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Abstract

This paper analyzes the effects of Chinese and Indian demand for gold jewelry on global gold prices using quarterly data from 2010-2022. Granger causality between Chinese and Indian demand for gold jewelry on gold price is tested with a lag of one quarter. The causality results show that changes in gold jewelry demand in China Granger cause changes in gold price. The most complete regression does not show that the magnitude of these changes, however, are statistically significant. The regression indicates that a 1% change in Chinese demand results in a 0.042% decrease in price. Furthermore, demand in India is not shown to Granger cause changes in gold price, nor is its magnitude in regressions proven to be statistically significant.

Introduction

In this section I look at the sources of demand for gold and how it differs from the demand for other precious metals, why gold is a highly sought after asset for both central banks and individual investors, and the case of gold jewelry as a specific form of consumption-to-investment.

Gold has two principal sorts of demand: investment, whether in the form for demand of gold bars or gold ETFs, and its practical applications, such as in jewelry and industrial uses. Gold is unique among both precious and non-precious metals because the size of these two demands are almost equal (Central Banking, 2020). The result is that gold is extremely anti-cyclical, particularly compared to other industrial (also known as base) metals which are extremely pro-cyclical. In times of economic expansion, composition of the demand for gold changes as the relative share of jewelry demand rises and investment demand slows down. When the economy is in decline, investment demand increases as investors seek to use gold as a hedge against inflation and as a so-called safe haven asset. The percentage of gold demand by sector since 2021 is displayed in the Figure 1.

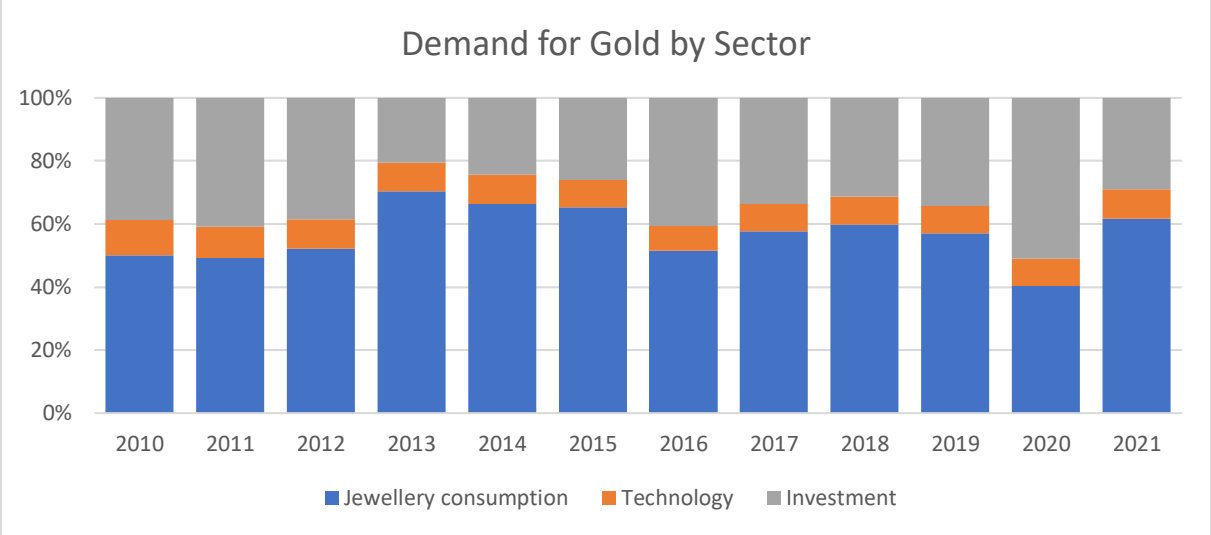

Figure 1: Relative shares of the demand for Gold by Sector. Source: Gold Demand Trends from the World Gold Council

An asset is considered to have safe-haven status if the asset's volatility and return respond in the same way to positive and negative market developments. The principle is that a good safe haven asset is one whose performance does not change much depending on changes in overall market conditions. Mathematically speaking, an asset is a safe-haven asset if it has a zero or negative correlation with other assets during times of economic turmoil (Bulut and Rizvanoghlu, 2019). Caporale, Spagnolo, and Spagnolo (2017) confirm this finding, as gold prices react positively to bad economic news, and negatively to good economic news, which is the opposite of almost all other commodities. Further highlighting gold's almost unique property are Roache and Rossi (2010), who find that gold is the only commodity that reacts more strongly to negative news than to positive news. Because of this safe-haven status, and because gold has a fixed, scarce quantity with no default (counterparty) risk[1], gold is frequently

[1] Gold is no one's liability

referred to as a hedge against inflation, although calculations from Barsky, et al. (2021) on Figure 2 shows that gold price has diverged from inflation expectations since approximately 2000. Despite the divergence, this attitude continues to be shared by central bankers; Róbert Rékási, head of foreign exchange reserves management at the Central Bank of Hungary, says: "Gold is a good hedge against inflation; it is the ultimate store of value" (Central Banking, 2020).

