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# Demand Characteristics for Imported Cod Products in Portugal Frozen, Salted & Dried and Salted

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# Working Paper No. 09/15

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**An Application of PCAIDS and Demand Growth Index Modelling**

**by**

**Frank Asche and Daniel V. Gordon**

SNF Project No. 5228
Competion, cluster and market analyses for the salted cod and salted and dried cod industry

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# Demand Characteristics for Imported Cod Products in Portugal Frozen, Salted & Dried and Salted

An Application of PCAIDS and Demand Growth Index Modelling

Frank Asche and Daniel V. Gordon

NFR-prosjekt 233840 - Competion, cluster and market analyses
for the salted cod and salted and dried cod industry.

*Abstract*:

The demand function represents the fundamental building block in economics and provides important information for investment and policy purposes. The aim of this paper is to characterize and measure the demand structure for imported cod products to Portugal. A PCAIDS model is used to identify own- and cross-price elasticities of demand for frozen, salted & dried and salted cod products. The estimated elasticities of demand are then used in combination with a demand growth index to measure shifts in demand overtime impacting price of product.

Results suggest that over the period of study a strong positive shift in demand for frozen product doubling the price of the product relative to the initial period. But both imported salted & dried and salted product show overall negative shifts in demand decreasing price and may represent a structural shift towards frozen product.

*Keywords*: Imported Cod Products, PCAIDS, Market Growth, Portugal

## Introduction

The purpose of this paper is to identify and measure demand characteristics for imported cod products in Portugal. Portugal has a long history of fishing cod but the introduction in 1977 of the exclusive economic zone (EEZ) imposed by many costal states reduced drastically the cod harvest by the Portuguese fleet and increased Portuguese imports of cod products (Bjørndal *et al*., 2015). Portugal imports cod from many countries primarily in three forms; frozen, salted and salted & dried (klippfisk) but consumption of cod is primarily as a salted & dried product (see Asche, et al., 2007).

Norway is the major producer and exporter of salted & dried cod but Portugal also produces of its own salted & dried cod based on imported frozen or salted cod. In this paper, the interest is twofold; first, in measuring the elasticity of demand for imported frozen, salted and salted & dried cod and, second in measuring shifts or growth in demand for imported product. The price elasticity of demand will provide a measure of how sensitive import demand is to changes in own-price, whereas the cross-price elasticity of demand will allow a measure of how sensitive import demand is to changes in price of other imported cod products. Once own-price changes are accounted for, additional movements or shifts in the demand function are a measure of the growth in market demand for imported cod products. The growth in market demand may be caused by changes in income or price of substitutes, or a change in preference for the product (Bjørndal *et al.*, 2014).

It is common in economics to measure elasticities based on the Almost Ideal Demand System (AIDS) modelling framework[1] of Deaton and Muellbauer (1980). The AIDS model can incorporate the theoretical properties of the demand structure within the estimated model. However, to estimate a full and exhaustive AIDS model requires information on quantity, price and expenditure on all commodities within the market structure of interest. The data

[1] See Wellman (1992) for an example of AIDS modelling in the fishery.

available here for analysis provides information only on quantity and price of select codfish products exported to Portugal. For this paper, a version of the Proportionally Calibrated Almost Ideal Demand System (PCAIDS) model as developed by Epstein and Rubinfeld (2002, 2004) is used. The PCAIDS model maintains many of the economic structure of the AIDS structure but when data is limited or incomplete, it is designed as a calibrated simulated model used to recover demand elasticities. Coloma (2006) shows a regression procedure using incomplete data to provide an initial estimate for calibration of the PCAIDS model.

Marsh (2003) shows a straightforward technique for measuring growth in market demand using an index approach. The technique is a decomposition of a change in quantity demanded between the percentage change accounted by a price change along (i.e., a movement allow the demand curve) and the percentage change accounted by a shift in the demand curve. Asche, et al., (2011) provide an example of the technique applied to demand growth for Atlantic salmon in the French market.

The paper is organized as follows. The next section describes the data available for analysis and reports summary statistics to identify and characterize the Portuguese market for imported cod. This is followed by a brief description of the PCAIDS and market demand index models used to measure elasticities and import demand growth. The final section offers discussion.

**Data and Summary Statistics**

The data available for investigation are obtained from Eurostat and provided by the Norwegian Seafood Council[2] and covers all countries' exports of frozen, salted & dried and salted cod to Portugal for the period 1990-2013. The data are available monthly but for presentation the data are aggregated to an annual basis. Cod is harvested and processed in

[2] We thank Kristin Lien for providing data.

only a few countries, but Cod products can pass through many countries on the way to Portugal. The transportation and transaction for cod products depends on costs, taxes and European /import regulations. To show how the assigned country of origin has changed over the period of analysis, Table 1 reports the country of origin share for cod product exports to Portugal for major suppliers, select years 1990 -2013. For frozen product, in 1990, Spain and the US were the major countries of origin for exports to Portugal, but by 2013 Netherlands has taken the top spot. On the other hand, Norway and to a lesser extent Denmark and Iceland were the major countries of origin for salted & dried and salted cod products but by 2013 Sweden dominates both markets. Product from the Netherlands, Sweden and Denmark largely represents transshipment of fish originating in countries such as Norway, Iceland, Russia, the US and Canada (Bjørndal and Ellingsen, 2015).

Table 1: Assigned Country of Origin; Share of Cod Products

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2013 |
|---|---|---|---|---|---|---|
| | | | Frozen | | | |
| Netherlands | 0.0 | 0.008 | 0.0 | 0.015 | 0.224 | 0.494 |
| Russia | 0.0 | 0.526 | 0.511 | 0.408 | 0.135 | 0.075 |
| Spain | 0.149 | 0.101 | 0.02 | 0.115 | 0.188 | 0.208 |
| US | 0.414 | 0.044 | 0.22 | 0.287 | 0.322 | 0.101 |
| | | | Salted & Dried | | | |
| Denmark | 0.217 | 0.388 | 0.75 | 0.155 | 0.021 | 0.149 |
| Norway | 0.427 | 0.432 | 0.662 | 0.218 | 0.017 | 0.012 |
| Spain | 0.232 | 0.108 | 0.171 | 0.072 | 0.041 | 0.081 |
| Sweden | 0.0 | 0.0 | 0.01 | 0.379 | 0.792 | 0.623 |
| | | | Salted | | | |
| Iceland | 0.231 | 0.130 | 0.482 | 0.172 | 0.069 | 0.048 |
| Netherlands | 0.041 | 0.005 | 0.008 | 0.134 | 0.224 | 0.262 |
| Norway | 0.159 | 0.626 | 0.195 | 0.051 | 0.001 | 0.003 |
| Sweden | 0.0 | 0.0 | 0.0 | 0.085 | 0.449 | 0.471 |

Figure 1 (a, b, c) shows annual quantity (tonnes) imports of frozen, salted & dried and salted cod, respectively (note different units on vertical axis).[3] The three figures show

[3] Portugal also imports other cod products (fresh fillet, fresh whole, frozen fillet, frozen fish meat) that accounts for about a 3% share of the total imported cod market.

different patterns of development for each of the three products. On the one hand, both frozen and salted & dried show a general increase over the period but frozen product shows considerable variation over time starting from a very low level of only 7,000 tonnes in 1990 to a high of 55,000 tonnes in 2006,then dropping to under 40,000 tonnes in 2011 to increase again to about 50,000 tonnes in 2013. Salted & dried cod shows a very stable import path from 1990 to the mid 2000s, however, for the period 2006-08 imports fall by about 9,000 tonnes to rise again to over 30,000 tonnes by 2013. On the other hand, salted product shows a serious and steady decline in imports from a high of 66,000 tonnes in 1996 to less than half this quantity (24,000 (t)) in 2013.

