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Supply Chain Disruptions and Their Effect on Volatility of Rice Prices in Saudi Arabia

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Abstract

This research has examined the issue of supply chain disruptions and how they affect price volatility in the commodities marketplace. Specifically, this point was discussed and examined in relation to the rice imports undertaken by Saudi Arabia with respect to how supply chain disruptions in the rice supply channel contributes to price volatility. The supply chain was first identified to consist of various nodes along which market participants work to move the commodity from one point to another. The observation was confirmed that any disruptions up the supply chain tended to manifest themselves in downstream effects such as the bullwhip effect in which increased inventory levels or decreasing inventory levels are felt successively further down the supply chain. These and factors relating to supply as well as demand in other markets also were identified to contribute to price volatility for Saudi Arabia and its rice imports. The analysis demonstrated that every major global economic disturbance over the past 50 years corresponded to fluctuations in the price of food commodities. Saudi Arabia was shown to receive the vast majority of rice supplies from a single market which is India. India supplies Saudi Arabia with some 72% of its rice imports which ensures that any transportation or customs issue encountered by any supply channel participant prior to the Kingdom's receipt of its rice will alter the price profile of these rice commodities. Saudi Arabia was shown to already have experienced substantial price volatility of its rice imports with much of this volatility originating in India due to suppliers in India responding to competing demand for its Basmati varieties of rice. This volatility was manifested during 2012 and 2013 when rice prices per metric ton increased some 40% overall. Finally, this report also undertook regression analysis of the rice import data that found positive correlations between variables such as time between harvest and distribution, milling facility ownership and road/shipping lane conditions and the price structure of rice. The conclusion is that supply chain disruptions can and periodically do result in price volatility for rice in Saudi Arabia. Hence, this report finds that certain factors such as information access, the establishment of long-term contracts as well as trade group membership can be effective at reducing the transaction costs in the Kingdom's rice market. Essentially, these factors can work to place downward pressure on rice prices by the metric ton which would flatten out some of the price volatility in Saudi Arabia's rice imports.

Keywords: supply chain, rice prices, Saudi Arabia, world food

1. Supply Chain Characteristics

The global supply chains in commodities such as food products like rice are highly complex systems. These complex systems consist of various nodes that are both interconnected and that are subject to external influence due to the nature of the commodities. The typical supply chain consists of suppliers or producers, manufacturers or processors, storage facilities and warehousing units, distributors and shipping companies, retailers and wholesale accounts and finally consumers (Sun, 2013). All of these nodes on the typical supply chain are interconnected by both physical pathways for commodities and products as well as technology supported pathways.

When one speaks of the global supply chain for major food commodities such as rice, this supply chain system becomes much more complex in character. This is because the supply chain that is responsible for the global movement of these types of commodities has to account for and adapt to global disruptions both to supply as well as to the efficiency of the supply chain itself. A typical global supply chain resembles the following logical paradigm:

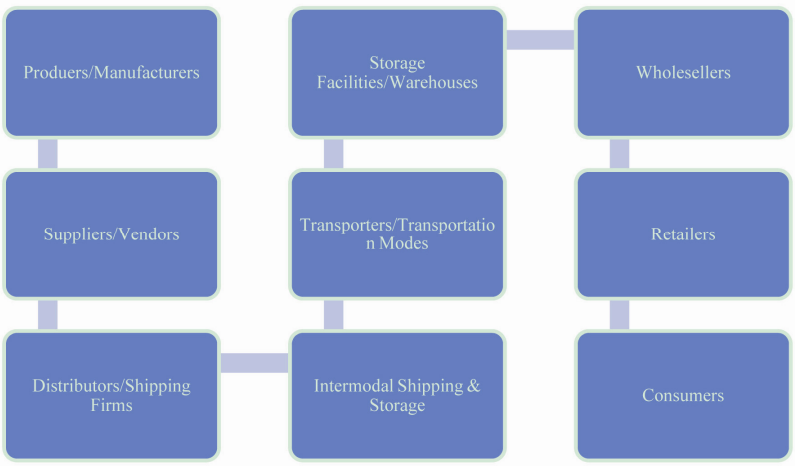

Figure 1. Global supply chain model

Source: Puettmann & Stadtler, 2010; Novickis, Vinichenko, Sotnichoks, Lesovskis, & Amalistskaya, 2015.

