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Application of econometric models for price impact assessment of antidumping measures and labelling laws on global markets: a case study of Vietnamese striped catfish

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Abstract

Since obtaining membership to the Asia–Pacific Economic Cooperation in 1998, Vietnamese fishery product exports, particularly frozen catfish fillets, to the USA have increased significantly, supported by a bilateral trade agreement (BTA) between the two countries signed in December 2001. With similarities in texture and taste, but of lower price, catfish imports from Vietnam were a concern for US catfish producers. To protect its catfish sector, the US Congress passed a labelling law in November 2002 restricting the use of the word 'catfish' to only those fish of the Ictaluridae family, which is farmed popularly in southern states of the USA. Antidumping measures, a trade policy permitted by the World Trade Organization, were also issued by the USA in 2003 leading to tariffs ranging from 44.66% to 63.88% levied on frozen fillet catfish imported from Vietnam. This paper uses selected econometric models to examine the effects of the US laws and policy on prices and trade flows, as a part of a comparative case study of primary production. The models show that the antidumping tariff raised the US domestic price of processed catfish and lowered the Vietnamese export price. The fall in the price of Vietnamese catfish caused by the US tariff raised market demand outside the USA and consequently boosted the Vietnamese export volume of catfish. Empirical models with monthly data from January 1999 to December 2005 examined the effects of the BTA, the US antidumping and the labelling laws on the price and trade flow of frozen catfish fillets. Although the BTA benefited US consumers, the antidumping measures were not favourable to them or to US farmers. The labelling law in reality harmed the US catfish industry.

Key words: antidumping, catfish, econometric model, labelling, trade, world market.

Introduction

Globalization benefits growth, encourages technology transfer and alleviates poverty, hunger and malnutrition. Through various negotiation rounds of the World Trade Organization (WTO) and its predecessor the General Agreement on Tariffs and Trade (GATT), tariff barriers have decreased worldwide, but antidumping measures have surged to play a crucial role as one of the most important non-tariff barriers (Zanardi, 2004). Antidumping duties have been recently used with increasing frequency by more countries and against more products (Prusa 2005). From 1980 to 2004, the USA alone filed 1092 antidumping tariff cases and 461 of them led to an affirmative determination and an antidumping duty imposed on the targeted imports.

Antidumping duties are enforced by the Continued Dumping and Subsidy Offset Act of 2000, commonly referred to as the Byrd Amendment (US ITC 2002a). The Byrd Amendment permits successful petitioners for antidumping duties to collect tariff revenues. As substitutes for imported products, an increase in the price of domestic products would force consumers to switch to buying more imported goods. If an antidumping tariff is

imposed on foreign firms, calculated as a percentage of their revenues, an increase in their sales may result in an increase in tariff revenues. The Byrd Amendment therefore provides an increased incentive for domestic firms to increase their prices because by doing so it increases the sales of the foreign firms, which increases the domestic firm's revenue from the tariff. This concept will be further developed later in the text with reference to farmed catfish imports to the USA. As a consequence, the Byrd Amendment has the paradoxical effect of increasing the value and total volume of imports (Evenett 2006) compared with the equilibrium without the Byrd Amendment and thereby undermines the original intent of the duty. Related research suggests that antidumping duties in a competition tend to be ineffective in that an importing country's demand for a product from a particular supply source tends to be highly elastic in relation to supply from that source, leading to the duty being borne by the foreign supplier rather than the importing-country consumer (Kinnucan 2003).

As processed and differentiated agricultural products are increasingly traded across national borders (Reimer & Stiegert 2006) more of them are facing antidumping measurements conducted by the importing countries (Table 1). This review examines the case of Vietnamese catfish, of which the USA used to be the biggest importer before an antidumping tariff was imposed on the product, as an example from the fish trade, which is becoming increasingly important, particularly to developing countries (Kurien 2005). Catfish represents a useful case study in that it shares characteristics with other agricultural products that are subjected to antidumping activity, data are available to measure impacts, and *ex ante* research based on a simulation model predicted that the tariff would be ineffectual (Kinnucan 2003). A 2001 bilateral trade agreement (BTA) between the USA and Vietnam and a 2002 federal labelling law to differentiate the US product from imported catfish also provide the opportunity for an empirical estimation to test whether such institutions affect the price and trade flow of catfish.

Prior to model estimation to explore the impacts of the trade policy, the globalization of the Vietnamese catfish industry is summarized, along with a review of antidumping processes and arguments on the Byrd Amendment. With a simplified world market of US and Vietnamese catfish, first-difference logarithmic and error-correction models are specified under perfect competition conditions, followed by an estimated equation system of price-reaction functions implied by a market-clearing model for imperfect competition to identify the price and demand impacts of the tariff scheme.

First and foremost the impacts of the steps adopted by the USA with respect to catfish imports to the USA were examined to demonstrate their relevance on a fast developing food commodity sector that supports over 150 000 livelihoods and generates nearly US$1bn per annum revenue to a developing country. Second, catfish is considered to be one of the most significant instances in which an aquaculture commodity has been dealt with and has drawn the attention of the public at large.

Globalization of Vietnamese catfish and the US market

Catfish farming, based on the tra and/or striped catfish *Pangasianodon hypophthalamus*, in Vietnam developed rapidly with the country adopting a 'free economy' and the consequent joining global fora to facilitate marketing (Cohen & Hiebert 2001), with the sector currently employing almost half a million people (Narog 2003). Under close cooperation between French and Vietnamese fisheries researchers, artificial catfish propagation techniques were developed and commercialized in 1998 involving 15 000 families (Cohen & Hiebert 2001) and concurrently relevant management techniques were improved with respect to, for example, feeds and feeding and health management, and catfish farming gradually took root in the Mekong Delta in South Vietnam from the latter half of the 1990s. Vietnamese farmers adopted advanced feeding technologies to improve fish meat quality to comply with the requirements of US and European Union (EU) consumers, and catfish processors in turn invested in state of the art machinery (Cohen & Hiebert 2001) to enable them to comply to the quality control protocols of Hazard Analysis Critical Control Point (HACCP) and the Good Aquaculture Practice (GAP) recommended by the US Food and Drug Administration and the Food and Agriculture Organization.

Since gaining membership to the Asia–Pacific Economic Cooperation (APEC) in 1998, an organization of economic cooperation oriented to reducing tariff and non-tariff barriers among its 21 member economies in the Asia–Pacific region, Vietnamese fisheries export to the USA has increased significantly, particularly in catfish sales, from less than 280 thousand kg in 1998 to more than 7.7 million kg in 2001 (Sengupta 2003). Although catfish was exported before 1995, when the official embargo on Vietnamese exports was lifted by the USA, the tremendous spurt in exports to the USA occurred in 1999 when raw seafood tariffs were dropped (Fig. 1), and with the subsequent BTA between the USA and Vietnam in December 2001 the volume reached 8.3 million kg of catfish valued at US$55.1m in 2002 (Sengupta 2003).

With similarity in texture and taste, but lower price, the 'most similar product in characteristics and uses' (US ITC 2002b), Vietnamese catfish was beginning to

Table 1 Examples of global antidumping cases for agricultural and fisheries products (modified after Kinnucan & Myrland 2005; with data from Brown 2006)

Product	Year	Filing country	Target countries
Apples	1994	Canada	USA
	1998	Canada	USA
	1997	Mexico	USA
Beef	1991	Poland	European Union
Bovine meat	1993	Mexico	European Union
	1994	Mexico	USA
	1998	Mexico	USA
Canned ham	1990	Australia	Denmark, Ireland and the Netherlands
Canned mushrooms	1982	USA	China
Chicken	1999	Argentina	Brazil
Crawfish tail meat	1996	USA	China
Dried salted codfish	1984	USA	Canada
Fresh Atlantic Salmon	1990	USA	Norway
	1997	USA	Chile
	1996	European Union	Norway
	1998	Mexico	USA
Fresh Atlantic Salmon	2002	Canada	Chile
	2004	European Union	Chile, Faroe Islands and Norway
Fishmeal	1994	Mexico	Chile
Frozen beef	1993	Mexico	European Union
Garlic	1994	USA	China
	1996	Canada	China
	2000	South Africa	China
	2001	Canada	China and Vietnam
Fresh round white potatoes	1983	USA	Canada
Fresh-cut roses	1983	USA	Columbia
	1986	USA	Canada, Columbia, Costa Rica, Ecuador, Mexico and Peru
	1994	USA	Columbia and Ecuador
Frozen catfish fillets	2002	USA	Vietnam
Frozen orange juice	1986	USA	Brazil
	1991	Australia	Brazil
Honey	1994	USA	China
Kiwi fruit	1991	USA	New Zealand
Large Rainbow Trout	2003	European Union	Norway, Faeroe Islands
Lettuce	1992	Canada	US
Live catle	1998	USA	Canada and Mexico
Live swine	2004	USA	Canada
Non-frozen apple juice concentrate	1999	USA	China
Peaches	1997	Mexico	Greece
Pineapple	1994	USA	Thailand
Pork	1993	Australia	Canada
Poultry meat	1999	South Africa	USA
Shrimp	2003	USA	Brazil, China, Ecuador, India, Thailand and Vietnam
Slaughter hogs	1998	Mexico	USA
Sour cherries	1991	Australia	France and Italy
Sour cherries	1998	Canada	USA
	1995	Canada	USA, Denmark, Germany, Netherlands and UK
Sugar	1998	Panama	Columbia and Mexico
Tart cherry juice	1991	USA	Germany and Yugoslavia
Turkey	1999	Yugoslavia/Slovenia	Hungary
Vegetable oil	2001	Peru	Argentina
Whole potato	1985	Canada	USA
Yellow onion	1986	Canada	USA

