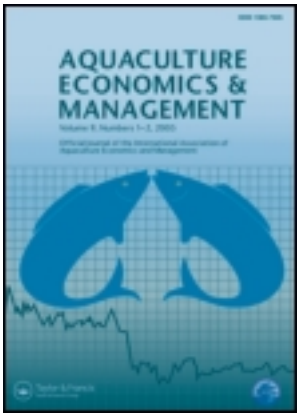

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THE RUSSIAN SEAFOOD REVOLUTION: SHIFTING CONSUMPTION TOWARDS AQUACULTURE PRODUCTS

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THE RUSSIAN SEAFOOD REVOLUTION: SHIFTING CONSUMPTION TOWARDS AQUACULTURE PRODUCTS

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□ *A food consumption revolution is taking place in Russia. After decades of severe constraints on food consumption options under the communist regime Russian consumers are now adopting new food products—including seafood products – at a high pace. Since Russian consumers have previously had very limited seafood consumption choices, the market can be seen as an interesting laboratory for investigating consumer responses to products that have previously not been available. Among imported seafood products are both wild and farmed species. Furthermore, Russian imports include both traditional species such as herring, and 'new' species such as pangasius. We analyze market integration among seafood products using Russian monthly import prices from 2002 to 2007 on several products, such as herring, salmonids and pangasius. We find that pangasius compete in the white fish segment, and is a price leader. In the salmonids market, farmed salmon trout appears to be the price leader, both in the fresh and frozen market segment.*

Keywords aquaculture products, import demand, market integration, Russia

INTRODUCTION

Russia represents a very interesting laboratory in the study of seafood markets. What happens when a country suddenly opens up its previously closed market to imported goods, has an average annual real GDP growth rate of 7% and at the same time rapidly develops modern retail distribution channels?[1] At what rate will globally leading aquaculture products be adopted when domestic consumers have very little experience with some of the dominant aquaculture species and the products made from them? To what degree will these consumers

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perceive new aquaculture products and traditional wild-caught products as substitutes? Consumers in Japan, USA, France, Germany and the UK have adopted new aquaculture products over a fairly long time period, as they have become commercially viable on a large scale from the 1970s and onwards. Russian consumers, on the other hand, have been subjected to an import liberalization 'shock', where a wide range of species and products became suddenly available at the turn of the millennium, to the extent that the market were able to develop domestic distribution channels and consumers were willing to accept the products at sufficient speeds.

The Russian seafood market is an interesting case as it can shed light on the competition between aquaculture and traditional seafood products in emerging markets. Globally, aquaculture products have gained market shares at the expense of traditional capture fisheries products since the 1970s. In 2006, aquaculture comprised 41.8% of total seafood supply, up from 5.1% of total seafood supply in 1970. In terms of final sales value aquaculture products probably have a market share above 50% today. Innovation and productivity growth at the farm stage explains much of the 7% average annual growth rate of aquaculture since 1970. Growth could not have been sustained over time, however, if aquaculture products had not been accepted or preferred by professional buyers and consumers.

Much of the growth of aquaculture products has occurred in national markets which have a very small domestic aquaculture production and are consequently net importers. Many of these countries have a significant domestic fisheries sector supplying products that compete with products from aquaculture. The focus of our study, Russia, certainly has these characteristics. It is one of the larger fisheries nations with domestic catches of 3.3 million metric tonnes in 2005.

In this paper we analyze the relationship between imported seafood products in Russia from 2002 to 2007. We focus particularly on the competition between seafood from traditional fisheries and aquaculture. Our analysis shows that seafood from aquaculture experienced an impressive growth both in terms of value and quantity. This development goes hand in hand with a rapid growth in modern distribution channels during the same period.

To investigate market integration among the imported seafood products we analyze their price relationships using monthly import prices from 2002 to 2007. The Johansen cointegration procedure allows us to test for both market integration and price leadership. In this manner we can identify market segments and obtain information on the price formation process in those market segments. This is particularly useful when we wish to analyze the interaction among aquaculture and wild-caught seafood products. Several studies have used similar methods to study other seafood markets (Gordon et al., 1993; Asche et al., 1999; Jaffry et al., 2000; Asche et al., 2004; Nielsen, 2005; Asche et al., 2005; Asche & Tveterås, 2008; Norman-López &

Asche, 2008; Norman-López & Bjørndal, 2009). This attests to the interest in the changing market structures that has characterized global seafood markets during the last decades.

BACKGROUND

To analyze the Russian seafood revolution it is important to take into account the development of the Russian economy as a whole during the last 15–20 years. After a period of economic decline in the 1990s, resulting in the devaluation of the ruble in 1998, imports were reduced and Russian consumers substituted towards domestically produced goods. This strengthened many domestic privatized industries, including food processing industries (Kadochnikov, 2006). After 1998, the Russian economy has experienced strong growth and revived activity in many industries.[2] Due to these developments seafood imports were not able to accelerate until the post-1998 period, which is the period covered in our analysis of the Russian seafood market.

An important issue is how economic growth and a larger selection of products change the consumptions habits of the Russian consumer. For example, market penetration of newly introduced aquaculture products can be inhibited by Russian meal traditions. Russian consumers have several strong meal traditions that many claims they would like to maintain (Honkanen & Voldnes, 2006). Traditional food rarely includes products from farmed fish species, and a high degree of maintenance of food traditions would therefore be a barrier to growth for aquaculture products. For example, among seafood ingredients the wild-caught herring has a strong position in traditional meals. However, preparation time for traditional meals at home is long, and this is probably a contributing factor to a decline as particularly younger Russian consumers would like to reduce their meal preparation time. There is evidence that many younger people cannot prepare traditional food (Honkanen & Voldnes, 2006). Another factor is that during the communist era Russians had to use food ingredients of a low quality, including white fish in frozen blocks. Many have negative associations related to quality and taste with traditional meals and food ingredients from the communist era, and would like to move away from these and try new food ingredients and meals that they perceive to have preferable attributes.

One factor that contributes to adoption of meals based on new marine species and products is the dramatic increase in Russians' vacations and business travels abroad (Tribilustova, 2007). The number of Russian tourists visiting countries outside the former Soviet Union grew from 2.6 million in 1995 to 7.1 million in 2006. The Russian middle class travel to many Western European countries, North America and Asia, where they learn about new food ingredients and meals.

As consumer purchasing power increases one expects that preferences will shift toward higher value-added products. As Russians are increasingly adopting busier and more westernized lifestyles, much of the change in demand for food centre around convenience and quality factors such as packaging, advance preparation and eating out, rather than on increased absolute food consumption. An increase in number of households with microwaves and freezers contribute to this trend.