Figure 2. Real price of gold and ten-year inflation expectations. Source: The Federal Reserve Bank of Chicago

From the perspective of central banks, gold offers a range of benefits depending on what the central bank wishes to achieve. In a 2020 survey conducted by *Central Banking* and *Invesco* sent to reserve managers at central banks around the world, maintaining portfolio diversity was the most frequently cited motivation for holding gold. The second most cited reason differs depending on the central bank. Reserve managers at central banks of high-income countries prioritize contribution of risk to their portfolios, while managers at central banks of middle-income countries responded that low real interest rates is their secondary motivation for holding gold reserves. For the latter group, the low opportunity cost of holding an asset that does not pay interest is a key factor when deciding whether, or how much, gold to hold. The survey results suggest the role of gold reserves changes depending on the economic conditions of a country, which in turn affects the objectives of a country's central bank and how its bank may use gold to achieve its objectives. In the face of recent interest hike rates around the world, the question remains as to how central banks' demand for gold reserves will change. The decision for many central banks, particularly for those of high-income countries, will be whether or not to divest in gold in favor of other assets that offer a higher yield. This would be a question of whether the portfolio diversification benefits that central banks value outweigh the higher yields that other investment opportunities may offer. Preventing this shift may be the fact that reserve managers recognize that it may not be politically popular for a country to sell its gold (Das, Johnson-Calari, Kobor, 2019). It is for this reason that, although gold is conventionally thought of as a highly liquid assets, most central banks do not consider gold to be a part of their liquid assets.

Gold's relative long-term stability from the two categories of demand helps explain why other precious metals (palladium, platinum, and silver) do not behave in the same way as gold as an investment vehicle. Palladium and platinum both suffer from similar problems. First, one of the largest applications of palladium and platinum are in the production of catalytic converters. Total demand is predicted to decrease in the long run as emissions restrictions will reduce demand for diesel automobiles. Furthermore, palladium's supply is not stable, as approximately one third of the world's supply comes from Russia, causing a level of uncertainty in the market (Diaz, 2015). Platinum, meanwhile, is more expensive than gold but does show signs of being a safe-[haven] asset (Diaz, 2015). However, because of its scarcity and lack of a large financial market for platinum, its price is much more volatile than gold. Additionally, platinum (and palladium) have been shown to be net receivers of spillovers from shocks in other commodity markets, particularly gold, silver, and oil (Cuando, Gabauer, and Gupta, 2021). Platinum is extremely vulnerable to even small disruptions in its production can have outsized effects in its market, as was the case when mine strikes in South Africa halted production for several months, resulting in a near six percent price increase during this time (Diaz, 2015). Silver is the precious metal that acts most like gold; it is found to be a safe-haven asset, though not as strong as gold (Caporale, Spagnolo, and Spagnolo, 2017) and is a net transmitter of shocks, once again weaker than gold (Cuando, Gabauer, and Gupta, 2021). However, a much larger percentage of silver's demand comes from its consumer and industrial applications than gold, making the former more pro-cyclical than the latter.

While real gold price is shown to diverge from both inflation expectations and from real U.S. Treasury yields, gold price behaves in noticeably different ways relative to the prices of other metals (both precious and industrial) depending on the condition of the economy. Figure 3 is the plot of quarterly data showing a 3-year rolling correlation between the price of gold and silver, platinum, copper, and aluminum. One can see an overall trend in the correlations between gold and the other metals. In times of economic expansion, gold behaves much like any other metal, precious or otherwise. During times of economic crisis, however, this pattern changes and gold price either moves in the opposite direction as those of other metals, or exhibits little to no correlation at all. This is evident in Figure 3, where there are dips during the *Global Financial Crisis* that began in 2007, the *Taper tantrum* and *Eurozone sovereign debt crisis* in the early 2010s, and most strongly in response to the outbreak of the coronavirus pandemic at the start of 2020. The negative correlation is stronger between gold and industrial metals than between gold and other precious metals, particularly silver. This demonstrates how gold's precious metal and investment qualities make themselves clear in times of economic downturn. The correlations also help explain how gold behaves both like an industrial metal and a unique precious metal. The chart also shows that silver, which had a much different correlation with gold than any of the other three metals, then converges with the rest shortly after 2000, and its price tends to move in step with gold closer than the other metals.

