Competition Between Imported Tilapia and US Catfish in the US Market

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Abstract This paper investigates the competition between domestic catfish fillets and imported tilapia fillets in the US market. The market segmentation between fresh and frozen fillets of both species is also considered. The substitutability between catfish and tilapia is of interest because market reports have recently suggested that the rapid increase in tilapia imports in the last few years is the result of tilapia taking market share from domestically produced catfish. The competition between fresh and frozen fillets of catfish and tilapia imports in the same market is examined using market integration and demand analysis. The results indicate that imports of fresh and frozen tilapia fillets lie in different market segments, while fresh and frozen catfish fillets compete in the same market. Furthermore, fresh and frozen fillets of catfish and tilapia imports do not compete in the same market.

Key words Catfish, demand analysis, market integration, tilapia.

JEL Classification Codes C22, Q11, Q17, Q22.

Introduction

Farmed tilapia is currently the third most imported seafood product in the United States of America (USA) after shrimp and Atlantic salmon. Imports have increased from virtually nothing in the early 1990s to 134,869 tonnes in 2005 (NMFS 2006). This growth has been particularly strong in the last four years, when imports have more than doubled. This is mainly due to the increased imports of frozen fillets, the volume of which has risen almost sevenfold from 7,372 tonnes in 2001 to 55,615 tonnes in 2005 (NMFS 2006). The recent increase in tilapia imports suggests that consumers may be substituting at least some of their consumption of other products for tilapia.

Industry commentators have suggested that tilapia is competing with domestically produced catfish in the US market (Harvey 2002; Josupeit 2005). The main reason is that the increase in tilapia imports has coincided with a reduction in the imports of basa (catfish) from Vietnam during the last few years.1 However, not all

1 In November 2001, the US senate passed a law prohibiting basa (also known as tra) to be labelled as catfish, as it belongs to the family Pangasididae not the family Ictaluridae as with domestic catfish.
tilapia product forms may be taking market share from domestic catfish. Of the three products imported (fresh and frozen fillets and whole, frozen fish), only the imports of fresh fillets have continued to increase in quantity while maintaining a fairly constant price. Frozen fillets have also experienced a sharp increase in imports, but for this product form prices have declined substantially. Imports of whole, frozen tilapia have remained stable while prices have dropped. The different trends depicted by these three tilapia products suggest they may lie in different market segments.

Tilapia products may also be segmented in the US market because they are imported from different countries with varying production technologies, qualities, and transportation costs. In particular, the fresh fillets are mainly shipped from Latin America, while the frozen products are primarily imported from South-East Asia. Freshness and purchase price have been identified by Halbrendt et al. (1995) as the most important attributes determining retailer preferences for tilapia, as well as that of catfish, salmon, and trout. Therefore, differences in the price and quality between producers may affect consumer preferences for the different tilapia products. Consequently, it is possible that tilapia has created new market segments, as well as winning market share from a variety of whitefish products, including catfish. Muir and Young (1999) argue that high-quality tilapia may be competing with high-valued species, including snapper and grouper in the US market, while Anderson (2006) suggests that tilapia can be a substitute for flatfish, snapper, and other whitefish.

The purpose of this paper is to investigate the possible competition between fillets of imported tilapia and fillets of domestically produced catfish in the US market, as well as competition between the different tilapia product forms. If there is competition, then the extent of the substitutability between these products will be investigated. Whole frozen tilapia is not considered because imports of this product form have remained relatively stable during recent years, while fresh and frozen tilapia fillets have accounted for most of the import growth. Moreover, in the USA catfish is primarily marketed as fresh and frozen fillets.

The results will be of interest to exporters of tilapia into the USA and the US seafood industry in general, as the substitutability between these products may offer some insights into the future development of tilapia in the US whitefish market. The implications of strong competition between imported tilapia and domestic catfish could result in actions being taken by the catfish industry in an effort to reduce tilapia import demand. The catfish industry could target marketing campaigns against tilapia imports. Furthermore, tilapia imports could face higher import tariffs if the domestic catfish industry successfully files an anti-dumping complaint against tilapia exporters. This has been the experience of Vietnamese basa exporters. Conversely, if there is no competition between these species, then the question remains open as to what seafood product(s) tilapia is taking market share from. In addition, actions targeting tilapia would then not benefit US catfish producers.

