Integration of a local fish market in Namibia with the global seafood trade: Implications for fish traders and sustainability

Abstract

Within the last decades, globalization has changed the international seafood trade, allowing low-income countries to access markets in high-income countries and vice versa. Nevertheless, the effects of globalization are controversial and in particular the impacts on small-scale fishers and local fish traders are unclear. This paper examines the economic effects of globalization on a local fish market in Katima Mulilo, Namibia along the Zambezi River and near the border with Zambia. Using market data from January 2008 to December 2016, we test two hypotheses. First, we test if the local market is integrated with global markets. Second, we test whether local prices are increasing and associated with positive terms of trade. Using time series methods and hedonic models, results show that the Katima market is linked to the world market, and local fish traders receive higher prices over time as predicted by an increasingly globalized seafood trade.

Keywords: small-scale fisheries, fish trade, globalization, market integration, size-based pricing, telecoupling

JEL code: C22, O13, Q11, Q22

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Introduction

The effects of globalization on fisheries are controversial. Globalization has unquestionably expanded the international seafood trade, allowing low-income countries to access markets in high-income countries and vice versa. The key economic questions are whether individual participants in fisheries benefit from this increased trade and whether increased exposure to trade compromises fisheries sustainability in the long run. At the aggregate level, the seafood trade primarily reflects a quality exchange between developing and developed countries. Developing countries export high-value seafood to developed countries in exchange for low-value imports (Asche et al., 2015). One interpretation is that developing country sellers of fish obtain higher prices than they would in the absence of globalization, while food imports compensate to maintain low prices for developing country consumers. This optimistic view is consistent with the aggregate data, as per capita seafood consumption has continued to rise in developing countries despite large export volumes (FAO, 2018).

However, there are reasons that economic benefits to small-scale fishers and local fish traders might not materialize. First, it is possible that corrupt government officials or powerful intermediaries capture all of the gains from the seafood trade and fail to pass them on to local fishing communities (Kaczynski & Fluharty, 2002). If gains from trade were not passed along, despite evidence that developing country export markets are integrated with global markets (Tveterås et al., 2012), the local markets in developing countries would appear independent. Second, higher prices in the export market create incentives to overexploit natural resources that have ill-defined property rights (Chichilnisky, 1994) or where there is inadequate enforcement. Consequently, short-run gains from selling more fish into the export market can be offset by long-

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run losses from degrading fish stocks (Brander & Scott Taylor, 1998; Anderson, 2007). As indirect support for each of these concerns, seafood net exports are correlated with low scores on governance measures, including corruption, property rights, rule of law, and government effectiveness (Smith et al., 2010). Moreover, weak governance and net exports are both associated with lower per capita seafood consumption at the country level (Asche et al., 2015). A similar concern is that exposure to global markets could destabilize otherwise effective self-organized governance of the commons (Dietz et al., 2003; Cudney-Bueno & Basurto, 2009). Nevertheless, recent empirical evidence at the country level points in the other direction and shows that trade liberalization is not associated with overexploitation of fish stocks in countries with weak governance (Erhardt, 2018).

A complementary framing is to ask whether the global seafood trade—or trade liberalization more broadly—is pro-poor (Bene, Lawton, and Allison 2010). There are potential economic benefits of trade but also potential food security costs of exporting healthy seafood protein and/or increasing domestic seafood prices. Bene, Lawton, and Allison (2010) find that at the macro scale, i.e., measuring country-level development and macroeconomic indicators, the effects of the seafood trade for sub-Saharan African nations are inconclusive. While these country-level tests provide an important backdrop, quantitative studies of local markets are essential to inform whether positive terms of trade are passed on to small-scale fishers and fish traders.

Documenting whether short-run gains from trade provide more compensation to resource users is important because, in the absence of higher compensation, it is difficult to imagine channels through which the seafood trade could be pro-poor. Receving higher prices for fish may not be a sufficient condition, but it may be necessary for global seafood trade benefits to materialize. A

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number of case studies suggest that small-scale fishers, fish farmers, and traders face difficulties accessing lucrative export markets (Tran et al., 2013; Crona et al. 2016; Kaminski et al. 2018) or simply do not receive higher prices despite exporting seafood (Mitchell and Coles 2011). Moreover, the finding of Erhardt (2018) — that trade liberalization is not associated with overexploitation in the presence of weak governance — could be explained by powerful intermediaries capturing all of the terms of trade benefits such that price signals are not transmitted to the fishery and thus there are no new incentives to overexploit.

Beyond effects on individual fisheries, there are concerns that globalization will induce global-scale or systems-level phenomena that compromise sustainability. For example, the combination of rising demand and globalization of fishing fleets allows so-called "roving bandits" to deplete unregulated fish stocks around the world (Berkes et al., 2006). At the same time, the globalization of the seafood market could mask growing scarcities from depleted stocks, as price signals are dampened when more species and regional markets are added into the global market (Crona et al., 2016).

Understanding how commercialization affects small-scale fisheries and markets is especially important in the context of Namibia. Namibia has a highly commercialized marine fishery. However, it is also an arid country with scarce freshwater resources. Freshwater fisheries are an important source of protein and part of livelihoods in sub-Saharan Africa (Kolding et al. 2019). Namibia's policy towards freshwater fisheries has prioritized subsistence use over commercialization (Government of Namibia, 1995). Growing levels of fishing effort have led to apparent declines in abundance of large freshwater fish in the Upper Zambezi River (Tweddle et al., 2015), although abundance of small pelagics remains high in many areas (Kolding et al. 2019).

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Whether the region's fisheries are governed sustainably in the future could have severe consequences for food security. This is especially important in the light of the recent extended drought in the region, which has affected not only fisheries, but also farming and livestock.

In this paper, we test two hypotheses about the effects of globalization on a local fish market in a developing country. First, local markets are integrated with global markets. Second, local prices are increasing and associated with favorable terms of trade. Two recent papers on price transmission in Vietnamese fisheries are closely related to our second hypothesis regarding trends in fish price (Sapkota et al., 2015; Pham et al., 2018). We analyze data from a local fish market in Katima Mulilo, Namibia along the Zambezi River and near the border with Zambia, Angola and Botswana. In this market, researchers have collected a long-term panel data set spanning a period of significant political, economic, and environmental change (Abbott et al., 2007; Abbott et al., 2015). We first test for market integration of the three most traded species in the Katima Open Market with the global Fish Price Index (Tveterås et al., 2012). We also test for the Law of One Price and demonstrate that it holds for each of these species. These findings are consistent with improvements in local infrastructure and transportation that facilitate product market integration (Liese et al., 2007; Abbott et al., 2015). We then use hedonic models to decompose price changes and find that fish traders are indeed receiving higher prices. Alternative explanations for price increases are considered, including local scarcity, but in light of our time series results, the most plausible explanation is that price increases reflect integration into the global seafood market.

The paper is organized as follows. We first provide an overview of the empirical setting, including the key institutional and infrastructure changes that took place during the study period, and descriptive statistics of the data used. We then describe the empirical analyses used to test for

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market integration and price changes over time. The paper concludes with a discussion of the results and directions for future research.

Empirical Setting and Data

In this study we use fish data from the Katima Open Market (hereafter referred to as the Katima Market) located in Katima Mulilo, Namibia. Katima Mulilo is the capital of the Zambezi Region in northeast Namibia. Fish are brought in from the rivers and floodplain areas of the Zambezi-Chobe floodplains and more recently from a large shallow lake (Lake Liambezi) on the floodplain, which re-emerged for the first time in over 20 years after record flooding in 2009 (NASA Earth Observatory, 2009).

