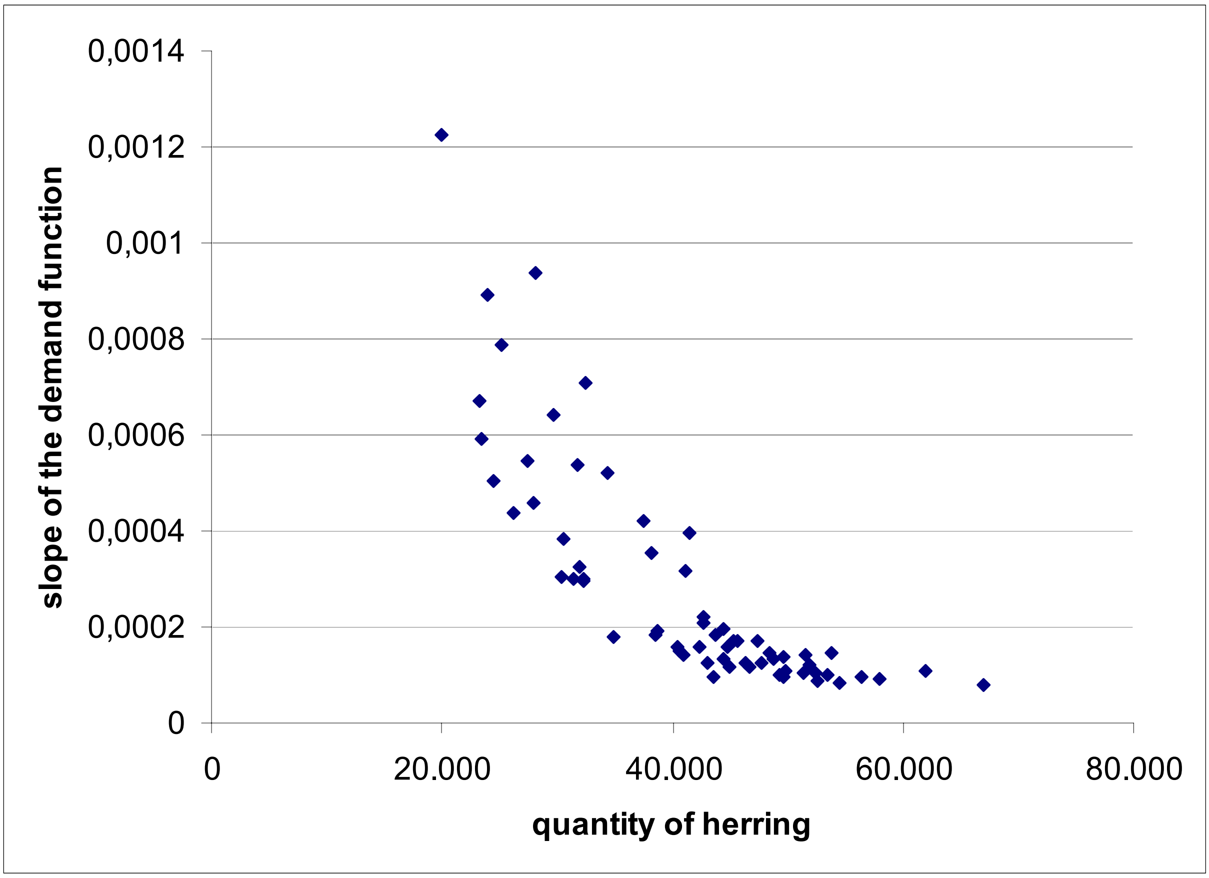
For the herring and plaice market, the slope of the demand curve can be calculated ((14)).[6] In calculating the slope of the demand function for herring and plaice, it is chosen to insert actual values for the Stone Index and the quantities for other species. If consumer surplus is going to be calculated 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 4, while Figure 5 presents the slope of the demand function for herring.

Figure 4: The slope of the demand function for plaice



6 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 5: The slope of the demand function for herring



From Figure 4 and 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 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 because the demand curve may have a positive slope.

4. Conclusion

In this paper it has been analysed whether IAIDS can be used for measuring consumer surplus. Based on theoretical arguments and on a case study where IAIDS has been estimated for three species of fish (cod, plaice and herring) it has been shown that in calculating welfare of a good, 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.

Despite the fact that IAIDS can not be used for welfare measurement, IAIDS can still be used for 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. However, when the analysis is extended away from the local approximation point, as when welfare is calculated, the demand curve may have a positive slope. The reason for this is that IAIDS is a second-order approximation to the true demand function. In estimating IAIDS, adding-up, symmetry and homogeneity are imposed as restrictions in order to secure theoretical consistency. If IAIDS is to be used for welfare measurement two additional restrictions must be added. First, it must be required that the demand curves have positive intercepts. Second, a global negative slope must be ensured.

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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