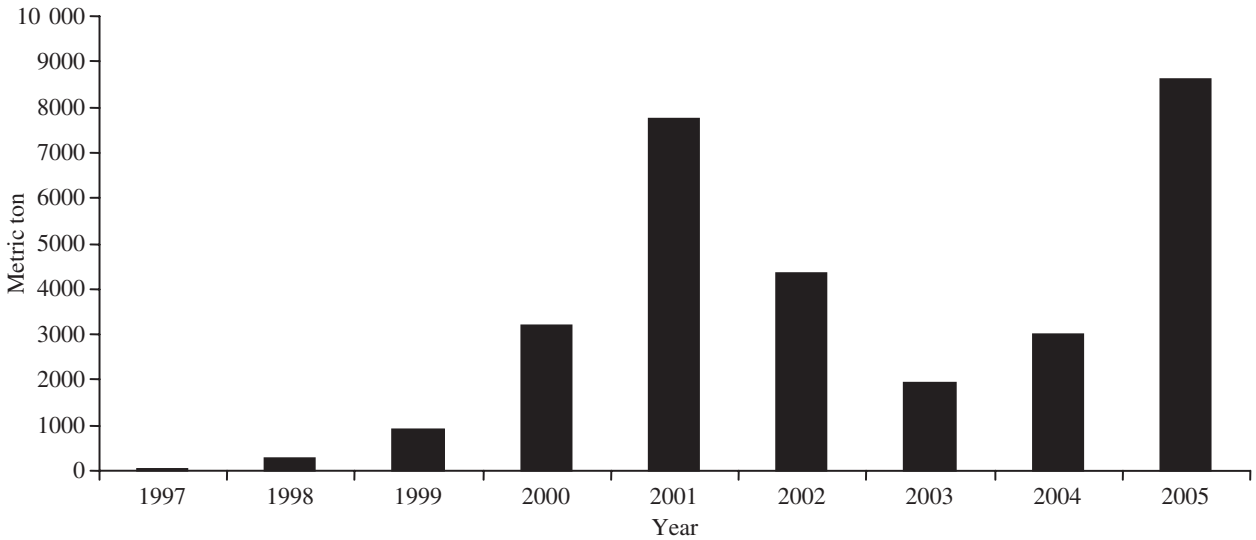

Figure 1 Vietnamese catfish exports to the USA from 1997 to 2005.

threaten US catfish growers and wholesalers when 90% of the catfish imported by the USA in 2000 was from Vietnam (Cohen & Hiebert 2001). Catfish production is the biggest aquaculture industry in the USA and frozen catfish fillets are the most important product of the US catfish processing industry (Harvey 2005). In 2005, 56.4 million kg of frozen catfish fillets were sold by domestic processors, an increase in 1.5% from 2004 (Harvey 2006). The most popular catfish raised in the southern states of the USA are from the Ictaluridae family, and are predominantly channel catfish *(Ictalurus punctatus)* and blue catfish (*Ictalurus furcatus*) farmed in closed ponds, whereas Vietnamese catfishes are basa (*Pangasius bocourti*) and tra (*Pangasianodon hypophthalamus*), which belong to the family Pangasidae, and are generally cultured in ponds and pens along the Mekong River, predominantly in pens.

After a marketing dispute, the US Congress passed a law in November 2002 restricting the use of the word 'catfish' for labelling to only varieties from the family Ictaluridae farmed in the USA (Narog 2003), and this was considered to be the first step of the 'catfish war' (Kinnucan 2003). The next step was lobbying for renegotiation of the 2001 BTA between the USA and Vietnam to set limits on catfish imports (Cooper 2001 cited by Kinnucan 2003). The third step was the antidumping suit filed by US producers that led to tariffs ranging from 44.66% to 63.88% being levied on frozen catfish fillets imported from Vietnam. Considering that the Vietnamese economy is 'non-market' for antidumping investigation purposes, the US Department of Commerce took India as a proxy country to identify the 'dumping margin' (Intrafish 2003). The tariff is theoretically a 'dumping margin' that is the difference between the price of the subjected goods sold in the home market and in the US market according to antidumping duty calculations suggested by the Department of Commerce (DOC) and the International Trade Commission (ITC). Therefore, the initial tariff imposed on Vietnamese catfish was actually the gap between the price of frozen catfish fillets sold in India and those sold in the US market, and not between the Vietnamese and US markets.

Antidumping measurement: definition and investigation process

Under the WTO regulations, foreign suppliers named in antidumping suits must comply with two criteria for duties to be imposed (Knetter & Prusa 2000). First, there must be evidence that the domestic industry has been materially injured (e.g. a loss or decline in profitability) by the foreign imports, and second the foreign suppliers must be found to be selling their products at 'less than fair value' prices. A dumping case occurs when the products are sold at a price 'less than fair value'. According to Knetter and Prusa (2000), 'less than fair value' is determined by: (i) showing that the price charged in the domestic market by the foreign suppliers is below the price charged for the same product in other markets (i.e. the 'price-based' method); or (ii) showing that the price charged in the domestic market is below the estimated of cost plus a normal return (i.e. the 'constructed-value' method).

In the USA, the DOC and the ITC administer the antidumping laws. Each institution has distinct roles in the

antidumping investigation process. In response to petitions filed by domestic firms, the DOC calculates whether foreign firms are selling the product to the USA at less than 'normal' or 'fair' value, that is, whether dumping has occurred. The department then calculates an *ad valorem* dumping margin equal to the percentage difference between the US transaction prices that they observe as fair value. The ITC, in its turn, has to determine whether the domestic industry has been materially injured or is threatened with material injury as a result of the targeted imported products. Both agencies make preliminary and final determinations during their investigations. According to Blonigen and Heynes (2002) if both arrive at affirmative preliminary determinations, the importer must post a cash deposit, a bond or other security equal to the preliminary margin determined by DOC for each entry of the subject product. This requirement stays in effect until either the DOC and/or ITC make a negative final determination. If both agencies give an affirmative final determination an order is issued by DOC to levy an antidumping duty equal to the estimated dumping margin on the subject product. Blonigen and Heynes (2002) summarized the investigation process and suggested that it would take up to 280 days from the date of filing the petition to the final determination.

The Byrd Amendment and its impacts

The 'Byrd Amendment', named after its sponsor, the Democratic Senator Robert Byrd, and passed by US Congress in 2000 permits plaintiffs to collect revenues from antidumping and/or countervailing duty. The disbursement is available only to 'affected domestic producers for qualifying expenditures'. An 'affected domestic producer' is defined as a manufacturer, producer, farmer, rancher or worker representative (including associations of such persons) that: (i) was a petitioner or interested party in support of a petition with respect to which an antidumping or countervailing duty order was in effect; and (ii) remains in operation. Producers that have ceased production covered by the order or that have been acquired by a firm that opposed the petition would not be considered as an affected domestic producer.

The Byrd Amendment has been found to be in violation of WTO trade remedy rules (Jung & Lee 2003) and imposes distortions on the US economy. In this regard, the Congressional Budget Office (2004) estimated that US$3.85bn in revenues collected will be distributed to firms between 2005 and 2014. Between 2001 and 2004, US$1bn was paid to 770 firms that were allegedly harmed by unfair trade practices (GAO 2005), but more than one-third was to a single corporation, the Timken Company, and two of its subsidiaries (CITAC 2006). More than half of the US$226m of Byrd Amendment payouts in 2005 was to five companies, and 80% of the payouts went to only 34 companies (CITAC 2006) and two-thirds of the disbursement flow to only three of the 77 eligible industries (GAO 2005). The three industries that benefited the most from the Byrd payments were manufacturers of ball bearings, candles and steel (CITAC 2006). In the catfish case, the Byrd disbursement gave US processors US$9.2m in the two fiscal years of 2005–2006, or 3% of their 2005 sales revenue of frozen catfish fillets. The amounts disbursed to individual corporations were accused of distorting the competitive structure of an industry, leading to a reduction in competition.