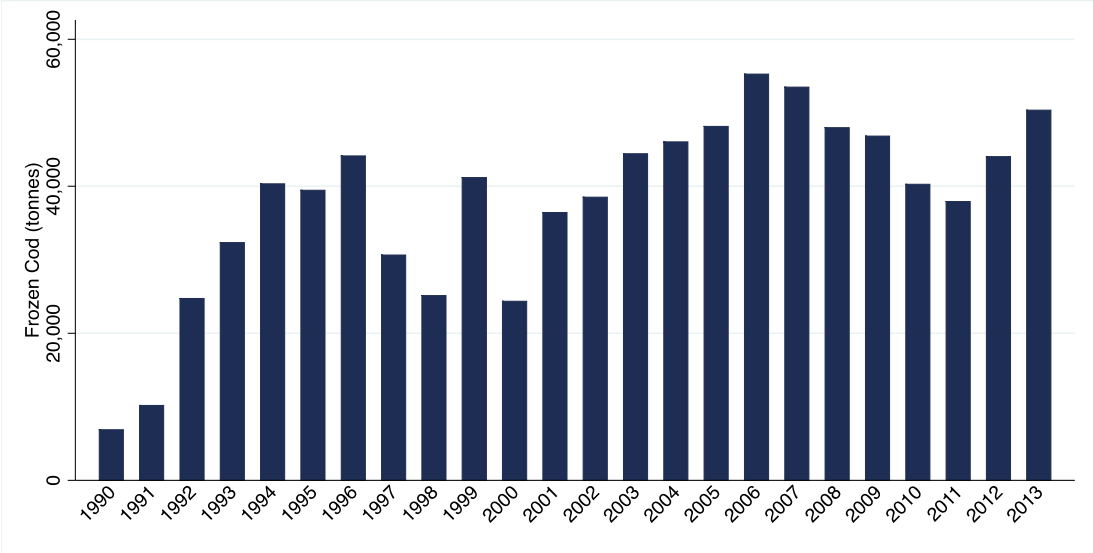


Figure 1a: Total Imports of Frozen Whole Cod to Portugal: 1990-2013

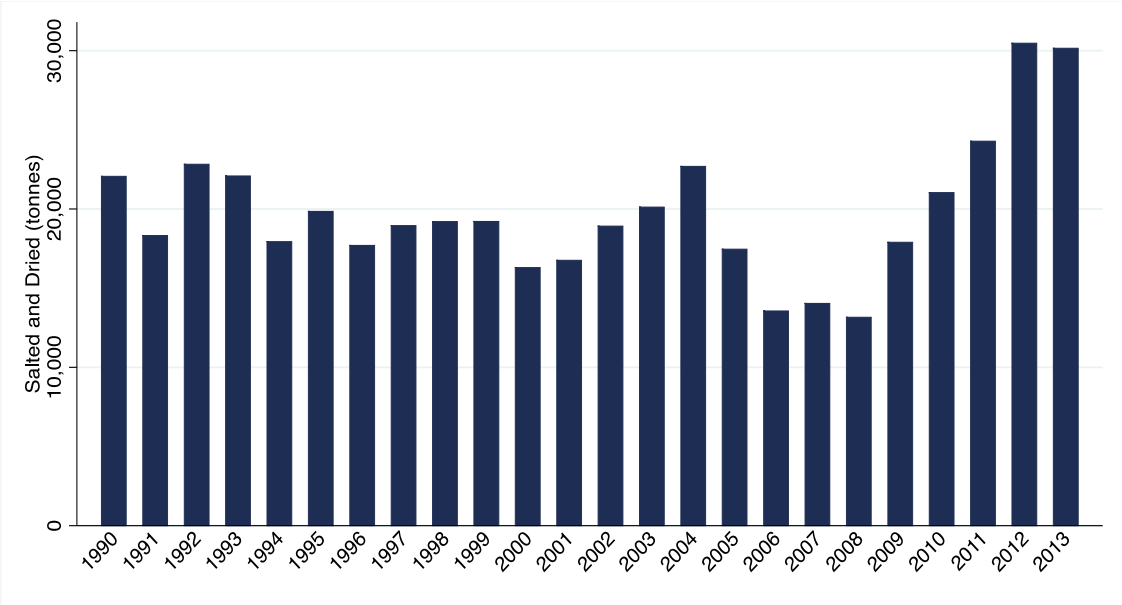


Figure1b : Total Imports of Salted & dried Cod to Portugal: 1990-2013

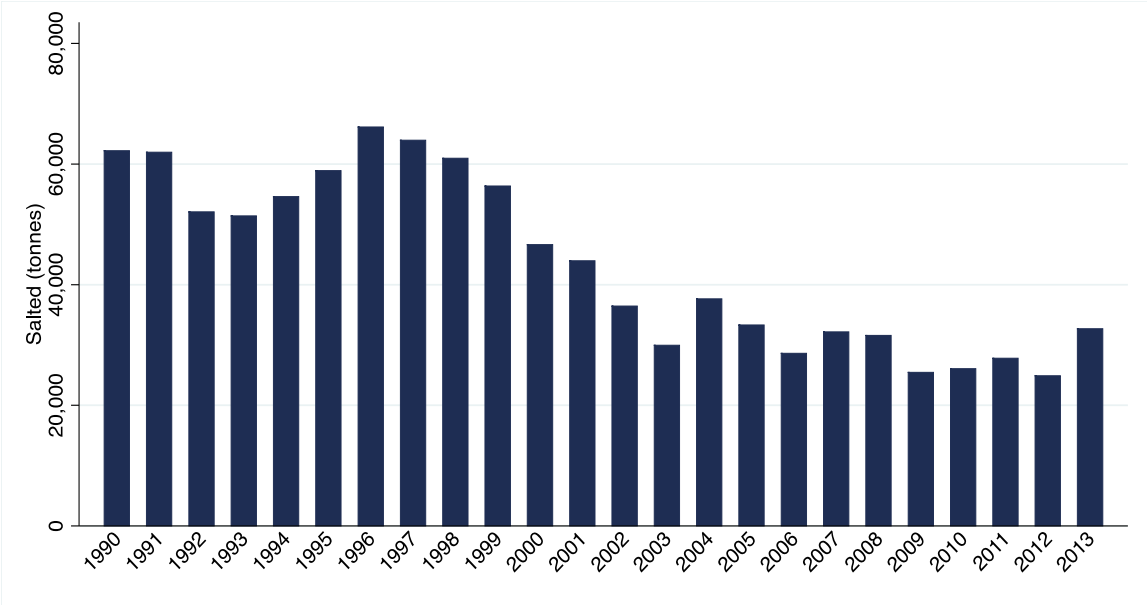


Figure1c : Total Imports of Salted Cod to Portugal: 1990-2013

Figure 2 (a, b, c) reports the real revenue[4] (i.e., nominal revenue divided by CPI) received by export suppliers for frozen, salted & dried and salted cod product, respectively over the reporting period. Figure 2a shows that revenue from frozen product does not follow

[4] Prior to 1999 Eurostat uses a normalization or conversation ratio for Portuguese Escudo/Euro to define a virtual Euro.

the upward trend of frozen cod import. We do observe revenue increasing up to the end of the 2008, reaching a high of € 195 million in 2007 but thereafter a drastic fall in revenue for the period 2009-13 that averages only 100 million € per year.

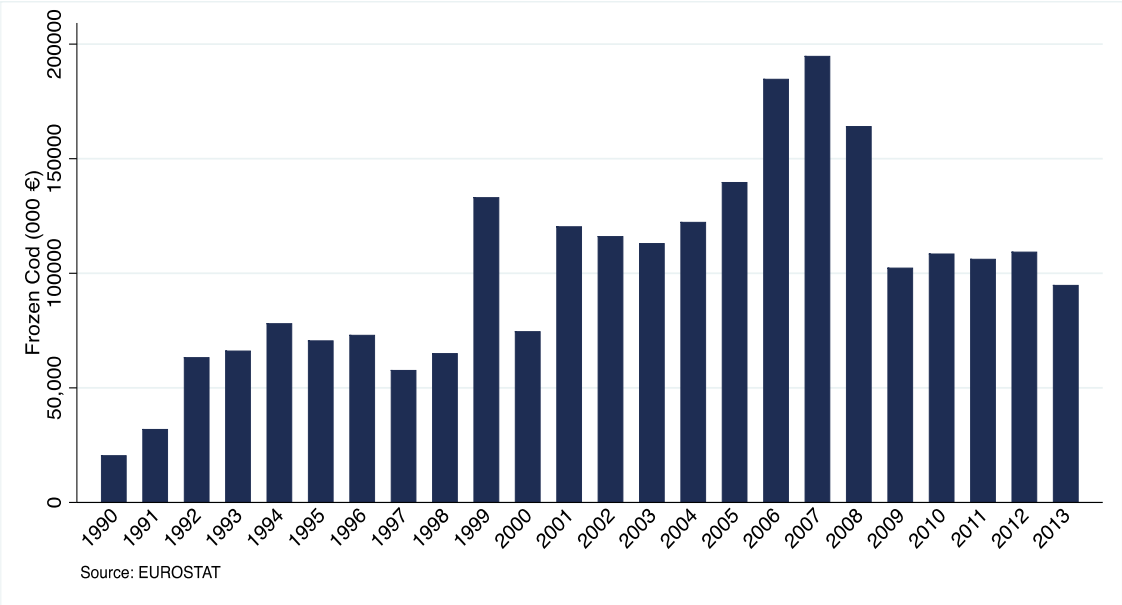


Figure 2a : Real Value (000 € ) Frozen Whole Cod Imports to Portugal: 1990-2013.

Figure 2b reveals that the real revenue value for salted & dried product actually fell in the early 1990s from over 200 million € in 1990 to just over 100 million € in 1997. As observed for the rest of the period through to 2013, there is some variation in revenue averaging somewhat less than 150 million €, particularly 2006 -2009.

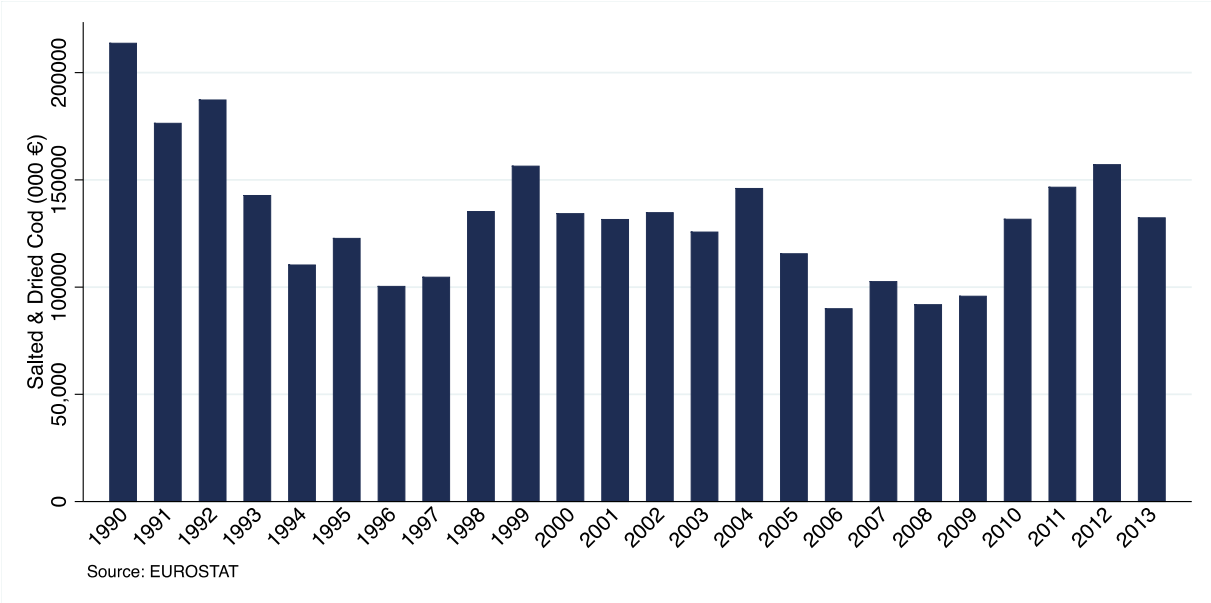


Figure 2b: Real Value Salted & Dried Cod Imports to Portugal: 1990-2013

Figure 2c shows that the real revenue value of salted cod has declined over the period in line with the downward trend in imported salted cod. We observe a high of over 430 million € in 1991 to just over 100 million € in 2009; subsequently there is little variation in real revenue. The reduction in 2009 can be attributed to the financial crisis that had a major impact on the Portuguese economy (Bjørndal *et al*., 2015).