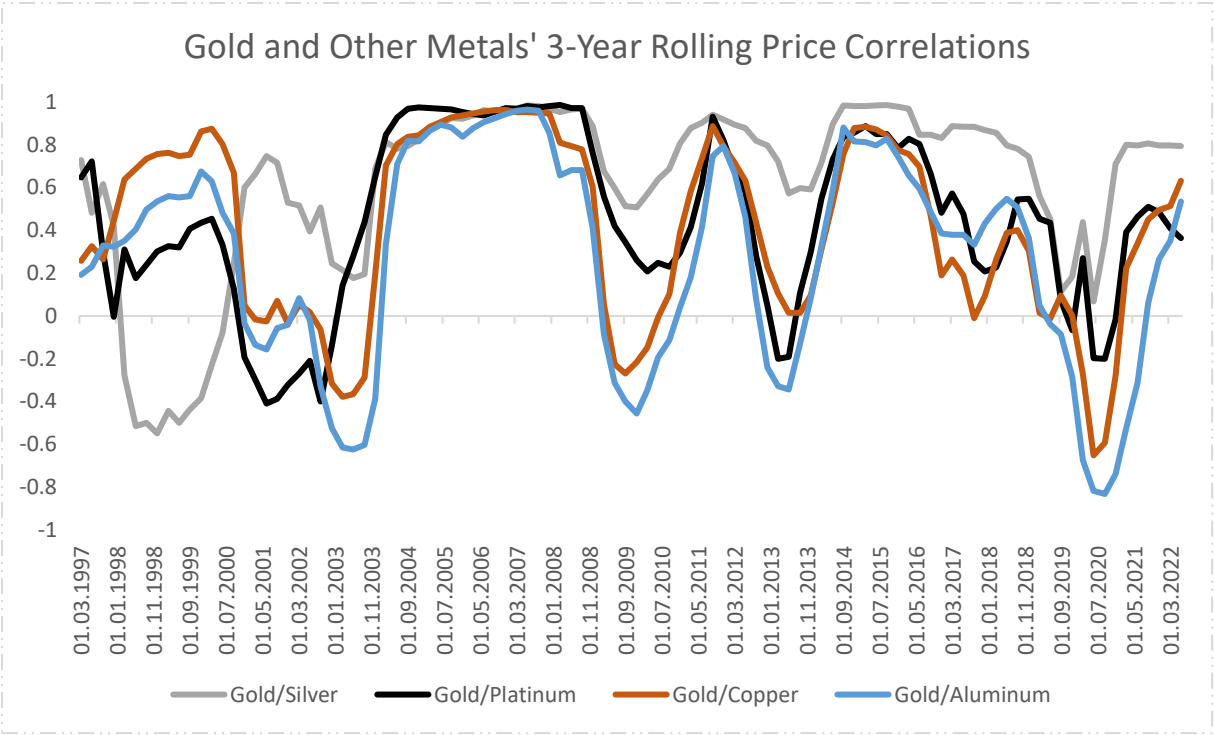

Figure 3: Correlations between gold and selected metals. Source: London Bullion Metals Association, Bloomberg, and author's calculations.

The size for consumer (physical) gold markets is massive, particularly for gold jewelry which in 2019, was responsible for forty-three percent of total global demand (World Gold Council, 2019). Over half of this demand came from China and India alone. To understand jewelry demand, it is necessary to look deeper into factors which may influence the level of consumers' demand for gold jewelry in these two countries. There is evidence to suggest, though not confirm, the effects of weddings on gold prices due to the common practice of gifting gold, particularly in the form of jewelry, as dowry. Baur (2012) identifies that the Indian "wedding season" overlaps September and November, the two months of the year when gold prices consistently increase positively and significantly. While this may contribute to fluctuations, other seasonality effects (such as pre-holiday shopping in the West) and investment trends may have a larger impact and make it difficult to establish any definitive connection between the wedding season and changes in gold prices.

Research Question/Paper Objectives

Given gold's unique status as a precious metal that is in high demand in the financial, consumer, and industrial sectors, it is worth knowing the main drivers of its price behavior in the long- and short-term. With greater financialization in recent decades, it is possible that developments in the financial market have more weight in affecting gold prices (in the short term) than the market for gold in jewelry, despite the latter's considerable size. The primary aim of this paper is to investigate whether Chinese and Indian demand for gold jewelry Granger cause changes in gold price, or vice versa. The secondary aim of this paper is to find whether demand for gold jewelry in China and India has a positive, significant effect on global gold price, and whether gold price has a significant, positive effect on demand for gold jewelry in China and India.