Heterogeneous Consumers

There are larger differences between the centre, represented primarily by Moscow and St. Petersburg, and periphery in Russia than most other countries in Europe. The differences are economic, social and cultural. The highest income is concentrated in the regions of Moscow and St. Petersburg, and in the oil-rich region Ural. The income in the most affluent region, Ural, is 97% higher than in the South region, and this relative difference has only been reduced marginally from 2005 to 2007. Another noteworthy feature is the rapid increase in real income. Both in 2006 and 2007 the real income increase on a national basis was around 13%. In a country as diverse as Russia there will always be significant differences in consumption patterns, including seafood consumption.

Distribution Channel Developments

In developed economies, the majority of seafood distribution takes place in so-called *modern retail distribution channels*, which predominantly include supermarkets and hypermarkets owned by large retail chains. Aquaculture products appear well suited for distribution in retail chains, in particular, due to consistent supply of large volumes and uniform quality of products (Asche et al., 2007a; Kvaløy & Tveteras, 2008). Russia has over the last few years experienced a rapid growth in modern retail distribution channels. This development has partly been driven by income growth. According to Figure 1, the share of modern distribution channel grocery sales in per cent of total retail sales has increased from 7% in 1999 to 45% in 2006.

Modern Russian distribution channels have much more advanced logistics than older ones, which were dominated by open or closed markets and small shops. They have partly adopted information and logistical technologies from the multinational retail chains, and have greater capacities in transportation and storage of chilled food. These new retail chains supply a greater diversity of products, including more value added products. The increasing range of products available in the shops is both an indication of shifts in Russian consumers' incomes and preferences, and the increased ability of suppliers to bring these

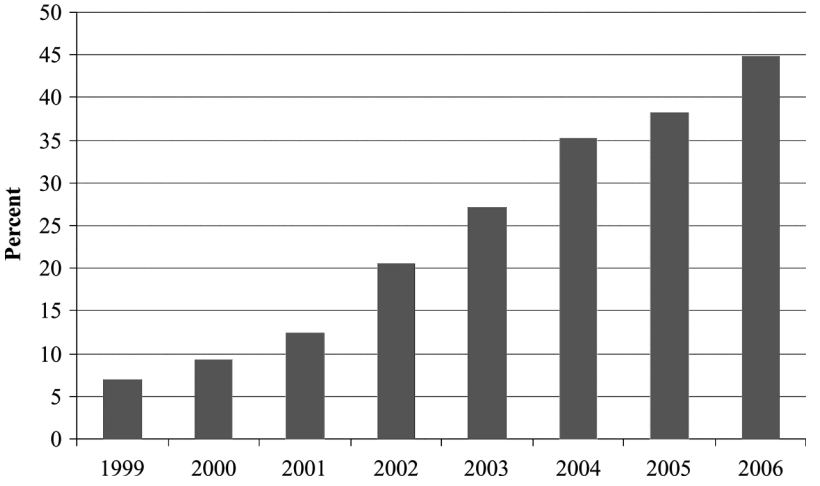

FIGURE 1 Modern distribution channel grocery sales in per cent of total retail sales (*Source:* Planet Retail, 2008).

products to the consumers. The increasing range of products in many food product categories respond to consumers' preferences for quality, variation, convenience ("easy to prepare"), and health benefits. This also seems to be the case for seafood in general, and herring in particular.

Moscow and St. Petersburg have a more modern supply structure with supermarkets, hypermarkets and up-to-date grocery stores. They also have a large share of the retail trade turnover in Russia. To give an idea about the degree of concentration Moscow's share of national retail trade turnover was 22% in 2006, down from 30% in 2000 (Tribilustova, 2007). The more rural areas of Russia are lagging behind and still rely on traditional distribution channels such smaller shops and markets. Both multinational and national supermarket chains are following the practices of the West in many ways. The past years have seen a shift towards centralized procurement systems. Traditionally retailers would buy from local wholesalers, but with the expansion of supermarket and hypermarket chains following western practices, retailers' preferences are shifting toward "preferred supplier" systems where producers are selected based on their meeting new quality and safety standards and ensuring lower transaction costs.

GOVERNMENT IMPORT REGULATIONS AND TARIFFS

Russia is a net importer of food products. It is not yet a member of the World Trade Organization. The average import duty on seafood products from most favored nations (MFN) into Russia is 12.8% (WTO, 2008).

The Russian government has on many occasions intervened with different measures on imported foodstuffs and plants due to cited food safety concerns (Kokkvold, 2007). In many cases the food safety related import regulations have targeted products experiencing rapid growth and achieving a substantial import value. This has also been the case for seafood imports, and the interventions have influenced the volume and value of those seafood products that have been affected, at least for some time period. Most prominent among the seafood products affected by Russian import regulations due to cited food safety concerns are Norwegian farmed salmon in 2006 and Vietnamese farmed pangasius in 2007. In both cases imports were temporarily halted or limited, and for farmed salmon only a limited number of processing plants in Norway and Chile that have been inspected and certified are allowed to export to Russia. The number of approved Russian importers has also been limited. It is difficult to estimate the effects of these measures on import volume and value, but it is reasonable to assume that salmon and pangasius import levels would have been higher without the measures. Altogether, import products from aquaculture have been more affected than products from fisheries by government food safety regulations (Kokkvold, 2007).

Import Developments

Russian seafood imports have grown in nominal terms from 159 million USD in 2000 to around 1877 million USD in 2007, which amounts to 43% annual nominal growth. If we take into account inflation in Russia, the annual real import growth rate in the same period was 26%. Figure 2 shows how the value of Russian seafood imports has increased from 1998 to 2007.

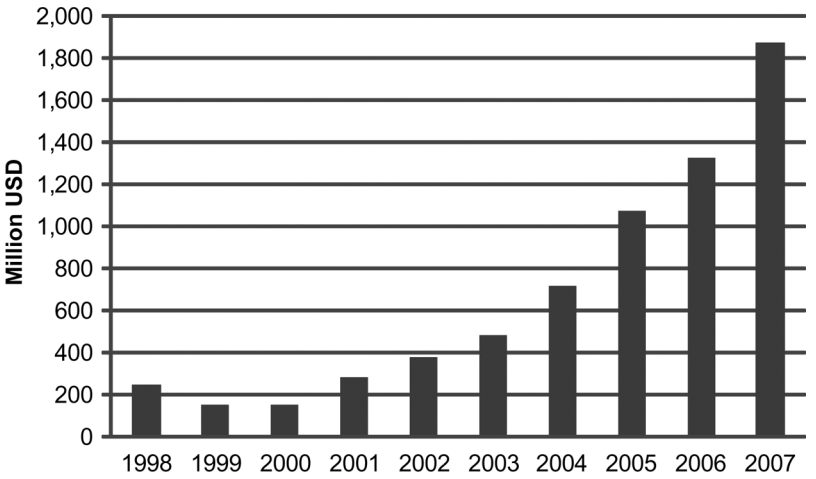

FIGURE 2 Total value of Russian seafood imports from 1998 to 2007 in nominal prices (*Source:* UN, 2009).

