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AN ERROR CORRECTION INVERSE ALMOST IDEAL DEMAND SYSTEM: WHOLESALE DEMAND FOR FISH GRADES IN GREECE

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Abstract

Inverse demand systems explain price variations as functions of quantity variations. This paper presents a dynamic inverse AIDS model based on recent developments on cointegration techniques and error correction model. The case of fish landed at Geek sea ports appears to suit this model well. The results indicate that the underlying distance function is homothetic while the own-quantity flexibilities suggest that the responses of price to own-quantity changes are inelastic. Finally, the results of cross-quantity uncompensated flexibilities suggest that the substitution possibilities among fish grades are rather limited. The Allais interaction intensities verified the substitutability among fish grades as well.

JEL classification**:** D12 ; C32 ; C51

Key words: Inverse demand systems, AIDS, error correction model, Fish demand, Greece

1. Introduction

In industrialized economies consumers are price takers and quantity adjusters for most of the commodities and services usually purchased. In case of quickly perishable goods such as fish and fresh vegetables, the supply is virtually fixed in the short-run (Barten and Bettendorf, 1989). The use of quantity dependent (direct) systems in modeling the demand for such commodities is inappropriate. The reason is that, given a pre-determined quantity, the price must adjust in order to clear the market. The predetermination of quantities is reinforced by the fact that many perishable goods such as vegetables, fish etc are not fit for storage, even for short periods of time. An inverse demand system is then plausible.

Until the late of 1980s, inverse demand systems were typically specified in an ad hoc manner (Freebain and Rausser, 1975; Arzac and Wilkinson, 1979). The last decades the search for better specification of direct demand systems has paid much attention to the choice of functional form (translong model, Rotterdam model AIDS). Since then, based on the above specific approaches to the consumer behaviour .various specifications of inverse demand systems (dual and differential) have been formally derived and applied to commodities such as meat, fish, fresh fruits and vegetables (Eales and Unnevehr, 1994; Barten and Bettendorf, 1989; Rickertsen 1998; Fousekis and Revell, 2002). The Inverse Almost Ideal Demand System (IAIDS hereafter) developed by Eales and Unnevehr is by far the most common used model in empirical work. More recently, Moro and Sckokai (1999), augmenting common inverse demand systems to account for further non-linearities developed the Quadratic inverse demand system.

Until recently, the inverse AIDS model has been estimated with conventional econometric techniques, i.e. SUR and MLE, without paying any attention to either statistical properties of the data or the dynamic specification arising from time series analysis. As far as the direct AIDS model is concerned, the studies of Balcombe and Davis (1996), Karagiannis et al (2000) and Duffy (2003) have attempted to incorporate dynamic elements into AIDS model by relying on the statistical properties of the data. The first paper proposed the canonical cointegrating regression procedure for estimating the AIDS model and the other two represented a dynamic specification of the AIDS model based on the recent developments on cointegration techniques and error correction model (ECM hereafter). In case of inverse demand systems, we may have an analogous situation.

Applied demand analysis has been heavily influenced in recent years by the concurrent development of the huge body of literature on cointegration analysis. Modern demand studies are characterized, to an increasing extent, by the careful attention given to the time series properties of the data, and the use of model selections that allow for both short-run dynamics and the identification of long-run equilibrium positions. This paper follow a similar strategy by developing and estimating an inverse demand system based upon the ECM format for the first time according to the author's knowledge. The general approach followed is conditioned on the view that there may exists a long-run 'equilibrium' cointegrating inverse demand system which is worth identifying and estimating for it would provide an appropriate basis for testing the long-run effects of supplied quantities and/or other factors that affect the wholesale demand or the demand for perishable goods. In order to meet the above requirements (the representation and estimation of long-run preferences parameters in a cointegrating inverse demand system and the separation of short-run from long-run behaviour) this paper employs a dynamic error-correction specification of Anderson and Blundell (1982, 1983, 1984). This approach can be interpreted as one that exploits the well-known connection between cointegrated time series and their error-correction representation. In the Anderson and Blundell formulation, however, the ECM is expressed in terms of deviations from a long-run position that is described by the direct AIDS model. The Anderson and Blundell approach to the estimation of long-run relationships is preferred to the popular Johansen (1988) reduced rank regression technique. Some economists have described the Johansen approach as being too atheoretical, because it concentrates too much on statistical properties and makes little use of economic theory at least in the early stages of the specification and estimation of a model (Pesaran, 1997). Given the structure of an ECM, short-run and long-run responses can be analysed. In the empirical part, the paper provides evidence and measures for short-run and long-run flexibilities estimates for an ECM-IAIDS for wholesale fish demand in Greece.

The rest of the paper is organized as follows: The theoretical model and a short description of Greek fishery sector are presented in sections 2 and 3 respectively. The econometric results as well as the flexibility estimates are reported respectively in sections 4 and 5 while conclusions are offered in section 5.

2. The ECM-IAIDS model

In this paper of different categories of fish distinguished into three grades according to their values, it assumed weak separability of the total commodity bundle into these grades of fish on the one hand and other groups of commodities on the other hand. Thus, the demand for these grades of fish can be treaded in isolation from the demand of other products.

To derive an inverse demand system, preferences are represented by the distance function, characterizing the amount by which all quantities consumed must be changed proportionally to attain a particular level of utility. Differentiation of the distance function with respect to quantity of a particular good yields the compensated inverse demand function for that good.

Eales and Unnevehr (1994) and Moschini and Vissa (1992) followed this approach and developed an inverse AIDS. The expenditure share w_i of a good i is given by:

$$w_i = \alpha_i + \sum_{j=1}^{n} \mathrm{g}_{ij} \ln q_j + b_i \ln Q \qquad (1)$$

where q_j is the quantity of good j. The quantity index lnQ is defined by:

$$\ln Q = \alpha_0 + \sum_{k=1}^{n} \alpha_k \ln q_k + 0.5 \sum_{k=1}^{n} \sum_{j=1}^{n} g_{kj} \ln q_k \ln q_j \qquad (2)$$

Since the sum of shares across ***i*** is unity by definition, the parameters of (1) and (2) must satisfy the following adding up restrictions $\sum_i \alpha_i = 1 \;\; \sum_i g_{ij} = \sum_i b_i = 0$ while the restriction of homogeneity $\sum_j g_{ij} = 0$ and symmetry $\mathrm{g}_{ij}=g_{ji}$ can be easily imposed or tested.