The Katima Market is a municipal building providing vendors space to sell fish, as well as other goods such as beef, produce and fabrics. Fish vending takes place in a series of tiled counters, with each vendor allocated a numbered space, 1m wide, to sell their fish, although some may choose to take up two spaces, or double up on a single space. The market can accommodate 100 vendors at maximum capacity. Both fresh and dried fish are sold in adjacent parts of the Katima Market, and very occasionally vendors will sell a mix of both.In contrast to other fish markets in sub-Saharan Africa that draw on freshwater fisheries, very small dried fish (e.g. *kapenta*) was rarely observed for sale in Katima Market. While there were typically more vendors selling dry fish, fresh fish inventory and volume arriving to the market is usually much higher. Vendors often stay more than one day, often refreshing their inventory over time sometimes through supplies from family members, or more frequently by purchase from intermediaries (described below) or other vendors.

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The importance of fish vending as a livelihood strategy varies among particpants. Some fish vendors depend on the activity as an important and consistent source of income. As such, they frequently have arrangements with fishers to ensure a regular supply. The highly seasonal nature of farming, livestock, and gardening that characterizes rural livelihoods in many parts of the world (e.g., Allison and Ellis, 1999) means that other vendors may choose to leave the market due to demands from other livelihood activities. In these cases, they may choose to sell their inventory at a reduced price, either to customers or other vendors.

The market opens at 8 am and stays open until 5 pm daily. Fish sold can be stored overnight at the market, but more often vendors rely on a daily supply of freshly caught fish. Pickup trucks carrying fish begin arriving around 10 am. Vendors will either have purchased a supply of fish in advance or will run alongside a pickup truck and 'claim' a cooler full of fish.

As described in Abbott et al. (2015), fish supply and demand in the Katima Market changed between 2005 and 2012 as a result of environmental and economic changes. We expect that these changes contributed to greater integration into the global seafood market. As mentioned earlier, high seasonal flooding in 2009 resulted in the refilling of Lake Liambezi. This shallow body of water was highly productive, yielding large amounts of commercially desirable tilapiine cichlid species (Peel et al., 2015). Compared to the Zambezi-Chobe floodplains, the lake was also more accessible by vendors and intermediaries. In the Zambezi-Chobe floodplains, fishers landed their catch in locations scattered throughout the wetlands, with roads being prone to flooding. By contrast, fishers at Lake Liambezi typically landed their catch at one of three sites, all serviced by more reliable roads.

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This emergence of a reliable supply of large amounts of fish occurred at the same time that demand for fish in the region was expanding. A bridge connecting Namibia and Zambia was completed in 2004, and at the same time, the Zambian road network was extensively upgraded. These infrastructural improvements opened up new markets, particularly in the Zambian Copperbelt, where rising prices in the early 2000s for copper led to the reopening of mines (The Economist, 2013) and a rise in Zambia's Gross Domestic Product Per Capita (Boos & Holm-Müller, 2016). Vendors from Katima Market reported trading fish as far as the Zambia-Democratic Republic of Congo border (Abbott et al., 2015). Fresh fish packed on ice were shipped to a number of Zambian destinations including Katima Mulilo (there is also a Katima in Zambia), Livingstone, Sisheke, Lusaka, and Mboma, with Lusaka being about 700km from Katima Market. Fresh fish were also shipped without ice to locations within 200 km, including Katima, Mwandi, Livingstone and Sisheke.

During our study period, Zambia also experienced substantial growth and commercialization in its aquaculture industry with associated improvements in logistics and supply chain management (Kaminski et al. 2018). Large-scale producers, which farm 99% tilapia, developed the ability to access higher-income market segments within the country by selling large, high-quality fish (Kaminski et al. 2018). In summary, within a decade an environmental change increased the supply of marketable fish in the region, demand in the neighboring region grew as a result of expanded mining activity and the development of new high-end markets, and new physical infrastructure connected the Katima Market to the regional market.

Fish brought to the Katima Market is either sold in smaller quantities to inhabitants of Katima Mulilo or accumulated for sale in markets in other parts of Namibia to cater to specific

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preferences (e.g. *Clarias* spp.) or to markets in Zambia and the Democratic Republic of Congo. Fish going to more distant markets is typically sold in larger quantities via one or more intermediaries. Fish are piled according to price, and prices are communicated orally and open to bargaining. A local buyer typically purchases between one to three fish, to consume at their next meal.

Data were collected at least twice a month from the Katima Mulilo Open Market from January 2008 to December 2016. The survey team, composed of trained local staff, first recorded the number of stalls occupied by either fresh or dried fish vendors. From this enumeration, five fresh fish vendors were randomly chosen for sampling. Upon consent from the vendor, the entire inventory was recorded, including fish species, total length, weight and price. Data collection and quality was controlled by the authors. We focused on price and species trends in only fresh fish for this paper due to accuracy concerns. The shrinkage, loss of mass, and discoloration that typically occurs when fish are dried and/or smoked affects both measurement and species identification. By focusing on fresh fish, we are able to study prices consistently over time. Moreover, because fresh fish constitutes the largest volume and highest turnover in Katima Market, there is more information about seafood markets contained in the fresh fish prices.

The dataset contains the prices (per kg) and lengths of individual fish representing 24 distinct species sold at the Katima market during the period sampled. Moreover, flood cycle phases of the Zambezi River are recorded. Table 1 presents the descriptive statistics of the species in the dataset and their respective prices and length. The monthly prices are recorded in Namibian Dollars (N$) per kg and are inflation adjusted using the monthly Namibian consumer price index (CPI) (base year = 2010).

Table 1 clearly shows that the three tilapia species *Oreochromis andersonii*, *Oreochromis macrochir* and *Coptodon rendalli* comprised about 80% of the total fish sold at the Katima Market in the period from 2008 to 2016. The remaining 21 species accounted for only 20% of the total. This picture is similar when looking at the individual years. The one exception is in the year 2008, where the species *Serranochromis macrocephalus,* also a tilapia species, accounted for 11%, decreasing to 3% in 2009. The frequency of the fish species otherwise remained roughly constant over the observation period. The mean prices ranged between N$5.92 per kg for *Clarias ngamensis* to N$53.60 per kg for *Oreochromis niloticus.* It is important to note that, unlike the rest of the species recorded in the market survey, *O. niloticus* is a non-native fish species which has begun to be farmed in neighbouring countries.

Figure 1 shows the average price in N$ per kg for all fish species and the average water level of the Zambezi River during the study period. The monthly price averaged over all species continuously increases beginning in 2012. In January 2012 the mean price for all species was N$ 16.50. The price increased up to N$ 46.63 in December 2016, which is a large increase of nearly 300%. However, it is not obvious whether there was a linkage between flood cycle phase and fish price. In the time series analysis below, we include the flood cycle as a covariate to allow for how it can influence the supply of fish exogenously.

In the following section, we first test if the Katima Market is affected by globalization using cointegration methods, which we describe below. Cointegration in our context implies that prices for fish from Katima Market and prices reflecting global seafood markets move closely together in the long run. Afterwards, we estimate hedonic models, also described in more detail below, to decompose local price changes in the Katima Market.