As this figure demonstrates, there are a significant number of links that connect the various nodes in the typical supply chain. The efficient movement of the commodity in question can be negatively affected at any point within this supply chain by a variety of different factors.

2. Supply Chain Disruptions and Downstream Effects

Supply chains and the complexity that now accompanies them ensure that any disruptions within them have significant effects throughout the entire system. Of course, common sense argues that a supply chain is focused on the delivery of products, goods or services and that therefore any disruption in the system would interrupt supply and inventories further downstream. However, given the adoption by most contemporary producers, manufacturers, suppliers and even entire industries of just-in-time processes, contemporary supply chains do not have buffer inventories held at specific points within the supply chain to accommodate such disruptions (So & Sun, 2011). Consequently, supply chain disruptions across an industry such as commodities like rice tend to result in much more pronounced effects than in previous eras. Increasingly, these effects are reflected in the dramatic rise and fall of prices associated with the commodities or, as this phenomenon is referred to, price volatility.

The fact that the majority of price volatility within food commodities is due more to supply chain disruptions than other causes are confirmed within the literature. Supply chain disruptions ensure that food commodity supplies are erratic and force other parties within the distribution channel to seek out strategies to compensate for such volatility. Research has indicated, for example, that supply chains tend to reflect agricultural product to be sure but that they also tend to reflect the uncertainty of the various participants in an entire commodities industry:

> Price volatility, characterized by unexpected price changes, entails risk to farmers who may react by reducing output supply and investment in productive inputs...The downstream sector of food supply chains is additionally subject to sourcing uncertainties arising from unexpected price fluctuations in agricultural production inputs. (Assefa, Meuwissen, Alfons, & Lansink, 2013, p. 4)

Hence, food commodities are absolutely dependent upon uncontrollable factors such as the weather and are highly subject to geopolitical factors such as regional conflicts and so forth. However, supply chains across food commodities distribution channels are also subject to the artificial manipulation of the markets by other geopolitical factors, transportation fuel costs and technological interruptions which all can contribute to increased distribution expenses.

The downstream effects within commodities supply channels such as rice can be understood in the context of the supply chain composition. Within the rice commodities supply chain, there are various parties that are specific to the rice producing industry itself. The following figure displays these supply chain entities in greater detail:

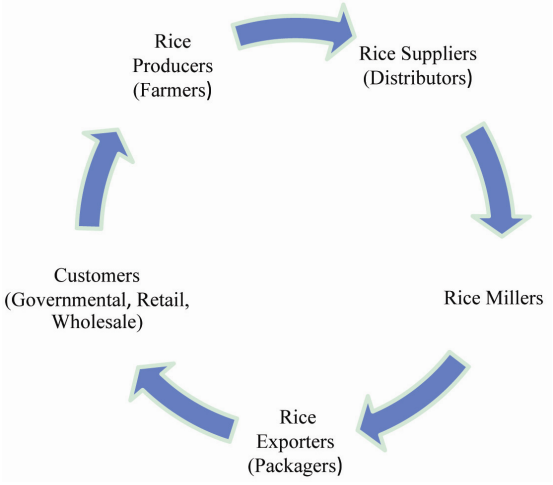

Figure 2. Rice producing/distribution supply chain

Source: Thongrattana& Robertson, 2008, p.1861.

An overview of this general supply chain composition indicates that as new orders are placed in the customer node of the supply chain, this has immediate upstream effects in the inventory levels in the exporter, miller and supplier inventories. If inventories are dramatically affected, this has an immediate impact on the price of the commodity back downstream on the supply chain.

3. Price Volatility of Food Commodities

The phenomenon of price volatility within food commodities such as rice is typically mediated through risk management strategies in the marketplace. The problem is within the context of the supply chain, there is some innate friction that exists between market participants who prefer smooth price fluctuations and financial market investors who profit from wide price fluctuations in the commodities that they invest in. Consequently, rice producers, for instance focus on reducing the uncertainly in commodity prices because they need to make long-term planting decisions, labor investments and production agreements that are primarily risk averse factors (Lyman, Jagadish, Nalley, Dixon, & Siebenmorgen, 2013). It is apparent that price volatility in the downstream supply channel can greatly disrupt profitability for food commodities producers.