TABLE 1 Leading Seafood Exporters to Russia in 2007 and Their 2004 Exports Quantity in 1000 Metric Tons

	2007	2004	% Change
Norway	372.556	294.206	26.6
China	79.440	11.260	605.5
Vietnam	58.322	6.047	864.5
UK	53.826	58.263	−7.6
Mauritania	43.320	45.684	−5.2
Denmark	42.625	30.951	37.7
Iceland	39.416	39.895	−1.2
Estonia	35.443	24.053	47.4
Canada	32.634	17.453	87.0
Chile	27.906	11.260	147.8
Total	997.609	738.757	35.0

Source: Fishnet, Russia's seafood imports in 2004–2007.

To put the Russian seafood imports into perspective, total Russian imports increased 490% in value from 2000 to 2007.[3] Russian imports of foodstuffs increased 194% in value. Russian seafood imports, on the other hand, increased by as much as 739% in value during the same period.

As shown in Table 1, Norway was the leading supplier in 2007 with exports of 373 thousand metric tons valued at 630 million USD.[4] Norway holds this position primarily because of its exports of herring, which is the most consumed fish in Russia, and because of increasing farmed salmon and salmon trout exports. China was number two measured in volume, with Vietnam in third place. China has a diversified portfolio of seafood export products to Russia, where Alaska pollock, octopus and tilapia are among the largest. In the case of Vietnam, which by far had the highest percentage increase in export volume from 2004 to 2007, it is mainly increased exports of pangasius that has made this country the third largest seafood exporter to Russia, measured in volume.

Figure 3 shows the import quantity for major seafood products in 2007 together with their average annual import growth rates from 2002 to 2007. The dark blue bars represent products based on raw material from aquaculture, while the light blue represent products based on raw material from fisheries. Frozen shrimp is an intermediate case. Previously it has been a product group primarily sourced from fisheries, but now comprises an increasing share of farm-based products. We see that in volume terms frozen whole herring was by far the biggest import product, followed by frozen whole sardines, and frozen mackerel. These are all sourced from the fisheries sector. However, these are also the products with the lowest growth rate from 2002 to 2007. The biggest individual product sourced from aquaculture is frozen pangasius fillet, followed by whole fresh and frozen salmon products which altogether represent a larger quantity than

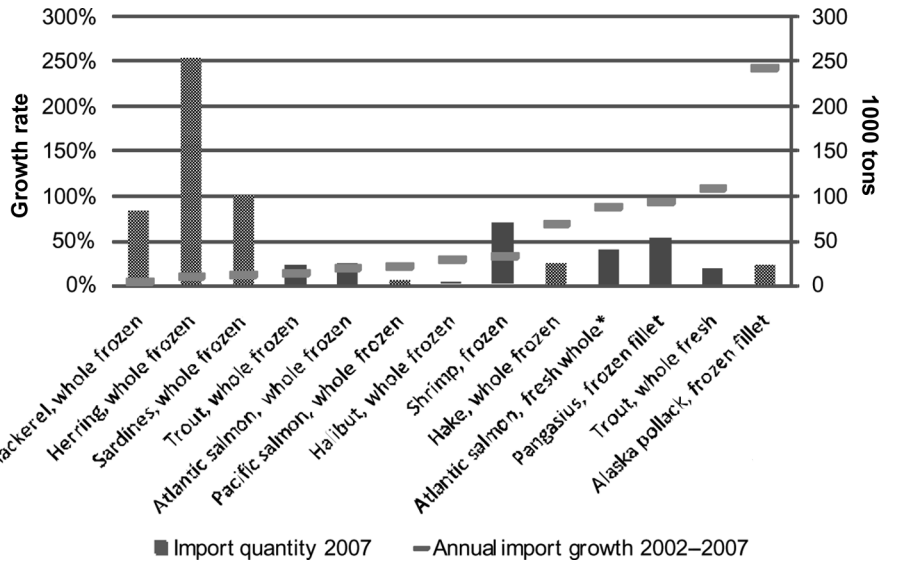

FIGURE 3 Import quantity in 2007 and average annual import growth rates 2002–2007 for major seafood products (*Source:* NSEC). *Whole fresh Atlantic salmon is Norwegian *export* quantity to Russia (NSEC).

pangasius products. On average, the products sourced from aquaculture have experienced a higher import growth rate than those sourced from fisheries.

Figure 4 shows the import value for major seafood products in 2007 together with their average annual import growth rates from 2002 to 2007. The picture is somewhat different from that in Figure 3, as the products sourced from aquaculture on average receive a higher price than those sourced from fisheries. Frozen herring is still the biggest import product, now followed by frozen shrimp, which still is primarily sourced from fisheries. But salmon, salmon trout and pangasius products sourced from aquaculture now play a much more prominent role than when measured in volume terms. Again we see that on average, the products sourced from aquaculture have experienced a higher import growth rate than those sourced from fisheries.

Figures 5 and 6 show the distribution of the entire Russian seafood import in volume and value. In terms of the relative importance, we estimate that aquaculture products account for roughly 17–24% of import volume and 34–39% of import value. Figure 5 shows the importance of herring in the Russian household, as it constitutes 26% of the imports measured in volume. Other small pelagic species like sardines and mackerel are also important, accounting for 12 and 8% of imports. Shrimp and salmon both account for 7%, while salmon trout represents 4%. Pangasius constitutes around 5% of the Russian imports.