In the analysis, we use monthly data for the period from January 1997 to February 2006. Two main approaches are employed. First, we study the relationship between the prices of fresh and frozen fillets of imported tilapia and US catfish fillets. Second, we estimate demand equations for the imports of fresh and frozen tilapia fillets to the US and the wholesale demand for fresh and frozen fillets of domestic catfish. During the last decade, testing for market integration has become a common approach for investigating the long-run relationship between products. Nevertheless, demand analysis provides more information on the interactions between products than tests for market integration.² Testing for market integration has

² See Asche, Salvanes, and Steen (1997) and Asche, Bjørndal, and Gordon (2007) for discussions of the relationship between market integration and demand analysis.
the advantage that it is less data intensive. This is an issue in this analysis as the data set is relatively short (110 observations) and cannot be extended backwards because of the limited imports of tilapia fillets before 1997. While one would definitely prefer a longer dataset, the results obtained in the demand analysis and market integration tests are complementary.

The paper is organized as follows: In the following section, we discuss the demand for tilapia in the US market and investigate the patterns of quantities and prices of imported tilapia fillets and sales of domestic catfish fillets in the US market. The data used are also presented along with an analysis of their time series properties before we describe the methodology used in the study. This is followed by the presentation of our empirical results before some concluding remarks are made in the final section.

Markets for Tilapia and Catfish in the USA

Catfish and tilapia are popular farmed fish species in the US market, ranking respectively as the fifth and sixth most consumed seafood species in 2005. Catfish has traditionally been a popular product in the USA and is supplied almost entirely by domestic producers. Tilapia, on the other hand, is primarily imported and only entered the top 10 most consumed species in 2001, following a strong increase in imports.

Demand for tilapia was originally limited to people of African and Asian origin living in the USA. However, the recent growth in demand implies that this may no longer be the case. Tilapia meets the typical requirements of fish preferred in the US market: its meat is white and can be easily filleted; it is odourless, with a mild flavour; and it is very versatile for cooking (Vannucchini 2001). As a result, tilapia is no longer only supplied to retailers catering to the Asian and African population, as well as restaurants of these ethnic origins, but is also widely available to the general US public in fish markets and supermarkets (Burger et al. 2004).

Tilapia is sold live, fresh, and frozen and in different product forms (whole, gutted, gutted and scaled, and fillets). The limited US production is mainly marketed live, as US producers have a geographical advantage over non-domestic producers. Each of the three main product forms imported comes from a wide range of countries. However, the majority of imports are supplied by a small number of countries. The main exporters of fresh tilapia fillets to the USA are South and Central American countries. As shown in the 2005 National Marine Fisheries Service (NMFS) statistics, 92.0% of fresh tilapia fillet imports were from Ecuador, Honduras, and Costa Rica. On the other hand, the main exporters of frozen fillets and whole frozen tilapia to the USA were South-East Asian countries. In 2005, 96.4% of US frozen tilapia fillet imports were from China, Indonesia and Taiwan. For whole, frozen tilapia in 2005, 97.5% of imports were from China and Taiwan.

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3 In 2005, the per capita consumption of catfish was 0.47 kg and that of tilapia was 0.39kg (NFI 2007).
4 Other exporters of fresh tilapia fillets to the USA (in order of market share) were Brazil, El Salvador, Colombia, Panama, Nicaragua, Jamaica, Peru, Chile, Indonesia, the United Kingdom, and Mexico (NMFS).
5 Other exporters of frozen tilapia fillets to the USA (in order of market share) were Thailand, Vietnam, Ecuador, Panama, Costa Rica, Hong Kong, Chile, South Korea, Ghana, Nicaragua, Bangladesh, Brazil, and Malaysia (NMFS 2006).
6 Other exporters of whole, frozen tilapia to the USA (in order of market share) were Vietnam, Panama, Indonesia, Thailand, Ecuador, Hong Kong, Philippines, India, Malaysia, Canada, Costa Rica, Brazil, Japan, and South Korea (NMFS 2006).
The per capita consumption of catfish in the USA has increased from 0.19 kg in 1985 to 0.47 kg in 2005 (NFI 2007). This is partly due to the introduction of a wide variety of products to satisfy the rapid changes in consumption patterns and consumer desire for new food products (Silva and Dean 2001). Another reason is the intensive marketing efforts by the US catfish industry. In particular, The Catfish Institute (TCI) has been identified as “the promotional arm of the domestic catfish industry” (Quagrainie 2006). TCI’s marketing campaign is funded by feed mills within the states producing catfish (Hanson 2001). The funding has increased from $2 million in 1986 to $3.6 million in 2002. This advertisement was mostly generic, and it was identified to have a positive effect on consumption by several studies (Kinnucan and Venkateswaran 1990; Zidack, Kinnucan, and Hatch 1992; and Kinnucan and Miao 1999). Moreover, individual companies have funded their own marketing campaigns in addition to the generic marketing effort. However, a lack of published literature on the advertising campaigns of individual private companies makes it difficult to account for their impact on catfish consumption.