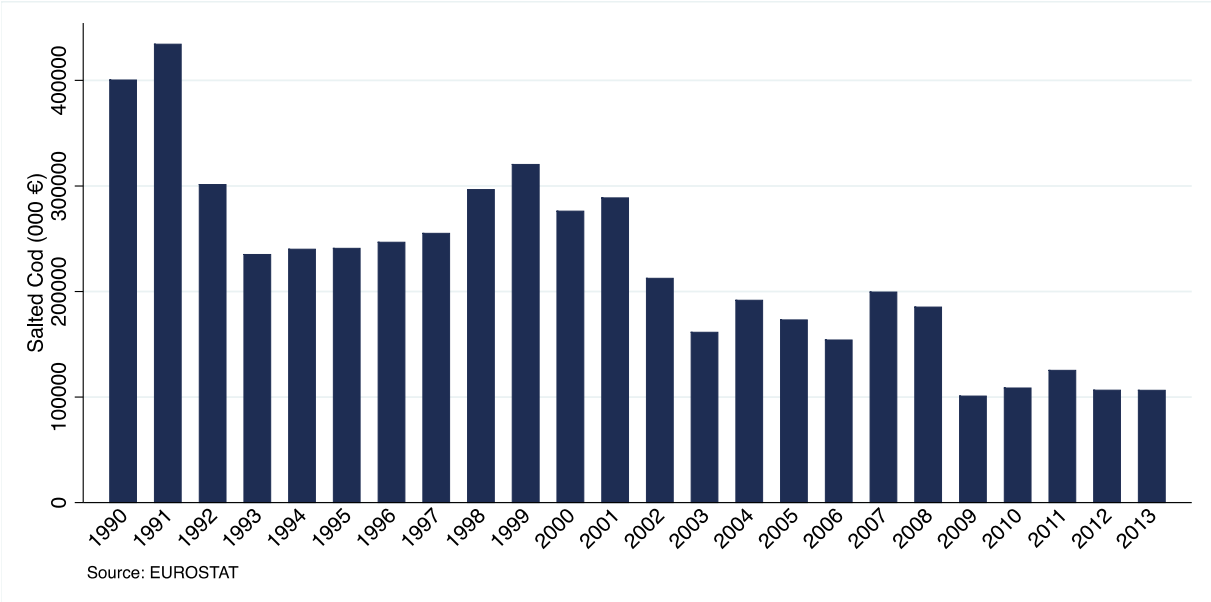


Figure 2c: Real Value Salted Cod Imports to Portugal: 1990-2013.

Total real revenue for the three products (frozen, salted & dried and salted cod) combined reached a mximum revenue in 1991 at 650 million € but declined by roughly 50 percent over the period to just 330 million € in 2013. Figure A1 in Appendix A graphs out the total reveune figure.

Overall the real revenue picture for suppliers of frozen, salted & dried and salted cod products does not look bright. Both frozen and salted product show serious declines in revenue with only salted & dried product maintaining a somewhat stable revenue source for suppliers. Of course, the link between quantity and revenue is price and we now move on to represent the real price of cod imports.

Figure 3 graphs out the real price[5] for frozen, salted & dried and salted imported cod products. Over the period salted & dried receives the highest price per kg with salted receiving a premium over the low-priced frozen product. It is interesting that over the period 1990 to 2013 the import prices trend togther very closely with an average price difference of 1.7 € per kg for salted & dried and salted product and 2.5 € per kg for salted and frozen product. Notice the sharp drop in all prices in 2008 due to the recession.[6] Keep in mind that salted & dried is a final product whereas frozen and salted must be processed before final sale. The figure compares prices at different levels in the market demand structure and thus the differences in prices reflect the degree of processing. Nevertheless, prices show that the markets for these three products are closely linked.

[5] Price is defined as real revenue divided by quantity.
[6] See Verick and Islam, 2010.

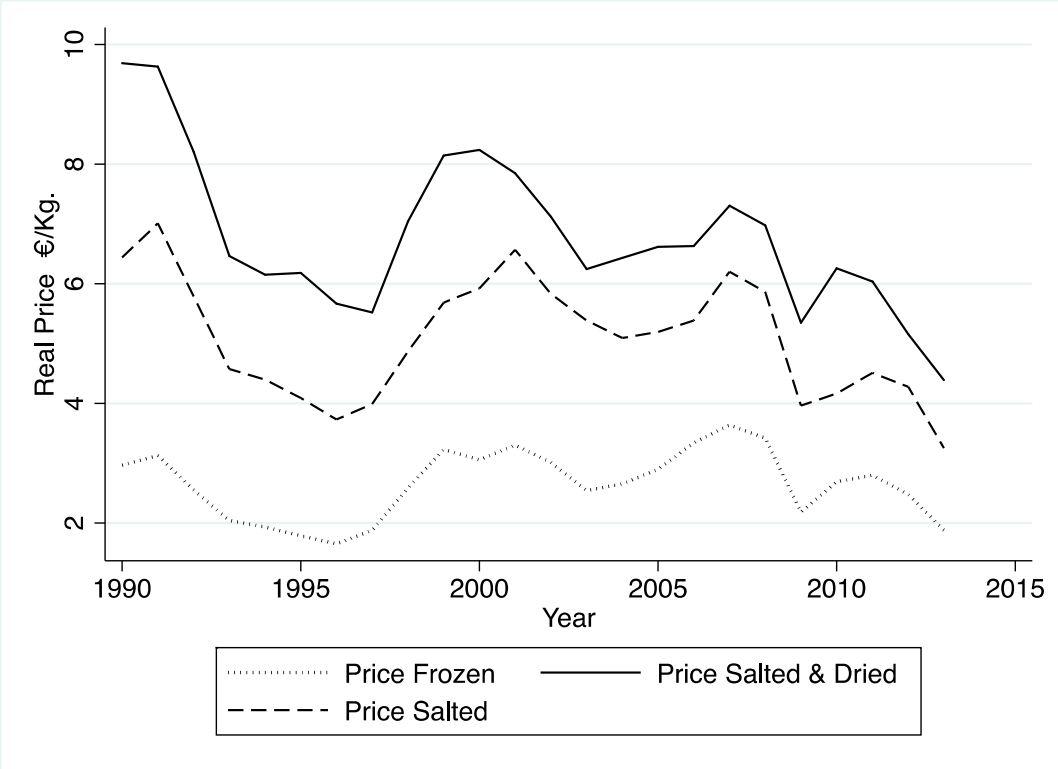


Figure 3: Average Annual Real Price: Frozen, Salted & dried, Salted Cod Imports Portugal

It is interesting and worthwhile to look more closely at China and the development of the Chinese export trade in frozen, salted & dried and salted cod product to Portugal. China did not enter the Portugese cod market until the mid 1990s and even then it was a sproadic participant in the Portuguese market up to the mid 2000s. By 2006 China was a regular participant in all cod markets. Table 2 reports for selected years the quantity and real value share of Chinese exports of frozen, salted & dried and salted cod to Portugal. Notice that in 2005 China was a very minor player in all three product forms but by 2013 China had captured over 10% of the salted market and over 1% of the salted & dried market. In terms of quantity supplied, in 2013 China was exporting 82 tonnes of frozen product, 326 tonnes salted & dried product and 3,092 tonnes salted product to Portugal. The market share for frozen is

negligible.[7] This makes sense, as China does not have its own cod fishery so that any export would be transshipments from the North Atlantic or North Pacific.

Table 2: Chinese Quantity and Value Share for Salted & dried and Salted Cod Imports to Portugal: Selected Years. Percentage of Market

| Cod Product | | 2005 | 2010 | 2013 |
|---|---|---|---|---|
| Salted & dried | Quantity | 2.43 | 3.78 | 1.08 |
| | Value | 1.50 | 2.17 | 0.97 |
| Salted | Quantity | 1.83 | 5.69 | 9.45 |
| | Value | 1.54 | 5.21 | 10.60 |

[a)] Quantity share of Portuguese market
[b)] Value share of Portuguese market

Although currently not a major player in the Portuguese cod markets, China has the potential to build on gains made in these markets. China appears to have an advantage in the price of the product on the Portuguese market. One must be careful in that the apparent price advantage may reflex quality variation in product offered. Certainly, this is likely for salted & dried cod but for frozen and salted product this is likely a pure cost effect. Figure 4 (a, b, c) shows the real price advantage for China for all three markets during the period of active business in Portugal.

[7] China has made gains in both the salted & dried and salted Portuguese market but the data does not allow us to identify whom if any supplier has lost market share.

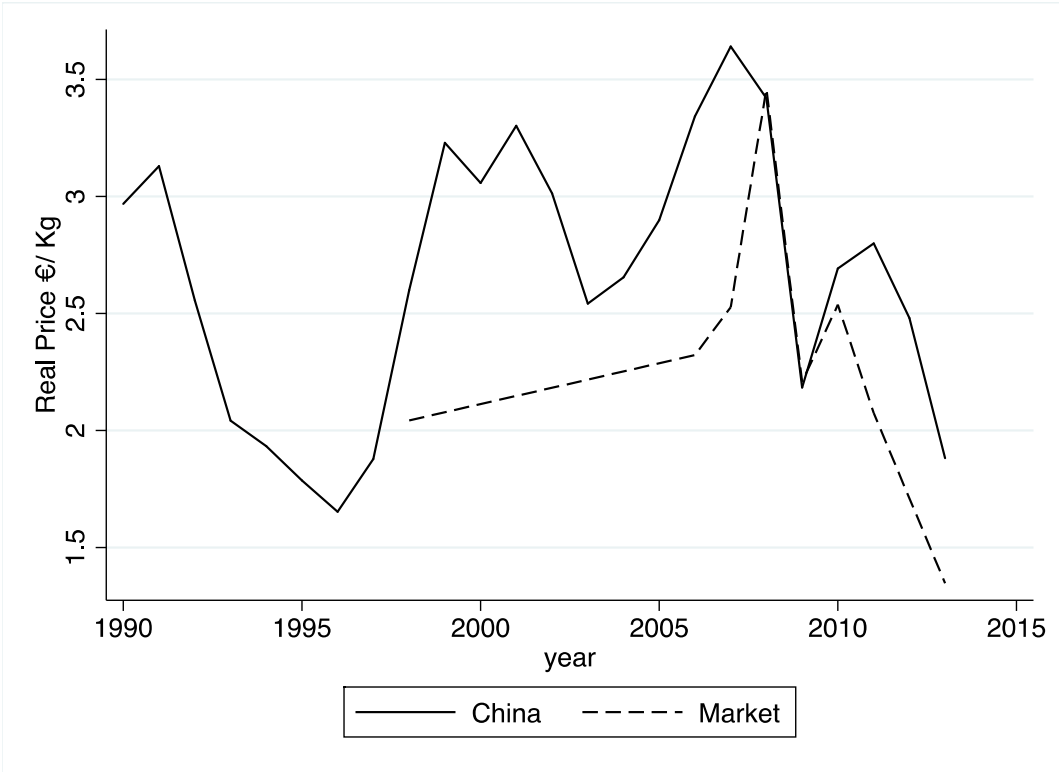


Figure 4a: Average Real Price Frozen Cod Import Market Portugal: China vs. Market