Such unpredictability that rice and other food commodities producers tend to disfavor is a natural byproduct of the marketplace. However, artificial interference greatly exacerbates these natural fluctuations resulting in even greater uncertainty which in turn results in even more erratic fluctuations if not anticipated or controlled within the supply chain. A brief overview of world food commodities prices over the past 50 years indicates just how erratic the price of these food commodities can be from one year to the next and from one decade to the next:

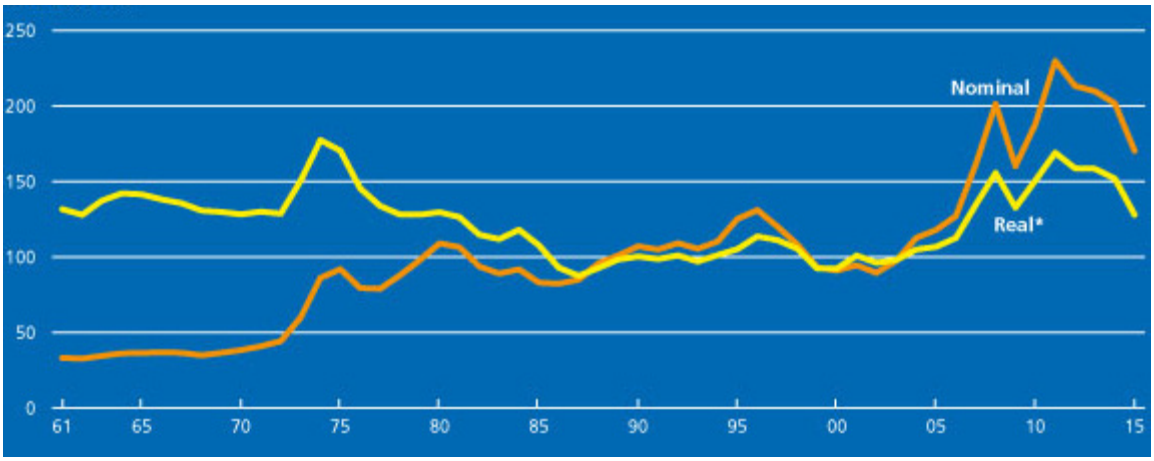

Figure 3. World food price index movement (Food, 2015)

This data demonstrates that in the mid-1970s, mid-1990s and late 2000s, there were quite dramatic swings in the price of food commodities globally. In fact, each of these major period price fluctuations tend to correspond with major interruptions in the global financial markets, global economy or periods of global inflation.

Of course, each of these major global developments that corresponded with such food commodities price fluctuations also affected the efficiency of the global supply chains that moved these commodities. This loss of efficiency in these global supply chains for food commodities is what resulted in the significant price volatility reflected in the data. For example, the mid-1970s the major world markets were experiencing fuel shortages that resulted in extreme increases in the cost of global shipping and transportation costs; the mid-1990s some of the major world consumer markets and many of the major rice producing markets experienced currency contagion which affected both commodities production and transportation costs; and of course the latter portion of the 2000s saw the collapse of global real estate and financial sectors (Coulter, 2011; Moussa, 2014; Martin, 2011). Hence, these major global financial, economic and geopolitical events all resulted in what amount to price volatility in food commodities not because of production issues but because of supply issues related to the supply chains that moved the commodities.

4. Rice Price Volatility in Saudi Arabia

The literature and the global data available indicates that the supply chain and rice price volatility are integrally related. Both of these conceptual constructs consisting of the supply chain composition and price determinants of rice affect the other. This interplay is one that depends on circumstances in the marketplace such as demand, supply, transportation costs, participant efficiencies and a host of other factors. Given the knowledge that Saudi Arabia is a net importer of rice, it is dependent upon a host of different rice producing markets that are geographically removed from it nationally as well as regionally. This is apparent given that the world's leading rice producing nation is China which produces some 141.8 metric tons annually but is also one of the world's leading consumer markets for rice and the only significant regional net producer of rice is Egypt with just 4.1 metric tons annually (See Appendix A). Therefore, the Kingdom is inherently dependent upon the efficient operation of global supply chains maintained by independent rice producers and distributors to supply its rice commodity requirements.