To capture seasonal effects, likely to be important in fish demand, the α_i's are augmented with three seasonal dummies $\boldsymbol{D}_k$ (k=2,3,4) whose associated coefficients must sum to zero over i for adding up. Thus the form of model that was employed for the estimation of the parameters and flexibilities is given by the following equation:

$$w_i = \alpha_i + \sum_k d_{ik} D_k + \sum_{j=1}^{n} \mathrm{g}_{ij} \ln q_j + b_i \ln Q \qquad (4)$$

where the quantity index lnQ now is given by:

$$\ln Q = \alpha_0 + \sum_{j=1}^{n} (\alpha_j + \sum_k d_{jk} D_k) \ln q_j + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln q_i \ln q_j \;\text{[1]} \qquad (5)$$

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[1] Eales and Unnevehr (1994) footnote 13 on page 109

In the present approach equation (4) are regarded as the long-run inverse demand equations. For that reason, the time subscript has been omitted and it is important to recognise that the coefficients represent the long-run effects of the explanatory variables on budget shares. The short-run dynamic profile of responses to changes in quantities and total expenditure is modelled through an error-correction specification. This specification allows for a flexible pattern of non-uniform market responses to supplied quantities over time by allowing for short-run dynamic adjustments of the pattern of demand towards long-run equilibrium.

Firstly, it is necessary to investigate the time series properties of the data used in Eq. (1) before specifying the most appropriate dynamic form, in order to be able to formally assess whether the long-run demand relationships are economically meaningful or merely spurious. Initially, the number of unit roots should be identified for each individual time series (i.e. the order of integration). This may be implemented by employing various tests such as the Dickey-Fuller, the augmented Dickey-Fuller (Dickey and Fuller, 1981) and Phillips-Perron (Phillips, 1987; Perron, 1988) tests.

Whether both $\boldsymbol{w}_i$ and the vector of explanatory variables are integrated to the same order, cointegration may be established for all fish categories. However, it is also possible to have a cointegration regression even thought the variables of interest have a different time series properties and thus, a different order of integration. According to Granger representation theorem, a linear combination of series with a different order of integration may consist a cointegration regression. Therefore, ultimate time-series properties are not a necessary condition to proceed further. If, however, cointegration cannot be established for at least one share equation, we cannot proceed further and more likely a different model specification may used or data set should be enlarged.

Having established the cointegration, a dynamic modeling procedure is recommended by Anderson and Blundell (1982) and Duffy (2003). The Eq.(4) can be written in matrix notation as:

$$w_t = \mathbf{\Pi} x_t \qquad (6)$$

where $\boldsymbol{w}_t$ is the n-vector of budget shares; $\boldsymbol{x}_t$ is a k-vector of intercept, quantities, total expenditure variables and seasonal dummies; and **Π** is the (*n*x*k*) matrix of long-run IAIDS equation parameters. Eq. (6) represents the long-run equilibrium position. In the short-run, after changes in any of the elements of $\boldsymbol{x}_t$, the system may be ‘out of equilibrium’ for some periods as full adjustment to the equilibrium is delayed by inertia that is due to habits and/or imperfect information. However, the demand system as a whole may be classified as ‘cointegrating’ if any such disequilibria diminish towards zero for all products over time. This dynamic process of adjustment may be modeled by a vector-autoregressive distributed lag (VARDL(z, r)) model:

$$\boldsymbol{C}(L)w_t=\boldsymbol{A}(L)x_t+e_t \qquad (7)$$

Where **C(**L) and **A**(L) are matrix polynomials of order z and r, respectively, in the lag operator L and e_t is an independent identically distributed random disturbance vector. Determining the value of r is often accomplished by estimating an initial, relatively high-order VARDL, then testing down for shorter maximum lags in an attempt to obtain a parsimonious, but data consistent model. According to Johansen (1995), a relatively low-order VAR models will generally suffice in cointegration analysis of seasonally unadjusted data. Hence, in the present paper was decided to carry out all estimation and inference within the context of a first order VARDL (z=1). This does not mean that the dynamic response of demand to a change in quantities is constrained to achieve long-run equilibrium in a short period of time. So, a general first-order dynamic model may be written as:

$$w_t = A_1 x_t + A_2 x_{t-1} + C w_{t-1} + e_t \qquad (8)$$

where $\mathbf{A_1}$, $\mathbf{A_2}$ and $\mathbf{C}$ are appropriately dimensioned matrices.

The last equation can be written as an error-correction model by:

$$\Delta w_t = A_0 \Delta x_t - \Phi[w_{t-1} - \Pi x_{t-1}] + e_t \qquad (9)$$

where $\mathbf{A_0} = \mathbf{A_1}$, $\mathbf{\Phi} = (\mathbf{I} - \mathbf{C})$ and $\mathbf{\Pi} = [\mathbf{I} - \mathbf{C}]^{-1}[\mathbf{A_1} + \mathbf{A_2}]$ and $\mathbf{\Delta}$ represents the first difference operator and e_t is assumed to be characterized by a singular independent and identical distribution over time.