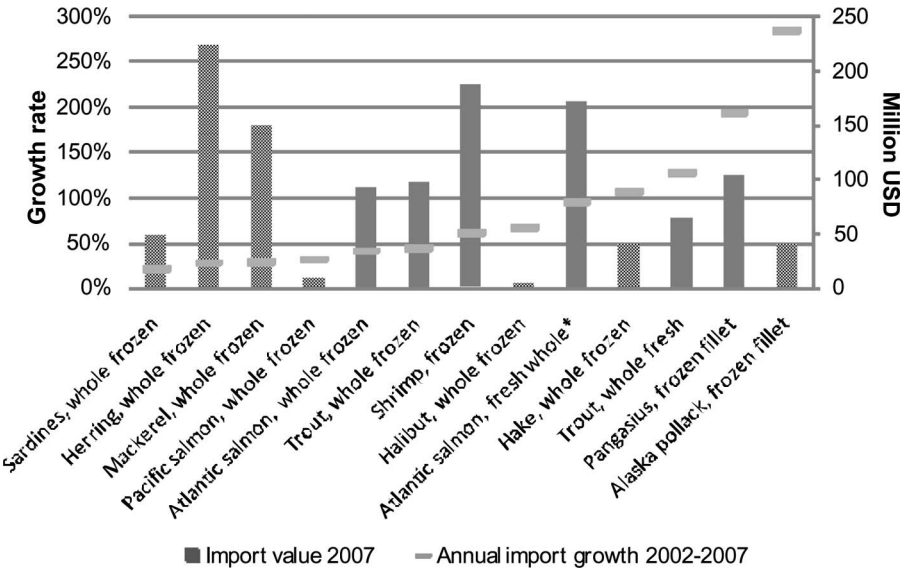

FIGURE 4 Import value in 2007 and average annual import growth rates 2002–2007 for major seafood products (*Source:* NSEC).* *Whole fresh Atlantic salmon is Norwegian *export* value to Russia (NSEC).

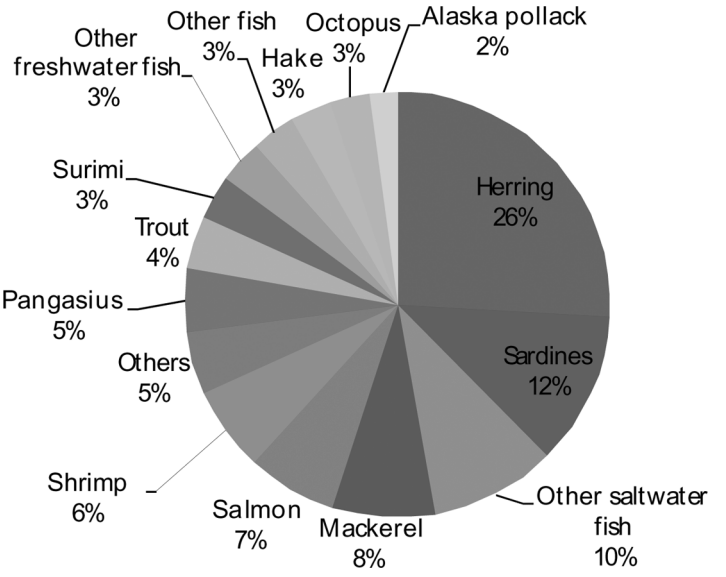

FIGURE 5 Import volume shares by seafood species groups in 2007 (*Source:* NSEC/Federal Customs Service).

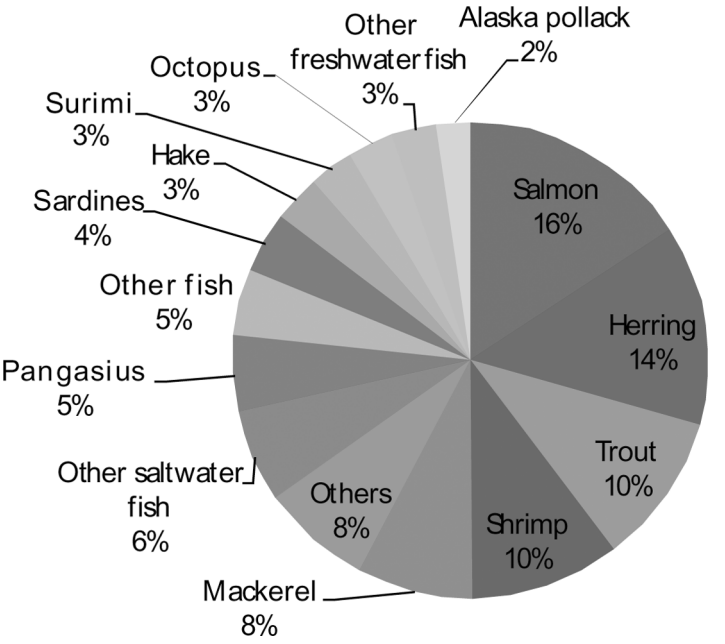

FIGURE 6 Import value shares by seafood species groups in 2007 (*Source:* NSEC/Federal Customs Service).

However, the relative importance of the species change when we measure imports by value instead of volume. As shown in Figure 6, salmon accounts for the largest import share with 16% followed by herring with 14%. Salmon trout has moved up 6 places to the third place with 10% import share alongside with shrimp. Just as herring, the other two small pelagic species, mackerel and sardines, have also been relegated in importance. Pangasius imports account for around 5%.

METHODOLOGY

Our empirical analysis will focus on the relationship between the prices, such as market integration, the law of one price and price leadership, as we examine the role of farmed and wild-caught seafood products in the rapidly growing Russian seafood market. This section presents the econometric model framework that will be used in the analysis.

The basic relationship to be investigated when analyzing the long-term relationships between the prices of imported seafood products is

$$P_{1t} = \alpha P_{2t}^{\beta} \tag{1}$$

where α is a constant term (the log of a proportionality coefficient) that captures quality differences and β gives the relationship between the import prices of the two seafood products P_1, and P_2. Equation 1 can be linearized by taking the logarithms of the prices on both sides of the equation.

$$p_{1t} = \alpha + \beta p_{2t}, \tag{1'}$$

where p_1 and p_2 are the logarithms of the import prices. If $\beta = 0$, there is no relationship between the prices and therefore no substitution, while if $\beta = 1$ the Law of One Price holds, and the relative price is constant. In this case one can say that the goods in question are perfect substitutes. If β is greater than zero but not equal to one there is a relationship between the prices, but the relative price is not constant, and the goods will be imperfect substitutes. One can also show that if $\beta < 0$, this implies a complementary relationship between the two goods. Dynamics can be accounted for by introducing lags of the two prices. If desirable, the model with dynamics can be formulated either as an autoregressive distributed lag model (ADL) or, alternatively, as an error correction model (ECM). These two formulations are equivalent. An ECM formulation with e.g., two lags can be written as

$$\Delta p_{1t} = \alpha + \delta_1 \Delta p_{2t-1} + \delta_2 \Delta p_{2t-1} + \theta(p_{1t-1} - \beta p_{2t-1}) + u_t. \tag{2}$$

The long-term relationship is captured in parenthesis in equation (2). θ captures the speed of adjustment to the long term relationship when the prices are in disequilibrium. This parameter is important when we want to investigate for price leadership. Note that even when dynamics are introduced, the long-run relationship has the same form as equation (1). One can also show that there is a close relationship between market integration based on relationships between prices and aggregation via the composite commodity theorem (Asche et al., 1999). In particular, if the Law of One Price holds the goods in question can be aggregated using the generalized commodity theorem of Lewbel (1996).