Supply chains may not be the most noticeable or interesting element within the global rice commodities marketplace but they are perhaps the most critical. Since Saudi Arabia is competing globally for a substantial amount of the world's supply of rice commodities, its awareness of supply chain variables vis-a-vis price volatility forms the nucleus of its ability as a nation to secure affordable supplies of rice for its population. Saudi Arabia is a water deficient nation which prevents it from developing its own rice crop production which has led to its large rice importation profile: "Analysis of Saudi Arabia's imports and exports between 2005 and 2009 suggests promising changes in Saudi Arabia's agricultural policy, with increasing import of cereal crops...to satisfy the domestic market" (Grindle, Siddiqi, & Anadon, 2015, p. 241). This has led the Kingdom to expand its overall rice imports even while being aware that supply chain disruptions undermine the pricing structure of these rice imports. The complexity and sophistication of these supply chain scenarios for Saudi Arabia can be seen in the variety of the major rice supplying markets that it imports rice from:

Table 1. Rice importation and supply

Countries of Origin	2012-2013 Quantities	Overall Market Share	2013-2014 Quantities	Overall Market Share
India	888,427	66.1%	1,021,000	72.7%
Pakistan	201,530	15.0%	162,000	11.5%
United States	136,734	10.2%	101,253	7.2%
Thailand	67,324	5.0%	75,371	5.4%
Other Markets	50,000	3.7%	45,000	3.2%
Total	1,344,015	100%	1,404,624	100%

Note. *All figures in metric tons (Rice, 2015).

The data in the above table indicates that Saudi Arabia's largest rice supplying market by far is India. India provides Saudi Arabia with more than 1 million metric tons of rice annually which is some 72% of the market's overall rice imports.

Likewise, Pakistan is Saudi Arabia's second largest supplier market which some 162 thousand metric tons imported annually at about 11% of Saudi Arabia's overall supply of rice. A simple analysis of the geopolitical

position of these two markets reveals that the supply chain for rice originating from them is subject to significant threats. Not only are India and Pakistan separated from Saudi Arabia by overland routes that are subject to open conflict but the waterways between Saudi Arabia and these two supplier markets are dense with traffic, maritime patrols by international forces and piracy (Ghitis, 2015). Added to this mix of supply chain uncertainties is the fact that these two supplying markets are hostile to one another and therefore compete for international economic resources and so forth. Saudi Arabia could, conceivably, attempt to compensate for some of this geopolitical uncertainty within the supply chain of its two primary rice suppliers by shifting some supply to other markets. However, the other markets such as the United States and Thailand could not match the price competitiveness of India or Pakistan.

This price advantage for India and Pakistan occur because the other supplying markets are even further removed geographically from Saudi Arabia. This in turn increases shipping and transportation costs of the commodity and these factors among others contribute to costs within the supply chain. Still other factors affect the cost of rice within Saudi Arabia in respect to the supply chain which relate to demand in other markets for instance:

> The prices of the Indian Basmati rice varieties in the Saudi market skyrocketed...over concerns over supply shortages and increased Iranian demand for Indian rice... The average price of the 40 kg of Indian basmati rice sack...soared from $50...to $70...an increase of about 40 percent in a three-month period. (Ahmed & Mousa, 2013, p. 2)

This passage makes quite transparent how supply, demand and proximity all affect the price of rice in Saudi Arabia evident in the 40% increase referred to in the literature. Of course, such price volatility is exasperated by the fact that Saudi Arabia is not a rice producing market and as such is dependent upon its import partners in order to meet demand.