Unlike tilapia, there is a large literature investigating the market for catfish in the USA. Marketing studies have found catfish consumption to be uneven among different geographical regions, ethnic groups, and educational and income levels (Drammeh et al. 2002; Engle 1998; Kinnucan, Nelson, and Hiariey 1993). Nevertheless, the introduction of new product forms and marketing practices might affect these consumption patterns over time. For example, early studies indicated a negative relationship between income and catfish consumption (Hu 1985) due to the negative perception that consumers had of catfish (Kinnucan et al. 1988). However, the catfish industry managed to overcome this image problem, resulting in a positive income elasticity of demand (Kinnucan and Miao 1999; Kouka 1995; Zidack, Kinnucan, and Hatch 1992).

Furthermore, price and consumer perceptions regarding nutrition, freshness, safety, appearance, etc.; also affect catfish consumption (Drammeh et al. 2002; Engle 1998; Halbrendt et al. 1995; Kinnucan, Nelson, and Hiariey 1993). In particular, the 2000–01 US survey on farm-raised catfish indicated that consumers rank price as the main factor affecting their consumption of catfish (House et al. 2003).

In figure 1, the rapid increase in tilapia imports since 1997 is compared with the volume of domestically raised catfish sold by processors. Processed US catfish includes the entire range of product forms, although overall sales are mainly driven by changes in the sale of fresh and frozen catfish fillets (Harvey 2001). As shown in figure 1, tilapia imports have increased from a monthly quantity of 1,866 tonnes in January 1997 to 10,390 tonnes in February 2006. During the same period, sales of processed US catfish increased at a much lower rate.

Figure 2 shows the imports of fresh and frozen tilapia fillets and sales of fresh and frozen fillets of domestically processed catfish in tonnes from January 1997 to February 2006. As shown, the sales of fresh and frozen fillets of domestic catfish increased from 1,645 tonnes and 3,738 tonnes in January 1997 to 2,317 tonnes and 5,179 tonnes in February 2006, respectively. This represents almost a doubling of sales over the period considered. However, sales growth for domestic catfish fillets is substantially lower than for tilapia fillets. Imports of fresh and frozen tilapia fillets experienced a significant increase throughout the sample period, with the growth of frozen fillets being particularly strong. For instance, fresh fillets of imported tilapia increased from 203 tonnes in January 1997 to 1,894 tonnes in February 2006. Over the same period, frozen fillets of tilapia imports increased from 117 tonnes to 4,432 tonnes.

Figure 3 presents the nominal wholesale processor prices of fresh and frozen fillets of domestic catfish and the nominal import prices of fresh and frozen tilapia.
Competition Between Tilapia and US Catfish

Figure 1. Total Sales (tonnes) of Processed US Catfish and Tilapia Imports, January 1997–February 2006

Figure 2. Total Sales (tonnes) of Fresh and Frozen US Catfish Fillets and Fresh and Frozen Tilapia Fillets Imports, January 1997–February 2006
The figures are in $/kg and cover the period from January 1997 to February 2006. In general, the wholesale prices of fresh and frozen domestic catfish fillets follow a similar pattern, increasing from $6.06/kg and $5.80/kg in January 1997 to $6.39/kg and $6.31/kg by June 2000, respectively. After this date, the wholesale prices of fresh and frozen fillets of domestic catfish dropped until early 2003, reaching a minimum value of $5.36/kg in March 2003 for fresh fillets and $5.20/kg in December 2002 for frozen fillets. Several factors may have contributed to this decline, including increasing imports of *basa* frozen fillets until the end of the 2001 and the increasing sales of domestic catfish fillets. Since 2003, the wholesale processor prices of fresh and frozen domestic catfish fillets increased to $6.33/kg and $5.93/kg, respectively, in February 2006.

Figure 3 also shows the import prices of fresh and frozen tilapia fillets. Fresh tilapia fillet prices fluctuate slightly over time but generally follow a declining trend until May 1999, when they reached their lowest value at $4.16/kg. Since that point, import prices have increased along with quantities, indicating an increase in market size. Catfish is a possible substitute, as the prices of fresh tilapia fillets and fresh and frozen catfish fillets have been similar since the end of the year 2000.