The Johansen test for cointegration is based on a vector autoregressive (VAR) system, but can also be reformulated in a vector error correction form (VECM). In VECM formulation the ECM single-equation formulation in equation (2) is extended to a system of equations. The existence of cointegration vectors is necessary if the multivariate model is to converge to long term equilibrium. Two asymptotically equivalent tests exist in this framework, the *trace* test and the *maximum eigenvalue* test. We report results from the trace test, which is considered the more robust (Chung & Lai, 1993).[5]

The Johansen procedure allows hypothesis testing on the structural coefficients, using likelihood ratio tests (Johansen & Juselius, 1990). In our case, it is restrictions on the parameters in the cointegration vectors β which are of most interest. As one moves from the bivariate case, using two price series, to a multivariate approach, one is exposed what Henry (1995, p. 313), labels the "curse of dimensionality" in dynamic models, since one with a limited number of observations and thereby degrees of freedom will have to choose between number of lags and number of variables. Bivariate analysis is less exposed to this problem, but one may obtain several, possible conflicting, estimates of the same long-run relationships. We will therefore estimate both a multivariate system and bivariate systems.

Weak exogeneity tests are of interest because they indicate price leadership. To determine if a variable is weakly exogenous in a system amounts to testing if all the elements of the row in the θ matrix corresponding to the variable Δp_{1t} are not significantly different from zero. These elements in θ are the speed of adjustment parameters that decide at which rate the others variables influence Δp_{1t}. When a price is weakly exogenous the speed of adjustment parameter θ will be close to zero for the relevant equation. An advantage with the VAR framework used in the Johansen procedure is that it allows for testing of weak exogeneity, and consequently we can test hypotheses of price leadership.[6]

Since the cointegration test procedure investigates if variables share stochastic trends, we must first make sure that the variables we use contain stochastic trends. Otherwise the variables will form by themselves cointegration vectors. Testing for stochastic trends amount to testing for unit roots, and we use the Augmented Dickey–Fuller test (ADF) to determine whether the price series are non-stationary with a unit root. This amount to testing the null hypothesis that $\rho = 0$, i.e., the presence of a unit root, in the estimated equation

$$\Delta x_t = \rho x_{t-1} + \sum_{i=1}^{p-1} \beta_t \Delta x_{t-1} + \mu + \gamma t + u_t. \tag{3}$$

The lag length p is determined by choosing the highest significant lag in an initial model containing 12 lags. The trend parameter t is included in the event the series is trend stationary.

Data

We have access to Russian import trade data from the Federal Customs Service on frozen seafood products, which includes whole frozen hake, salmon, salmon trout, halibut, herring, mackerel and sardines, frozen fillets/meat of Pangasius and Alaska Pollock and frozen shrimp.

In addition, we have import trade data on fresh salmon trout. Finally, NSEC has provided trade data on Norwegian export of fresh Atlantic salmon to Russia, which accounts for most of the fresh Atlantic salmon imported to Russia. The data series are monthly from January 2002 to December 2007, except for hake prices which commence in March 2002. From Figures 5 and 6 one can see that the products included in this study cover the majority of Russian seafood imports.

We use data from 2002 and onwards because of the economic downturn, currency crisis and structural changes in the Russian economy that took place in the late 1990s and early 2000s (Chiodo & Owyang, 2002; Kadochnikov, 2006). These economic events caused large shocks to Russian consumers and imports. Furthermore, before 2002 the import volume of several of the included seafood products that have now gained substantial market shares was very thin or zero. Since our analysis is of imported seafood products, most of which are best suited for domestic processing industries, retail chain outlets and restaurants, the most interesting period is after these food industry sectors were more developed. Consequently we have chosen to use monthly data from 2002–2007, since we can make more reasonable assumptions regarding unobserved factors during this period.

EMPIRICAL RESULTS

Here we present the results of the market integration tests for some of the largest imported seafood products to Russia. By analyzing the relationship between the prices such as market integration, the law of one price and price leadership we can examine the role of farmed and wild-caught seafood products in the rapidly growing Russian seafood market. The main focus is on frozen seafood products, which account for the largest part of the seafood imports.

The price series used in the analyses are plotted in Figures 7–9. A large part of seafood processing takes place in Russia, which is one reason why frozen whole is the largest import category. Table 2 report results from Augmented Dickey–Fuller unit root tests. All price series appears to be containing a unit root, except sardines and halibut that show evidence of being trend stationary. These two price series will be excluded from the cointegration analysis because of stationarity.

Frozen White Fish Imports

Russian imports of white fish have grown rapidly, dominated by species such as Alaska pollock, hake and pangasius. Note that most of the Alaska pollock imports from China probably originate from Russia, but because of lower labor costs it is shipped to China for processing. While hake and

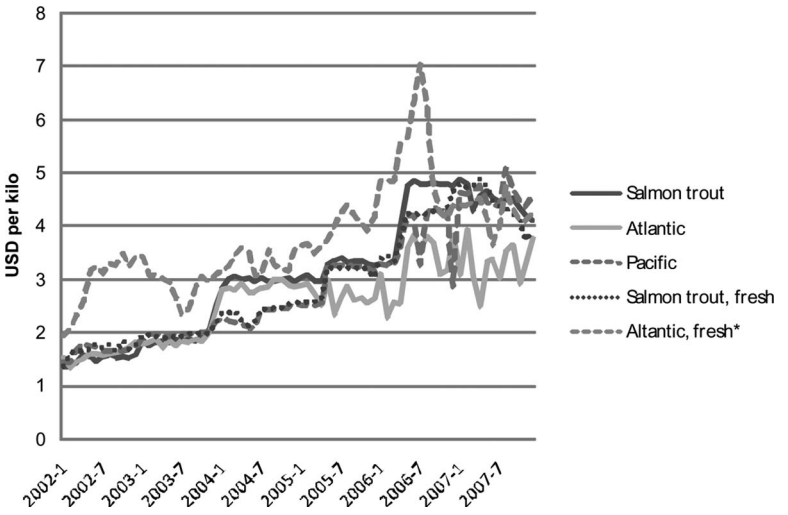

FIGURE 7 Monthly import prices of whole fresh and frozen salmon trout, whole fresh and frozen atlantic salmon, and frozen whole Pacific salmon from January 2002 to December 2007. *Whole fresh Atlantic salmon is a Norwegian export price (NSEC).