5. Supply Chain Disruptions and Rice Prices

The fact that interruptions in the supply chain can disrupt pricing factors in the rice market seems self-evident. However, without fully analyzing all the various factors within the supply chain that can negatively or even positively affect prices, it is difficult if not impossible to adequately hedge against unknowns in the marketplace. Hedging in the commodities marketplace such as the rice industry is also relied upon by producers, suppliers and distributors to smooth out the supply channel as well. The table below contains some of the most relevant figures on the Saudi rice market that affect pricing in the market in the context of the supply chain:

Table 2. Rice production vs. distribution

Variables	Min.	Max.	Mean	St. Dev.	Skew
Rice Production	81	16181	943.4	1428.7	8.2
Rice Distributed	7	16181	799.2	1419.1	8.7
Rice Quantity Demand	7	16181	796.8	1419.5	8.7
Price Variability	66.7	111	99.5	3.3	-8.1

The figures presented above demonstrate that production, distribution and demand all work to affect the price of rice. In other words, the standard deviation of the figures in the preceding table indicate that is not necessarily peaks or valleys in any one of these variables in the rice market that create price volatility.

Rather, the figures indicate that the relationship of these variables to each other create an environment in which price is either stable or highly unstable. This threat to Saudi Arabia's rice imports in terms of either consistency or price stability is evident in the data on the country's historical rice supply. Researchers have found that exports of India's primary rice crop, Basmati rice, have diversified over the past few years with Iran ordering some 1.6 million metric tons in 2012 and rice exports from India to China increasing significantly (Ahmed & Mousa, 2013). This sudden increase in Iranian demand for Indian rice exports caught the Kingdom off guard because it manifested in a rapid increase in the cost per metric ton of Indian rice imports. The point being that any competing market willing to pay more for Saudi Arabia's largest rice supplier's rice commodities is a threat to the nation. This development is further strengthened by the capacity for supply chain disruptions to alter export decisions of Saudi Arabia's primary rice supplying partners. The following data factors in the supply chain considerations that alter shipment and transportation decisions which go on to affect the price of rice:

Table 3. Supply chain cost factors

Transportation Cost Factors in Supply Chain	Regression Analysis	St. Error Estimates
Distance from production to primary road route	-1588	397
Time for commodity to hit the market	2839	541
Independent millers involved	5915	1533
Farmer/producer owned milling	5137	1858
3rd party shipping & transportation contractor	-4175	2335
Road & shipping lane conditions	1364	1659
Constants	-1244.	181
Probability is greater than Chi-2: 1.111		

This regression analysis of the rice import data for Saudi Arabia affirms the assertion that supply chain disruptions contribute substantially to price volatility. There is a positive correlation in the data for time-to-market factors in rice delivery which is a direct assessment of supply chain efficiency. This particular factor negatively affects the price of rice because as inventories dwindle, demand places upward pressure on the price of the commodity which, in this case, is rice.

6. Prices as a Reflection of the Supply Chain

The supply chain is a mechanism that is governed, ultimately, by distance. Within the context of geographic distance then, other factors go on to affect who forms of transportation methods are chosen, how fuel is hedged and import/export duties and so forth. All of these factors are inter-related and their interplay contributes to price stability or instability in the rice market for Saudi Arabia. Additionally, the form of the rice imports also affects the overall cost profile of the rice as well and these two factors, distance and form, are displayed in the following table:

Table 4. Milled/unmilled rice prices factored by distance

Comparison of Mean	Mean Milled/Unmilled	Mean Milled/Unmilled	Differential	99% Reliability	T-value	Probability
Shorter Distance	2.8	4.0	-1.2	<-2.5;0.1>	-1.8	0.078
Longer Distance	1399	2310	-911	<-1251;-572>	-5	0.000

The data that is analyzed above factors in both the distance that rice imports into Saudi Arabia must travel as well as whether the rice is milled or unmilled in form. In this instance, the vast majority of rice imported into the Kingdom is in milled form. The data and analysis clearly demonstrate that there is a positive correlation in which the longer the distance that rice must be managed through the supply chain, the resulting commodity price increases.