The import prices of frozen tilapia fillets show a declining trend from January 1997 to February 2006 as well as a fall in price fluctuation (figure 3). This may be related to the strong increase in imports of this product. For frozen tilapia fillets, the re-

![Graph showing monthly wholesale prices](image)

**Figure 3.** Monthly Wholesale Prices ($/kg) of Fresh and Frozen US Catfish Fillets and Import Prices of Fresh and Frozen Tilapia Fillets, January 1997–February 2006

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7 Prices obtained from import values.
A relationship between prices and quantities suggests that a reduction in price is the result of a movement down the demand schedule (figure 2). This indicates that frozen tilapia fillets may compete in a different market from fresh tilapia and catfish fillets.

The data used in the econometric analysis are the monthly import quantities and prices of fresh and frozen tilapia fillets in the USA.\(^8\) The data were obtained from the foreign trade information provided by NMFS. The monthly volume sold and wholesale processor prices of fresh and frozen domestic catfish fillets were obtained from the catfish processing reports of the USDA's National Agriculture Statistics Service (USDA 2006). Monthly income is derived from the seasonally unadjusted indices of aggregate weekly payrolls. This variable, together with the historical consumer price index for all urban consumers (from 1913 to the present), is from the Bureau of Labor Statistics of the US Department of Labor.

Our original intention was to consider the entire NMFS data set on tilapia fillet imports available at the time of analysis (July 1992 – February 2006). However, until the late 1990s, tilapia fillet imports were still very small, resulting in strong fluctuations in monthly import prices.\(^9\) Consequently, we restricted the data set to begin in January 1997 when prices were observed to be more stable.

To study the time-series properties of the data, we tested for unit roots using the commonly applied Augmented Dickey–Fuller (ADF) test.\(^10\) If a data series contains a unit root (I(1)), it is non-stationary, and unless it combines with another non-stationary series to form a stationary cointegration relationship, regressions involving this variable will falsely identify the presence of a significant economic relationship. A requirement of the ADF test is that the adequate lag length is set in order to achieve white noise in the error term. We have done this by using the Schwarz information criteria and autocorrelation tests (LM). ADF tests for each series were performed in levels and first differences with a constant and trend. The null hypothesis in the ADF test is that each series is non-stationary (I(1)). Table 1 presents the ADF tests on nominal and real prices, quantities, and real income. The values in brackets represent the chosen number of lags for each ADF test. All data series were found to be non-stationary in levels but stationary in first differences.

**Methodology**

In this section, we discuss the market integration analysis using non-stationary prices. We then describe the demand model specification.

**Testing for Market Integration**

Stigler (1969) defined a market as, “the area within which the price of a commodity tends to uniformity, allowance being made for transportation costs.” Other definitions of a market apply this concept not to a geographical space but to product space, so quality differences will take the place of transportation costs (Stigler and Sherwin 1985). Following these definitions, prices may deviate from each other in the short run, but in the long run, arbitrage and substitutability will ensure that prices form an equilibrium relationship. Therefore, products will be in the same market when prices hold an equilibrium relationship (that is, they are cointegrated).

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\(^8\) Prices obtained from import values.

\(^9\) The fluctuation is particularly strong for import prices of frozen tilapia fillets.

\(^10\) All unit root tests were performed with the econometric software package EViews 5.0.
A variety of seafood studies have examined the market relationship between different goods by analysing their prices with tests for cointegration.\(^{11}\)

There are two approaches to test for cointegration: the Engle and Granger test (1987) and the Johansen test (Johansen 1988). We use the Johansen test in the market integration analysis as it allows hypothesis testing (such as the ‘law of one price’).

In our study, we test for market integration between two price series at a time. The Johansen test is based on a vector autoregressive (VAR) system. To start, we set a vector \(z_t\) containing two \((N)\) of the price series we are investigating. Then, we model \(z_t\) as an unrestricted VAR model with \(k\) lags containing these variables in levels, where, \(z_t\) is \((n \times 1)\) and each of the \(\Pi_i\) is an \((n \times n)\) matrix of parameters. The system is in reduced form with each variable in \(z_t\) regressed on only lagged values of both itself and all other variables in the system. In order to use the Johansen test, the VAR representation needs to be turned into a vector error correction model (VECM) of the following form:

\[
\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_k \Delta z_{t-k+1} + \Pi z_{t-k} + \mu_t, \tag{1}
\]

where \(\Gamma_i = -(I - \Pi_1 - \ldots - \Pi_i),\) \((i = 1, ..., k-1),\) and \(\Pi = -(I - \Pi_1 - \ldots - \Pi_k)\). The Johansen test centres on an examination of the \(\Pi\) matrix. \(\Pi\) is the long-run “level solution” to equation (1), because in equilibrium all the first differences of the price series \(\Delta z_{t-k}\) will be zero, and setting the error terms, \(\mu_t\) to their expected value of zero will leave \(\Pi z_{t-k} = 0\). Furthermore, \(\Pi = \alpha \beta'\), where \(\alpha\) represents the speed of adjustment,

\[^{11}\text{Applications to seafood data include Gordon and Hannesson (1996); Jaffry et al. (2000); Asche, Gordon, and Hannesson (2004); Nielsen (2005), and Nielson et al. (2007).}\]

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levels</th>
<th>First Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
<td>Trend</td>
</tr>
<tr>
<td>Tilapia, fresh fillets, nominal prices</td>
<td>-1.599 (1)</td>
<td>-2.770 (1)</td>
</tr>
<tr>
<td>Tilapia, frozen fillets, nominal prices</td>
<td>-1.905 (2)</td>
<td>-3.278 (3)</td>
</tr>
<tr>
<td>Catfish, fresh fillets, nominal prices</td>
<td>-1.591 (0)</td>
<td>-1.423 (0)</td>
</tr>
<tr>
<td>Catfish, frozen fillets, nominal prices</td>
<td>-1.988 (1)</td>
<td>-1.835 (1)</td>
</tr>
<tr>
<td>Tilapia, fresh fillets, real prices</td>
<td>-2.429 (1)</td>
<td>-2.833 (1)</td>
</tr>
<tr>
<td>Tilapia, frozen fillets, real prices</td>
<td>-0.920 (2)</td>
<td>-3.101 (3)</td>
</tr>
<tr>
<td>Catfish, fresh fillets, real prices</td>
<td>-0.852 (1)</td>
<td>-1.844 (0)</td>
</tr>
<tr>
<td>Catfish, frozen fillets, real prices</td>
<td>-0.958 (1)</td>
<td>-1.804 (1)</td>
</tr>
<tr>
<td>Tilapia, fresh fillets, quantity</td>
<td>-1.167 (1)</td>
<td>-2.734 (1)</td>
</tr>
<tr>
<td>Tilapia, frozen fillets, quantity</td>
<td>-0.372 (2)</td>
<td>-3.376 (2)</td>
</tr>
<tr>
<td>Catfish, fresh fillets, quantity</td>
<td>-2.099 (12)</td>
<td>-0.478 (12)</td>
</tr>
<tr>
<td>Catfish, frozen fillets, quantity</td>
<td>-2.593 (4)</td>
<td>-3.208 (4)</td>
</tr>
<tr>
<td>Real income</td>
<td>-0.223 (12)</td>
<td>-3.430 (2)</td>
</tr>
</tbody>
</table>

The values in parentheses indicate the number of lags.
Prices are in \$/kg, quantities are in kg and real income in $.
* indicates significance at the 1% level; **indicates significance at the 5% level.
while $\beta$ is a matrix of long-run coefficients. Both $\alpha$ and $\beta$ are $(N \times r)$ matrices.

There are two asymptotically equivalent tests for cointegration in the Johansen framework: the likelihood ratio test and the trace test. The test for cointegration between the $z_t$ is calculated by looking at the rank of the $\Pi$ matrix via its Eigen values. The rank of $\Pi$, $r$, determines how many linear combinations of $z_t$ are stationary. If $r = N$, the variables in levels are stationary. If $r = 0$, none of the linear combinations is stationary ($\Pi = 0$). When $0 < r < N$, there exist $r$ linear stationary combinations of $z_t$, or $r$ cointegration vectors. In this instance, we need to determine how many $r \leq (n-1)$ cointegration vectors exist in $\beta$. If the series are cointegrated, we further investigate whether the two price series are imperfect substitutes or whether they are perfect substitutes (LOP), so their relative price is constant. We test for the LOP by imposing the restriction $\beta' = (1, -1)'$.