Alaska pollock are traditional wild-caught species characterized by large volume landings, pangasius is an aquaculture product from Vietnam which production has been expanding rapidly in recent years. The imports of pangasius started with modest volumes in 2000, but has grown rapidly since and become the largest of all white fish imports. In 2007 the imports of frozen fillets from Vietnam, dominated by pangasius, where around 47 million metric tons (mmt) product weight. The corresponding

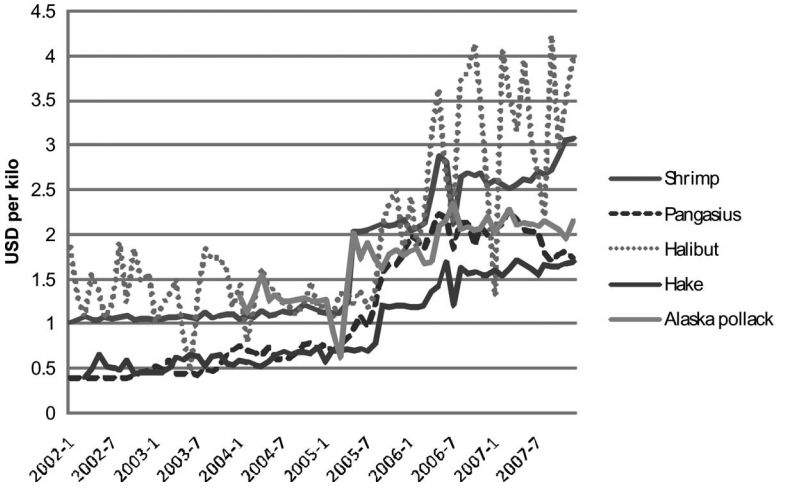

FIGURE 8 Monthly import prices of frozen shrimp, whole frozen Halibut, whole frozen hake, frozen fillets Pangasius and frozen fillets Alaska pollock from Jan 2002 to Dec 2007.

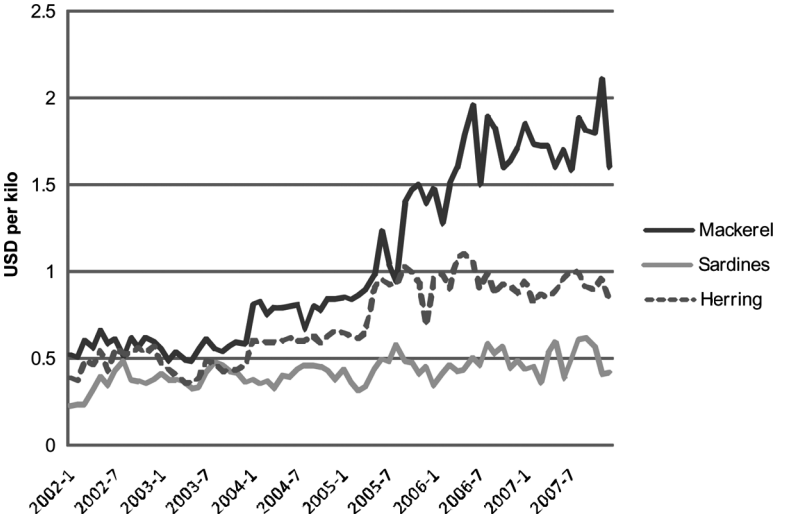

FIGURE 9 Monthly import prices of whole frozen mackerel, whole frozen herring and whole frozen sardines from January 2002 to December 2007.

imports of whole frozen hake and frozen fillets of Alaska pollock imports in product weight were 25 and 22 mmt. We use price series for *Alaska pollock, frozen fillets, hake, whole frozen* and *pangasius, frozen fillets* to investigate whether there are strong links between these two products. Imports of Alaska pollock frozen fillets have only recently grown in volume, and hence the cointegration results with Alaska pollock are from January 2004

TABLE 2 Augmented Dickey–Fuller Unit Root Tests of the Logarithm of the Seafood Prices

	Levels				First difference			
	Constant	Lag	Constant and trend	Lag	Constant	Lag	Constant and trend	Lag
Atlantic salmon	−1.617	1	−2.891	1	−9.045**	0	−9.032**	1
Mackerel	−0.6329	1	−2.552	1	−12.15**	0	−12.05**	0
Sardines	−2.215	7	−5.999**	4	−10.94**	0	−10.94**	0
Herring	−1.695	1	−3.039	0	−10.87**	0	−10.86**	0
Salmon trout	−1.903	11	−1.785	11	−5.013**	0	−5.213**	0
Pacific salmon	−1.950	1	−3.085	5	−6.975**	2	−6.904**	2
Shrimp	−0.3409	0	−2.335	0	−8.713**	0	−8.704**	0
Hake	−0.8393	1	−3.209	0	−10.95**	0	−10.85**	0
Pangasius	−1.137	0	−1.362	0	−8.644**	0	−8.651**	0
Alaska pollock	−2.831	3	−2.922	0	−3.646**	10	−4.030*	10
Halibut	−1.026	3	−5.056**	0	−6.787**	4	−8.328**	2
Fr. Atl. salmon	−1.426	2	−1.904	2	−6.701**	1	−6.653**	1
Fr. salmon trout	−1.124	0	−1.143	0	−6.461**	0	−6.470**	0

**Indicates significant at 1% level.

TABLE 3 Bivariate Tests of Cointegration and Price Leadership between Imported Frozen Fillet of Pangasius, Whole Frozen Hake and Frozen Fillet of Alaska Pollock from 2002 to 2007

Null hypothesis prices	Lags	H_0: *No auto-correlation*	H_0: *Zero coint. vectors*	H_0: *One coint. vector*	H_0: *First price weakly exogenous*	H_0: *Second price weakly exogenous*
Pangasius, fillet/ Hake, whole	3	0.72695 [0.7896]	15.44 [0.049]*	1.17 [0.278]	0.035772 [0.8500]	12.862 [0.0003]**
Pangasius, fillet/Alaska pollock, fillet†	2	1.1364 [0.3429]	23.47 [0.002]**	1.01 [0.314]	0.16284 [0.6866]	19.873 [0.0000]**

*Indicates significant at 5%; **indicates significant at 1%.
†Data span from Jan 2004 to Dec 2007, due to limited Alaska pollock imports prior to 2004.

to December 2007, i.e., four years of observations. We normalize the cointegration tests on pangasius prices, consequently only $n-1$ bivariate cointegration tests are required, where n is the number of price series.