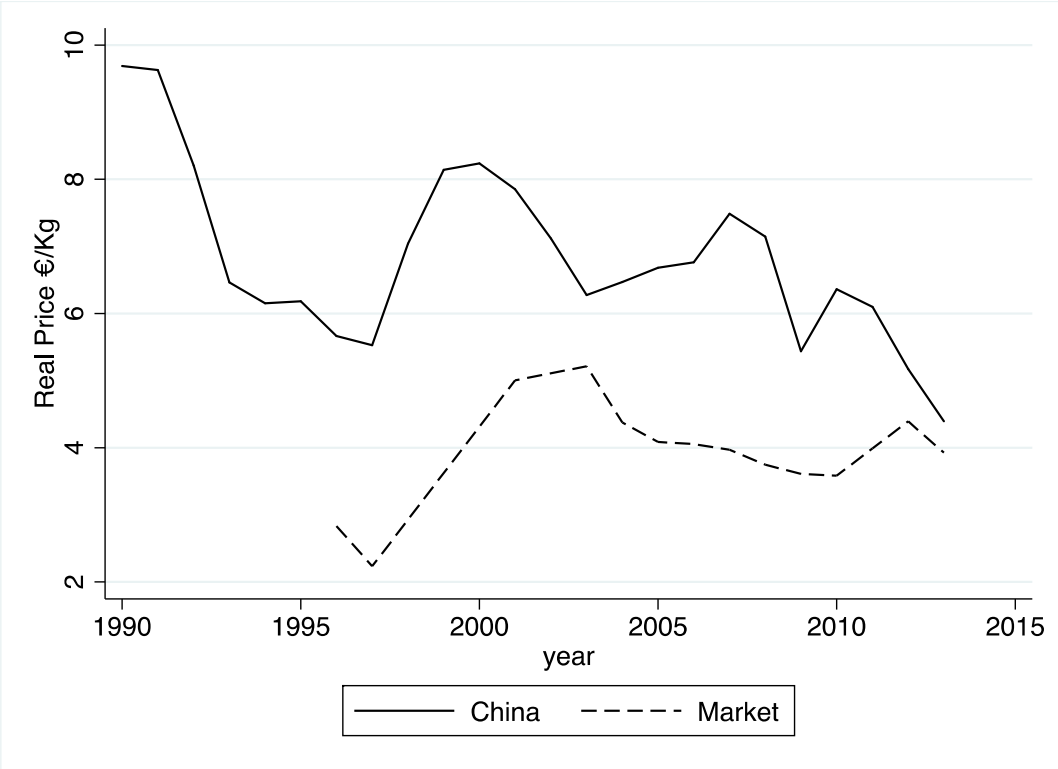


Figure 4b: Average Real Price Salted & dried Cod Import Market Portugal: China vs. Market

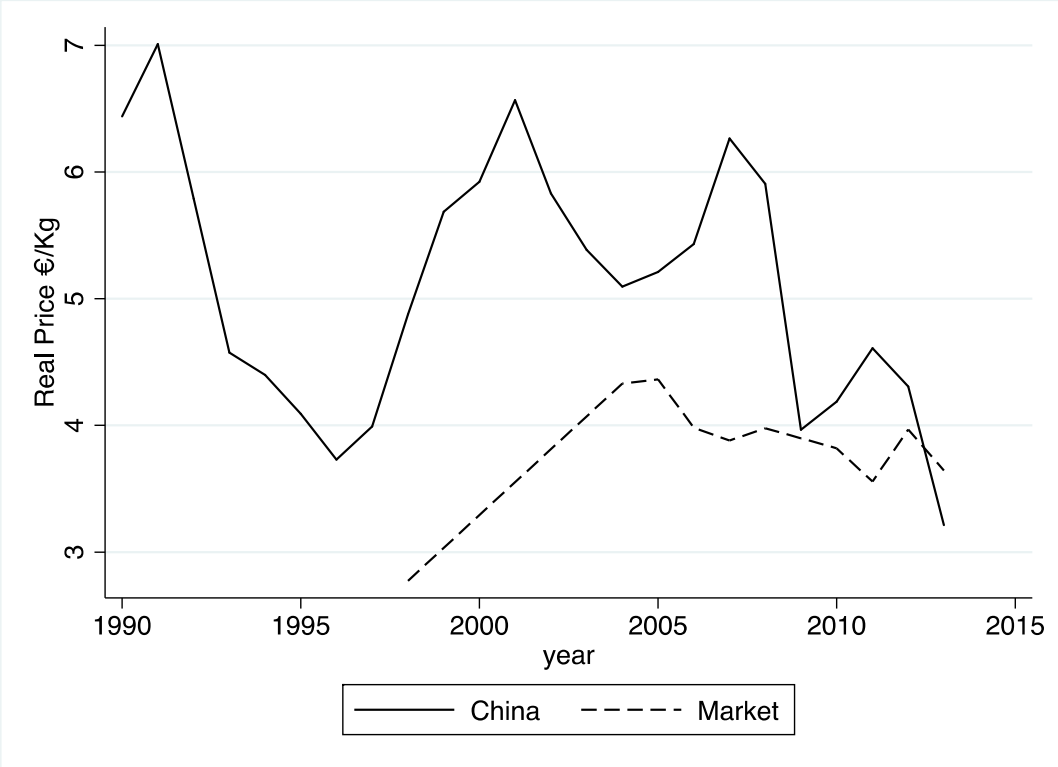


Figure 4c: Average Real Price Salted Cod Import Market Portugal: China vs. Market

The next section will use the information on market share and real prices to investigate market characteristics and growth potential for imported cod products to Portugal.

## Methods and Results

### *PCAIDS*

In this section, the goal is to statistically characterize the import demand structure for cod in Portugal. A popular empirical procedure for evaluating demand possibilities and calculating elasticities is the AIDS model introduced by Deaton and Muellbauer (1980). The AIDS model is a very flexible procedure that satisfies a number of theoretical properties in conventional demand analysis. Consider an AIDS representation of a market characterized by *n* products written as a linear approximation:

$$S_f = a_{f0} + a_{ff} \cdot lnP_f + a_{12} \cdot lnP_k + a_{fs} \cdot lnP_s + \cdots + a_{fn} \cdot lnP_n + a_{fI} I$$

$$S_k = a_{k0} + a_{kf} \cdot lnP_f + a_{kk} \cdot lnP_k + a_{ks} \cdot lnP_s + \cdots + \alpha_{kn} \cdot lnP_n + a_{kI} I \qquad (1)$$

$$S_s = a_{s0} + a_{fs} \cdot lnP_f + a_{ks} \cdot lnP_k + a_{ss} \cdot lnP_s + \cdots + \alpha_{sn} \cdot lnP_n + \alpha_{sI} I$$

$$S_n = a_{n0} + a_{fn} \cdot lnP_f + a_{ns} \cdot lnP_k + a_{ns} \cdot lnP_s + \cdots + \alpha_{nn} \cdot lnP_n + \alpha_{sI} I$$

where $S_i$ represents the share of the $i^{th}$ product in total market revenue over all $n$ products, $P_i$ represents the $i^{th}$ price assumed exogenous to the model and $I$ represents some demand shift factors. The demand shift factor is usually some function of total expenditure and a weighted price index of products in the market. For estimation additive error terms are appended to each equation and a systems estimator is used in recovering the parameters. Equation (1) is econometrically identified if $E(\varepsilon_n | P_i, I) = 0$ for all $n$ where $\varepsilon$ is the additive error term for each equation.

To maintain theoretical consistency, the system of equations must satisfy a number of regularity conditions: Adding up, homogeneity and Slutsky symmetry. With these conditions satisfied the system of equations represents the economic structure of the complete product market. Moreover, what is important for demand analysis is that the estimated $a_{ij}$ coefficients in the system (call it the 'AIDS A' matrix) have a correspondence to the demand elasticities that characterize the market structure or,

$$\eta_{ii} = -1 + \frac{a_{ii}}{S_i} + S_i + (\eta + 1) \qquad (2)$$

$$\eta_{ij} = \frac{a_{ij}}{S_i} + S_j \cdot (\eta + 1)$$

Here $\eta_{ii}$ is the own-demand elasticity for each product, $\eta$ is the aggregate demand elasticity for the product market and $\eta_{ij}$ is the cross-price elasticity.

If data are available then the consistent and efficient procedure for empirical work is to characterize the structure of demand by estimating the full system of equations defined by equation (1). However, as is often the case, the data for a complete description of the market is not available. In cases with limited data or data for only a subset of the total product

market, Epstein and Rubinfeld (2002 and 2004) suggest a simulation approach based on the assumption of 'proportionally consistent market shares' or PCAIDS model. What this means is that under a price change for one product, demand shifts towards other products in the market according to relative market shares. Epstein and Rubinfeld (2002) prove that based on the proportionally consistent market shares assumption the PCAIDS model has many of the ideal theoretical properties of the full AIDS model and what is most important the following conditions hold,

$$a_{jj} = \frac{S_j \cdot (1 - S_j)}{S_i \cdot (1 - S_i)} \cdot a_{ii} \qquad (3)$$

$$a_{ij} = \frac{-S_i}{1 - S_j} \cdot a_{jj}$$

In words, if we are able to obtain an estimate of $a_{ii}$ then based on equation (3) the complete 'AIDS A' matrix can be recovered using only the one initial value of $a_{ii}$.[8] In addition, if an estimate of the aggregate market demand elasticity, $\eta$, is available then a full elasticity description of the market can be calculated using equation (2).