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Empirical Analysis

Integration of the Katima Open Market into Global Markets

We are interested whether the most common species brought to the Katima Market are integrated with the world market, which would imply that the region is affected by globalization. By integrated, we mean that there are stable long-run relationships in the prices of fish traded in the Katima Market and representative prices of the global seafood market. To this end, we test for cointegration. A stronger version of market integration, which we also test below, is that the Law of One Price (LOP) holds. LOP means that the relative prices are statistically constant over time. We use monthly observations from January 2008 to December 2016 and concentrate on the three tilapia species (*O. andersonii*, *O. macrochir* and *C. rendalli*), as these species account for nearly 80% of the species sold at the Katima Market. The prices are real prices in N$ per kg (base year=2010) and averaged for each tilapia species and each month. With no observations missing, the time series consists of 108 observations.

Figure 2 depicts the log price developments of the tilapia species and the UN Food and Agriculture Organization's Fish Price Index (FPI). Taking the natural log of each price series allows us to test the LOP below using a linear regression. The FPI currently includes seafood imports to the European Union, Japan and the USA and six major species aggregates (salmon, whitefish, other fish, crustaceans, small pelagics, and tuna). The FPI, which is based on an average seafood trade bundle in the sample period, is indexed to 2002-2004 (Tveterås et al., 2012). We then deflate the nominal FPI by the US producer price index (PPI) (base year=1982). Figure 2 shows

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that the prices of the three tilapia species behave similarly to each other, and all three species are volatile throughout the observation period. The inflation-adjusted FPI, which is based on aggregating many more species and fish trades, displays less volatility but shows some similar directional changes.

It is not obvious from the graphs if the underlying data-generating processes are stationary or nonstationary (i.e. contain a unit root), and stationarity needs to be determined with econometric tests. Moreover, it is unclear whether there is a stable, long-run relationship between prices of fish traded in the Katima Market and the Fish Price Index that represents the global seafood trade. Only through time series analysis that conditions on the flood cycle, can we establish whether these relationships exist statistically.

Following Stigler (1967) and Cournot (1971), a market can be defined as the area within which the prices of goods tend to equalize after controlling for transportation costs and quality differences. This is known as the law of one price (LOP). When the LOP holds, markets are integrated, thus building a common market. In this setting, we are interested whether the Katima Market is integrated with the global seafood market. Recall that integration into the global market does not require that seafood in Katima Market is directly sold into global markets. Rather, it requires that Katima Market seafood is exposed to sufficient trade competition (directly or indirectly) such that the global market drives prices. As an indicator of the global seafood market, we use the FPI, and we can test for LOP using time series methods to analyze the FPI together with price data from Katima Market.

In the following, we describe how we analyze seafood market integration. The general approach—tests for statinority, bivariate cointegration tests, and a tests for the Law of One Price--

is quite standard and has been used extensively to test for seafood market integration across a range of species and geographical settings (Asche, Bremnes, and Wessells 1999; Asche, Gordon, and Hannesson 2004; Bronnmann, Ankamah-Yeboah, and Nielsen 2016; Pincinato and Asche 2016; Ankamah-Yeboah, , Ståhl, and Nielsen 2017; Smith et al. 2017).

The basic relationship between two prices that nests the possibilities of no market integration and complete market integration can be expressed in logarithmic form as:

$$lnp_t^1 = a + \beta lnp_t^2 + \varepsilon_t \qquad (1)$$

where the parameter a is a constant term that reflects transportation costs and quality difference between two prices, p^1 is the price of one of the tilapia species in time *t*, respectively, p^2 is the fish price index. The parameter β indicates the long-run relationship between the prices. If $\beta = 0$, the product prices are unrelated to each other, indicating that there is no substitution effect[1] between the products, while $\beta = 1$ indicates that the law of one price holds and there is complete market integration. In case of $\beta \neq 1$ in an integrated market, the commodities are imperfect substitutes. How to deal with equation 1 depends on the nature of the stochastic processes of the vector of prices. In the presence of nonstationary price series, equation 1 produces spurious results. Hence, cointegration is mandatory for nonstationary price series data. The principle of the cointegration analyses is that a linear combination of time series integrated of order one is stationary (Engle & Granger, 1987).

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[1] The substitution effect is the change in consumption patterns due to a change in the relative prices of goods. When a price of one good increases, consumer switch to buying a relatively lower priced substitute good.

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Using the Augmented Dickey-Fuller tests, we find that all of the prices under study are non-stationary but are first order integrated (1). Thus, market integration can be investigated using co-integration tests. We use the (Johansen, 1988) cointegration test, which is based on an error correction model (ECM) representing of the Vector Auto Regressive (VAR) model with I(0) vector Δp_t containing prices given by:

$$\Delta p_t = \sum_{i=1}^{k-1} \Gamma_i \, \Delta p_{t-1} + \Pi p_{t-1} + \mu + \varepsilon_t \qquad (2)$$

The matrix Π contains the parameters in the long-run relationship with the cointegration vectors where $\Pi = \sum_{i=1}^{k-1} \mathrm{A}_k - I_k$ and $\Gamma_i = -\sum_{j=i+1}^{k} A_j$, and A is the coefficient matrix of the VAR representation. If the cointegration matrix has reduced rank r<n, then there exists (n x r) matrices α and β, each with rank r such that $\Pi = \alpha'\beta$ where α is the speed of adjustment and β the matrix of the long-run coefficient and $\beta' p_t$ is stationary. The tests for cointegration use two likelihood ratio tests: the trace and maximum eigenvalue test. The null hypothesis in each test is that there are not more than *r* cointegration vectors. The alternative hypothesis of the trace test is that there exist *n* cointegration vectors. The maximum eigenvalue test tests the null against the alternative of *r*+1 cointegration vectors. We test the LOP by imposing restrictions on β, following Juselius (2006).

The presence of cointegration in a bivariate system with $rank(\Pi) = 1$ implies that the cointegrated VECM can be decomposed by:

$$\begin{pmatrix} \Delta p_t^1 \\ \Delta p_t^2 \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (p_{t-1}^1 - a - \beta p_{t-1}^2) + \begin{pmatrix} \theta_{11} & \vartheta_{12} \\ \theta_{21} & \vartheta_{22} \end{pmatrix} \begin{pmatrix} \Delta p_{t-j}^1 \\ \Delta p_{t-j}^2 \end{pmatrix} + \begin{pmatrix} e_t^1 \\ e_t^1 \end{pmatrix} \qquad (3)$$

where μ_i is the constant term, $\theta \; and \; \vartheta$ are the own- and cross-lagged price parameters, and *e* represents the error term assumed to be independent and identically distributed with zero mean and a finite variance. To account for the effects of the flood cycle on fish availability in the Katima Market, all models are estimated with controls for the monthly water level (ΦD_t) as well as seasonality using monthly dummies (ΨS_t). Thus, equation (2) can be written as:

$$\Delta p_t = \sum_{i=1}^{k-1} \Gamma_i \Delta p_{t-1} + \Pi p_{t-1} + \sum_{i=1}^{k} \Phi D_t + \Psi S_t + \mu + \varepsilon_t \quad (4)$$

We performed pairwise co-integration tests to identify common markets and to assess whether the price series move together over time. We selected the lag lengths by considering the following information criteria: LR, FPE, AIC, SC and HQ, from which the most frequent selected lag was used.[2] We also assume a restricted deterministic trend.