Although equations (8) and (9) are observationally equivalent the convenience of using (9) over (8) is that the error correction model has the crucial advantage of yielding direct estimates of long-run parameters which are the focus of attention in this paper. Due to the fact that all budget shares sum to unity, Eq. (9) cannot be estimated since the right-hand side variables in each equation are perfectly collinear. Anderson and Blundell (1982, 1983) derive a number of restrictions that must be imposed on Eq (8) in order for estimation to be feasible. The error correction term (in the square brackets) being the deviations of actual budget share in the previous period $\boldsymbol{w}_{t-1}$ from the values that were desired on the basis of the information available then, $w^*_{t-1} - \Pi x_{t-1}$ (where the asterisk denotes a desired value). Consumers in the current period attempt to change $\boldsymbol{w_t}$ from its value in the previous period $\boldsymbol{w}_{t-1}$, with the aim of closing some of the gap that may existed between $\boldsymbol{w}_{t-1}$ and its desired level w^*_{t-1}. These adjustments move budget shares in the direction of their desired values, eventually establishing long-run equilibrium with $\mathbf{w}=\mathbf{\Pi x}$. The impact of new information on prices, quantities, expenditures or even for non-price variables such as nutrition information, stocks etc., is captured by the first term on the right-hand side of (9), $\mathbf{A}_0\mathbf{\Delta x}_t$

Matrix $\mathbf{\Phi}$ is the adjustment coefficient matrix and indicates the speed of adjustment of the *i*th budget share towards its desired value. It should be noted that the adjustment coefficient parameters (Φ_{ik}) are of full dimension, implying that the speed of adjustment of *i*th budget share will depend on the extent of disequilibrium in all the budget shares. The own adjustment coefficients (Φ_{ii}) are expected to be negative The cross-adjustment coefficients Φ_{ij} ($i \neq j$) measure the extent to which adjustments in a particular budget share depend on the deviations from equilibrium of other budget shares in the system. Following Burton and Young (1992), a restricted form of the model (termed diagonal adjustment) can be investigated by setting $\Phi_{ik}=0$ for $i \neq k$. However, in this form of the model, according to Bewley (1986), adding up implies that $\Phi_{ik}=\Phi_{kk}$ hence there is the same adjustment coefficient (Φ_{00}) for each share. The negative sign of the adjustment coefficient indicates that the deviations from the long-run equilibrium are corrected within the time period.

3. Description of the Greek Fishery

Fishery sector contributes a 0.36 percent to Greece’s GDP (in current prices 1997) and a 4.4 percent to its Gross Agricultural Product. Also, the employment in this sector represents 1.2 percent of the total national employment and 5.1 percent of the employment in the primary sector. Despite, its low contribution in terms of GDP and employment, the fishery sector in Greece is consider to be a significant one due to the fact that it promotes the economic and social cohesion of remote inshore areas such as the small islands in the Aegean and Ionian sea.

The National Statistical Service of Greece (NSSG) distinguishes the Greek fleet between three types of fishing vessels, namely, the overseas, the opensea, and the inshore ones. The fleet of overseas vessels includes large boats 24 – 65m in length that fish mainly in the Atlantic Ocean and to a lesser extent in the Persian Gulf and in the Indian Ocean. The open-sea vessels include trawlers, purse seines and mixed operating in the international water of Mediterranean Sea (trawlers 20 – 25m long) and in Greek and international opensea waters (trawlers and purse seines 11 –25 long). The inshore fleet comprises of small-sized boats (4-15m long) that are self sufficient for 24 hours and operate in the mainland sea – shores and island coast. According to the NSSG (1998) 85 percent of the country's fishing vessels, that is 6914 vessels, belonged to the inshore fleet[2]. Also, 12.459 persons were involved in inshore fishing (which constitutes 73 percent of total employment in the fishing sector). The inshore fleet contributes 39 percent of total landings and 48 percent of the total value of landing. The high share of the total value must be attributed to the fact that inshore vessels target high value species compared to the other segments of the national fleet.

The production of overseas and open sea vessels is marketed mainly through the Greek fish auction while the landings from the inshore fleet are marketed directly to the local markets and/or consumers, as well as, to fish auctions. One of the main

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[2] NSSG excludes vessels with engine < 19 HP.

structural problem facing the fish market is the small number of wholesalers that control the entire fish market in auction halls.

The Common Structural Fisheries Policy was established in 1983 introducing a common measure for restructuring, modernising, and developing the fishing industry and for developing aquaculture. One of the key instruments for its implementation was the system of Multiannual Guidance Programmes (MGPs). The first of these programs were adopted over the period 1983-86, having as an objective to stabilise or to reduce the fleet capacity by the end of the season. In the case of Greece, the new regulation was more restrictive than the existing one in granting support, Thus, small fishermen, the majority of the total number in Greece, were essentially excluded from support aiming at restructuring and modernisation. In addition, investment plans had to be within the framework of the approved by the European Commission MPGs. In any case, priority was given to the replacement of older vessels and was not encouraged the increasing of vessel capacity in tonnage or in engine power. The establishment of MPGs I, II and IV in Greece resulted to the substantial reduction of fishing fleet (20% in trawlers and 15% in overseas fishing vessels).

The quarterly data for the empirical analysis comes from the bulletin *Results of the Sea Fishery Survey by Motor Vessels* published by the National Statistical Service of Greece (NSSG) and covers the period 1971(1) to 1998(4). Fish landed by the domestic fleet are distinguished by NSSG into three grades namely ‘First’, ‘Second’ and ‘Third’ according to their quality. The ‘First’ grade includes high-value species, the ‘Second’ medium value and the ‘Third’ grade low value species. It is noted that the same data set has been used by Fousekis and Karagiannis (2001) for the estimation of a differential inverse demand system. A list of the species classified in terms of value is presented in Appendix.

The evolution of the budget shares for the three fish grades over the data period is reported in Figure 1. Ignoring the patterns results from the seasonality, it is clear that up to the middle of 70's the shares for the three grades of fish have remained more or less unchanged. Thereafter, the share of the *Second grade* have followed an downward trend while the share of the *Third grade* fish have followed an upward trend until the end of 90's. The budget share for the *First grade* category was relatively constant until the end of 1990, a point time where we observe a drop. The decline of fish landings for the three categories is mainly due to the different approach that NSSG used to estimate the total production and secondly to the implementation since 1992of MPGs.

(Figure 1 here)

4. Econometric results

The results related with the time-series properties of these data are reported in Table 1. Based on the augmented Dickey-Fuller test (ADF), the hypothesis that all the variables in Eq.(1) contain a unit root cannot be rejected at 10% significant level. When first differences are used, unit root non-stationarity was rejected at the same level of significance. This indicates that the levels of all tested variables are non-stationary i.e. I(1). The next step is to test for cointegration between the variables of Eq (1) using the Engle and Granger (1987) methodology. The results of cointegration test are reported in the third column of the Table 1. According to these results, all budget shares are cointegrated with fish quantities at 10% significant level. Cointegration ensures that shocks affecting fish quantities will be reflected on different expenditure shares in the similar way showing that these variables are moving together in the long-run and obey an equilibrium constraint.