The fact is that the price of rice in Saudi Arabia is a major governmental concern. The Kingdom's leadership is highly sensitive to the price of rice because it is concerned about the quality of life of all of its citizens. Since rice is one of the Kingdom's primary food staples, any increase in the price of rice imports ultimately is passed onto the nation's consumers. The literature states that, "The Saudi government is concerned about the soaring rice prices in domestic markets and their overall impact on the cost of living for low-income consumers. It has been closely monitoring price trends of rice..." (Ahmed & Mousa, 2013, p. 3). This rapid price increase for rice surprised most analysts in the Kingdom because they did not anticipate the increased domestic demand within India for its rice commodities and the increased demand in other emerging markets for India's rice production as well. The only way to adequately mitigate price volatility of rice is to ensure that there is a diversity of available suppliers from which to purchase rice commodities. Furthermore, these suppliers must originate from different rice exporting markets as well. The analysis presented below reveals that the price of rice commodities originating from either India or Pakistan is associated with a significant level of uncertainty:

Table 5. Regression analysis for rice price outcomes

Factors	Regression Analysis	Standard Error
Milled rice supplies	920	95
Unmilled dry rice supplies	-190	87
Time separating rice harvest and rice distribution	44	24
India	-275	132
Thailand	19	177
Pakistan	-188	133
US	12	170
Constant (Intercept)	1405	149
Prob is greater than F/Chi2	0.000	0.000
# Data Observations	151	151

Also, in terms of the supply chain and distribution of rice imports in Saudi Arabia, the faster that rice is received in the Kingdom from the point of harvest, the more stable the price profile is.

In general, global supplies of rice of all varieties remain fairly stable and fairly ample in character. Given the observation that basic supplies of most rice varieties are stable, there should be little upward pressure on commodity prices in the open market leaving supply chain and related issues as the primary culprit in any significant price volatility in the marketplace. Essentially, the most recent data indicates that Japonica rice strains has been the only rice variety that has experienced major price increases during 2014 and 2015 with price indices for Indica and Aromatic varieties dropping on average from the mid-200s to just under 200 from 2013 to 2015(Food, 2015, p. 24). In essence, some of the alternative factors then that are contributing to price volatility for the overall rice market and specifically for Saudi Arabia consist of market transparency factors as well as contract issues and transaction costs and so forth. These alternative factors are assessed descriptively in the data below:

Table 6. Alternative variables affecting price

Alternative Variables	Small Rice Exporter (%)	Medium Rice Exporter (%)	Large Rice Exporter (%)
Pricing information access	24	48	35
Long-term contracts	17	26	25
Trade group membership	33	52	85
High transaction trust	12	43	6
Moderate transaction trust	46	29	35

Clearly, the size of the export market as well as the size of the export firm impacts price stability in the marketplace. The data demonstrates that the larger markets and firms in the rice industry are able to either provide volume discounts or, alternatively, manipulate prices higher by altering production and distribution characteristics within the supply chain. In contrast, the smaller the export market and the smaller the exporting firm, the less control over market factors they have which places the at a disadvantage with respect to pricing factors.

7. Conclusions and Observations

The supply chain is a conceptual model that sutures together various physical nodes in the transportation and distribution of commodities. The interaction of all these nodes not only defines the efficiency at which the supply chain operates but also partially determines the character of the pricing characteristics of those commodities in the supply chain. The analysis and discussion of the supply chain in this project reveals how each individual node within the typical supply chain may negatively impact the price of the commodity which is rice in this case. The point that has been made within this report is that disruptions within the supply chain adversely affect commodity delivery, storage and distribution which places upward pressure on the price of the commodity. However, inventory levels, consumer demand and increased production can counteract many of these elements within the supply chain and drive prices back down. This constant interplay of these variables in the supply chain is what contributes to price volatility in the marketplace.

Furthermore, price volatility is also associated with uncertainty, doubt and unexpected or unanticipated price shifts as well. Within the rice commodities industry that Saudi Arabia depends upon for a substantial percentage

of its food supply, there are also geopolitical factors along with geographic factors that also tend to contribute to volatility. As the research stipulated, the majority of Saudi Arabia's supply of rice is sourced from India with Pakistan being the next largest supplier albeit much smaller than India by volume. The supply chain that moves rice from these markets relies on different supply channel participants such as suppliers and millers along with exporters that are often in completely different markets themselves from the source of origin of the rice. Furthermore, the added complexity of hedging strategies in the marketplace by certain market participants such as farmers to smooth out pricing and by transportation companies to smooth out fuel costs also exacerbates price volatility of the actual commodity. This is because once the financial markets get involved in a commodities industry such as rice, complex financial instruments are developed which in turn govern how market participants dispense their inventories.