The results of the bivariate cointegration tests are in Table 2 and indicate market integration. For all three tilapia species, Katima Market prices and the FPI representing the global seafood market are integrated according to the trace and maximum eigenvalue statistics at the respective ranks. The first null hypothesis, r=0 (no cointegration) is rejected for all pairs and the second null hypothesis, r=1 (cointegration) is not rejected in any of the cases. Importantly, in all cases, the null hypothesis that the LOP holds cannot be rejected. The weight of the evidence shows that the global seafood market shapes the price formation process for the tilapia species (*O. andersonii* (OAND) *O. macrochir* (OMAC) and *C. rendalli* (TREN)) sold at the Katima Market. This means that in general the fish in the regional Namibian market is exposed to international trade competition whether the particular fish are traded internationally or not. Tilapia species brought to Katima Market, which account for 80% of fish sales, compete in the global marketplace.

[2] LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion and HQ: Hannan-Quinn information criterion

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The estimated models do not suffer from misspecification since the null hypothesis of no autocorrelation (reported the p-value of LM-statistic of lag order 6 of 12) and normality (reported p-value of Jarque-Bera statistic) of residuals cannot be rejected at the 5 percent level, which is shown in Table 3.

Hedonic Modeling of Katima Market Prices

To examine whether the market integration documented above leads to higher prices for fish traders in local markets, we estimate hedonic models of Katima Market prices. The first formal characterization of the hedonic price function was provided by Rosen (1974) building on Lancaster´s characteristics theory of value (Lancaster, 1966). The basic premise is that the sales price of a good is a composite of implicit prices that reflect individual attributes of the good. In real estate transactions, for example, the price of a property is decomposed into implicit prices for number of bedrooms, number of bathrooms, square footage, school district quality, and other attributes. In food markets, hedonic models typically include specific product type (e.g. species of seafood), quality attributes such as freshness, type of processing, package size, branding, and other value-added characteristics. Thus, hedonic modeling can provide a rich understanding of what factors affect the fish prices at the Katima Open Market. We use a fixed effect model (Model 1 in Table 3) to pool all species together and investigate how the water level, the length of the fish sold, the year, seasonality, and interactions of year and size affect the price of fresh fish. The fixed effect captures the species-specific intercept. We estimate separate OLS models for each of the three tilapia species as well (models 2-4 in Table 3). As in the time series analysis above, transactions reflect purchases of individual fish, and the prices are converted to inflation-adjusted Namibian

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dollars per kg. We include fish length as a covariate in the model to proxy for a market premium on larger fish. We specify the following semi-log fixed effects model for all species:

$$\ln p_{it} = \alpha_i + \boldsymbol{x}'_{it}\boldsymbol{\beta} + \varepsilon_{it} \tag{5}$$

where $\ln p_{it}$ is the log price of the fish species *i* at time *t*, $\boldsymbol{x}_{it}$ are the regressors *i* at time *t*, α_i are species-specific effects that are constant over time, and ε_{it} is an idiosyncratic error. The α_i is permitted to be correlated with the $\boldsymbol{x}_{it}$ ($u_{it} = \alpha_i + \varepsilon_{it}$). We control for the following covariates: length of the fish species in cm and mean water level of the Zambezi River in m. Furthermore, interaction terms of year and length as well as year and month effects are included.

Table 4 shows the estimation results, which are broadly consistent with other hedonic models of seafood markets (Asche, Chen, and Smith 2014; Bronnmann and Asche 2016). Model 1, which pools all species and applies the panel fixed effects estimator, uses cluster robust standard errors with 23 clusters corresponding to the number of species. Model 2 through Model 4, which are estimated for the individual tilapia species, use OLS and report robust standard errors without clustering since there is a separate regression for each species. In all models, larger fish are more expensive than smaller fish as indicated by the positive and statistically significant coefficients on length. The flood events led to price increases for all species, but the effect is not statistically significant in the model for one of the tilapia species.

As in hedonic models of housing markets, year dummy variables isolate the background market appreciation after conditioning on other factors that affect price. In our case, those other factors include length of fish sold, species, the flood cycle, and seasonality (captured by monthly dummies). We also control for the possibility that size-based scarcity is increasing over time by including year and fish length interaction terms.

Across models, many of the year dummies are statistically significant. Negative coefficients are more common in the early years of our sample, and positive coefficients more common in later years. We examine the trends in year dummies to evaluate whether prices increase over time. Figure 3 depicts these trends for point estimates of the year dummies in each of the four models. Here we see clearly that prices are increasing over time after initial drops from the base year of 2008 until 2010. All conditional prices are higher in the final period (2016) than in the base year, although two of the 2016 year dummies are not statistically different from zero. These results overall are consistent with rising prices associated with globalization, implying that fish traders are receiving more for their fish as a result of trade competition with global seafood markets.

Figure 4 depicts the fish length and year interactions. Including these interactions in the model allows us to exclude the possibility that increasing overall background prices are an artefact of rising premiums for larger fish. The results show clearly that the interaction effects not trending upwards. For three of the models, there is an initial increase up to 2010. However, in all models the interactions are trending downwards after 2010, and all interaction terms end up at or below the base 2008 level by 2016.

Discussion

Our first main finding is that fish prices in the Katima Market in Namibia are integrated with a global seafood price index. To our knowledge, our study provides the first evidence of an inland seafood market in a developing nation being integrated with the global seafood market.

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Many studies find evidence of seafood market integration in industrialized countries when imports from developing countries are prevalent— e.g. U.S. Gulf of Mexico shrimp (Smith et al. 2017); cold- and warm-water shrimp in Europe (Ankamah-Yeboah, Ståhl, and Nielsen 2017), whitefish in Germany (Bronnmann, Ankamah-Yeboah, and Nielsen 2016), and crustaceans in Germany (Ankamah-Yeboah and Bronnmann 2018). Moreover, Pham et al. (2018) find evidence of price transmission from Polish retail markets to Vietnamese pangasius farmers. Nevertheless, our findings are surprising because the Katima Market and the internationally traded seafood that make up the raw data used to construct the FPI are not directly connected. Specifically, the FPI is based on trade records from the EU, the U.S., and Japan, but Katima Market fish are not exported to these markets, and Namibia does not import tilapia—the predominant fish traded in Katima Market—from any of these markets.

If one had to guess at a seafood market that was minimally influenced by globalization but where fish were still bought and sold for money, one would choose a place like Katima Market: a place that is located in a developing country, far from a large city or any densely populated areas, inland and not near a major ocean port, not close to a major airport, one that experiences seasonal and inter-annual variation in supplies, and one where the fish traded are not exported to any of the world's largest seafood markets. Yet we find evidence that Katima market–despite its size, geography, and role in the trading system—is integrated with the global market for seafood.

In our setting, the mechanisms for global market integration are complex and indirect. Namibia is a significant seafood exporter to the EU. In 2015, Namibia exported $10.9 million (USD) of mollusks, $36.6 million in whole frozen hake, and $88.9 million of frozen hake fillets to

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Spain alone with another $10.2 million of hake fillets going to Italy.[3] Thus, Namibian seafood is heavily exposed to the European market. However, these exports are marine species, so links to price formation in inland markets for freshwater fish are at best very indirect.