(Table 1 here)

Having established that all variables are I(1) process and cointegrated, the ECM form of the inverse AIDS model can be formulated. The inverse demand systems by construction satisfy the adding up conditions. As a result, the error covariance matrix is singular and one equation has to be dropped for the estimation. For the purpose of this study, the demand equation for ‘third’ has been dropped[3]. Then, it was checked if the restricted dynamic model (diagonal adjustment) is preferred. According to LR test, the diagonal adjustment model is accepted.[4]. Thus the form of the model that was employed for the estimation of the parameters and flexibilities is given by the following equation:

$$w_i = w_{it-1} + \Phi_{00}\{w_{it-1} - (\alpha_K + \sum_k \delta_{ik} D_{kt-1} + \sum_j \gamma_{ij} \ln q_{jt-1} + \beta_{i0} \ln Q_{t-1})\} + \sum_k d_{ik}(D_{kt} - D_{kt-1}) + \sum_j g_{ij}(\ln q_{jt} - \ln q_{jt-1}) + b_{i0}(\ln Q_t - \ln Q_{t-1}) + u_t \qquad (9)$$

where the quantity index *lnQ* now is given by Eq. (5).

The model was estimated by non-linear maximum likelihood method of SHAZAM 7.0 econometric package.

(Table 2 here)

An interesting property of demand systems is homotheticity. When the underline distance function is homothetic, the cost shares and the normalized prices of the goods in the bundle are independent of the total volume available (Eales and Unnevehr, 1994). Homotheticity, therefore implies that all scale effects are equal to the respective budget shares or equivalently, that all scale flexibilities are equal with minus one. For the ECM-IAIDS model, both short-run and long-run homotheticity require the test of the hypothesis $\beta_{i0} = b_{io} = 0$ where i denotes the ‘First’ and the

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[3] The empirical results are not robust to the choice of equation to be dropped.

[4] The Log Likelihood values of Full and Diagonal adjustment models are 565,41 and 562,25respectively while the critical values of χ^2distribution with 3 degree of freedom at 5% and 1% significant level are 7,81 and 11,34 respectively.

‘Second’ grade of fish. Here, a Wald test (Judge et al, 1988) has been used to test these properties. The results of the homotheticity tests (short-run homotheticity, long-run homotheticity and homotheticity in both short and long-run) are presented in Table 2. For all hypotheses, the theoretical values of χ^2 are found smaller than the critical values which mean that the homotheticity cannot be rejected. Evidence of homotheticity in wholesale level demand found in previous studies of Barten and Bettendorf (1989) and Brown et al (1995) (scale effect close in magnitude to cost shares) without however, the homotheticity hypothesis to be formally tested. Also, it must be noted that the hypothesis of homotheticity was not rejected in Fousekis and Karagiannis (2000) using differential inverse model.

5. Flexibility estimates

In the inverse demand systems, sensitivities are measures by flexibilities (Houck, 1965). According to Anderson (1980) and Eales and Unnevechr (1994), price flexibilities are defined as the percentage changes in normalized prices (prices divided by total expenditure) caused by 1 per cent change in the consumption of that good. Scale flexibilities are the analogue to expenditure elasticities in the ordinary demand systems. It shows the percentage change in the normalized price of that good in response to a proportionate change in the consumption of all goods. The uncompensated price flexibility, f_{ij} and scale flexibility, f_i are calculates as:

$$f_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + \frac{\beta_i}{w_i}(\alpha_j + \sum_k \gamma_{kj} \ln q_k) \qquad (10)$$

$$f_i = -1 + \frac{\beta_i}{w_i} \qquad (11)$$

where δ_{ij}=1 for i=j and δ_{ij}=0 otherwise. The compensated price flexibilities f^*_{ij} may be calculated as:

$$f^*_{ij} = f_{ij} - w_j f_i \qquad (12)$$

The equations (11) and (12) are referred in the calculation of the short-run price and scale flexibilities. For the calculation of long-run price and scale flexibilities we substitute the estimates parameters γ_{ij} and β_i by the long-run ones g_{ij} and b_i respectively.

(Table 3 here)

Table 3 presents the short-run and the long-run parameter estimates from the homothetic dynamic model. In order the dynamic model to be consistent with the underling theory, the theoretical restrictions of homogeneity and symmetry are imposed *a priori* both in the short and the long-run. According to Burton and Young (1992), in the short-run symmetry is expected to not hold. In contrast if homogeneity did not hold in the short-run, an equal increase in all quantities and expenditure would cause the system at equilibrium to diverge and then return to the same equilibrium. The vast majority of the estimates are statistically significant at 5% significant level. The estimated parameter of the error correction term Φ_{00} is statistically significant with negative sign indicating that deviation from the long-run equilibrium is corrected within the time period. The rather low speed of adjustment toward equilibrium (27%) is due to the market structure as it has been point out above. The small number of wholesale traders in auction halls, in line with the perishable nature of fish products, drives the market to operate under oligopsonistic conditions.