The Byrd Amendment not only harms the US economy, but also hurts US exporters. After complaints filed by 11 trading partners, including Europe, Canada and Mexico, the WTO ruled in January 2003 that the Byrd Amendment was in violation of US trade obligations and complaining countries were awarded the rights to impose retaliatory duties on US exports, up to US$134m in 2005 (Odessey 2006). Thus, the longer Byrd payments are still offered to US domestic industries, the more the US's trade partners are able to retaliate against US goods. The effects of antidumping measurements and the impacts of the Byrd Amendment have been dealt with previously by Blonigen and Prusa (2001), Blonigen and Heynes (2002), Kinnucan (2003), Zanardi (2004), Hansen and Prusa (1996), Prusa (2005), Feenstra (2004) and Kinnucan and Myrland (2005); Jung and Lee (2003) suggested that the Byrd Amendment provided an incentive for domestic industries to file antidumping legislations, distort competition between the firms who are beneficiaries and those who did not have sufficient resources or information to support petitions. The amendment disappoints the legitimate expectation from exporting countries and infringes on the rights of other countries to open and transparent trade. In addition, it hurts downstream industries, consumers and global welfare. The empirical results of Olson (2005) provide strong evidence that more US domestic industries have lobbied for more tariff protection or filed more antidumping petitions since passage of the Byrd Amendment. Modelling pricing behaviours over bureaucratic discretion and the Byrd Amendment, Evenett (2006) showed that where the latter raised prices in equilibrium, a seemingly paradoxical result arose as the foreign firm began to be better off. The foreigner's profit rises because of the excess price over marginal cost increases and the amount of dumping duties paid per unit falls as the foreign firm's price increases. In view of the apparent disadvantages and the imbalances that were brought about by the Byrd Amendment it was repealed

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by the US Congress in January 2006 and came into force in October 2007.

Methods

For simplification, the product of catfish in the world market was assumed to be identical to a combination of *Ictalurus* catfish and *Pangasius* catfish, so the market is called the world catfish market in short. With that assumption, an equilibrium displacement model (EDM) was developed for the world market to explore the theoretical impacts of the antidumping measures on the price and trade flows in the world market. Based on the reduced equations derived from the EDM, time-series econometrics with first-difference logarithmic and error-correction models were estimated under perfect competition conditions.

The subsidy effect of the Byrd Amendment on prices of the two products, US and Vietnamese catfish, was analysed along with an estimated equation system of price-reaction functions for imperfect competition to identify the price and demand impacts of the tariff, using the Seemingly Unrelated Regression (SUR) method. The analysis also examined the previous suggestion by Evenett (2006) that the Byrd Amendment had the paradoxical effect of increasing the value and total volume of imports and undermined the original intent of the duty because it gave an incentive for the domestic firms to increase their price for an increase in the sales of the foreign firm, which increased the domestic firm's revenue from the tariff.

Monthly data from January 1999 to August 2006 were used for the regressions in the empirical models. A description and the source of the data are presented in Tables 2 and 3. The data since January 1999 focus on efforts to isolate the possible effects on the Vietnam–US BTA issue related to the APEC membership of Vietnam in November 1998. The membership created lots of advantages for Vietnamese producers to export their products to the USA as US custom tariffs on Vietnamese products were reduced considerably.

Table 3 Descriptions of the variables in the equation system of the price-reaction functions

Variable	Description	Unit	Source
P_1	Domestic price of frozen catfish fillets	\$ lb^{-1}	USDA
P_2^-	Price of Vietnamese frozen catfish fillets	\$ lb^{-1}	NMFS
P_{sal}	Price of salmon import	\$ lb^{-1}	NMFS
P_p	US poultry price	\$ lb^{-1}	IMF
P_o	Non-US market price of Vietnamese catfish fillets	\$ lb^{-1}	VN MoF
I	US personal income per capita	\$ $year^{-1}$	US BEA
F	Freight index from Pacific		US BLS
W	US wage of manufacturing sector	\$ h^{-1}	US BLS
G	Energy index in US market		US BLS
X	Real exchange rate of VND against US\$	VND \$$^{-1}$	oanda.com

BEA, Bureau of Economic Analysis; BLS, Bureau of Labor Statistics; IMF, International Monetary Fund; NMFS, National Marine Fisheries Service; USDA, US Department of Agriculture; VN MoF, Vietnamese Ministry of Fisheries.

Effectiveness of antidumping measures on catfish markets

Model specification

As mentioned earlier, frozen fillets of US channel catfish and imported *Pangasius* catfish are considered perfect substitutes in this review. This consideration is based on

Table 2 Description of variables in the reduced form equations of the world market

	Unit	Source	Mean	Minimum	Maximum	Definition
P_{us}	cent lb^{-1}	USDA	223	202	245	US price of processed catfish
P_v	cent lb^{-1}	VN MoF	144	101	284	Free-on-board VN price of catfish
M_u	1000 lb	NMFS	1007	53	4638	US import of catfish
X_v	1000 lb	VN MoF	7602	4	37 708	VN catfish export
Y_{US}	\$	BEA	27 267	23 647	31 094	US disposable income per capita
P_{poul}	cent lb^{-1}	IMF	66	57	81	Price of US poultry
P_{salm}	cent lb^{-1}	IMF	233	155	306	Price of Atlantic salmon
P_f	cent lb^{-1}	USDA	220	186	310	Price of catfish feed in the USA
F_a	–	BLS	107	89	133	Freight index from Atlantic
F_v	–	BLS	105	73	130	Freight index from Pacific
BTA	Dummy variable, BTA = 0 before December 2001, otherwise BTA = 1					
TAX	Dummy variable, TAX = 0 before February 2003, otherwise TAX = 1					
LABEL	Dummy variable, LABEL = 0 before December 2002, otherwise LABEL = 1					
Q_i	Dummy variables for quarters (i = 1,2,3), Q_i = 1 if data in quarter *i*, otherwise Q_i = 0					

BEA, Bureau of Economic Analysis; BLS, Bureau of Labor Statistics; IMF, International Monetary Fund; NMFS, National Marine Fisheries Service; USDA, US Department of Agriculture; VN, Vietnam; VN MoF, Vietnamese Ministry of Fisheries.

affirmation by the US ITC (2002b) that they are 'most similar product in characteristics and uses'. On the world catfish market, the word 'catfish' may be used for a combination of *Ictalurus* catfish and *Pangasius* catfish. Vietnam import and US export of catfish are negligible and were not considered in this review. Free trade is assumed in the model specification. The antidumping tariff is a tool of trade remedy, permitted by the WTO. Transaction costs and insurance are assumed to be constant and the 'rule of one price' also holds.

Demand (import) side

The EU imports, but does not produce either *Ictalurus* or *Pangasius* catfish; the Rest-of-World (ROW) is treated as a group of importers. Accordingly, the three demand equations for three importers are:

$$M_{eu} = M(P_{eu}, Z_{eu}) \quad \text{EU demand for catfish imports} \quad (1)$$

$$M_{us} = M(P_{us}, Z_{us}) \quad \text{US demand for catfish imports} \quad (2)$$

$$M_{r} = M(P_{rd}, Z_{r}) \quad \text{ROW's demand for catfish imports} \quad (3)$$

where, Z_{eu}, Z_{us} and Z_r are demand shifters of catfish imports to the US, EU and ROW; P_i (i = us, eu and rd) is the consumer price of the frozen catfish fillets in the markets of the US, EU and the ROW.

Supply (export) side

On the supply side, freight cost is the most important trade cost of catfish exports. A rise in freight cost lowers catfish exports. Assuming that Vietnam is globally the biggest exporter of catfish, the supply equations for Vietnamese catfish exports and its competitors from the ROW are described as:

$$X_v = X(P_v, C_v) \quad \text{Vietnamese export quantity of catfish} \quad (4)$$

$$X_r = X(P_{rs}, C_r) \quad \text{ROW export quantity of catfish} \quad (5)$$

where P_v and C_i (i = v, r) are export prices and costs of Vietnamese and ROW's exporters, respectively.

Price linkage functions

The price linkage functions among the markets can be written as:

$$P_{us} = P_{us}(P_v, T) \quad (6)$$

$$P_{eu} = P_{eu}(P_v) \quad (7)$$

$$P_{rd} = P_{rd}(P_v) \quad (8)$$

$$P_{rs} = P_{rs}(P_v) \quad (9)$$

where $T = (1 + t)$ with t as the *ad valorem* US tariff rate imposed on the Vietnamese catfish imports.

Market equilibrium

Under a free trade assumption and zero balance of trade with the sum of exports equal to the sum of imports, the market equilibrium is defined by:

$$X_v + X_r = M_{us} + M_{eu} + M_r. \quad (10)$$

The above 10 equations can be rewritten under an EDM form as:

$$M^*_{eu} = -\mu_{eu}P^*_{eu} + z_{eu}Z^*_{eu} \quad (11)$$

$$M^*_{us} = -\mu_{us}P^*_{us} + z_{us}Z^*_{us} \quad (12)$$

$$M^*_{r} = -\mu_{r}P^*_{rd} + z_{r}Z^*_{r} \quad (13)$$

$$X^*_{v} = \varepsilon_{v}P^*_{v} - \varepsilon_{vc}C^*_{v} \quad (14)$$

$$X^*_{r} = \varepsilon_{r}P^*_{rs} - \varepsilon_{rc}C^*_{r} \quad (15)$$

$$P^*_{us} = P^*_{v} + T^* \quad (16)$$

$$P^*_{eu} = \sigma_{eu}P^*_{v} \quad (17)$$

$$P^*_{rd} = \sigma_{rd}P^*_{v} \quad (18)$$

$$P^*_{rs} = \sigma_{rs}P^*_{v} \quad (19)$$

$$k_vX^*_v + k_{xr}X^*_r = k_{us}M^*_{us} + k_{eu}M^*_{eu} + k_{mr}M^*_r \quad (20)$$

where the asterisks represent percentage changes in the variables (e.g. $X^\star = \mathrm{d}\ln X = \mathrm{d}X/X$). Endogenous variables include $M^*_{us}, M^*_{eu}, M^*_r, X^*_v, X^*_r, P^*_{us}, P^*_{eu}, P^*_{rd}, P^*_{rs}$ and P^*_v and the exogenous variables are $Z^*_{us}, Z^*_{eu}, Z^*_r, C^*_v, C^*_a$ and T^*.