A more plausible link to global markets is the exposure of the regional market for tilapia to trade competition. While regional exports are also dominated by marine fish—mostly mackerel going to South Africa, Mozambique, Zambia, and Democratic Republic of Congo—Namibia exports and imports large volumes of tilapia. Namibia exported 76,500 kg of fresh tilapia to Zambia in 2015 along with 2,651,630 kg of frozen tilapia. Consistent with our interviews with vendors, some (possibly a large share) of the fresh tilapia exports originate in the Katima Market. Namibia also imported 3,670,910 kg of frozen tilapia from China in 2015. As the largest producer, consumer, importer, and exporter of seafood, China's importance in the global seafood trade is undeniable. For the case of tilapia in particular, China provides a link from the regional tilapia market in sub-Saharan Africa to the U.S. and EU markets. Moreover, the magnitudes of frozen tilapia imports from China and exports to Zambia suggest that Namibia is involved in transshipment, which in international trade means importing and then re-exporting the same product. Transshipment is another common feature of globalization.

Developments in the region both enabled and reinforced links to global markets. Improvements in infrastructure, particularly the bridge across the Zambezi River and improvements in the Zambian road network, mean that the Katima Market became more connected physically to large regional markets. Importantly, these regional markets experienced a growth in

[3] Product-level trade statistics are from the UN Comtrade Database, https://comtrade.un.org/.

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demand, particularly in Zambia with rising incomes associated with reopening copper mines. At the same time, the burgeoning tilapia aquaculture industry in Zambia began to segment the tilapia market by selling larger (>300g for Grade 1), higher quality fish to relatively high-income consumers in urban regions (Kaminski et al. 2018). Development of this market infrastructure created new opportunities for exporting fresh tilapia from Katima Market to Zambia, as many tilapias sold in the Katima Market are larger than the cutoff for Grade 1 fish in the Zambian market. This development also created opportunity for frozen tilapia from China to compete in these markets. Lastly, technological change supporting globalization likely contributed to market integration as well. A well-known study in fisheries development found that the introduction of mobile phones decreased price dispersion across artisanal fishing markets and led to a "near-perfect adherence to the Law of One Price" (Jensen, 2007, p. 879). Similar efficiency improvements and reductions in price volatility were found in a study of mobile phone use in Ghanaian fisheries (Salia et al. 2011). The confluence of physical and market infrastructure developments, rising demand, indirect links to EU markets, direct links to China, and technologies supporting globalization enabled the integration of the Katima Market with the global seafood market.

Our second main finding is that local traders are receiving higher real prices for fish over time. In our hedonic model, we control for fish size, environmental conditions, and seasonality, which allows for a consistent comparison of real prices over time. The positive and significant coefficients on fish length are consistent with a large literature documenting similar effects in seafood markets (McConnell and Strand 2000; Kristofersson and Rickertsen 2007; Asche, Chen, and Smith 2015; Sjöberg 2015; Bronnmann and Asche 2016).

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Rising real prices are surprising because supplies increased during our study period. Specifically, the refilling of Lake Liambezi triggered a substantial increase in supply during the sample period. At the same time, regional tilapia supplies increased due to growth in the Zambian aquaculture industry. However, these supply increases were accompanied by rising demand and market and physical infrastructure developments that allowed the Katima Market to integrate more into regional markets, which ultimately facilitated more global market integration. Thus, the demand-side and market integration features ultimately dominated supply increases and put upward pressure on prices. This finding is consistent with the broader patterns of globalization: upward pressure on prices for low-income developing countries and downward pressure on prices for high-income industrialized countries.

Under plausible conditions, higher real prices provide benefits to fish traders. By construction, our hedonic model isolates price trends such that the results can be interpreted as holding all other things equal. That is what multivariate regression does. If the same fish traders receive higher prices for the same fish, holding everything else constant, they are indeed better off. To the extent that fish traders pass on these higher prices to fishers, the fishers are likely to benefit as well by receiving higher prices for the fish they sell to traders. However, because higher prices are associated with other transformations of seafood markets and market integration, whether fish traders and fishers are better off overall is less clear. For example, our data do not track individual people over time, so it is possible that incumbent fish traders (or new entrants) have benefited while others have exited the market and do not experience benefits of higher prices. One possible mechanism that we are unable to test is that traders of dried or smoked fish were crowded out as the market for fresh fish improved. Changes in Katima Market could also have triggered changes

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in relationships between traders and creditors, which theoretically could lead to gains or losses for traders. If powerful intermediaries, for instance, gained more market power as a result of market integration, higher prices for traders may not constitute a benefit and may only be a symptom of a larger transformation of the market. Lastly, it is important to note that higher prices are short-term gains from trade. Sustaining these benefits over the long run requires that higher prices do not create new incentives to overfish and degrade the resource base.

The debate about whether the global seafood trade is pro-poor highlights the importance of our findings. Bene, Lawton, and Allison (2010) conclude on the basis of their cross-sectional country-level regressions, “the absence of correlation between [sub-Saharan African] fish trade revenues and development indicators seriously challenge the hypothesis of a trickle down effect and suggest instead that trade revenues are ‘dissipated’ before they have the chance to impact any economic and/or human development indexes” (p. 946). Our results directly support the hypothesis of trickle down, at least in terms of higher prices that are passed along to local fish traders.

Our findings also illustrate the concept of telecoupling, the notion of soecioeconomic and environmental feedbacks and interactions across often large distances (Liu et al. 2013). A recent application of telecoupling to small-scale fisheriers describes three types of interactions: market export, market competition, and market spillover (Crona et al. 2016). Our qualitative understanding of the Katima Market and regional seafood markets in sub-Saharan Africa together with quantitative information on exports and imports suggest that all three types are relevant to our case. The modest exports of fresh and frozen tilapia to Zambia support the case for market export. The large imports of frozen tilapia from China and what appears to be transshipment to Zambia, on the other hand, supports market competition. There is no evidence that frozen tilapia ends up competing directly with fresh fish in Katima Market, but it competes in the neighboring Zambia where locally farmed tilapia also competes with fresh tilapia brought from the Katima Market. Lastly, there are strong indications of spillover effects. The large-scale exports of marine fish to the EU and to the regional African markets may very well be contributing factors to price determiniation in Katima, but even more likely is the interactions of China with the global tilapia trade. Demand for tilapia in the U.S. and EU markets likely exerts some influence on the distant Katima Market.

One limitation in our analysis concerns the ability to discern the relative effects of the annual flooding of the Zambezi River and changes in the levels of Lake Liambezi on fish supply and potentially prices. Floodplain fish production is influenced by both the degree and timing of annual floods (King, Humphries, & Lake, 2003; Taylor, Weyl, Hill, Peel, & Hay, 2017). We would therefore expect the supply of fish to the Katima Market to be affected. However, the refilling of Lake Liambezi in 2010 led to the supply being largely from the lake. As a result, the potential effect of the annual flood cycle on fish supply and price would be considerably reduced. However, we chose to consider the effect of flood cycles on fish price as there was still some fish coming from the Zambezi River and floodplains.

The most important caveat for the analysis is that we did not test for whether short-term gains are sustainable. In other fisheries, higher prices associated with globalization can destabilize otherwise effective common-pool resource governance (Cudney-Bueno & Basurto, 2009; Bennett & Basurto, 2018). Because we do not directly measure the status of the fish stocks supporting the trade in Katima Market, we have no way to test for long-run degradation of the resource in our study. It may be that higher prices degrade the resources over time, and the short-run economic

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gains from trade must be weighed against long-run losses due to increased overfishing as modeled by Brander & Taylor (1998). Further research is needed to examine whether overfishing is occurring and whether there is stable resource governance that is resilient to the growing influence of globalization.