At a fundamental level, the analysis indicated that the rice market is governed by supply and demand. Saudi Arabia is not a net producer of rice and thus is a large importer of the commodity. This places Saudi Arabia at a position of disadvantage because it relies on major rice exporting markets which seek the highest price possible. The chart below demonstrates how the global supply of rice has not increased substantially for the last 5 years but utilization has:

	2011/12	2012/13	2013/14	2014/15 estimate	2015/16 forecast	
					Previous (04 June 2015)	**Current (09 July 2015)**
	(. . . . . million tonnes . . . . . .)					
Production[1]	486.0	490.1	496.7	494.7	500.5	**499.3**
Supply[2]	631.9	652.9	673.9	676.9	677.2	**676.5**
Utilization	469.5	476.4	490.3	500.3	508.6	**507.2**
Trade[3]	38.7	37.2	42.8	42.0	42.5	**42.1**
Ending Stocks[4]	162.8	177.2	182.3	177.2	168.8	**169.4**
	(. . . . . percent . . . . . .)					
World stock-to-use ratio	34.2	36.1	36.4	34.9	32.5	**32.9**
Major exporters' stock-to-disappearance ratio[5]	25.0	28.6	26.9	23.2	19.3	**19.0**

Figure 4. World rice prices and supply

Note. World, 2015.

Perhaps more alarming for major rice importers like Saudi Arabia, is the major exporters' inventory to use ratio. This figure is listed above as the stock-to-disappearance ratio and while it was 25% in 2011, it had fallen to 19% as recently as the first half of 2015.

The data indicated that Saudi Arabia currently imports an estimated 72.7% of its rice supply from India and just 11.5% from Pakistan. The analysis of this data and the current literature revealed that competing markets for India's rice supplies were driving up the price of Indian basmati rice varieties which accounted for most of the Kingdom's rice imports. Therefore, Iran is quite willing to attempt to undermine Saudi Arabia's supply channels for its rice commodities but to do so through purchasing operations on the open market. At any rate, irrespective of the specific supply chain disruptions in question, supply chain disruptions do influence price volatility primarily through interruptions to supply chain and supply channel efficiencies. The regression analysis of the rice import data for Saudi Arabia found that there is a positive correlation between the supply chain and price volatility through factors such as time-to-market, the number of millers involved and road and shipping lane conditions among other factors.

The review of the information and literature highlighted the fact that the Saudi government is aware of the threat that price volatility poses to stable rice supplies. Additionally, reports such as this one work to illustrate how supply chain disruptions both create and contribute to price volatility in the rice marketplace. There were also positive correlations in the regression analysis that confirmed the assumption that distance certainly contributed to cost factors. However, these same correlations revealed that certain supply chain variables such as time between harvest and distribution and whether the rice was milled or unmilled also contributed to price volatility. Finally, it was also noted within this analysis that certain factors such as information access, the presence of long-term contracts and trade group membership all worked to reduce transaction costs which work to place downward pressure on rice prices by the metric ton.

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Appendix A

Global Production and Leading Producers

	2013	2014 *estim.*	2015 *f.cast*	Change: 2015 over 2014
	million tonnes, milled equivalent			%
China (Mainland)	139.5	141.4	141.8	0.3
India	106.7	103.0	105.5	2.4
Indonesia	44.9	44.6	46.0	3.1
Bangladesh	34.4	34.8	34.5	-0.8
Viet Nam	29.4	30.0	29.9	-0.4
Thailand	24.4	22.7	23.2	2.1
Myanmar	17.8	18.2	18.4	1.0
Philippines	12.3	12.4	12.9	4.0
Brazil	7.9	8.1	8.3	2.3
Japan	7.8	7.6	7.6	-0.5
United States	6.1	7.1	7.0	-1.0
Pakistan	6.8	6.7	6.5	-3.7
Cambodia	6.0	5.9	6.0	0.7
Korea Rep. of	4.2	4.2	4.1	-3.5
Egypt	4.2	4.1	4.1	-1.7
World	496.6	494.4	500.1	1.2