Parameters in Equations 11–20 are described in Table 4 and are all theoretically positive, assuming that the product is normal in all markets. The methods to build the EDM are based on Kinnucan (2003). Solving the above equations, we have:

$$\psi X^*_{vn} = -\varepsilon_{vf}(\psi - \varepsilon_v k_v)C^*_v + \varepsilon_v k_{xr}\varepsilon_{rf}C^*_r + \varepsilon_v k_{us}z_{us}Z^*_{us} + \varepsilon_v k_{eu}z_{eu}Z^*_{eu} + \varepsilon_v k_{mr}z_rZ^*_r + \varepsilon_v k_{us}\mu_{us}T^* \quad (21)$$

where

$$\psi = (k_v\varepsilon_v + k_{xr}\varepsilon_r\sigma_{rs} + k_{us}\mu_{us} + k_{eu}\mu_{eu}\sigma_{eu} + k_{mr}\mu_r\sigma_{rd}) > 0. \quad (22)$$

Therefore, the reduced form equation of Vietnamese exports will be:

Table 4 Descriptions of the parameters used in the conceptual model

μ_i	Price elasticity (in absolute value) of import demand for catfish in ith market (i = US, EU and ROW)
z_{us}	Elasticity of US import demand for catfish with respect to Z_{us}
z_{eu}	Elasticity of EU import demand for catfish with respect to Z_{eu}
z_r	Elasticity of ROW import demand for catfish with respect to Z_r
ϵ_i	Supply price elasticity of catfish from ith source (I = Vietnam, ROW)
ϵ_{vc}	Supply elasticity of Vietnamese catfish exports with respect to C_v
ϵ_{rc}	Supply elasticity of ROW frozen catfish exports with respect to C_r
σ_{eu}	Transmission price elasticity between EU market price and Vietnamese catfish price
σ_{rd}	Transmission price elasticity between ROW purchase price and Vietnamese export price
σ_{rs}	Transmission price elasticity between export prices of ROW and Vietnam
k_{us}, k_{eu}, k_{mr}	Global import shares of US, EU and ROW, respectively
k_v, k_{xr}	Global export shares of Vietnam and ROW

EU, European Union; ROW, rest-of-world.

$$X^*_{vn} = [-\varepsilon_{vf}(\psi - \varepsilon_v k_v)/\psi]C^*_v + (\varepsilon_v k_{xr}\varepsilon_{rf}/\psi)C^*_r + (\varepsilon_v k_{us} z_{us}/\psi)Z^*_{us} + (\varepsilon_v k_{eu} z_{eu}/\psi)Z^*_{eu} + (\varepsilon_v k_{mr} z_r/\psi)Z^*_r + (\varepsilon_v k_{us}\mu_{us}/\psi)T^*. \quad (23)$$

Similarly, the reduced form equations of exported Vietnamese catfish price, US catfish price and US imports of catfish will be:

$$P^*_v = (k_v\varepsilon_{vf}/\psi)C^*_v + (k_{xr}\varepsilon_{rf}/\psi)C^*_r + (k_{us} z_{us}/\psi)Z^*_{us} + (k_{eu} z_{eu}/\psi)Z^*_{eu} + (k_{mr} z_r/\psi)Z^*_r - (k_{us}\mu_{us}/\psi)T^* \quad (24)$$

$$P^*_{us} = (k_v\varepsilon_{vc}/\psi)C^*_v + (k_{xr}\varepsilon_{rc}/\psi)C^*_r + (k_{us} z_{us}/\psi)Z^*_{us} + (k_{eu} z_{eu}/\psi)Z^*_{eu} + (k_{mr} z_r/\psi)Z^*_r + [(\psi - k_{us}\mu_{us})/\psi)]T^* \quad (25)$$

$$M^*_{us} = -(\mu_{us} k_v\varepsilon_{vf}/\psi)C^*_v - (\mu_{us} k_{xr}\varepsilon_{rf}/\psi)C^*_r + [z_{us}(\psi - \mu_{us}k_{us})/\psi]Z^*_{us} - (\mu_{us} k_{eu} z_{eu}/\psi)Z^*_{eu} - (\mu_{us} k_{mr} z_r/\psi)Z^*_r - \mu_{us}(\psi - k_{us}\mu_{us})/\psi T^*. \quad (26)$$

The theoretical effects of antidumping measures on Vietnamese export price and consumer price in the USA could be derived as follows:

$$P^*_v/T^* = -k_{us}\mu_{us}/\psi \le 0 \quad (27)$$

$$P^*_{us}/T^* = (\psi - k_{us}\mu_{us})/\psi < 1. \quad (28)$$

The effects can be interpreted in the tariff elasticities of the prices. A 1% increase in the antidumping tariff raises the US price of catfish by less than 1% and lowers the Vietnamese price by <1%.

The elasticities of other endogenous variables with respect to the exogenous variables are summarized in Table 5.

Empirical estimation of the reduced form equations

The US personal income per capita and the price of catfish feed are considered to be demand shifters of US import demand. For demand shifters in the EU and ROW markets, prices of salmon and poultry are assumed to be suitable substitutes for catfish. Accordingly, a reduced form equation of Vietnamese exports of frozen catfish fillets could be regressed as:

$$X^*_{vn} = \beta_1 F^*_v + \beta_2 F^*_a + \beta_3 Y^*_{us} + \beta_4 P^*_f + \beta_5 P^*_{salm} + \beta_6 P^*_{poul} + \beta_7 T^*_v + \varepsilon. \quad (29)$$

Dummy variables Q_1, Q_2 and Q_3 for yearly quarters and an intercept are then included in the above model, following a suggestion from Kinnucan and Miao (1999). Descriptions of the variables are given in Table 2.

In efforts to compete with Vietnamese catfish, the labelling legislation in November 2002 supported US catfish producers because it did not permit *Pangasius* catfish to be called 'catfish'. With the labelling legislation, US catfish producers expected a price increase. The dummy variable LABEL, therefore, is added into the empirical reduced equations to explore the effects of the legislation. The LABEL gets unit value from December 2002 when the labelling law became effective and its value is zero before then. The effect of US antidumping can be explored with the dummy variable TAX. Until January 2003, the time tariff imposed on Vietnamese catfish import to the USA, the dummy variable TAX equals zero. TAX obtains a value of one after January 2003 until December 2005. An additional dummy variable BTA is included in the model to examine the effect of the BTA between the USA and Vietnam signed in December 2001. The variable BTA also helps to control the effect of the agreement when exploring the effects of antidumping and the labelling law. Equations 24 and 25 for Vietnamese and US prices become:

$$P^*_v = \alpha_0 + \alpha_1 \mathrm{BTA} + \alpha_2 \mathrm{TAX} + \alpha_3 \mathrm{LABEL} + \alpha_4 Y^*_{us} + \alpha_5 P^*_f + \alpha_6 P^*_{salm} + \alpha_7 P^*_{poul} + \alpha_8 F^*_v + \alpha_9 F^*_a + \alpha_{10} Q^*_1 + \alpha_{11} Q^*_2 + \alpha_{12} Q^*_3 + \varepsilon. \quad (30)$$

Table 5 General elasticities of the endogenous variables with respect to the exogenous variables