The Johansen test results reported in Table 3 suggests that the import market for *pangasius, frozen fillets* is integrated both with the import market for *hake, whole frozen* and for *Alaska pollock, frozen fillets*, as the null hypothesis of zero cointegration vectors is rejected at a 5% and 1% level respectively, while the null of one cointegration vector is not. This means there are price links between farmed pangasius, on the one hand, and wild-caught hake and Alaska pollock in the Russian white fish market. However, the law of one price is rejected in both of these cases, which suggest that these markets are imperfectly integrated. Furthermore, the weak exogeneity tests suggest that frozen pangasius is the price leader both in relation to whole frozen hake and frozen Alaska pollock fillets. Consequently, in the Russian frozen white fish market an aquaculture species is the leading product, influencing the prices of major wild caught species. Several studies have identified integrated white fish markets (Gordon et al., 1993; Asche et al., 2004; Nielsen, 2005). However, with the exception of the price relationships between wild and farmed salmon products that have been documented (Asche et al., 1999, 2005; Asche & Tveterås, 2008), to our knowledge only a couple of studies have presented empirical evidence of market linkages between wild and farmed white fish products (Nielsen et al., 2007; Norman-López & Asche, 2008). Hence, the finding of an integrated frozen white fish market where a farmed product is price leader attests to changing market structures.

Fresh and Frozen Salmon and Salmon Trout Imports

Like farmed pangasius imports, Russian imports of other aquaculture products such as farmed salmon and salmon trout have also grown rapidly. Previous studies have found that salmon products do appear to

TABLE 4 Bivariate Tests of Cointegration and Price Leadership Between Imported Salmon and Salmon Trout Frozen Products

Null hypothesis prices	Lags	H_0: *No auto-correlation*	H_0: *Zero coint. vectors*	H_0: *One coint. vector*	H_0: *First price weakly exogenous*	H_0: *Second price weakly exogenous*
Salmon trout, whole/ Atlantic, whole	2	0.98439 [0.4346]	17.49 [0.023]*	1.55 [0.212]	0.044479 [0.8330]	12.014 [0.0005]**
Salmon trout, whole/ Atlantic, fresh whole	2	1.2116 [0.2592]	16.10 [0.039]*	3.05 [0.081]	0.55857 [0.4548]	8.7300 [0.0031]**
Salmon trout, whole/ Salmon trout, fresh whole	1	0.60129 [0.9050]	19.16 [0.012]*	1.49 [0.222]	0.67244 [0.4122]	12.384 [0.0004]**
Salmon trout, whole/ Pacific, whole	5	0.77488 [0.7377]	19.86 [0.009]**	3.17 [0.075]	0.30049 [0.5836]	13.449 [0.0002]**

*Indicates significant at 5%; **indicates significant at 1%.

be substitutes with others types of seafood products (Jaffry et al., 2000; Asche et al., 2001). From 2002 to 2007 whole frozen and fresh salmon trout imports increased from 12 to 22 mmt and from 1 to 19 mmt, and whole frozen and fresh Atlantic salmon imports increased from 12 to 25 mmt and from 4 to 41 mmt. Finally, the import of whole frozen pacific salmon, which is a wild-caught species, increased from 2 to 5 mmt. The cointegration tests in Table 4 have been normalized on *salmon trout, whole frozen.*

The results in the first two rows indicate that whole frozen salmon trout is in the markets of both frozen and fresh Atlantic salmon, as the hypothesis of zero cointegration vectors is rejected at a 5% significance level for both tests, while the H_0 of one cointegration vector is maintained. The Law of One Price, however, is rejected in both cases, which implies that these markets are imperfectly integrated. The weak exogeneity tests indicate that whole frozen salmon trout is the leading price in these markets. This result is surprising given that there are larger volumes of both fresh and frozen Atlantic salmon. Furthermore, salmon trout is more frequently used in everyday meals, e.g., salted on sandwiches and other cold dishes, while salmon is to a larger extent perceived as a luxury item used in hot meals in weekends.

However, it might be that imports of Chilean frozen salmon trout have put price roof on Atlantic salmon imports from Norway. A price leader role of Chilean salmon trout has been found in the Japanese market as well (Asche & Tveterås, 2008). The results in the third row are between the same species, salmon trout, but different products format, frozen and fresh. The tests between these two product formats indicate imperfectly integrated markets, where frozen products appear to be the price leader. The fourth row in Table 5 indicates that frozen salmon trout is integrated with wild-caught Pacific salmon. The weak exogeneity test suggests also in this case that frozen salmon trout is price leader. In summary, the tests

TABLE 5 Bivariate Tests of Cointegration and Price Leadership Between Imported Shrimp and Other Imported Frozen Seafood Products

Null hypothesis prices	Lags	H_0: *No auto-correlation*	H_0: *Zero coint. vectors*	H_0: *One coint. vector*	H_0: *First price weakly exogenous*	H_0: *Second price weakly exogenous*
Shrimp – Salmon	2	0.98212	5.76	0.16		
		[0.4889]	[0.725]	[0.689]		
Shrimp – Hake	2	1.3552	18.85	0.03	1.5523	14.002
		[0.1626]	[0.014]*	[0.862]	[0.2128]	[0.0002]**
Shrimp – Alaska Pollock†	2	1.1089	34.64	1.03	8.9440	29.574
		[0.3663]	[0.000]**	[0.310]	[0.0028]**	[0.0000]**
Shrimp – Mackerel	2	0.84109	9.18	0.16		
		[0.6596]	[0.356]	[0.687]		
Shrimp – Herring	2	0.45355	8.99	0.58		
		[0.9777]	[0.373]	[0.445]		
Shrimp – Salmon trout	2	0.48651	3.86	0.91		
		[0.9670]	[0.908]	[0.341]		
Shrimp – Pangasius	2	0.91550	6.13	0.53		
		[0.5687]	[0.684]	[0.466]		

*Indicates significant at 5%; **indicates significant at 1%.
†Data span from Jan 2004 to Dec 2007, due to limited Alaska pollock imports prior to 2004.

indicate that there are price links between these markets, but the markets are not perfectly integrated. The price movements in Figure 7 also suggest that these markets are not perfectly integrated. It is not unlikely that the import restriction on e.g., fresh salmon trout and Atlantic salmon have disrupted the relationship among these markets.