Another caveat is consideration of whether fish traders are better off. As argued above, traders are better off receiving higher prices and holding all else constant. But our data do not allow us to rule out other changes in the market structure that came along with, and possibly as a consequence of, market integration. Hypothetically, if market integration created conditions for powerful intermediaries or lenders to capture more value in the supply chain, it is possible that fish traders were left worse off despite selling fish for higher prices. Further research that couples quantitative analysis of market integration with detailed ethnographic surveys could help to resolve whether fish traders are indeed better off receiving higher prices. Ethnographic data would help to resolve whether traders perceive they are actually benefiting from new market conditions.

A final caveat is that we are unable to conclude what the consequences of higher prices are for local consumers. Higher prices, ceteris paribus, are better for individuals whose livelihoods depend on the fisheries, namely fish traders and fishers. And some of these higher revenues are likely to be reinvested into the local economy. In most market settings, higher prices would transfer some consumer surplus to producers and lead consumers to substitute away from fish toward other proteins and sources of micronutrients. Whether those substitution possibilities are available and affordable in this region is unclear. A growing literature on food security and seafood suggests that seafood may not be easily replaced in diets of the poor (Allison et al., 2009; Golden et al., 2016). Similarly, protein substitution due to a decline in local availability of fish can lead to deleterious

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effects on the sustainability of other sources of protein, such as bushmeat (e.g., Brashares et al., 2004).

Nevertheless, concerns about higher prices may be overstated because the most important sources of freshwater fish protein for low-income households in sub-Saharan Africa are dried and smoked small pelagics for which there are less concerns about overfishing (Kolding et al. 2019). These small pelagics may be less connected to global markets and thus less likely to experience upward pressure on prices associated with globalization. Evidence from an artisanal fishery in Kenya supports this possibility. Wamukota and McClanahan (2017) find that, despite the presence of an export-oritented octopus fishery, local fish prices from a coral reef fishery in Kenya are not integrated with the global market, and high prices in the export market do not undermine local food security. Ultimately, whether increased prices from globalization have negative nutritional consequences for consumers around the Zambezi River is an important question for future research that could be addressed with quantitative dietary and market surveys combined with detailed ethnographies.

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Table 1: Descriptive Statistics for the fish species recorded surveys of the Katima Open Market, 2008-2016. The three most abundant species are indicated in bold.

			Price of the fish speice in N$/kg				Length of the fish species in cm			
	Variable	**frequency in %**	**Mean**	**Min**	**Max**	**Std. Dev.**	**Mean**	**Min**	**Max**	**Std. Dev.**
Clarias gariepinus	CGAR	0.35	6.97	1.70	139.40	10.038	44.45	16.00	78.50	10.909
Clarias ngamensis	CNGA	0.24	5.92	1.70	20.30	3.470	43.98	24.00	75.00	10.038
Marcusenius altisambesi	GMAC	0.37	23.49	9.00	160.70	12.678	17.31	12.50	31.00	3.000
Hemichromis elongatus	HELO	0.05	16.99	5.00	30.70	7.328	16.58	14.00	20.00	1.715
Hepsetus odoe	HODO	2.80	13.74	1.70	64.70	5.948	31.92	16.00	48.00	4.810
Hydrocynus vittatus	HVIT	1.07	12.58	0.80	54.80	6.874	33.54	17.50	77.20	9.349
Labeo lunatus	LLUN	0.21	8.54	3.10	16.30	3.135	28.36	14.00	47.40	6.659
Mormyrus lacerda	MLAC	0.48	12.99	4.00	37.30	5.357	28.74	16.00	46.00	6.112
Oreochromis andersonii	OAND	32.30	19.46	0.80	235.50	8.884	26.33	3.05	71.00	4.568
Oreochromis macrochir	OMAC	23.99	18.26	0.70	209.80	8.323	23.30	11.70	48.60	3.957
Oreochromis niloticus	ONIL	0.22	53.60	37.20	99.50	9.540	28.63	23.00	38.00	2.767
Petrocephalus catostoma	PCAT	0.02	8.74	3.50	10.50	2.871	15.80	13.50	18.50	1.494
Serranochromis altus	SALT	0.37	14.42	4.20	36.70	5.445	27.90	17.00	50.50	6.017
Serranochromis angusticeps	SANG	2.07	17.84	2.90	99.70	9.938	27.36	15.50	48.00	4.104
Sargochromis carlottae	SCAR	1.50	15.41	4.00	50.00	6.893	23.15	14.00	39.20	3.445
Sargochromis codringtonii	SCOD	1.37	14.93	3.30	50.30	6.283	22.16	11.50	47.00	3.487
Serranochromis macrocephalus	SERM	4.51	15.93	2.50	355.40	10.262	26.22	7.00	60.00	4.292
Sargochromis giardi	SGIA	0.61	16.40	0.80	42.00	6.789	25.33	15.00	47.00	5.164
Schilbe intermedius	SMYS	1.98	10.58	1.70	74.30	7.169	21.31	12.20	33.00	3.311
Serranochromis robustus	SROB	1.83	13.95	1.70	44.90	5.568	25.44	16.00	45.00	3.481
Synodontis sp.	SYNN	0.28	12.84	0.40	33.30	7.220	18.01	10.50	36.46	4.155
Coptodon rendalli	TREN	22.73	18.87	0.80	262.50	8.635	23.43	11.50	50.00	3.746
Tilapia sparrmanii	TSPA	0.65	11.48	1.70	29.40	5.515	16.36	11.50	32.00	2.494
Overall mean		**4.35**	**16.38**	**4.05**	**93.83**	**7.138**	**25.90**	**14.04**	**47.28**	**4.742**

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Table 2. Bivariate Cointegration Tests three tilapia species (the three most abundant species) recorded in surveys from 2008-2016 at the Katima Open Market.

Market Pairs (selected lags)	$r = 0$		$r = 1$		LOP
	L_{trace}	L_{max}	L_{trace}	L_{max}	LR, (p-value)
OAND – FPI (1)	38.06***	30.27***	7.80	7.80	0.10 (0.76)
OMAC – FPI (2)	38.60***	27.93***	10.66	10.66	0.50 (0.48)
TREN – FPI (3)	35.85**	26.24***	9.61	9.61	1.54 (0.21)

*, **, and *** indicate significance at the 10, 5 and 1% levels, respectively. Under the LOP column is the LR statistic and their p-values.

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Table 3. Misspecification tests for the three most abundant species recorded in surveys from 2008-2016 at the Katima Open Market.

Market Pairs	P(LM Stat) (l=6)	P(JB Stat)
OAND - FPI	0.80	0.74| 0.49
OMAC - FPI	0.14	0.65| 0.62
TREN - FPI	0.26	0.63| 0.97

Determinants of Price Over Time in the Katima Market

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Table 4. Estimation results from hedonic pricing models for all species and the three most abundant species recorded in surveys from 2008-2016 at the Katima Open Market.