(Tables 4 and 5 here)

Apart from the scale elasticities[5] which are constrained in the homothetic dynamic model, the estimates of short-run and long-run uncompensated price flexibilities (calculated at the sample mean) as well as, their asymptotic standard errors, are reported in Table 4 and 5 respectively[6]. The short-run own-price flexibilities for all fish grades are found to be negative and statistically significant and thus the corresponding inverse demand curves are downward sloping. Also, the price flexibilities are substantially lower than minus one suggesting inelastic responses in normalized prices to own-quantity changes. In other words, for the landings of the 'First' grade (Fish A') the uncompensated own-quantity flexibility is estimated to be -0.55 which means that a 1% increase of the supplied quantity leads to a 0.55% decrease in the marginal value of that category. Additionally, if the supplied quantity of 'Second' and 'Third' grade fishes (Fish B' and C' respectively) increase by 1%, the marginal value of those categories of landings will decrease by 0.77% and 0.56% respectively. The long-run own-price flexibilities are found also negative and statistically significant. It is interesting to be noted that for the three fish grades with short and long-run inelastic demand exhibited only minimal changes in quantity responses between the short and long-run. Given that short-run flexibilities are smaller than their long-run counterparts for all fish grades, the LeChatelier principle holds[7]. Inelastic own-responses of fish demand have been reported among others, Eales *et al* (1997) for Japan, Barten and Bettendorf (1989) for Netherlands and Fousekis and Karagiannis (2001) for Greece. The calculated elasticities indicate that policies concern the increase of marketed quantity of fish from open sea are expected

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[5] The unconstrained Short-run and Long-run scale flexibilities as well as their asymptotic standard errors for the three fish grades are respectively: First: -1.00 (0.10242) and -1.05 (0.10242) Second: -1.18 (0.3646) and -1.19 (0.3646) and finally for Third:-0.85 (0.35509) and -0.80 (0.31155).

[6] It must be point out that, these are conditional elasticities and must be interpreted as such.

[7] The LeChatelier principle states that long-run demand functions are more price and expenditure sensitive than their short-run counterparts. Thus, at the optimum price and expenditure elasticities are greater in long rather than short-run (Silberberg, 1992 pp. 216-222)

to have only slightly impacts on the normalized prices. As it was decrypted above, one of the main problems of Greek fish market is the oligopsonistic condition exists in the market. Thus in the context of Third Community Support Framework for Greek fishery, it would be preferable if there was a measure financing the establishment of producer groups in order to market their production by themselves and not through the wholesaler. Such a measure, in line with the existing one targeting to the increase by 20% of the landings that are marketed via fish auctions might have serious impacts in the normalized fish prices.

(Tables 6 and 7 here)

Figures 2 and 3 present the short-run and long-run elasticities over the data period[8]. Ignoring the patterns resulting from the seasonality, it is clear that in the period under consideration, there were no tremendous changes in quantity responses for all fish grades in the sense that there are no interchanges between elastic and inelastic counterparts both in short-run and long-run. Specially, in the short-run for the first grade fish there is tendency for less quantity sensitive behaviour by wholesale traders. In the long-run, even if the fluctuations resulting from the seasonality have been eliminated, there is also a tendency for the first grade fish for more inelastic behaviour especially after the end of 90's a point time that the budget share of this fish category have followed a downward trend as it was mentioned above.

(Figures 2 & 3 here)

Tables 6 and 7 present the short-run and long-run compensated quantity flexibilities respectively. The negative signs of the compensated own–quantity flexibilities for the three fish grades ensure the concavity of the underling distance function. All the short and long-run cross-quantity compensated flexibilities are found

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[8] Tables with calculated short-run and long-run own price flexibilities with their asymptotic standard errors for the entire period under consideration are available from the author upon request

negative and statistically significant. The negative sign indicates gross substitution relationships between the three fish grades (Hicks, 1956) as *a priori* it was expected to hold. Barten and Bettendorf (1989) argue that the cross-quantity compensated (Antonelli) effects in differential systems are imperfect indicators of the relationships among goods. This is because the homogeneity restriction, along with the negative semi-definiteness of the Antonelli matrix entails dominance of positive cross-quantity compensated effects (i.e. dominance of complementarity). As they point-out a slightly superior indicator has been proposed by Allais (1943). Allais essentially worked with the transformation of the Hessian matrix such that the result is invariant under the monotone transformation of the utility function and can be considered to reflect interactions within the preference order independently of how it is represented. He also proposed a measure of the intensity of interaction namely:

$$a_{ij} = \frac{a_{ij}}{\sqrt{a_{ii} a_{jj}}} \qquad (13)$$

where

$$a_{ij} = f^{*}_{ij} / w_i w_j - f^{*}_{rs} / w_r w_s + (f_i / w_i - f_r / w_r) + (f_j / w_j - f_s / w_s) \qquad (14).$$

In Eq. (15) *r* and *s* refer to some standard pair of goods *r* and *s*. The scalar $\boldsymbol{\alpha}$ makes α_{rs}=0. Thus, $\alpha_{ij}>0$ indicates that *i* and *j* are more complements than r and s, while $\alpha_{ij}<0$ reflects that *i* and *j* are stronger substitutes than *r* and *s*. Clearly $\alpha_{ij}=0$ means that *i* and *j* have the same type of interactions as *r* and *s*. Allais coefficients for the three fish grades in Greece are reported in Table 8. We have selected as standard pair the interaction between the ‘Second’ and ‘Third’ grade fish. Diagonal entries of the table by construction are -1 consistent with the notion that a good is its own perfect substitute. All Allais interactions appear to be negative which expresses the intuitive idea that all the grades of fish considered here are substitutes. The interactions intensities for the other two pairs ‘First’ and ‘Second’ as well as, ‘First’ and ‘Third’ grade landings, are found to be very close (0.45 and 0.46 respectively). This means that the substutability between the three fish grades are more or less the same.

(Table 8 here)

6. Concluding remarks

This paper has been concerned with the specification and estimation of a dynamic inverse AIDS model based on the recent developments on data statistical properties and cointegrating techniques. According to the author knowledge, for first time it is attempted the incorporation of an error correction mechanism in an inverse demand system. Short-run dynamic adjustments to long-run equilibrium positions are modeled via a first order inverse error correction model, which separates short-run from long-run behaviour and allows the long-run parameters to be estimated directly. In order the model to be consistent with the demand theory, the theoretical restrictions of homogeneity and symmetry were imposed *a priori* in the model in the short-run and the long-run as well. Based on the Greek wholesale demand data over the period of 1971(1) to 1998(4), it was found that the rather low speed of adjustment towards to the long-run equilibrium is mainly due to the fish market structure with the low number of traders operating in this market. To analyse demand structure, the selected model has been subjected to homotheticity test. This test indicates that the underline function is homothetic in all fish grades. The own-price flexibilities in the long and short-run are lower than one (in absolute value terms) suggesting inelastic responses of the normalized prices to own-quantity changes. The estimated long-run own-price elasticities are in general quite plausible and similar to estimates that have been reported in other studies. The cross-price uncompensated flexibilities are all negative indicating substitutability something that was verified using the Allais coefficients.