In order to apply the PCAIDS model two conditions are required; first, is the assumption of proportionally consistent market shares, and second, the availability of initial estimates of both $a_{ii}$ and $\eta$. Epstein and Rubinfeld (2002) suggest that the PCAIDS assumption is robust to some variation in the proportionally consistent assumption and for empirical work here we maintain this assumption.

A serious but practical problem is the availability of initial estimates of both $a_{ii}$ and $\eta$. Coloma (2006) shows a regression procedure based on data for only a sub-component of the market to obtain initial estimates of the base parameters. For the case at hand, we do not have full data information on the fish import market for Portugal but we do have data information

[8] Epstein and Rubinfeld (2002) use estimates of $a_{ii}$ and $\eta$ obtained from the published demand literature.

for a sub-component of the import cod market (frozen whole, dried & salted, salted and other cod imports), so the system of equations available can be written as:

$$S_f = a_{f0} + a_{ff} \cdot lnP_f + a_{12} \cdot lnP_k + a_{fs} \cdot lnP_s + a_{fo} \cdot lnP_o + a_{fI} I$$

$$S_k = a_{k0} + a_{kf} \cdot lnP_f + a_{kk} \cdot lnP_k + a_{ks} \cdot lnP_s + a_{ko} \cdot lnP_o + a_{kI} I \quad (4)$$

$$S_s = a_{s0} + a_{fs} \cdot lnP_f + a_{ks} \cdot lnP_k + a_{ss} \cdot lnP_s + a_{so} \cdot lnP_o + \alpha_{sI} I$$

$$S_o = a_{o0} + a_{os} \cdot lnP_f + a_{os} \cdot lnP_k + a_{os} \cdot lnP_s + a_{oo} \cdot lnP_o + \alpha_{sI} I$$

Where subscript *i* defines *f*-frozen, *k*-salted & dried, *s*-salted and *o*-other, and *I* is defined as GDP per capita. Note that for the sub-component PCAIDS model the shares $S_i$ are defined to sum to one for the four products considered.[9] In estimation, a homogeneity assumption is imposed on the cross-price and own-price coefficients as suggested by Coloma (2006) or $a_{ii} = -\sum_{i \neq j} a_{ij}$. The PCAIDS 'A matrix' coefficients that we want to recover are defined in Table 3. Notice that each coefficient in the PCAIDS 'A matrix" is a function of market share and the initial $a_{ff}$ coefficient.

Table 3: Coefficients for PCAIDS 'A Matrix'

| | Pf | Pk | Ps | Po |
|---|---|---|---|---|
| Frozen | $a_{ff}$ | $\frac{-S_k}{1-S_f} \cdot a_{ff}$ | $\frac{-S_s}{1-S_f} \cdot a_{ff}$ | $\frac{-S_o}{1-S_f} \cdot a_{ff}$ |
| Salted & dried | $\frac{-S_k}{1-S_f} \cdot a_{ff}$ | $\frac{S_k \cdot (1-S_k)}{S_f \cdot (1-S_f)} \cdot a_{ff}$ | $\frac{-S_k \cdot S_s}{S_f \cdot (1-S_f)} \cdot a_{ff}$ | $\frac{-S_k \cdot S_o}{S_f \cdot (1-S_f)} \cdot a_{ff}$ |
| Salted | $\frac{-S_s}{1-S_f} \cdot a_{ff}$ | $\frac{-S_s \cdot S_k}{S_f \cdot (1-S_f)} \cdot a_{ff}$ | $\frac{S_s \cdot (1-S_s)}{S_f \cdot (1-S_f)} \cdot a_{ff}$ | $\frac{-S_s \cdot S_o}{S_f \cdot (1-S_f)} \cdot a_{ff}$ |
| Other | $\frac{-S_o}{1-S_f} \cdot a_{ff}$ | $\frac{-S_k \cdot S_o}{S_f \cdot (1-S_f)} \cdot a_{ff}$ | $\frac{-S_s \cdot S_o}{S_f \cdot (1-S_f)} \cdot a_{ff}$ | $\frac{S_o \cdot (1-S_o)}{S_f \cdot (1-S_f)} \cdot a_{ff}$ |

Coloma (2006) shows that given market share and prices for a subcomponent of the market an estimate of $a_{ff}$ can be obtained using a transformation of market share, the log of each price relative to a reference price and a measure of income as:

[9] On average for 1990-2013 market share is frozen (22%), salted & dried (28%), salted (46%) and other (3.0%).

$$\frac{S_f \cdot (1-S_f)}{S_s} = c_f + a_{ff} \cdot ln\left\{\frac{P_f}{P_s}\right\} + c_{fI} \cdot \ln(I) + \varepsilon_f$$

$$\frac{S_k \cdot (1-S_k)}{S_s} = c_k + a_{ff} \cdot ln\left\{\frac{P_k}{P_s}\right\} + c_{fI} \cdot \ln(I) + \varepsilon_k \qquad (5)$$

$$\frac{S_o \cdot (1-S_o)}{S_s} = c_o + a_{ff} \cdot ln\left\{\frac{P_o}{P_s}\right\} + c_{fI} \cdot \ln(I) + \varepsilon_o$$

where $\varepsilon_j$ are additive error terms. The price and share of salted imported cod product is defined as the reference product. The equations are estimated as a system with cross equation constraints on $a_{ff}$. A consistent estimate of $a_{ff}$ is achieved if,

$E(\varepsilon_j | \ln\left\{\frac{P_j}{P_s}\right\}, \ln(I)) = 0$. This seems reasonable as cod is part of a well-integrated international white fish market and Portugal is a price taker in this market.[10]

In addition, the available data is used to define an aggregate quantity index and a geometric weighted price to specify the market demand function as:

$$Q_t = a + \eta \cdot \ln(P_{avg}) + c_{gdp} \ln(GDP) + \varepsilon_Q \qquad (6)$$

where $Q$ is the per capita quantity of the sum of frozen, salted & dried, salted and other cod, $P_{avg}$ is the geometric share weighted value of price of all products and $GDP$ as defined above. From equation (6), if $E(\varepsilon_Q | \ln(P_{avg}, \ln(GDP)) = 0$ then $\eta$ represents a consistent estimate of the market demand elasticity.

The data fit the models reasonably well and Table 4 reports the estimated results for the PCAIDS initial coefficient $a_{ff}$ and aggregate demand elasticity.[11] Both coefficients are

[10] This assumption needs further thought as, salted & dried cod is a specialized product and Portugal a major market. Market conditions in Portugal may influence price.

[11] Econometrically the sample regression (Equation 5) is specified directly from the underlying theoretical or population model. However, as a robustness check the model is re-estimated in first differences and the results showed elasticity values somewhat smaller in magnitude but consistent with the original results.

estimated to be statistically valid and have the expected signs and magnitudes.[12] Based on these results the PCAIDS full set of own- and cross-price elasticities are reported in Table 5.

Table 4: PCAIDS coefficient and Aggregate Demand elasticity

| | Coefficient | Std. Err. | p-value |
|---|---|---|---|
| $a_{ff}$ | -0.328 | 0.0752. | 0.000 |
| $\eta$ | -0.918 | 0.416 | 0.028 |
| Obs. | 22 | | |

Table 5: Elasticities based on PCAIDS and Aggregate Demand Models

| | Frozen | Salted & Dried | Salted | Other |
|---|---|---|---|---|
| Frozen | -2.45[a)] | 0.321 | 0.519 | 0.034 |
| | (0.337)[b)] | (0.068) | (0.110) | (0.007) |
| Salted & Dried | 0.321 | -2.33 | 0.519 | 0.0344 |
| | (0.068) | (0.310) | (0.110) | (0.007) |
| Salted | 0.519 | 0.519 | -1.98 | 0.022 |
| | (0.110) | (0.110) | (0.233) | (0.004) |
| Other | 0.034 | 0.0344 | 0.022 | -2.834 |
| | (0.007) | (0.007) | (0.004) | (0.421) |

[a)] Calculated at Mean
[b)] Standard Error

Individual own-price elasticities reported on the diagonal of Table 5 show an elastic response to own-price change. For example and to be clear on interpretation a 1% change in the price of salted & dried product cause a 2.3% decrease in own-demand but a 0.32 and a 0.52% increase in the demand for frozen and salted product, respectively. Recall that the elasticities reflect the main assumption of the PCAIDS model that change is proportional to relative market share. The standard error reported with the elasticities will allow for a robust analysis in evaluating growth in market demand in the next section. The cross-price elasticities are statistically important and show substantial flexibility across the different product forms; other product forms have a very low cross-price elasticity with the main

[12] Bjørndal *et al*. (2015) provide a descriptive analysis of Portuguese economic development and particularly the importance of the fishery sector that provides antidotal support for the inelastic aggregate demand elasticity for imported cod products.

products of interest but keep in mind this is a residual of all other cod products. The other category is defined for specification purposes and not for direct interpretation.

Based on these elasticity estimates the next section will investigate the growth in demand for the three main cod import product forms.

***Market Demand Index***

Marsh (2003) outlines a technique for building a retail demand index for a food (beef) commodity. The index is a measure of the shift in retail demand caused by changes in income, price of substitutes, preferences, etc. The individual shift factors are not identified in the index but rather the index can be viewed as a measure of gross change in retail demand. Asche et al., (2011) argue that this gross measure of growth in demand is very useful information to the industry supplying the market for planning and investment purposes. In this section, we will apply the index to the demand for imported frozen, salted & dried and salted cod to Portugal.

The index is straightforward in that it measures the difference between what the product price would be in the absence of any shift in demand i.e., the counterfactual price, and the actual resulting price. The index will measure demand shifts from one period to the next and adding the index over time will provide a time series measure of growth in import demand relative to the initial period.

There are four steps to building the index; first, calculate the percentage change in quantity from one period to the next or;

$$\%\Delta Q_i = \frac{Q_{it} - Q_{it-1}}{Q_{it-1}}$$

Second, calculate the percentage change in price from one period to the next holding demand constant at the elasticity $\eta_{ii}$ (the own-price elasticity for the product) or:

$$\%\Delta P_i = \frac{\%\Delta Q_i}{\eta_{ii}}$$

Third, calculate the counterfactual price not allowing a shift in demand (the change in quantity is entirely a supply side effect) or;

$$P_i^{CF} = P_{it-1} + P_{it-1} \cdot \%\Delta P_i$$

Finally, calculate the demand index as the percent difference between actual price and the counterfactual price or:

$$\frac{P_{it} - P_i^{cf}}{P_i^{cf}} = \text{Change in Demand Index}$$

This value will represent the change in the index over time. A cumulative measure of demand growth relative to the initial period is represented by the sum of the demand index overtime. For evaluation purposes the growth index is normalized to one for the initial period.