VARIABLES	(1) All species Log price in N$ per kg	(2) OAND Log price in N$ per kg	(3) OMAC Log price in N$ per kg	(4) TREN Log price in N$ per kg
Length (cm)	0.0197***	0.0337***	0.0458***	0.0252***
	(0.005)	(0.003)	(0.007)	(0.004)
Monthly mean water level[m]	0.0119**	0.0162***	-0.0006	0.0231***
	(0.005)	(0.005)	(0.005)	(0.005)
2008year#length	0.0000	0.0000	0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
2009year#length	0.0027	-0.0049	-0.0158**	0.0141***
	(0.004)	(0.004)	(0.008)	(0.005)
2010year#length	0.0162***	0.0158***	-0.0023	0.0380***
	(0.004)	(0.004)	(0.007)	(0.005)
2011year#length	0.0036	-0.0079	-0.0025	0.0189***
	(0.004)	(0.005)	(0.007)	(0.005)
2012year#length	0.0160***	0.0033	0.0034	0.0133***
	(0.005)	(0.004)	(0.007)	(0.005)
2013year#length	0.0038	-0.0154***	-0.0149**	0.0160***
	(0.006)	(0.003)	(0.007)	(0.005)
2014year# length	0.0038	-0.0237***	-0.0165**	0.0087**
	(0.008)	(0.003)	(0.007)	(0.004)
2015year#length	0.0086	-0.0213***	-0.0063	0.0156***
	(0.007)	(0.004)	(0.007)	(0.004)
2016year#length	-0.0046	-0.0277***	-0.0241***	0.0007
	(0.007)	(0.004)	(0.007)	(0.004)
year = 2009	-0.3995***	-0.2474**	-0.0095	-0.7532***
	(0.104)	(0.098)	(0.168)	(0.131)
year = 2010	-0.9387***	-0.9581***	-0.4849***	-1.5295***
	(0.116)	(0.088)	(0.154)	(0.109)
year = 2011	-0.5318***	-0.2492**	-0.3930**	-0.9818***
	(0.123)	(0.123)	(0.160)	(0.111)

year = 2012	-0.6878***	-0.3976***	-0.4050***	-0.7201***
	(0.120)	(0.088)	(0.151)	(0.113)
year = 2013	-0.2331	0.2313***	0.1856	-0.5819***
	(0.159)	(0.080)	(0.148)	(0.105)
year = 2014	-0.1159	0.5853***	0.3333**	-0.3036***
	(0.191)	(0.084)	(0.148)	(0.101)
year = 2015	-0.0140	0.7622***	0.2867*	-0.2236**
	(0.185)	(0.096)	(0.150)	(0.098)
year = 2016	0.3286	0.9390***	0.7029***	0.0558
	(0.212)	(0.087)	(0.158)	(0.103)
month = 2	-0.0079	-0.0333**	0.0108	-0.0361*
	(0.017)	(0.015)	(0.019)	(0.019)
month = 3	-0.0266	-0.0336*	0.0108	-0.0804***
	(0.022)	(0.019)	(0.023)	(0.022)
month = 4	-0.0287	-0.0298	-0.0336	-0.0772***
	(0.020)	(0.021)	(0.025)	(0.024)
month = 5	0.0153	0.0084	0.0841***	-0.0168
	(0.026)	(0.019)	(0.022)	(0.021)
month = 6	0.0722***	0.0709***	0.0851***	0.0804***
	(0.012)	(0.014)	(0.016)	(0.017)
month = 7	0.0818***	0.0615***	0.1064***	0.0719***
	(0.013)	(0.013)	(0.014)	(0.016)
month = 8	0.0429***	0.0285**	-0.0018	0.0560***
	(0.011)	(0.014)	(0.016)	(0.016)
month = 9	0.0440***	0.0360**	0.0004	0.0593***
	(0.013)	(0.014)	(0.017)	(0.017)
month = 10	0.1131***	0.0944***	0.0664***	0.1508***
	(0.016)	(0.016)	(0.019)	(0.018)
month = 11	0.1239***	0.1352***	0.0670***	0.1052***
	(0.015)	(0.016)	(0.019)	(0.018)
month = 12	0.2047***	0.1994***	0.2004***	0.1686***
	(0.013)	(0.015)	(0.017)	(0.018)
Constant	2.4229***	2.1595***	1.9485***	2.4226***
	(0.131)	(0.071)	(0.139)	(0.089)
Observations	59,295	19,245	14,304	13,496
R-squared	0.387	0.467	0.383	0.455
Number of id	23			

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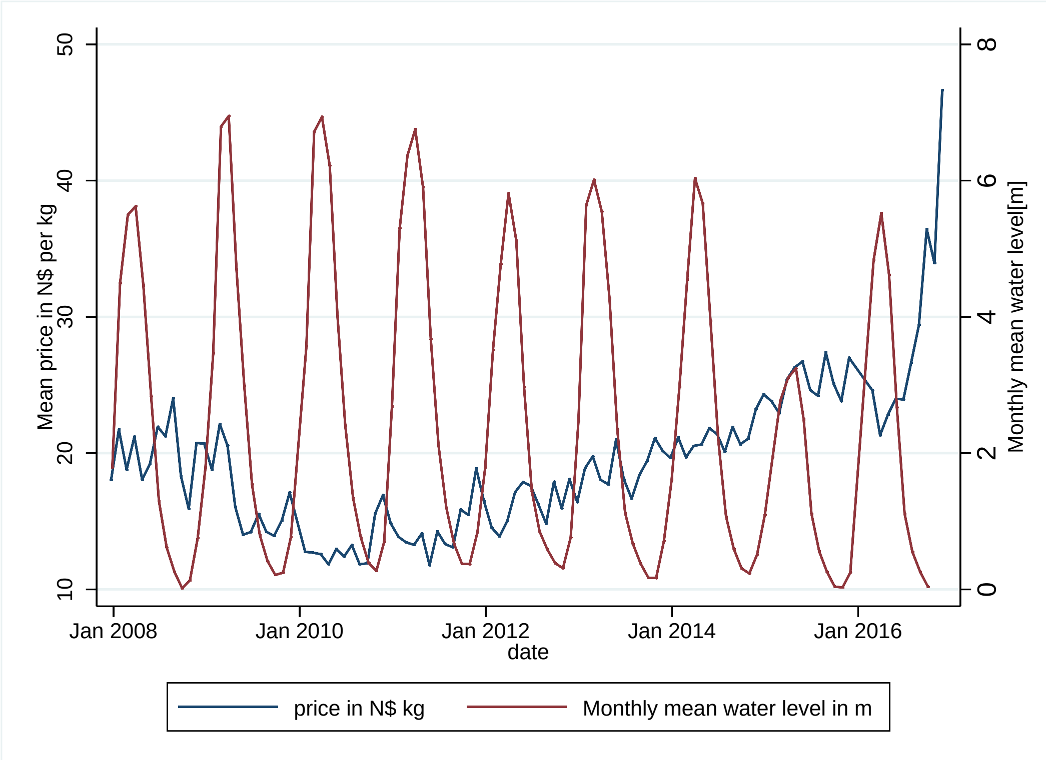

Figure 1. Relationship between mean prices of all species measured at the Katima Open Market, 2008-2016 and mean water level of the Zambezi River measured at Katima Mulilo. Water level data courtesy of Ministry of Water, Development and Rural Affairs, Namibia.