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References

Allais, M., 1943. Traite d'économic pure, tome I (Imprimerie Nationale, Paris)

Anderson, W., R., 1980. Some theory of inverse demand for applied demand analysis. *European Economic Review.* **14**, 281-290

Anderson, G. and Blundell, R., 1982. Estimation and Hypothesis testing in a dynamic singular equation systems. *Econometrica.* **50**, 1559-1571

Anderson, G. and Blundell, R., 1983. Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada. *Review of Economic Studies.* **50**, 397 - 410.

Anderson, G. and Blundell, R., .1984. Consumer non durables in the U.K.: a dynamic demand system. *Econ. Journal*, **94** (Conference paper Supplement), 35-44

Arzac, E., and Wilkinson, M. 1979. A quarterly econometric model for US livestock and feed grain markets and some of its policy implications. *Amer. Jour. of Agricl Econ.* **61**, 297-308

Balcombe, K. and Davis, J. R., 1996. An application of cointegration theory in the estimation of the almost ideal demand system for food consumption in Bulgaria. *Agric. Econ.* **15**, 47-60

Barten, A.P., and L.J. Bettendorf 1989. Price formation of Fish: An Application of an Inverse Demand system. *Eur. Econ. Rev.* **33**, 1509-25.

Bewley, R., 1986. *Allocation models*: *Specification, Estimation and Applications*, Cambridge Mass. Ballinger

Brown, G., Lee, J. and Seale, J. 1995. A family of Inverse Demand Systems and Choice of Functional Form. *Emp. Econ.* **20**, 519-530

Burton, M. and Young, T. 1992. The Structure of Changing Tastes for Meat and Fish in Great Britain. *Eur. Rev. of Agric. Econ.* **19**, 165-180

Deaton, A.S., 1979. The Distance Function in Consumer Behaviour with Application to the Index Numbers and Optimal Taxation. *Rev. of Econ. Stud*, **46**, 391-405

Dickey, D.A. and Fuller, W. A., 1981. Likelihood Ratio statistics for Autoregressive time series with unit root. *Econometrica*, **49**, 1057-1072

Duffy, M., 2003. Advertising and food, drink and tobacco consumption in the United Kingdom: a dynamic demand system. *Agric. Econ.* **28**, 51-70

Eales, J.S. and Unnevehr L.J., 1994. The Inverse Almost Ideal Demand System. *Eur. Econ. Rev.* **38**, 101-15.

Eales, J., Durham, C. and Wessels, C. (1997) Generalized models of Japanese demand for Fish. *Amer. Jour. of Agric. Econ.*, **79**, 676-88

Engle, R.F. and Granger, C.W.J., 1987. Cointegration and the error correction: Representation, estimation and testing. *Econometrica* **55**, 251-276

Freebairn, J. and Rausser, G., 1975. Effects of changes in level of US beef imports. *Amer. Jour. of Agric. Econ.* **57**, 676-688

Fousekis, P. and Karagiannis, G. 2001. Wholesale Level Demand for Fish Grades in Greece. *Appl. Econ. Let.* **8**, 479-482

Fousekis, P., and Revell, B. 2002. Primary Demand for Red Meats in the U.K. *Cah.s d'Econ. et Soc. Rur.* 63:2 31-50

Johansen, S., 1988, Statistical analysis of cointegrating vectors. *J. Econ. Dyn., Control*, **12**, 231-254

Johansen, S., 1995, Likelihood-based inference in Cointegrated vector auto-regressive models. Oxford University Press, Oxford

Judge, G., Hill, R., Luthkepohl, H. and Lee, T. 1988. *Introduction to the Theory and Practice of Econometrics*, John Wiley, Chichester

Hicks, J., R., 1956. A revision of demand theory. *Oxford University Press*, Oxford

Houck, J., P., 1965. The relationships of direct price flexibilities to direct price elasticities. *Jour. of Farm Econ.* **47**, 301-321

Karagianni, G., Katranidis S. and K. Velentzas, 2000. An error correction almost ideal demand system for meat in Greece. *Agric. Econ.* **22**, 29-35

Moschini G. and Vissa, A., 1992. A linear Inverse Demand System*, Amer. Jour. of Agric. Econ.* **17**, 294-302

Moro, D. and Sckokai, P., 1999. A Quadratic Inverse Demand System. *AAEA, Annual meeting*, Nashville, TN, Aug. 8-11

Pesaran , M.H., 1997. The role of economic theory in modeling the longs run. *Econ. Jour.* **107**, 178-191

Perron, P.P., 1988. Trends and random walks in macroeconomics time series : Further evidence and implications, *J. Econ. Dyn. Control.* **12**, 279-332

Philips, P.P., 1987. Time series regression with a unit root. *Econometrica*, **55**, 277-301

Rickertsen, K., 1998. The Effects of Advertising in an Inverse Demand System: Norwegian vegetables revisited. *Eur. Rev. of Agric. Econ.* 129-40

Silberberg, E., 1992. The Structure of Economics: A Mathematical Analysis, 2nd ed., McGraw-Hill Publ. Co, New York

Table 1: Tests for Unit roots and Cointegration‡

	Unit Root test		Cointegration test
	Levels	**First Difference**	**(t-test)**
w_1	-2.32	-6.86	-5.21
w_2	-1.73	-7.29	-4.54
w_3	-2.13	-7.21	-4.76
$\ln q_1$	-1.70	-6.79	
$\ln q_2$	-1.55	-6.54	
$\ln q_3$	-0.42	-6.50	