Before presenting the individual index results an aggregate or overall review will be presented of the imported cod market for Portugal for the period 1990 to 2013. The aggregate own-demand elasticity (Table 4) is used in building the aggregate index. The cumulative index is a measure of growth or shift in demand at a given point in time relative to the initial period. Keep in mind that growth indices reflect changes in demand but final product price is set by the intersection of both demand and supply schedules.

The index representing total growth in demand for imported cod products is shown in Figure 5. Here we see periods from the late 1990s to the late 2000s of positive demand growth but this demand effect does not last and over the full period the aggregate demand curve has shifted inward relative to the initial period and this will put pressure on price to decline. In addition to this effect, the total supply of imported cod products to Portugal increased over the period from 91,000t in 1990 to over 113,000t in 2013. This indicates an outward shift in the aggregate supply of imported cod products putting additional downward pressure on market

prices. In fact, the consequence of the combined aggregate supply and demand effects is that average real price declined by 43% over the period.

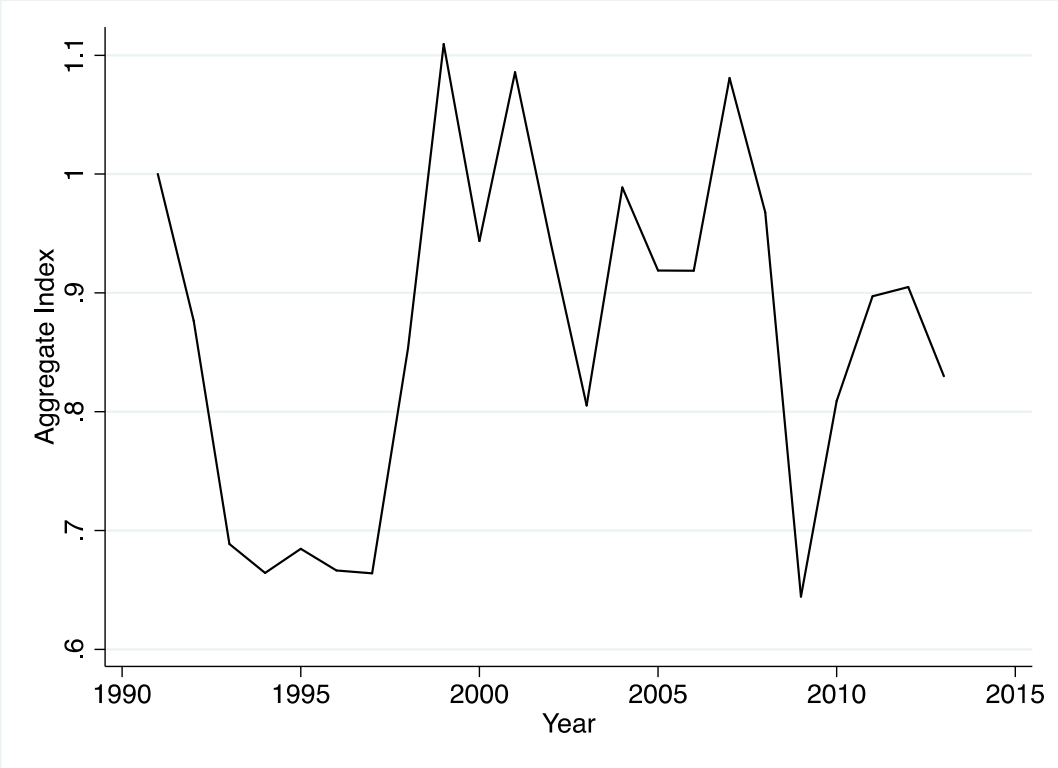


Figure 5: Aggregate Demand Growth Index, Imported Cod Portugal

Clearly, over the period of study, the aggregate or overall demand schedule for imported cod products has been shifting inwards. This is offset by an outward shift in supply of cod product resulting in an lower aggregate price. However, this does not imply that all products types have suffered a negative demand effect and we turn to investigate growth indices for the three product forms of interest here.

In building the index for the three imported cod products we have used the own-demand elasticities (Table 5) derived from the PCAIDS model. However, before presenting the index results it is interesting and informative to report the own price and counterfactual price for each of the product forms. These prices are graphed in Figure 6 (a, b, c) for frozen, salted & dried and salted cod, respectively. To be clear, if the demand for product is constant

over time (neither positive or negative growth) then the own price will equal the counter-factual price. If own price is above the counterfactual then demand growth is positive and the opposite relationship shows negative demand growth.

Figure 6a shows substantial variation for frozen cod with own price above and below counterfactual over the 24-year period. However, there are sustained periods of both positive (1990s and again 2004 – 2007) and negative growth (after 2007 to end of period). Overall positive demand growth is observed in 60% of the time periods investigated.

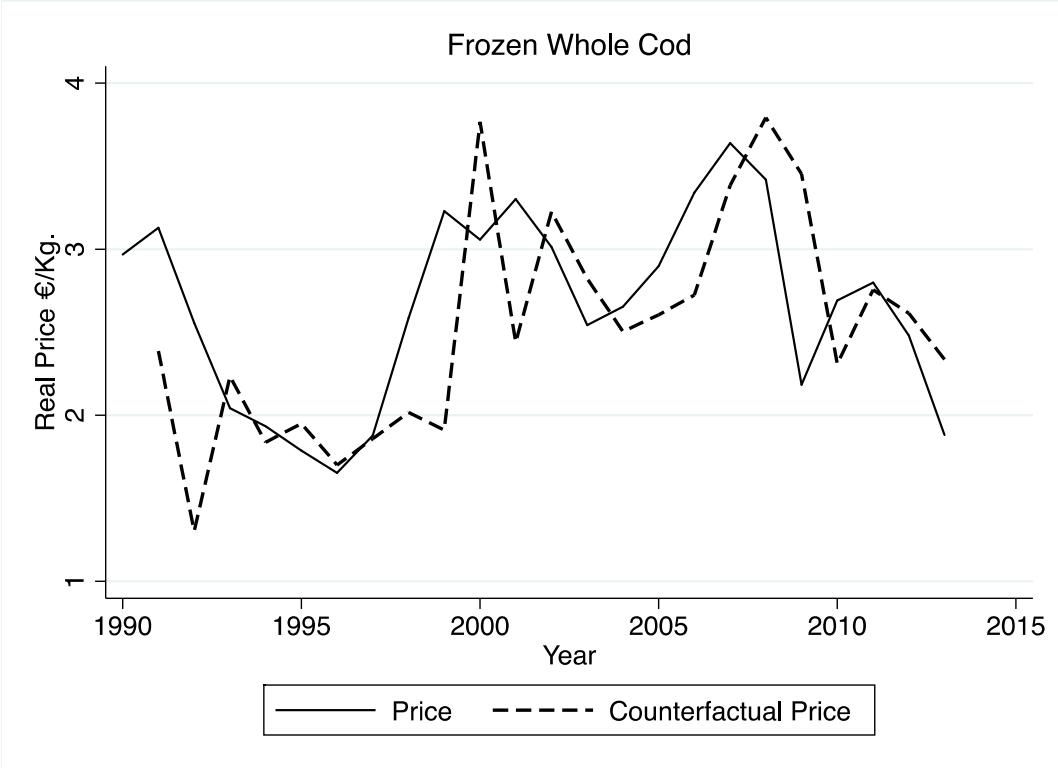


Figure 6a: Own Price and Counterfactual Price Frozen Cod

Figure 6b shows a similar figure for salted & dried product and again we observe variation in own price and counterfactual but in this case negative growth appears to dominate over the period except for sustained positive growth in demand for the period 1997-99.

Overall negative demand growth is observed in just less than 70% of the time periods investigated.

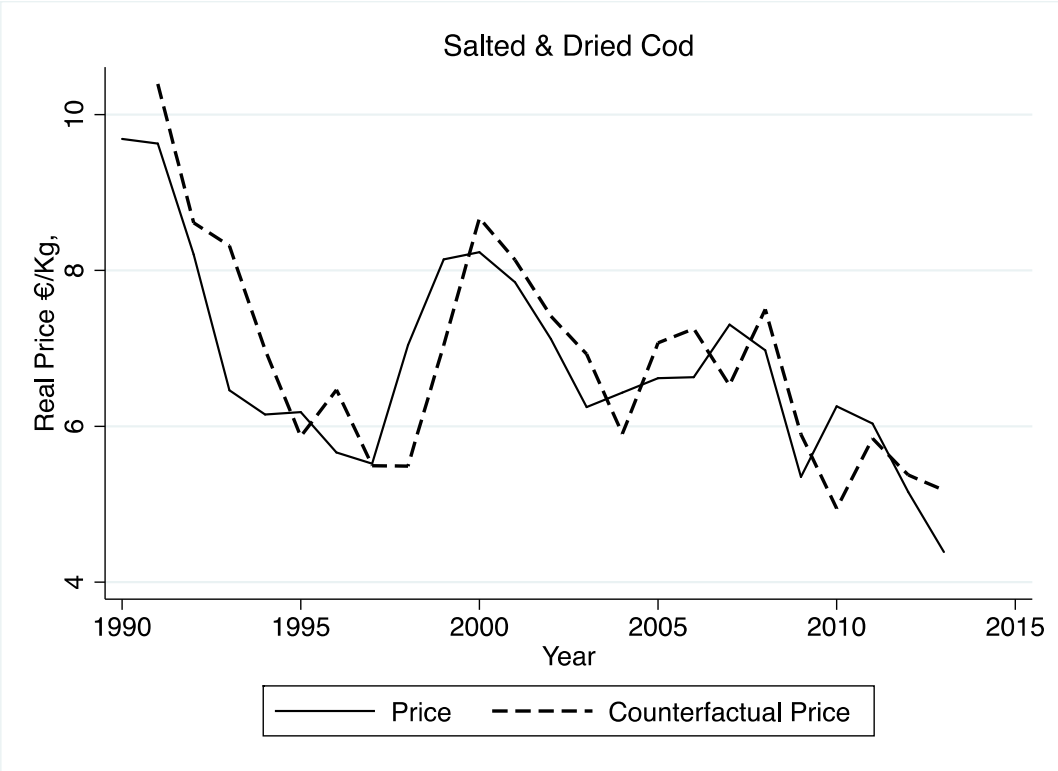


Figure 6b: Own Price and Counterfactual Price Salted & Dried Cod

Finally, Figure 6c shows results for salted product. Here we see sustained negative growth early in the period (1992-96) followed by sustained positive demand growth (1997-01) and again negative growth (2005-09). Overall negative demand growth is observed in just less than 60% of the time periods investigated.