	C_v^*	C_r^*	Z_{us}^*	Z_{eu}^*	Z_r^*	T^*
M_{us}^*	$-(\mu_{us}\ k_v\epsilon_{vf}/\psi)$	$-\mu_{us}k_{xr}\epsilon_{rf}/\psi$	$+z_{us}(\psi - \mu_{us}k_{us})/\psi$	$-\mu_{us}k_{eu}z_{eu}/\psi$	$-\mu_{us}k_{mr}z_r/\psi$	$-\mu_{us}(\psi - k_{us}\mu_{us})/\psi$
M_{eu}^*	$-\mu_{eu}\sigma_{eu}k_v\epsilon_{vf}/\psi$	$-\mu_{eu}\sigma_{eu}k_{xr}\epsilon_{rf}/\psi$	$-\mu_{eu}\sigma_{eu}k_{us}z_{us}/\psi$	$+z_{eu}(\psi - \mu_{eu}\sigma_{eu}k_{eu})/\psi$	$-\mu_{eu}\sigma_{eu}k_{mr}z_r/\psi$	$+\mu_{eu}\sigma_{eu}k_{us}\mu_{us}/\psi$
M_r^*	$-\mu_r\sigma_{rd}k_v\epsilon_{vf}/\psi$	$-\mu_r\sigma_{rd}k_{xr}\epsilon_{rf}/\psi$	$-\mu_r\sigma_{rd}k_{us}z_{us}/\psi$	$-\mu_r\sigma_{rd}k_{eu}z_{eu}/\psi$	$+z_r(\psi - \mu_r\sigma_{rd}k_{mr})/\psi$	$+\mu_r\sigma_{rd}k_{us}\mu_{us}/\psi$
X_v^*	$-\epsilon_{vf}(\psi - \epsilon_v k_v)/\psi$	$+\epsilon_v k_{xr}\epsilon_{rf}/\psi$	$+\epsilon_v k_{us}z_{us}/\psi$	$+\epsilon_v k_{eu}z_{eu}/\psi$	$+\epsilon_v k_{mr}z_r/\psi$	$+\epsilon_v k_{us}\mu_{us}/\psi$
X_r^*	$+\epsilon_r\sigma_{rs}k_v\epsilon_{vf}/\psi$	$-\epsilon_{rf}(\psi - \epsilon_r\sigma_{rs}k_{xr})/\psi$	$+\epsilon_r\sigma_{rs}k_{us}z_{us}/\psi$	$+\epsilon_r\sigma_{rs}k_{eu}z_{eu}/\psi$	$+\epsilon_r\sigma_{rs}k_{mr}z_r/\psi$	$-\epsilon_r\sigma_{rs}k_{us}\mu_{us}/\psi$
P_{eu}^*	$+\sigma_{eu}k_v\epsilon_{vf}/\psi$	$+\sigma_{eu}k_{xr}\epsilon_{rf}/\psi$	$+\sigma_{eu}k_{us}z_{us}/\psi$	$+\sigma_{eu}k_{eu}z_{eu}/\psi$	$+\sigma_{eu}k_{mr}z_r/\psi$	$-\sigma_{eu}k_{us}\mu_{us}/\psi$
P_{rd}^*	$+\sigma_{rd}k_v\epsilon_{vf}/\psi$	$+\sigma_{rd}k_{xr}\epsilon_{rf}/\psi$	$+\sigma_{rd}k_{us}z_{us}/\psi$	$+\sigma_{rd}k_{eu}z_{eu}/\psi$	$+\sigma_{rd}k_{mr}z_r/\psi$	$-\sigma_{rd}k_{us}\mu_{us}/\psi$
P_{rs}^*	$+\sigma_{rs}k_v\epsilon_{vf}/\psi$	$+\sigma_{rs}k_{xr}\epsilon_{rf}/\psi$	$+\sigma_{rs}k_{us}z_{us}/\psi$	$+\sigma_{rs}k_{eu}z_{eu}/\psi$	$+\sigma_{rs}k_{mr}z_r/\psi$	$-\sigma_{rs}k_{us}\mu_{us}/\psi$
P_{us}^*	$+k_v\epsilon_{vf}/\psi$	$+k_{xr}\epsilon_{rf}/\psi$	$+k_{us}z_{us}/\psi$	$+k_{eu}z_{eu}/\psi$	$+k_{mr}z_r/\psi$	$+(\psi - k_{us}\mu_{us}/\psi)$
P_v^*	$+k_v\epsilon_{vf}/\psi$	$+k_{xr}\epsilon_{rf}/\psi$	$+k_{us}z_{us}/\psi$	$+k_{eu}z_{eu}/\psi$	$+k_{mr}z_r/\psi$	$-k_{us}\mu_{us}/\psi$

Signs represent the direction of the effects.
$\Psi = (k_v\epsilon_v + k_{us}\mu_{us} + k_{xr}\epsilon_r\sigma_{rs} + k_{eu}\mu_{eu}\sigma_{eu} + k_{mr}\mu_r\sigma_{rd}) > 0$.

$$P_{us}^* = \beta_0 + \beta_1 \mathrm{BTA} + \beta_2 \mathrm{TAX} + \beta_3 \mathrm{LABEL} + \beta_4 Y_{us}^* + \beta_5 P_f^* + \beta_6 P_{salm}^* + \beta_7 P_{poul}^* + \beta_8 F_v^* + \beta_9 F_a^* + \beta_{10} Q_1^* + \beta_{11} Q_2^* + \beta_{12} Q_3^* + \varepsilon. \quad (31)$$

Other empirical models for Vietnamese catfish exports and US imports with explanatory variables identical to the above Equations 30 and 31 are also estimated to explore the effects of the BTA, antidumping measures and the labelling law on catfish trade flow.

Because the data series are stationary at the difference levels with Dickey Fuller tests, the effects of the BTA, the catfish antidumping measures and the labelling law are examined using logarithmic first-difference models and error correction models. Statistical tests show that TAX and LABEL do not create structural breaks in the dataset. Interaction terms between them and other explanatory variables are dropped for model simplification. In basic and simple graphs of supply and demand, the US antidumping tariff and the labelling law may shift (back or forward) the US import demand and/or Vietnamese export supply. The lags in the dependent variables are added in logarithmic first-difference models to capture the dynamic behaviour of the investigated economic variables.

Table 6 First-difference models of some empirical reduced-form equations

	US price		Vietnamese price		US import		Vietnamese export	
	Coefficient	*t-ratio*	Coefficient	*t-ratio*	Coefficient	*t-ratio*	Coefficient	*t-ratio*
BTA	−0.004	*−0.849*	−0.003	*−0.055*	−0.009	*−0.044*	0.041	*0.106*
TAX	0.007*	*1.727*	−0.023	*−0.553*	0.032	*0.195*	−0.074	*−0.238*
LABEL	0.001	*0.184*	0.017	*0.325*	−0.091	*−0.434*	0.118	*0.295*
US income	0.171	*0.990*	0.479	*0.232*	0.834	*0.134*	−10.767	*−0.901*
Poultry price	−0.131	*−1.141*	1.385	*1.041*	−6.683	*−1.454*	−2.819	*−0.324*
Salmon price	0.001	*0.060*	−0.230	*−0.747*	−0.994	*−1.180*	1.245	*0.770*
Atlantic freight	−0.041	*−0.514*	0.115	*0.122*	1.932	*0.603*	−1.194	*−0.197*
Pacific freight	0.115	*1.617*	−0.005	*−0.006*	3.317	*1.127*	−2.034	*−0.366*
Catfish feed price	0.106**	*2.043*	−0.167	*−0.262*	−5.573***	*−2.931*	2.122	*0.595*
Lag of dependents	0.121	*1.026*	−0.233**	*−2.183*	−0.204*	*−1.730*	−0.308***	*−2.785*
First quarter	0.014***	*3.174*	0.088*	*1.770*	−0.069	*−0.387*	−0.642*	*−1.892*
Second quarter	−0.004	*−0.698*	0.061	*1.084*	0.355*	*1.686*	−0.396	*−0.988*
Third quarter	0.000	*−0.067*	0.090*	*1.827*	0.009	*0.053*	−0.728**	*−2.158*
Constant	−0.005	*−1.379*	−0.069*	*−1.680*	0.015	*0.092*	0.446	*1.481*
R^2	0.29		0.36		0.27		0.20	
DW	2.16		2.19		2.16		2.13	

All continuous variables are in the first difference of logarithm forms.
*, **, ***, significant at 90, 95 and 99% levels.
Autocorrelations were corrected using the Prais and Winsten method.
BTA, Bilateral trade agreement; DW, Durbin–Watson statistics, statistical values for testing autocorrelation in econometric modeling.

Logarithmic first-difference models

The Ordinary Least Square (OLS, a popular method in econometrics) regression results of the logarithmic first-difference models showed that the BTA and the labelling law did not have a significant effect on the investigated variables of Vietnamese export price, US imports and Vietnamese exports (Table 6). The effect of the antidumping measures (represented by the TAX variable) was significant on the US price, but not significant for the other three variables. The antidumping effect on the US price was positive, consistent with the expected sign in the theoretical framework, but its incidence is very small. After imposing an antidumping tariff on Vietnamese catfish imports, the US price is estimated to rise by 0.7%. The equation of the US price also gives the expected positive coefficient of catfish feed price. The transmission elasticity between the prices of catfish feed and processed products is 0.11, confirming that feed is a major cost in the catfish farming industry.

A question mark remains over the negative effect of catfish feed on US imports. This matter can be explained by the important role of feed as a major factor in the catfish industry. Exported catfish from Vietnam rely increasingly on pellet feed imports and one of the USA's biggest feed companies, Cargill, established a plant in Vietnam to supply feed to the sector (Cohen & Hiebert 2001; Sengupta 2003). With advantages from low price and huge available supply of soybean, important ingredients in feed composition, US catfish feed is traded over the world. As catfish feed price decreased, the price of catfish from the exporters (Vietnam and ROW) decreased, making their products more competitive and thus US import increased as a consequence. A 1% drop in catfish feed price raised US catfish imports by 5.57%. With two crops per year, the striped catfish is usually harvested in the second and fourth quarters. Therefore, a shortage of catfish might occur in the first and third quarters of each year, leading to a decrease in export volume and an increase in the price in the quarters as predicted in the first-difference logarithmic models.