‡Note: Unit root is based $\Delta x_t = \alpha + \beta x_{t-1} + \gamma Time + \sum_j^n \theta_j x_{t-j} + u_t$ In this equation x_t denotes the variables concerned the Eq.(1) Table 1 reports the γ_t statistic (Dickey and Fuller, 1981). The test for no cointegression is given by a test for a unit root in the estimated residuals $\hat{u}_t$. The augmented Dickey-Fuller regression equation is given $\Delta\hat{u}_t = a_0\hat{u}_{t-1} + \sum_j^2 \phi \Delta\hat{u}_{t-j} + v_t$. In Table 1 a *t-ratio* test for α_0 is reported for each equation The econometric package used was SHAZAM 7.0 and for the unit roots tests the critical value at 10% significant level is -3.13 and for cointegration test -4.15

Table 2: Homotheticity tests

H_0	$x^2_{0,05}$	Degree of Freedom	Critical values	P value	Conclusions
$b_1=b_2=0$	0.22	2	5.99	0.8972	Accepted
$\beta_1=\beta_2=0$	0.34	2	5.99	0.8425	Accepted
$b_1=b_2=\beta_1=\beta_2=0$	1.02	4	9.48	0.9075	Accepted

Table 3: Parameters estimates from homothetic model

g_{11}	0.1454	(0.0140)†	α_1	0.8584	(0.1556)
g_{12}	-0.0213	(0.0084)	α_2	0.1748	(0.1870)
g_{13}	-0.1241		α_3	-0.0332	
g_{21}	-0.0213	(0.0084)	γ_{11}	0.0905	(0.0337)
g_{22}	0.0677	(0.0096)	γ_{12}	-0.0401	(0.0180)
g_{23}	-0.0464		γ_{13}	-0.0504	
g_{31}	-0.1241		γ_{21}	-0.0401	(0.0180)
g_{32}	-0.0464		γ_{22}	0.0446	(0.0180)
g_{33}	0.1705		γ_{23}	-0.0045	
d_{11}	1.1571		γ_{31}	-0.0504	
d_{12}	-0.2902	(0.0525)	γ_{32}	-0.0045	
d_{13}	-0.3185	(0.0530)	γ_{33}	0.0550	
d_{14}	-0.5484	(0.0943)	δ_{11}	-0.0528	
d_{21}	0.7893		δ_{12}	-0.8133	(0.0273)
d_{22}	-0.2810	(0.0485)	δ_{13}	1.9486	(0.0291)
d_{23}	-0.1330	(0.0300)	δ_{14}	-1.0825	(0.0258)
d_{24}	-0.3753	(0.0711)	δ_{21}	1.6136	
d_{31}	-1.9465		δ_{22}	-1.2879	(0.0388)
d_{32}	0.5712		δ_{23}	1.0527	(0.0447)
d_{33}	0.4515		δ_{24}	-1.3784	(0.0356)
d_{34}	0.9237		δ_{31}	-1.5608	
Φ_{00}	-0.2725	(0.0484)	δ_{32}	2.1012	
			δ_{33}	-3.0013	
			δ_{34}	2.4609	

†Numbers in parentheses are standard errors. Standard errors of certain coefficients are omitted because the associated coefficients have been derived from the theoretical restrictions. The DW statistics are 2.18 and 1.83.

Table 4: Uncompensated Short-run price flexibilities

		f_{ij}	
Fish A'	**-0.547***	**-0.066***	**-0.386***
	(0.0437)†	(0.0259)	(0.0636)
Fish B'	**-0.073***	**-0.766***	**-0.159***
	(0.0288)	(0.0331)	(0.0475)
Fish C'	**-0.319***	**-0.169***	**-0.561***
	(0.0526)	(0.0355)	(0.0805)

†Standard error * Statistically significant at 5% significance level

Table 5: Uncompensated Long-run price flexibilities

		f_{ij}	
Fish A'	**-0.718***	**-0.124***	**-0.156**
	(0.1049)†	(0.0561)	(0.1477)
Fish B'	**-0.138***	**-0.846***	**-0.015**
	(0.0621)	(0.0618)	(0.0878)
Fish C'	**-0.129**	**-0.011**	**-0.858***
	(0.1222)	(0.0656)	(0.1741)

†Standard error * Statistically significant at 5% significance level

Table 6: Compensated short-run price flexibilities

		f_{ij}^*	
Fish A'	**-0.226***	**-0.223***	**-0.002**
	(0.0437) †	(0.0259)	(0.0636)
Fish B'	**-0.247***	**-0.476***	**-0.228***
	(0.0288)	(0.0331)	(0.0475)
Fish C'	**-0.017**	**-0.170***	**-0.172***
	(0.0526)	(0.0355)	(0.0805)

†Standard error * Statistically significant at 5% significance level

Table 7: Compensated long-run price flexibilities

		f_{ij}^*	
Fish A'	**-0.397***	**-0.165***	**-0.231***
	(0.1049) †	(0.0561)	(0.1477)
Fish B'	**-0.183***	**-0.556***	**-0.372***
	(0.0621)	(0.0618)	(0.0878)
Fish C'	**-0.191**	**-0.278***	**-0.470***
	(0.1222)	(0.0656)	(0.1741)

†Standard error * Statistically significant at 5% significance level

Table 8: Long-run Allais coefficients

	Fish A'	**Fish B'**	**Fish C'**
Fish A'	-1	-0.46	-0.45
Fish B'		-1	0
Fish C'			-1