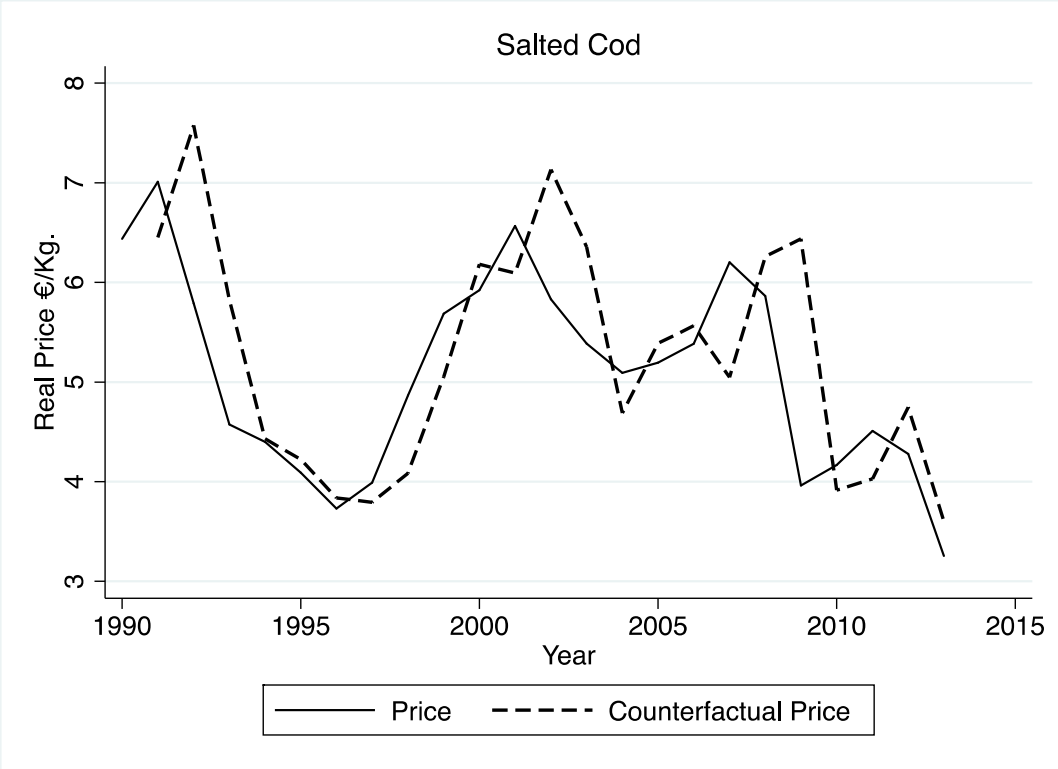


Figure 6c: Own Price and Counterfactual Price Salted Cod

One important conclusion of the price/counterfactual price figures is that once we account for own price effects, all three product forms are subject to substantial positive and negative year-to-year shocks to the demand structure. Keep in mind that these demand shocks are an aggregate effect of all economic and social factors impacting the Portuguese economy including import demand for cod products.

To allow a complete view of demand growth in each market the cumulative demand growth indices are reported for frozen, salted & dried and salted cod product in Figure 7.[13] The cumulative growth index for frozen cod shows a sharp positive increase in the early 90's but a very stable demand structure through the mid 90's and then a positive trend over the remaining period. What this tells us is that the demand curve for frozen cod has been shifting outward over the period resulting in an overall price of frozen product twice as high as it

[13] As a robustness check the cumulative growth index for each product is reproduced in Appendix A, Figures A2a, A2b and A2c and includes a 95% upper and lower bound based on the estimated standard errors reported in Table 4. For frozen product a large band is measured but nonetheless still showing an overall positive shift in demand impacting price. For salted & dried and salted product the confidence bound still shows an overall negative shift in demand impacting price relative to price in the initial period.

would be without the positive demand shift. Keep in mind that real price of frozen cod shows a negative trend over the period resulting in a decrease in real price of 37% (Figure 3). For this product, supply has increased impressively from a mere 7,000t in 1990 to over 50,000t in 2013 putting downward pressure on prices but the growth in demand for the product puts upward pressure on price. Certainly, without the positive demand shift over the period prices would have declined even further.

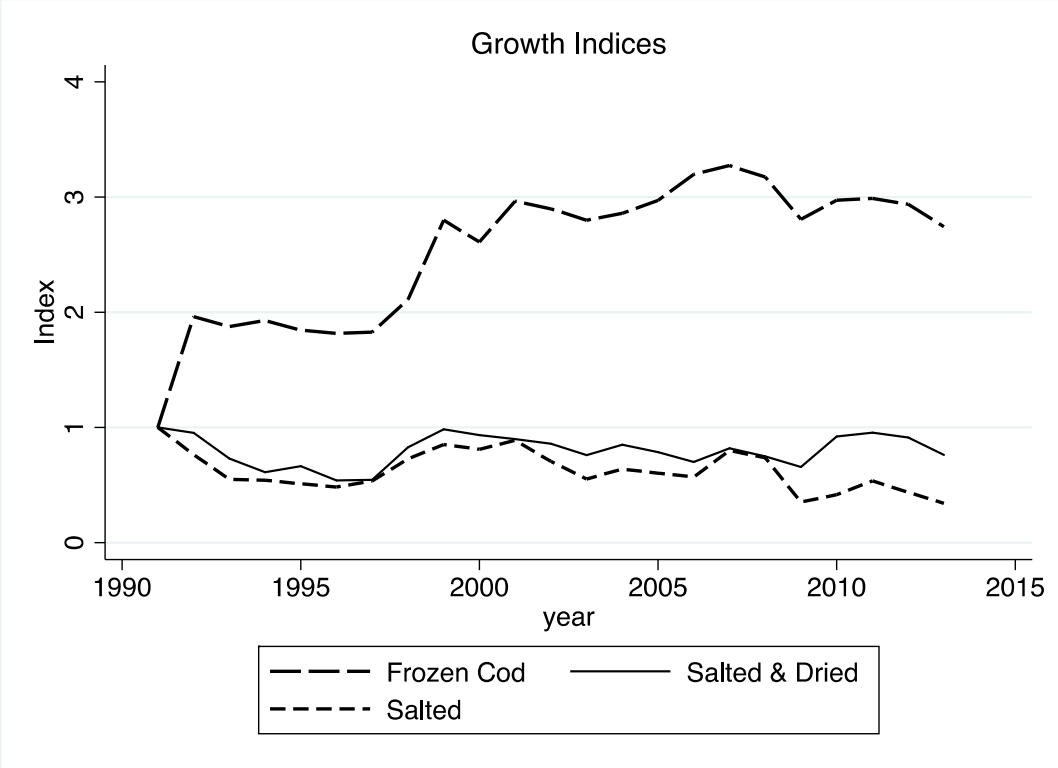


Figure 7: Demand Growth Indices, Frozen, Salted & Dried and Salted Cod

The story for salted & dried and salted cod is considerably different. Figure 7 shows that except for short periods in the late 90s and 2000s demand growth for these product forms has been generally negative over the period. (Note that the recession in 2008 shows a serious negative demand shock for both product forms.) What this tells us is that the demand schedule for both product forms as been shifting inwards over time, putting downward pressure on product price. Moreover, this tells us that it is the salted & dried and salted product forms that drive the negative shift in aggregate demand.

For salted & dried cod we observe an increase in supply from 22,000t in 1990 to over 30,000t in 2013 and this outward shift in supply combined with the inward shift in demand causes a real price decrease over the period of 55%. The inward shift in demand for salted & dried product tells us that Portuguese consumers have been substituting away from this high-value imported product.

For salted product we actual observe a decrease in imported supply of from over 62,000t in 1990 to just over 32,000t in 2013 and this will have a positive effect on price but given the elastic demand (Table 3) for this product total revenue will decline (Figure 2c). The consequence for this product of both an inward shifting supply and demand schedule is a 50% decline in real price. Again the conclusion is clear, Portuguese consumers are substituting away from this product form.

**Comments**

The Portuguese import cod market has over the period of study experienced a number of changes in the structure of both supply and demand conditions. On the supply side we observe a substantial increase in the quantity of frozen cod, a modest increase in salted & dried product and an overwhelming decline in the quantity of salted cod product entering the market. All three product forms report declines in real price with salted & dried and salted product showing prices declining by as much as 50% over the period. However, on a positive note, frozen cod does show an increase in real revenue over the period. On the other hand, salted and to a lesser extend salted & dried product record serious declines in real revenue. In fact, total real revenue for this industry has declined by about 48% over the period of study. Certainly on the supply side we observe a long-term shift away from salted product to frozen product.

On the demand side of the market there is serious evidence that Portuguese consumers are substituting away from both imported salted & dried and salted product to frozen product. The market growth simulation analysis combined with elasticity characteristics of the import market obtained from the estimated PCAIDS model show that both salted & dried and salted product have experienced substantial negative shifts in the demand schedule over the period of study. This will present a particular challenge to the industry in trying to maintain and develop the market for processed or semi-processed cod products.

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Appendix A.