Error correction models

Because first-difference models focus only on short-term behaviours, missing adjustments and underlying long-term relationships, these models may not show the potential effects of the BTA, the US antidumping and the labelling law, error correction models were considered as an alternative. The Johansen and Juselius (JJ) co-integration test using trace statistics (Table 7) justified that continuous variables in the four investigating equations are co-integrated, allowing the use of Ordinary Least Square regression for estimating error correction models. An important advantage of the error correction model is its ability to capture a long-term trend in a co-integrated series and to study short-term fluctuations in this trend. The error correction models described in Table 8 were estimated following Enders (2004), in which lags of spurious model residuals and lags of difference terms of explanatory variables are used (the spurious models are not reported in this review). Three dummy variables, BTA, TAX and LABEL, were also added along with three other dummy variables that represented the first three quarters of each year to be consistent with the first-difference models.

Table 7 Co-integration rank test using trace (H_1: Rank > r)

	H_0: Rank = r	Eigen value	Trace	5% Critical value	Drift in ECM	Drift in process
US price	0	0.4685	113.0524	109.93	NOINT	Constant
Equation	1	0.2758	61.2188	82.61		
	2	0.1878	34.7557	59.24		
Vietnamese price	0	0.509	114.3784	109.93	NOINT	Constant
Equation	1	0.2505	56.0547	82.61		
	2	0.153	32.4133	59.24		
US import	0	0.4124	109.8641	109.93	NOINT	Constant
Equation	1	0.2626	66.2579	82.61		
	2	0.239	41.2811	59.24		
Vietnamese export	0	0.4449	113.2996	109.93	NOINT	Constant
Equation	1	0.2662	65.0359	82.61		
	2	0.2013	39.6527	59.24		
US price	0	0.523	160.553	132.00	Constant	Constant
Equation	1	0.412	99.940	101.84		
	2	0.260	56.365	75.74		
Vietnamese price	0	0.521	143.901	132.00	Constant	Constant
Equation	1	0.350	83.586	101.84		
	2	0.220	48.207	75.74		
US import	0	0.505	154.299	132.00	Constant	Constant
Equation	1	0.356	96.631	101.84		
	2	0.261	60.535	75.74		
Vietnamese export	0	0.447	139.888	132.00	Constant	Constant
Equation	1	0.343	91.340	101.84		
	2	0.235	56.886	75.74		

ECM, error-correction model.

In the short run term, with error correction models in Table 8, the BTA had no significant effect on US domestic price, Vietnamese export price, US imports or Vietnamese exports. US antidumping creates an expected positive effect on the US domestic price and the labelling law shows its effect on reducing US catfish imports. After the labelling law became effective, catfish imports declined by 36.7%. However, the rise in US domestic price was insignificant.

The negative coefficients of poultry price in the USA and import equations represent the complementary attributes of poultry and catfish at a wholesale level. Salmon

Table 8 Regression results from the error-correction models

	US price		Vietnamese price		US import		Vietnamese export	
	Coefficient	*t*-ratio	Coefficient	*t*-ratio	Coefficient	*t*-ratio	Coefficient	*t*-ratio
BTA	−0.006	−1.122	−0.001	−0.019	0.315	1.633	0.044	0.140
TAX	0.008*	1.677	0.003	0.063	0.115	0.759	−0.109	−0.427
LABEL	0.002	0.291	−0.020	−0.309	−0.367*	−1.861	0.165	0.507
US income†	−0.014	−0.083	1.430	0.761	8.121	1.403	−10.309	−1.111
Poultry price†	−0.279**	−2.221	−1.677	−1.200	−9.648**	−2.365	−2.782	−0.396
Salmon price†	−0.008	−0.356	−0.074	−0.291	2.149***	2.873	−0.620	−0.493
Atlantic freight†	0.033	0.379	0.485	0.499	−5.743*	−1.972	−0.657	−0.137
Pacific freight†	0.031	0.417	0.750	0.886	−0.733	−0.298	1.196	0.288
Catfish feed price†	0.045	0.848	−0.173	−0.282	−0.584	−0.334	2.497	0.827
Error correction term	−0.196**	−2.152	−0.914***	−7.072	−0.468***	−4.133	−0.920***	−6.845
First quarter	0.015***	3.358	0.092*	1.768	0.007	0.044	−0.276	−1.077
Second quarter	0.004	0.734	0.076	1.404	0.348**	2.210	−0.157	−0.581
Third quarter	0.004	0.716	0.090	1.602	0.056	0.345	−0.135	−0.469
Constant	−0.008*	−1.781	−0.061	−1.229	−0.106	−0.735	0.093	0.382
R^2	0.15		0.49		0.38		0.47	
DW	2.06		2.20		2.11		2.25	

All continuous variables are in the first difference of logarithm forms.
*, **, ***, significant at 90, 95 and 99% levels.
†Represents the first lag of the variables.
BTA, Bilateral trade agreement; DW, Durbin–Watson statistics, statistical values for testing autocorrelation in econometric modeling.

is an important substitute for US catfish imports. Catfish imports increased by 2.87% with a 1% rise in the world price of salmon. Although freight costs from the Pacific Ocean had no effect, freight costs from the Atlantic Ocean exhibited its expected effect on US catfish imports. A 1% increase in the Atlantic freight cost reduced the import by 5.74%.

Long-run models

The significance of the error correction terms in the estimated error correction model allow us to derive long-run models as given in Table 9. Ignoring insignificant parameters, the significant parameter in the long-run models is long-run elasticity. US catfish imports apart from decreasing with the labelling law in the short term, also declined after the US antidumping tariffs were announced, controlling for the effect of the BTA. The BTA gave a significantly positive effect on US catfish imports. After the BTA, US catfish imports increased by 67%. This figure justifies the benefits of globalization, that is, US consumers get more opportunities to choose from products of similar quality at a cheaper price. The cheaper price of Vietnamese catfish introduced them to an alternative for domestic catfish. This extreme increase in catfish imports created pressure on US domestic catfish processors to reduce their price.

The long-run model in Table 9 might be relevant for the US price equation when the variables of poultry and salmon prices, and freight cost from Pacific Oceans gave expected signs of their coefficients. All three dummy variables investigated gave significant effects. After the BTA was signed in December 2001, the US domestic catfish price declined by 1.4%, reflecting the competition from cheaper catfish from Vietnam. However, trade policies for domestic production protection, such as the antidumping and labelling legislation, were ineffective in the long-run

Table 9 Long-run model derived from the error-correction models

	US price	Vietnamese price	US import	Vietnamese export
BTA	−0.014	n/a	0.674	n/a
TAX	−0.004	−0.237	−0.460	n/a
LABEL	−0.014	−0.221	−0.367	3.100
US income	n/a	n/a	n/a	−22.104
Poultry price	0.058	n/a	1.668	7.395
Salmon price	0.017	n/a	n/a	n/a
Atlantic freight	n/a	−1.047	1.773	n/a
Pacific freight	0.022	n/a	1.827	n/a
Catfish feed price	n/a	0.691	−3.776	n/a
First quarter	0.024	0.092	−0.151	−0.500
Second quarter	0.009	n/a	0.348	n/a
Third quarter	n/a	0.095	n/a	−0.477
Constant	−0.008	n/a	n/a	193.395
Lag in the dependent variable	0.803	0.086	0.532	0.080

All continuous variables in logarithms.
BTA, bilateral trade agreement.

model of US catfish price. The US domestic price declined, albeit to a small extent, after the labelling law was passed and after antidumping tariffs were imposed on catfish imports.

The effect of US income on Vietnamese export was negative, suggesting that Vietnamese catfish was an inferior product in the US market. This suggestion is consistent with the finding of Quagraine (2006). In long-run models, poultry is confirmed as a substitute for catfish. The Vietnamese catfish exporters seem to get a 'free rider' effect with the US labelling laws. This legislation differentiates Vietnamese catfish from US catfish and motivates Vietnamese exporters to rename their brand as 'tra, basa' in the US market and '*Pangasius* catfish' in other markets as well as forcing them to diversify their markets. The differentiation also gave Vietnamese exporters a monopolistic advantage to sell catfish not only in the US market, but also in other markets. However, the export price of Vietnamese catfish was negatively affected by the legislation. After differentiation by the US labelling laws, export of Vietnamese catfish increased by more than threefold, but its price decreased 22.1%. In addition, the US antidumping tariff depressed the Vietnamese catfish export price by 23.7%. This result supported the results of a study by Kinnucan (2003), who found that US catfish antidumping did more to punish the Vietnamese exporter than support the domestic catfish industry.

Tariff effects under imperfect competition

Theoretical analysis

The above models are estimated under perfect competition. For a further analysis on the subsidy effect of the Byrd Amendment on the prices of the two products, US and Vietnamese catfish, they were analysed along with an estimated equation system of price-reaction functions. In the empirical regression, the impacts of the antidumping measures were estimated under imperfect competition. The competition strategy assumed was the Bertrand (price) strategy in which one competitor would lead the competition by lowering its price, forcing the rival to lower price to retain market share. In the catfish case, based on Evenett (2006), US producers could raise their price, forcing Vietnamese exporters to increase their price to narrow the gap, which in its turn lessens a tariff incidence for the next years, following the calculation methods of antidumping duties. In this way, US producers get more money from Byrd disbursement, which is considered in its turn to be a subsidy to the US domestic industry under perfect competition.