Figure 1: Evolution of budget shares of fish grades over the data period

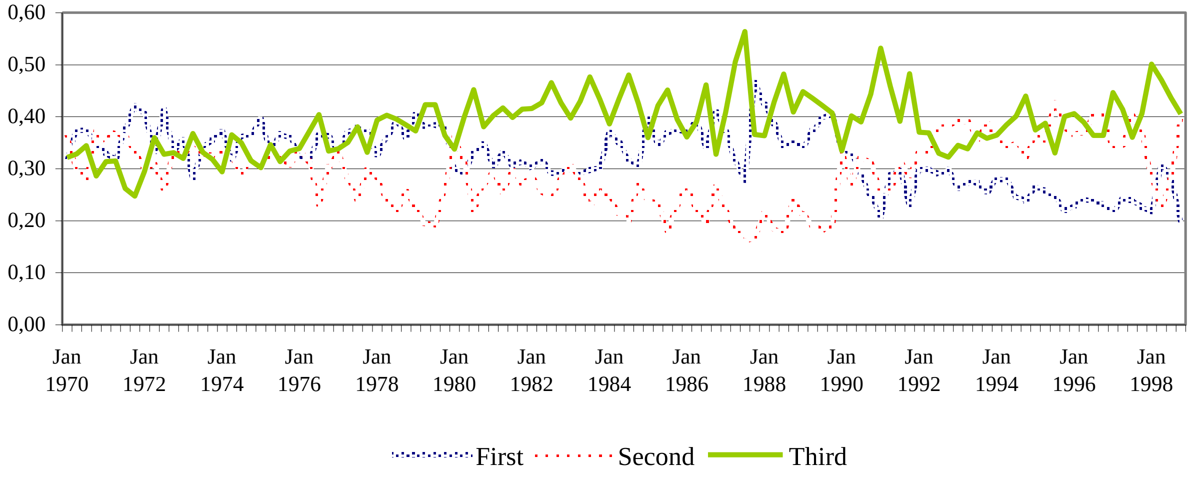


Figure 2: Evolution of short-run own-price flexibilities of fish grades over the data period

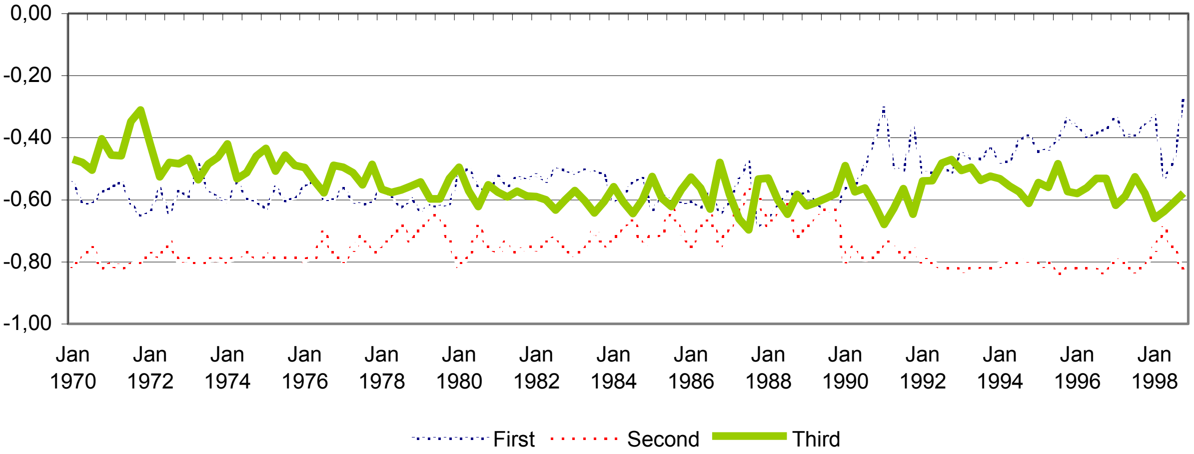
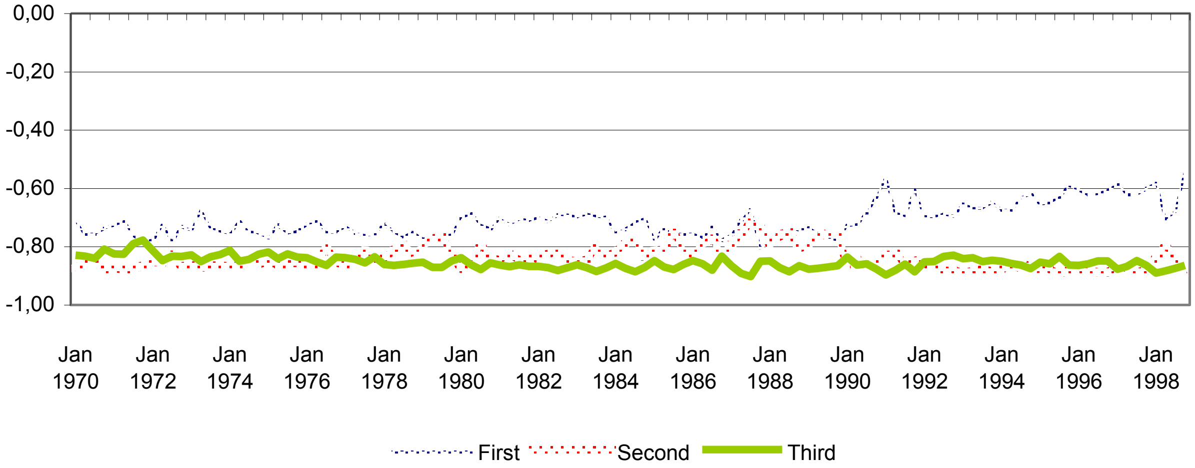


Figure 3: Evolution of long-run own price flexibilities of fish grades over the data period



APPENDIX

Landings classification according to their value

FIRST GRADE	SECOND GRADE	THIRD GRADE
Bass	Bay scallop	Anchovy
Common prawn	Black bram	Anglefish
Common sea bream	Black sea bream	Black mouth godfish
Crayfish	Bluefish	Blotched pickerel
Dog's teeth	Club markerel	Bogue
Dusky sea perch	Common Gray muller	Bonito
Lobster	Common squid	Brill
Red bream	Croaker	Comber
Red muller	Dog fish	Couch's fish bream
Red sea bream	Goatfish	Couch's whiting
Showrfish	Grouper	Crab
Shrimp	Gurnard	Cuttle fish
Sole	Hake	Daouki
	Markerel	Eel
	Mussel	Flying squid
	Octapus	Garfish
	Scorpion fish	Gild sardine
	Shapper	Goldline
	Tub fish	Guitarfish
	Tune fish	Horse markerel
	Warty venus	Jack markerel
	Whire bream	John dory
	Yellowtail	Large eyed dog's teeth
		Others
		Others Fish
		Oyster
		Pickerel
		Pilchard
		Poulp
		Rassa
		Skipjack
		Sprat
		Stone bass
		Thornback ray