**Demand Analysis**

Demand analysis is the most common approach used to estimate demand characteristics, including the degree of substitution. This includes the potential substitution between imports of tilapia fillets and domestic catfish fillets. Consumer theory indicates that the quantity demanded of any product is a function of its own-price, the prices of substitutes, and income. Demand analysis also allows us to derive cross-price elasticities empirically; these indicate the extent to which commodities compete in the same market. Demand models are generally estimated using traditional econometric tools, such as ordinary least squares (OLS). However, there is a problem when the data are non-stationary and there is no long-run relationship between the variables, as this will lead to spurious regressions. On the other hand, if cointegration exists between the series, OLS will achieve a consistent estimate of the long-run, steady-state relationship between the variables in the model, and all dynamics and endogeneity issues can be ignored asymptotically.

We estimate four double-log, static demand models for the import of fresh and frozen tilapia fillets and sales of fresh and frozen domestic catfish fillets. In these models, fresh tilapia fillets are assumed to compete with fresh catfish fillets in the same market and vice versa. Frozen tilapia fillets compete with frozen catfish fillets in the same manner. The specification of each model is as follows:

\[
\ln \ln q_{it} = \alpha_i + \lambda \ln p_{it} + \omega \ln p_{jt} + e \ln X_t + \epsilon_t, \tag{2}
\]

where $q_{it}$ is the quantity consumed of good $i$, $\alpha_i$ is a constant, $p_{it}$ is the real price of good $i$, $p_{jt}$ is the real price of good $j$, and $X_t$ is the consumer’s real income, all at time $t$. $\lambda$ represents the own-price elasticity, $\omega$ represents the cross-price elasticity, $e$ represents the expenditure elasticity, and $\epsilon_t$ is the error term. We also assume that there are deterministic trends and seasonal variation in demand. This is captured by introducing trend and dummy variables in the demand equations as appropriate.

To determine whether the static models consistently estimate the long-run relationship between the variables, we investigate the time-series properties of the error terms, $\epsilon_t$. If the series in each regression are cointegrated, $\epsilon_t$ will be stationary ($I(0)$), otherwise non-stationary ($I(1)$). When testing the residuals from the demand equations for stationarity, we use the critical values from MacKinnon (1991).
Empirical Analysis

Market Integration

To determine whether fresh and frozen fillets of imported tilapia and domestic catfish are competing within the same market, we perform bivariate Johansen cointegration tests (Johansen 1988) between the four price series of interest (table 2).\textsuperscript{12} All of the pairwise tests, with the exception of the test for fresh and frozen catfish fillets, fail to reject the null hypothesis of no cointegration vector with rank = 0 at the 5% level. The test for fresh and frozen catfish fillets rejects the null hypothesis of cointegration vector with rank = 0 at the 5% level. However, the hypothesis that there are two cointegrating vectors is rejected.

Hence, the main results from the market integration tests are as follows. First, the US wholesale processor prices of fresh and frozen catfish fillets form a long-run relationship during the period under consideration. Thus, fresh and frozen fillets of domestic catfish compete within the same market. Second, the import prices of fresh and frozen tilapia fillets do not form a long-run relationship. This result comes as no surprise because frozen fillets are mainly supplied by South-East Asian countries, while fresh fillets are mainly imported from South and Central American producers. Third, domestic catfish fillets and imported tilapia fillets are not within the same market. Hence, imported tilapia fillets cannot be taking market share from domestic catfish fillets, as they do not lie in the same market. That is, catfish and tilapia are regarded as unrelated products.

Given that the prices for fresh and frozen catfish fillets were found to be related, we have also tested whether the LOP holds in this relationship. As shown in the last column of table 2, the LOP was rejected for this relationship, with a test statistic of 10.967. Hence, we conclude that the market for catfish fillets is not fully integrated.

Demand Analysis

Tables 3 and 4 present the parameter estimates and summary statistics for the demand equations. The long-run own-price, cross-price, and income elasticities estimated from the demand models are reported in the first panel of each table. The second panels in tables 3 and 4 indicate the significance of the constant and joint significance of the seasonal dummies specified in every model. In all equations, the seasonal dummies are significant, indicating seasonal variation in demand. A trend has also been included in the demand model for frozen tilapia fillets, and the results indicate it is significant in this model. As our data series are non-stationary in levels (table 1), we confirm that the data series in each of the demand equations form a long-run relationship. This is done by testing whether the series are cointegrated through the first step of the Engle–Granger test. The results from these tests are reported in the last row of tables 3 and 4. The results indicate that the data series in all demand equations appear to be cointegrated. Furthermore, the four equations have high $R^2$ values; this also supports the hypothesis of cointegration in all equations. Reset tests also suggest no misspecification in any of the models. However, the test for error autocorrelation for lags 1 to 12 is rejected for fresh fillets of imported tila-