The difference between antidumping tariff effects under the Bertrand competition with the effects under perfect

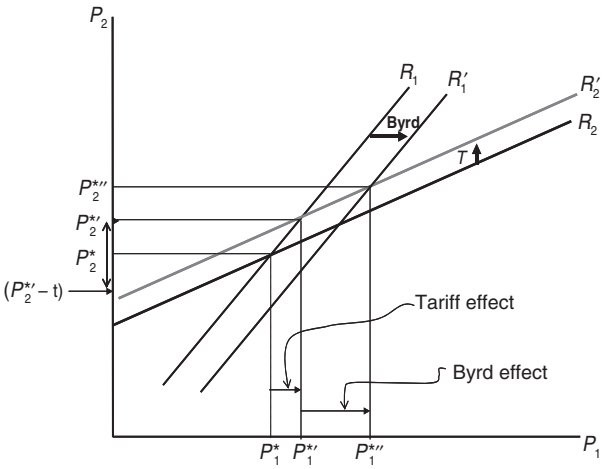

Figure 2 Effects of the antidumping tariff on the US catfish market with the Byrd Amendment under Bertrand competition.

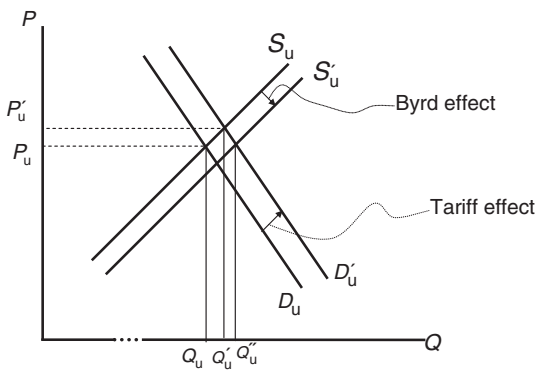

Figure 3 Effects of the antidumping tariff on US catfish with the Byrd Amendment under perfect competition.

competition is presented in Figures 2 and 3. In Figure 2, with the Bertrand competition strategy, when an antidumping tariff is imposed on an imported product, its price reaction function R_2 would shift up (to R_2'), leading to a rise in its price P_2^*, with an increase to $P_2^{*\prime}$, and also increase in the rival's price of P_1^* to $P_1^{*\prime}$. The actual price paid to the product's exporter would be $(P_2^{*\prime} - t)$ after tariff payment. With the motives to get more money disbursement from the Byrd Amendment (Evenett 2006), US producers could raise their price so that their price reaction function R_1 would shift up to R_1', and contribute to raising $P_2^{*\prime}$ to $P_2^{*\prime\prime}$, $P_1^{*\prime}$ to $P_1^{*\prime\prime}$. In perfect competition conditions (Fig. 3), when an antidumping tariff is imposed on its competitive imports, a substitute effect would shift the demand curve for domestic product D_u up to D_u', raising the equilibrium price P_u to P_u', respective with the equilibrium production from Q_u to Q_u'. With the Byrd Amendment, the domestic industry gets its

disbursement as production subsidy and its supply curve S_u would shift down to S'_u. Therefore, the Byrd effect can offset the tariff effect on domestic price. However, evidence is required to determine whether the final equilibrium price (respective with the final equilibrium production Q''_u) is higher, lower or equal to the initial price P_u needs.

Empirical models for price reaction functions

Model specification

For empirical regression with the frozen catfish fillets case, some assumptions were made: (i) Vietnamese catfish dominate US catfish imports when 90% of the catfish imported by the USA in 2000 originated from Vietnam (Cohen & Hiebert 2001), that is, US catfish imports from other foreign suppliers could be ignored; (ii) catfish fillets produced by US and Vietnamese processors are differentiated under 'labelling' law and biological species differences; and (iii) US and Vietnamese firms behave as price-setting duopolists. With these assumptions the econometric model used to test for duty effects is:

$$\begin{aligned}\Delta \ln P_{1,t} = {} & a_0 + a_1 \mathrm{PRELIM}_t + a_2 \mathrm{FINAL}_t + \sum_{k=3}^{5} a_k D_{k,t} \\ & + a_6 \Delta \ln P^{-}_{2,t} + a_7 \Delta \ln P_{p,t} + a_8 \Delta \ln P_{sal,t} \\ & + a_9 \Delta \ln I_t + a_{10} \Delta \ln f_t + a_{11} \Delta \ln W_t \\ & + a_{12} \Delta \ln G_t + a_{13} \Delta \ln P_{1,t-1} + e_{1,t} \end{aligned} \quad (32)$$

$$\begin{aligned}\Delta \ln P^{-}_{2,t} = {} & b_0 + b_1 \mathrm{PRELIM}_t + b_2 \mathrm{FINAL}_t + \sum_{k=3}^{5} b_k D_{k,t} \\ & + b_6 \Delta \ln P_{1,t} + b_7 \Delta \ln P_{p,t} + b_8 \Delta \ln P_{sal,t} \\ & + b_9 \Delta \ln P_{o,t} + b_{10} \Delta \ln I_{1,t} + b_{11} \Delta \ln f_t \\ & + b_{12} \Delta \ln X_t + b_{13} \Delta \ln P^{-}_{2,t-1} + e_{2,t} \end{aligned} \quad (33)$$

$$\begin{aligned}\Delta \ln Q_{1,t} = {} & c_0 + c_1 \mathrm{PRELIM}_t + c_2 \mathrm{FINAL}_t \\ & + \sum_{k=3}^{5} c_k D_{k,t} + c_6 \Delta \ln P_{1,t} + c_7 \Delta \ln P^{-}_{2,t} \\ & + c_8 \Delta \ln P_{p,t} + c_9 \Delta \ln P_{sal,t} + c_{10} \Delta \ln I_{1,t} \\ & + c_{11} \Delta \ln Q_{1,t-1} + e_{3,t} \end{aligned} \quad (34)$$

where $\Delta \ln x_t = \ln x_t - \ln x_{t-1}$ denotes the first-difference operator. Equations 32 and 33 are the price-reaction functions of US and Vietnamese catfish, respectively, whereas Equation 34 is the US catfish demand equation. A summarized description of the variables is presented in Table 3.

Tariff effects are modelled using two dummies: PRELIM for the period of investigation (June 2002–July 2003) and FINAL for the implementation period (August 2003–December 2005). The PRELIM variable is included to test whether foreign firms raise prices during the investigation period in order to reduce the dumping margin in the event of a positive ruling, as proposed by Blonigen and Heynes (2002) and by Feenstra (2004). The tariff effect is the sum of the estimated coefficients from the two dummies. Quarterly dummies are included to control for seasonal demand shifts (Kinnucan & Miao 1999). The first-difference logarithm specification is used because preliminary analysis showed that the variables are stationary, coefficients of dummy variables can be interpreted as a relative change, and coefficients of continuous variables can be interpreted as elasticities. Lagged dependent variables are specified to test for dynamic effects.

To determine the producer impacts of the tariff we augmented the foregoing wholesale-level model with the following inverse demand equation for farmed catfish:

$$\begin{aligned}\Delta \ln P_{f,t} = {} & d_0 + d_1 \mathrm{PRELIM}_t + d_2 \mathrm{FINAL}_t + \sum_{k=3}^{5} d_k D_{k,t} \\ & + d_6 \Delta \ln P_{1,t} + d_7 \Delta \ln Q_{f,t-5} + d_8 \Delta \ln P_{p,t} \\ & + d_9 \Delta \ln P_{sal,t} + d_{10} \Delta \ln P_{f,t-1} + e_{4,t} \end{aligned} \quad (35)$$

where $P_{f,t}$ is the price paid by US processors for live catfish purchased from farmers in month t, $Q_{f,t}$ is the quantity of live catfish purchased by US processors in month t, $e_{4,t}$ is a random disturbance term, and the other variables are as previously defined.

Regression results

To account for possible cross-equation correlation in the error terms the equations were estimated as a system using SUR. To assess the sensitivity of the results to the estimation procedure two sets of estimates were provided: a wholesale-level model consisting of Equations 32–34 and a combined wholesale-to-farm model consisting of Equations 32–35. Because the estimation results are similar our discussion focuses on the wholesale model unless indicated otherwise.