Frozen Shrimp Imports

Russian shrimp imports represent a mixture of wild caught and farmed shrimp. From 2002 to 2007 the total import quantity of frozen shrimp increased from 18 mmt to 68 mmt. Imports of small cold water shrimp from Denmark and Canada dominate, but the import share of farmed warm-water shrimp has started to rise. Large warm-water shrimp are mainly available in packaged products in modern high-end retail stores, while cold water shrimp is more widely available at reasonable prices. It is not obvious what other seafood products should be a close substitute to shrimp. Hence, our strategy has been to test for cointegration with the majority of seafood products, with a few exceptions. Fresh salmon trout and Pacific salmon have been excluded as these are not considered likely candidates as substitutes. Furthermore, since both the series for sardines and halibut are trend stationary, we can rule them out as well.

Of the seven cointegration tests reported in Table 5, the prices of hake and Alaska pollock are the only ones to show evidence of cointegration

TABLE 6 Bivariate Tests of Cointegration and Price Leadership between Imported Pelagic Whole Frozen Products

Null hypothesis prices	Lags	H_0: *No auto-correlation*	H_0: *Zero coint. vectors*	H_0: *One coint. vector*
Herring – Mackerel	2	1.2725 [0.2125]	14.07 [0.080]	0.94 [0.331]

with frozen shrimp prices. From Figure 8 it appears that Alaska pollock, hake and shrimp share common price trends. However, it is not obvious from a consumer perspective that these products should be substitutes. From the weak exogeneity tests shrimp appears to be the price leader in relation to hake. Shrimp and Alaska pollock, on the other hand, appear to have mutual influence on each other as both series are deemed endogenous in the bivariate system.

Frozen Pelagic Imports

Although aquaculture products are not represented among small pelagic species, this market is important as herring is the most widely consumed fish in Russia. Since domestic catches of herring is not sufficient to cover demand and imported herring is perceived of higher quality, herring imports have become the largest of all seafood imports measured both in volume and value. The dominant product format of herring imports is whole frozen. Two other important pelagic imports are mackerel and sardines.

Since sardines is trend stationary, while herring and mackerel have stochastic trends we can conclude that sardines represent a separate market. Hence, Table 6 only contains the results of cointegration tests between the import prices of herring and mackerel. The results do not reveal any close price relationship between these markets, as the two markets are only cointegrated on a 10% significance level. Moreover, the tests for weak exogeneity suggest that both prices are exogenous in the system, implying that they do not exert any notable influence on each other. As a result, we conclude that these constitute two separate markets.

CONCLUSIONS

The middle and high-income Russian consumer has experienced a revolution in the supply of seafood products due to rapid income growth accompanied by expansion of modern retail chains and restaurants that offer seafood products sourced from almost every corner of the

globe. From 2000 to 2007 total value of seafood imports increased from 159 to 1,877 million USD in nominal prices, which corresponds to an average annual growth of 43%. In particular, the imports of aquaculture species have expanded at a rapid pace, including both low and high value species and represented by the likes of salmon and pangasius. Wild-caught species still account for the largest share of the import volume in Russia, partly because Russians traditionally eat much herring and other small pelagics. However, given the current import trends in Russia and our knowledge of stagnant supply of fisheries products, it would not be surprising if aquaculture's share of import will soon exceed 50% in terms of value.

Our results indicate that in market segments where there are aquaculture products available in considerable quantities, they compete with wild-caught products. This implies that Russian consumers perceive these aquaculture and fisheries products as substitutes. Furthermore, when competing with fisheries products aquaculture products appear to have taken the role as price leaders. While this has been observed in several studies of global salmon markets (Asche et al., 1999, 2005), it is a surprising result that frozen farmed pangasius greatly influences the import price of frozen white fish species such as hake and Alaska pollock. With respect to the market integration analysis of Alaska pollock, a caveat is that only a four-year data span is used. Alaska Pollock imports have only recently risen in volume in Russia. However, given the magnitude of imports of frozen fillets from Vietnam in the last few years compared to those of hake and Alaska pollock, the results of farmed fish dominance in the frozen white fish market do not appear unreasonable.

In the salmonids market, farmed salmon trout appears to be the price leader, both in the fresh and frozen market segment. In the frozen market segment farmed salmon trout competes with farmed Atlantic salmon, while in the fresh market segment farmed salmon trout competes with wild-caught Pacific salmon. As already mentioned, it has been observed that farmed salmon have been acting as price leader in several regional markets since the 1990s.

Due to Russian consumers' strong traditions and preferences for lower valued herring and other pelagic products one should also in the future expect wild-caught species to dominate in terms of import volume. But despite of strong herring traditions there is still plenty of room for an increase in Russian households' consumption of farmed species. Among white fishes pangasius and tilapia are able to compete with harvested species in several market segments, and further growth of modern distribution channels should facilitate further expansion in imports. Continued expansion of high-value aquaculture products, such as Atlantic salmon, probably depend more on income growth development

in the coming years in Russia, accompanied by the growth of modern distribution channels. An import source of uncertainty is the future Russian import regulation regime and use of food safety related measures to limit or control imports. Since food safety regulations have tended to be associated with rapidly growing import products these will probably affect the fast-growing farmed species most.

In conclusion, the Russian consumer, who previously had little experience with seafood products besides herring and a few other products from domestic fisheries, is embracing new products from many countries at a rapid pace. The tendency is that the imports of aquaculture products are growing faster than wild-caught products, indicating that they are more competitive in the marketplace. This trend is important considering the potential growth of seafood markets in emerging economies such as India, China, Brazil, etc. The experiences from Russian seafood market suggest that in markets where there are modest cultural biases for specific types of seafood and a sufficiently large middle class is emerging, aquaculture products will be as competitive as in more developed Western hemisphere markets due to factors such as availability, uniform high quality and a range of consumer-friendly product formats.

NOTES

1. The average annual real GDP growth is calculated for the period 2002–2007 (Planet Retail, 2008).
2. Shleifer & Treisman (2005) provide the following broad description of the Russian economic transition: "Russia's economy is no longer the shortage-ridden, militarized, collapsing bureaucracy of 1990. It has metamorphosed into a marketplace of mostly private firms, producing goods and services to please consumers instead of planners."
3. *Source:* Russian Federal State Statistics Service, http://www.gks.ru/bgd/regl/b08_12/IssWWW.exe/stg/d02/26-11.htm
4. Note that the figures in Table 1 are based on category 03, fish/shellfish/etc., in the eight digits SITC trade classification system. Category 03 covers the majority of imported seafood products. The processed seafood products contained in categories 1604 and 1605 are not included.
5. The critical values for these tests are nonstandard, and are tabulated in Johansen & Juselius (1990).
6. Using this framework one can investigate both vertical and horizontal market linkages (Asche et al., 2007b). In this paper we concentrate on horizontal price linkages.

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