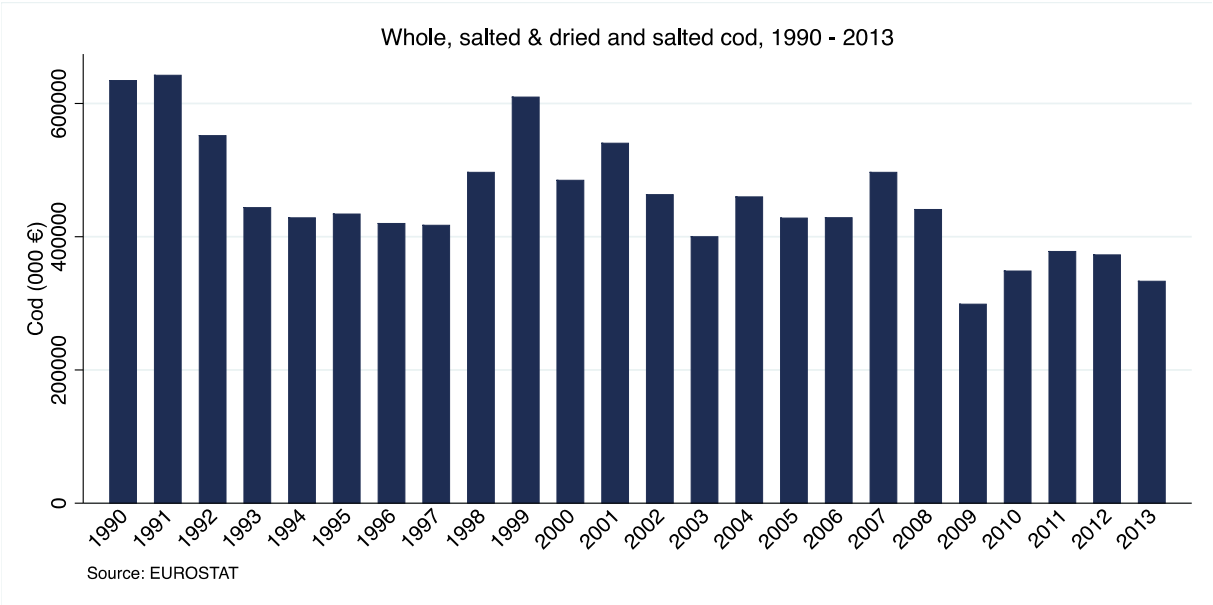


Figure A1: Total Real Revenue Cod Product Imports Portugal 1990-2013

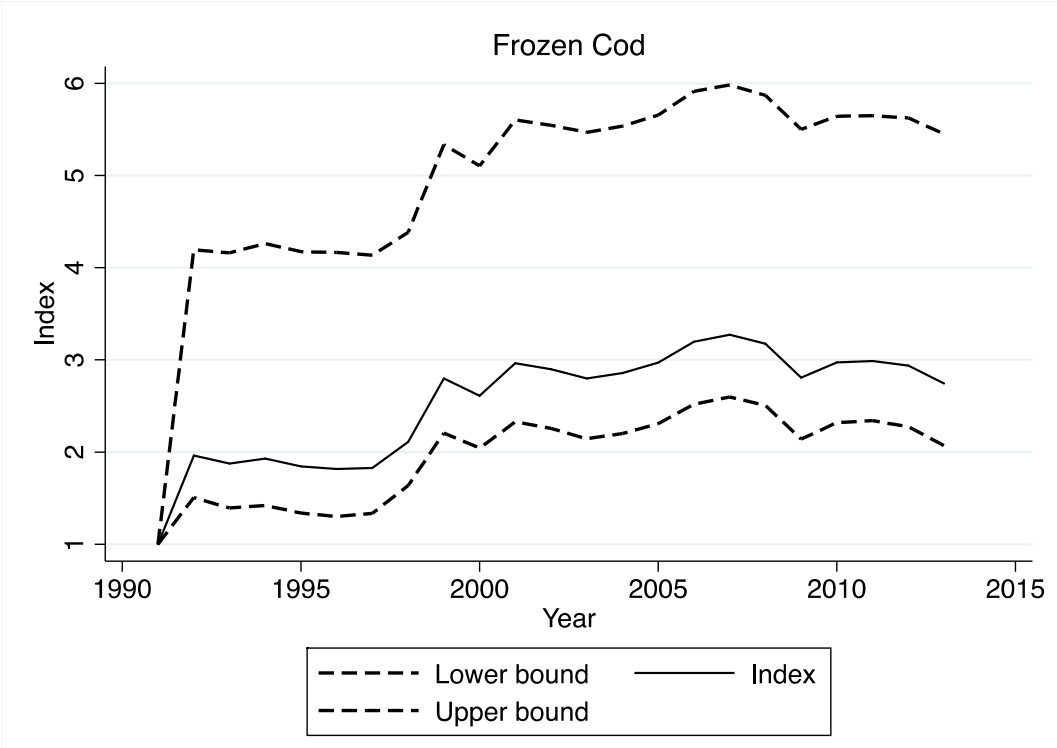


Figure A2a: Confidence Bounds on Growth Index Frozen Cod

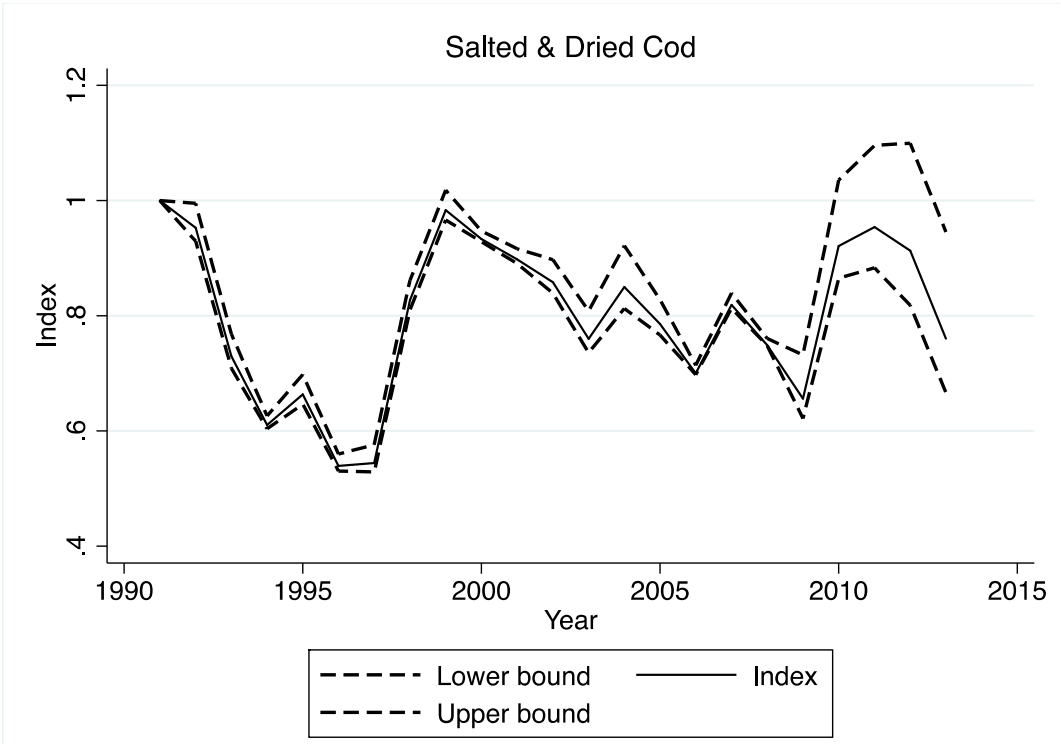


Figure A2b: Confidence Bounds on Growth Index Salted & Dried Cod

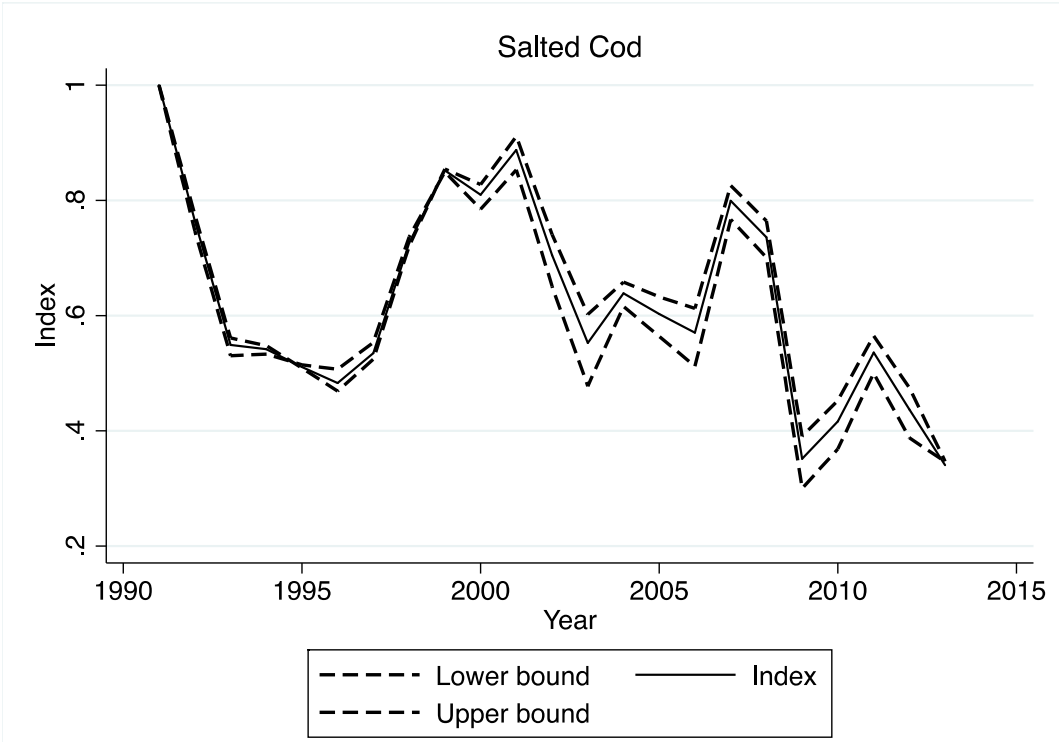


Figure A2c: Confidence Bounds on Growth Index Salted Cod

The demand function represents the fundamental building block in economics and provides important information for investment and policy purposes. The aim of this paper is to characterize and measure the demand structure for imported cod products to Portugal. A PCAIDS model is used to identify own- and cross-price elasticities of demand for frozen, salted & dried and salted cod products. The estimated elasticities of demand are then used in combination with a demand growth index to measure shifts in demand overtime impacting price of product.

Results suggest that over the period of study a strong positive shift in demand for frozen product doubling the price of the product relative to the initial period. But both imported salted & dried and salted product show overall negative shifts in demand decreasing price and may represent a structural shift towards frozen product.

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