Focusing first on the demand equation the model has an R^2 of 0.54 and most of the estimated coefficients have the correct signs. The estimated coefficient of US price is −2.4 with a t-ratio of −3.3, which suggests that the domestic demand for US fillets is price elastic. This implies that if the home industry raises the price to increase tariff revenues, as predicted by the Bertrand duopoly model, revenues from domestic sales will fall. The estimated coefficient of US income is 1.4 with a t-ratio of 1.4. Although the estimated income coefficient is larger than one, a one-tail test does not permit one to conclude that frozen fillets are a luxury good. Importantly, the estimated coefficient of Vietnam price is 0.13 with a t-ratio of 2.4. This suggests that a tariff-induced increase in the price of Vietnam fillets will have little effect on demand for US fillets. That US

Table 10 Regression for reaction-price equations and demand for US catfish

	US home price	Vietnamese price	Demand for US fillets
PRELIM	0.000	0.015	0.001
	(0.068)	(0.426)	(0.054)
FINAL	0.005	−0.022	0.019
	(2.126)	(−0.783)	(1.207)
US price	n/a	4.972	−2.359
	n/a	(3.801)	(−3.268)
Vietnamese price	0.019	n/a	0.13
	(2.613)	n/a	(2.407)
Non-US price	n/a	0.022	n/a
	n/a	(0.395)	n/a
Salmon price	0.016	−0.026	−0.122
	(1.208)	(−0.146)	(−1.211)
Poultry price	0.019	−0.289	−0.593
	(0.253)	(−0.293)	(−1.068)
US income	0.128	−0.215	1.421
	(1.228)	(−0.149)	(1.821)
Wage rate	0.207	n/a	n/a
	(1.329)	n/a	n/a
Energy index	0.004	n/a	n/a
	(0.151)	n/a	n/a
Freight index	0.114	−1.233	n/a
	(2.106)	(−1.658)	n/a
Exchange rate	n/a	0.192	n/a
	n/a	(0.705)	n/a
Lag in the dependent variable	0.345	−0.464	−0.533
	(3.879)	(−4.657)	(−6.246)
First quarter	0.008	0.014	0.202
	(2.374)	(0.341)	(8.392)
Second quarter	−0.003	0.049	0.039
	(−0.914)	(1.085)	(1.694)
Third quarter	−0.005	0.050	0.090
	(−1.748)	(1.242)	(4.034)
Constant	−0.003	−0.025	−0.095
	(−1.213)	(−0.741)	(−4.980)
R^2	0.48	0.26	0.54
DW-h	1.31	0	1.1

Numbers in parentheses are the asymptotic *t*-ratios.
DW-h, Durbin h-statistics, statistical values for testing autocorrelation in econometric modeling.

fillets are a poor substitute for Vietnam fillets should not be surprising in that the former are substantially more expensive (Table 10). And this is true even allowing for full tariff pass through (i.e. assuming that none of the tariff is absorbed by Vietnamese exporters). The estimated coefficient for the lagged dependent variable is −0.53 with a *t*-ratio of −6.2. The negative adjustment elasticity means that long-run elasticiites are smaller than short-run elasticities, which probably reflects inventory behaviour (in the short-run processors can meet a demand increase by drawing down inventory; in the long run production must be increased). The remaining variables, including the two policy dummies PRELIM and FINAL, are insignificant at 10%, 5% and 1% probability levels.

Turning to the price-reaction functions the US price equation showed better explanatory power ($R^2 = 0.48$) than the Vietnam price equation ($R^2 = 0.26$), as might be expected owing to the use of proxy variables in the latter. Coefficient estimates are consistent with theory in that the price-reaction functions are upward sloping with the estimated coefficient of the rival's price positive in each equation. However, the effects are asymmetric with the estimated coefficient of US price elastic at 5.0 (*t*-ratio = 3.8) and the estimated coefficient of Vietnam price inelastic at 0.02 (*t*-ratio = 2.6). Thus, whereas the Vietnam price is highly sensitive to changes in the US price, the reverse is not true. In particular, a 10% increase in the Vietnam price would raise the US price by a mere 0.2% *ceteris paribus*. This result reinforces the inference from the demand equation that US fillets are a poor substitute for Vietnam fillets over the observed price range.

The estimated coefficients of the lagged dependent variable in the US and Vietnam price equations are 0.34 and −0.46, respectively, with *t*-ratios exceeding 3.8 in absolute value. Dividing the foregoing price effects by one minus these estimated coefficients yields long-run elasticities of 3.4 and 0.03. Hence, the conclusion that price reaction is highly asymmetric is not much affected by the length of the run.

The prices of salmon imports and poultry have no significant effect on the prices of US and Vietnamese catfish fillets. However, freight costs from the Pacific gave significant and expected effects on the prices. A 10% increase in freight costs from the Pacific raised the price of the domestic product by 1.1%, but lowered the price of the imports from Vietnam by 12.3%.

PRELIM is not significant in either equation. Hence, the hypothesis that firms set prices strategically during the investigation period to influence the tariff rate is rejected. FINAL is significant in the US price equation, but not in the Vietnam price equation. As the Vietnam price is measured exclusive of the tariff, the lack of significance of FINAL in the Vietnam price equation implies that the US consumers bore the tariff. Despite the tariff's apparent ability to raise the US price of the imported product, it had little effect on the price of the US product. In particular, the estimated coefficient of FINAL in the US price equation was 0.005, which means that the US price during the duty period increased by a mere 0.5% *ceteris paribus*. The reason for this modest effect is the low cross-price elasticity of demand as explained in connection with the demand equation.

In the extension model to explore the tariff effect on US farm price (Table 11), the regression results for US home price and Vietnamese price equations were similar

Table 11 Seemingly Unrelated Regression for the equation system with the US farm price equation

	US price	Vietnamese price	US demand	US farm price
PRELIM	0.002	−0.004	0.012	0.004
	(0.657)	(−0.106)	(0.582)	(0.643)
FINAL	0.006	−0.029	0.031	0.006
	(2.531)	(−0.963)	(1.824)	(1.167)
US price	n/a	5.087	−2.958	1.148
	n/a	(3.656)	(−3.83)	(4.64)
Vietnamese price	0.017	n/a	0.126	n/a
	(2.318)	n/a	(2.244)	n/a
Non-US price	n/a	0.05	n/a	n/a
	n/a	(0.919)	n/a	n/a
Salmon price	0.016	−0.024	−0.169	−0.07
	(1.172)	(−0.127)	(−1.614)	(−2.161)
Poultry price	0.004	−0.441	−0.451	−0.113
	(0.049)	(−0.382)	(−0.704)	(−0.568)
US income	0.135	−0.935	1.454	n/a
	(1.291)	(−0.66)	(1.865)	n/a
Wage	0.232	n/a	n/a	n/a
	(1.472)	n/a	n/a	n/a
Energy index	0.003	n/a	n/a	n/a
	(0.133)	n/a	n/a	n/a
Freight rate	0.073	−0.952	n/a	n/a
	(1.263)	(−1.207)	n/a	n/a
Exchange rate	n/a	−0.531	n/a	n/a
	n/a	(−1.055)	n/a	n/a
US demand (lag 5)	n/a	n/a	n/a	−0.084
	n/a	n/a	n/a	(−3.139)
Lag in the dependent variable	0.32	−0.46	−0.547	0.208
	(3.444)	(−4.463)	(−6.321)	(2.248)
First quarter	0.009	0.009	0.205	0.011
	(2.471)	(0.223)	(8.35)	(1.596)
Second quarter	−0.003	0.056	0.029	−0.003
	(−0.831)	(1.205)	(1.201)	(−0.467)
Third quarter	−0.005	0.055	0.088	0.001
	(−1.562)	(1.362)	(3.888)	(0.189)
Constant	−0.005	−0.018	−0.103	−0.004
	(−1.629)	(−0.504)	(−5.279)	(−0.748)
R^2	0.46	0.23	0.54	0.55
DW-h	−1.53	−0.11	−1.65	0.9

Numbers in parentheses are asymptotic *t*-ratios.
DW-h, Durbin h-statistics, statistical values for testing autocorrelation in econometric modeling.

to the results in Table 10, except that the coefficient of the freight cost was not significant any more. The tariff coefficient in the demand equation for US frozen catfish fillets becomes significant, although just at the 90% level. After the US antidumping measures were implemented, the demand for US catfish fillets rose by 3.1%, associated with a 0.6% improvement in its price. However, the positive effect of antidumping on the US farm price was not significant.

Conclusion

Catfish imports to the US have increased since a BTA between the US and Vietnam was signed in December 2001. This review provides evidence for the futility of the US labelling law and antidumping tariffs imposed on catfish imports from Vietnam. In contrast to the positive effect on the domestic price in the short term, antidumping lowered the price in the long term, but with a very small incidence.

In the error correction model, the punishment effect of US antidumping on rival imports was large and lowered both US catfish imports and the Vietnamese export price. The price effect of the labelling law was not positive as expected by the US catfish processors. Despite lowering the price, Vietnamese catfish exports still increased.

With the Byrd Amendment effect included in a SUR estimation and Bertrand imperfect competition, the price and demand of domestic catfish increased after the US ITC imposed an antidumping tariff on Vietnamese catfish imports, but the tariff was estimated to be ineffective. Antidumping duty was confirmed to be a weak tool to protect the US catfish industry. Because the import price was not affected by the duty imposition, US consumers had to bear the duty as domestic price increased. Although the BTA benefited US consumers as free trade principles were applied, the antidumping tariff was futile and the labelling law caused negative effects on the domestic price of catfish.

This, to the author's knowledge, is the first time that a detailed analysis with econometric models has been undertaken on issues that have been dealt with in regard to an aquaculture commodity. The findings are significant as they also relate to the barriers that new commodities destined for export have to contend with. In the fishery sector, it is accepted that the gap between the demand and supply of fish needs, which is estimated to reach 30 to 40 million tonnes by year 2020, has to be mostly met by aquaculture (Cressey 2009; FAO 2009), the production of which is dominated by developing countries, particularly in Asia. It is therefore to be expected that new commodities will be destined for export to developed countries and cases comparable to catfish could well arise again and again, which are both economic and political concerns.

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