\textsuperscript{12} The Johansen cointegration framework was performed with the econometric software package EViews 5.0. The software allows the cointegration tests to be made using five different trend assumptions. We chose to have no intercept or trend in the cointegration test or VAR model following the Schwarz and Akaike information criteria.
### Table 2

<table>
<thead>
<tr>
<th>Nominal Prices</th>
<th>Rank (ρ) = 0</th>
<th>Rank (ρ) ≤ 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max^b</td>
<td>Trace^c</td>
</tr>
<tr>
<td>Tilapia (fresh)/Tilapia (frozen)</td>
<td>5.040</td>
<td>5.099</td>
</tr>
<tr>
<td>Tilapia (fresh)/Catfish (fresh)</td>
<td>3.580</td>
<td>3.602</td>
</tr>
<tr>
<td>Tilapia (fresh)/Catfish (frozen)</td>
<td>6.173</td>
<td>6.184</td>
</tr>
<tr>
<td>Tilapia (frozen)/Catfish (fresh)</td>
<td>3.410</td>
<td>3.734</td>
</tr>
<tr>
<td>Tilapia (frozen)/Catfish (frozen)</td>
<td>3.233</td>
<td>3.318</td>
</tr>
<tr>
<td>Catfish (fresh)/Catfish (frozen)</td>
<td>12.442**</td>
<td>12.467**</td>
</tr>
</tbody>
</table>

Results from Schwarz and Akaike Information Criteria.
^a The null hypothesis is that the number of cointegrating vectors is equal to ρ.
^b Maximum eigenvalue test.
^c Trace test.
* indicates significance at the 1% level; ** indicates significance at the 5% level.

### Table 3
Long-Run Parameter Estimates (Elasticities), Jan. 1997–Feb. 2006 (n = 110)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Fresh Tilapia</th>
<th>Frozen Tilapia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Standard Error</td>
</tr>
<tr>
<td>Tilapia, fresh price</td>
<td>–0.711*</td>
<td>0.249</td>
</tr>
<tr>
<td>Tilapia, frozen price</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Catfish, fresh price</td>
<td>–0.237</td>
<td>0.506</td>
</tr>
<tr>
<td>Catfish, frozen price</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Income</td>
<td>0.157</td>
<td>0.691</td>
</tr>
<tr>
<td>Constant</td>
<td>15.068 [0.000]^*</td>
<td>1.360 [0.246]</td>
</tr>
<tr>
<td>Trend</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Seasonals</td>
<td>46.610 [0.000]^*</td>
<td>4.075 [0.000]^*</td>
</tr>
<tr>
<td>R^2</td>
<td>0.986</td>
<td>0.966</td>
</tr>
<tr>
<td>RESET Test</td>
<td>0.0123 [0.912]</td>
<td>2.784 [0.099]</td>
</tr>
<tr>
<td>Error autocorrelation 1–12 lags</td>
<td>2.440 [0.009]^*</td>
<td>1.072 [0.394]</td>
</tr>
<tr>
<td>F-Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cointegration Test^a</td>
<td>–10.567*</td>
<td>–8.330*</td>
</tr>
</tbody>
</table>

* indicates significance at the 1% level; ** indicates significance at the 5% level.
^a Critical values for the cointegration tests are –3.8199 at the 5% level and –4.4273 at the 1% level (MacKinnon 1991).
The own-price elasticities of fresh and frozen tilapia fillets (table 3) and frozen fillets of domestic catfish (table 4) are –0.711, –0.689, and –0.773, respectively. These values indicate inelastic demand for these products, although they are close to unit elasticity. The own-price elasticity of demand for fresh fillets of domestic catfish (table 4) is –1.029; this indicates unit elastic demand for this product. The results for catfish fillets are consistent with previous findings that provide an own-price elasticity between –0.706 (Kinnucan and Miao 1999) and –1.17 (Kouka 1995).