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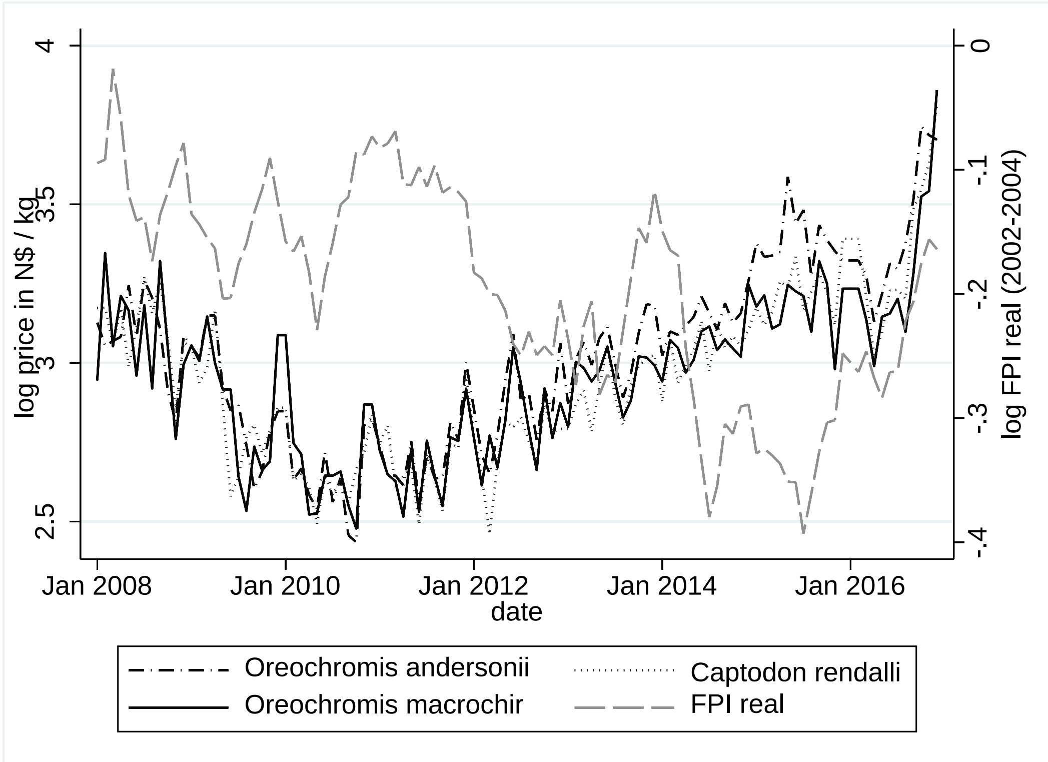

Figure 2. Development of mean monthly real prices of three tilapia species recorded in surveys from 2008-2016 at the Katima Open Market in N$, deflated Fish price Index

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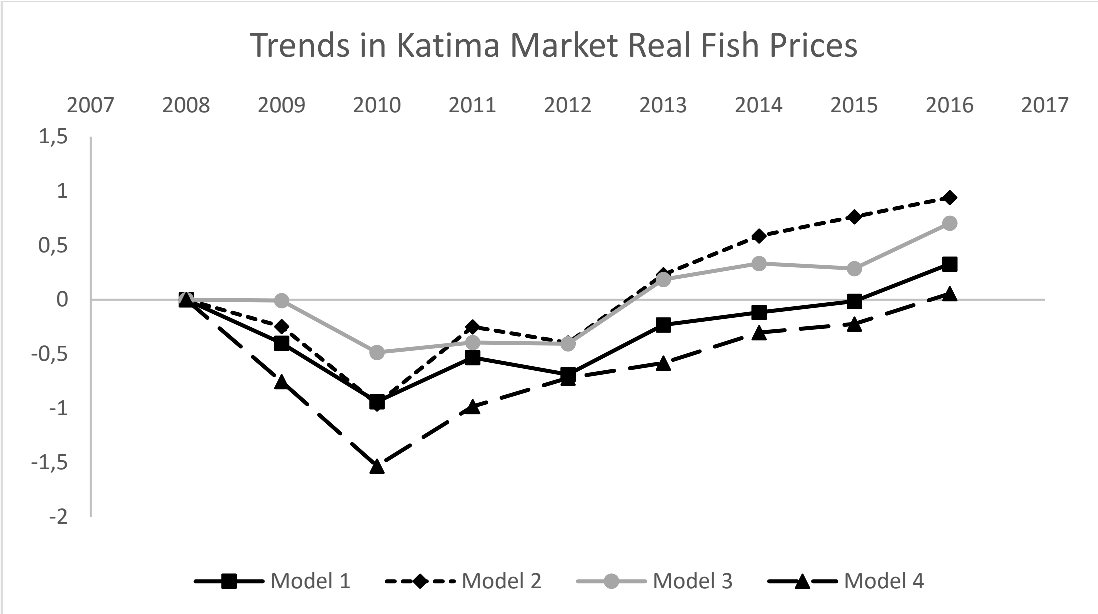

Figure 3. Conditional yearly real prices from hedonic models. Model 1 includes all species recorded in surveys from 2008-2016 at the Katima Open Market. Models 2-4 are *Oreochromis andersonii*, *Oreochromis macrochir*, and *Coptodon rendalli*, respectively.

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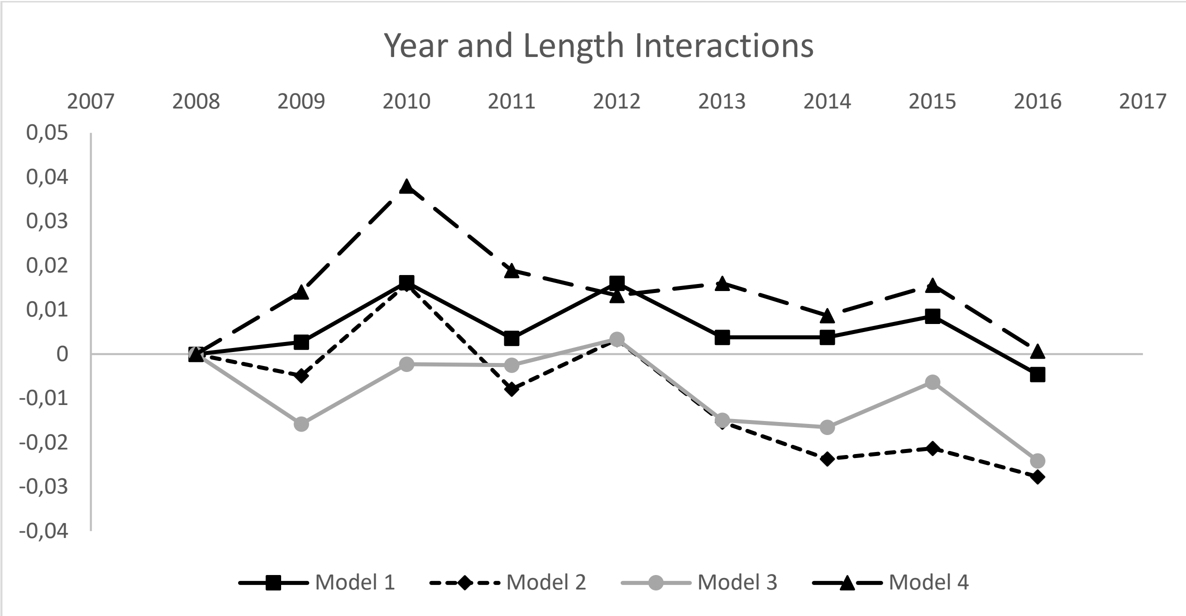

Figure 4. Conditional year and fish length interactions from hedonic models. Model 1 includes all species. Models 2-4 are *Oreochromis andersonii*, *Oreochromis macrochir*, and *Coptodon rendalli*, respectively.

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