The income elasticities of demand for fresh and frozen imported tilapia fillets and frozen domestic catfish fillets are 0.157, 0.564, and 0.540, respectively (tables 3 and 4). These positive, yet inelastic, income values indicate that consumers regard these products as normal goods. On the other hand, the income elasticity of fresh domestic catfish fillets is positive and highly elastic (2.015). This indicates that consumers regard fresh domestic catfish fillets as a luxury good. The variation in income elasticities between fresh and frozen domestic catfish fillets is of no great surprise, as previous studies have reported income elasticities ranging between 0.378 (Zidack, Kinnucan, and Hatch 1992) and 2.226 (Kouka 1995). The coefficients of the cross-price elasticities of demand in the four models (tables 3 and 4) are close to zero and insignificant (again, if ordinary inference theory applies), and

Table 4
Long-Run Parameter Estimates (Elasticities), Jan. 1997–Feb. 2006 (n = 110)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fresh Catfish</th>
<th>Frozen Catfish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catfish, fresh price</td>
<td>–1.029*</td>
<td></td>
</tr>
<tr>
<td>Catfish, frozen price</td>
<td>–</td>
<td>–0.773*</td>
</tr>
<tr>
<td>Tilapia, fresh price</td>
<td>–0.005</td>
<td>–</td>
</tr>
<tr>
<td>Tilapia, frozen price</td>
<td>–</td>
<td>0.089</td>
</tr>
<tr>
<td>Income</td>
<td>2.015*</td>
<td>0.540**</td>
</tr>
<tr>
<td>Constant</td>
<td>21.304 [0.000]*</td>
<td>155.438 [0.000]*</td>
</tr>
<tr>
<td>Trend</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Seasonals</td>
<td>26.593 [0.000]*</td>
<td>18.411 [0.000]*</td>
</tr>
<tr>
<td>R²</td>
<td>0.870</td>
<td>0.791</td>
</tr>
<tr>
<td>RESET Test</td>
<td>0.044 [0.835]</td>
<td>0.001 [0.979]</td>
</tr>
<tr>
<td>Error autocorrelation 1–12 lags</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-Test</td>
<td>3.130 [0.001]*</td>
<td>1.073 [0.394]</td>
</tr>
<tr>
<td>Cointegration Test</td>
<td>–6.267*</td>
<td>–7.881*</td>
</tr>
</tbody>
</table>

* indicates significance at the 1% level; ** indicates significance at the 5% level.

Critical values for the cointegration tests are –3.8199 at the 5% level and –4.4273 at the 1% level (MacKinnon 1991).

13 Note that the conclusions do not change if heteroskedastic and autocorrelation (HAC) consistent standard errors are used.
two of the relationships actually suggest complementarities. These findings imply that the demand for fresh and frozen imported tilapia is independent of the demand for fresh and frozen domestic catfish. This corroborates the findings from the market integration analysis. Hence, the demand analysis provides essentially the same results as the market integration analysis with respect to the competition between tilapia and catfish—they are not substitutes in consumption.

**Concluding Remarks**

The purpose of this article is to investigate whether imports of fresh and frozen fillets of tilapia and fresh and frozen fillets of domestic catfish compete in the same market. Industry commentators have suggested this is a possibility following the surge in tilapia imports over the last few years (Harvey 2004; Josupeit 2005). Our results are of interest, as they provide some insights into the future development of tilapia in the US market.

The rapid increase in imports certainly suggests that tilapia may be taking market share from other seafood products. If tilapia win market share from catfish, then the US catfish industry may experience negative pressure on prices, as this market is already considered to be saturated (O’Dierro, White, and Garfield 2003). This situation could cause the US catfish industry to target tilapia in a similar manner as it did with imports of Vietnamese *basa*. In 2000–2001, the US catfish industry favoured a ‘brand’ campaign over a generic campaign (Kinnucan *et al.* 2003). This new campaign emphasized that domestically raised catfish were of US origin and of a higher quality than the imported Vietnamese *basa*. In 2000–2001, the US catfish industry favoured a ‘brand’ campaign over a generic campaign (Kinnucan *et al.* 2003). This new campaign emphasized that domestically raised catfish were of US origin and of a higher quality than the imported Vietnamese *basa*. 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large increase in tilapia imports supports our conclusion that there must be other factors influencing the increase in tilapia imports.14

Another explanation for the increase in market share of tilapia is the decline in wild fishery landings. In particular, Muir and Young (1999) and Anderson (2006) have suggested wild flatfish, snapper, and grouper are other seafood products that tilapia may be competing with. Determining whether or not this is the case will be an important topic for future research. Alternatively, it is also possible the demand growth for tilapia is similar to that observed by Asche, Bjørndal, and Young (2001) with salmon. Their findings indicated that while salmon was winning market share from a large number of other food products, it was taking so little from each individual market that it was difficult to measure the impact.

References


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