Methodology

In this section, I explain the variables, sources of data, and the model I use to investigate the relationship between Chinese and Indian demand for gold jewelry with overall gold price. To find the relationship between Chinese and Indian demand for gold jewelry on global gold prices, I use quarterly data beginning in 2010, available from Goldhub's historical gold jewelry demand and supply database, produced by the World Gold Council. The demand, listed in tons, only includes newly produced jewelry and watches. The number excludes second-hand good purchases, items that are made of another metal and only plated with gold, and the value of items purchased by trading in jewelry. Gold price is the closing price from the London Bullion Market Association (LBMA), obtained from Bloomberg. For the regressions in China, the price is measured in renminbi; for India, the rupee, and the dollar price for the combined regression. I choose to measure the price in the countries' respective domestic currencies to account for the fact that imports of gold jewelry into China and India, and certainly purchases of gold jewelry by consumers in these two countries will overwhelmingly be done in renminbi and rupees. The renminbi and the rupee exchange rates against USD are also included. Theoretically, an increase in the strength of these currencies vis-a-vis USD would make imports cheaper, driving demand up, especially considering that India imports almost all of its gold. The data for both currencies' exchange rate are retrieved from Bloomberg. It is expected that a negative result in the regressions' coefficients indicates the renminbi or rupee's strength is positively correlated with physical demand for gold, and by extension price, because the index's data is the number of renminbi or rupees equivalent to one dollar; a higher number represents a weaker currency because one dollar is equivalent to a higher quantity of that currency.

I add three "external" economic indicators to account for more general, global economic conditions that have the potential to drive gold prices. These are returns on American 10-year Treasuries, inflation expectations, and uncertainty. The Treasury returns are retrieved from Bloomberg, specifically the S&P US Treasury Bond Current 10-Year Total Return index. Inflation expectations are measured from the Index of Common Inflation Expectations of the American Federal Reserve projected onto the Survey of Professional Forecasters from the Philadelphia division of the bank. This variable is used as a proxy to measure inflation expectations to control for the fact that demand for gold tends to increase when high inflation is anticipated. I measure uncertainty using the National Bureau for Economic Research's Uncertainty Index. The index measures the frequency of the word 'uncertainty' in the Economist's Intelligence Country unit reports. The percentage of the words is multiplied by 1,000,000. For example, an index score of 100 would mean that the word 'uncertainty' accounts for 0.01% of total words in the reports. This is included in order to account for the fact that, similar to inflation, market uncertainty tends to drive investors towards gold because it is a safe haven asset.

To answer the question as to whether or not demand for jewelry in China and India drive gold price, I use Ordinary Least Squares (OLS) regressions. Several regressions are run, the results of which can be found in the appendix. The first is gold price as a function of Chinese demand and renminbi exchange rate, then gold price as a function of Indian demand and renminbi exchange rate. Then 10-year Treasury returns, inflation expectations, and uncertainty are added

to both. All of the aforementioned regressions are then transformed using logarithms to certain variables to make interpretations of the results more straightforward. The variables which logs are applied to include gold price (denominated in both renminbi and rupee), Chinese (Indian) demand, renminbi (rupee) strength, 10-year Treasury returns, and uncertainty. Then regressions are done with both countries' variables added at the same time, both with and without the external factors and logarithms.

In order to test for causality, I use a Granger causality test with a one-quarter long lag to test for variations in gold demand causing variations in gold price. To investigate whether the relationship is the other way around, that is, whether demand for gold in China and India is actually driven by the price of gold, I run Granger causality tests in this direction as well, again with a lag of one quarter.

Results

The Granger causality tests show that changes in demand for gold jewelry in China Granger-cause changes in gold price, with a one quarter lag. Combined with the results from the regressions, both for Chinese exclusive data and combined with India, the interpretation is that variations in Chinese demand for gold jewelry cause variations in the opposite direction in gold prices, even though the size may or may not be statistically significant depending on which regression outcome one uses. The Granger causality is not present in gold price on Chinese or Indian demand, nor in Indian demand on price. This suggests that the cycle of price changes driving demand changes, which then drive price changes, and so on is not present in the market, at least not at the national level of China and India.

The regression table outputs as well as the Granger causality tests are available in the appendix, and the results are summarized in this section. When the full set of variables are included and the logarithms are applied, Chinese demand has a negative statistically significant impact (a 1% increase in Chinese demand leads to a 0.179% decrease in gold price), inflation expectations as predicted by the Federal Reserve have a significant positive impact (a 1% increase in inflation expectations leads to a 1.643% in price), and 10-year Treasury return has a positive significant impact on gold price in the regression with Chinese factors alone (a 1% increase in returns results in a 0.933% rise in price). In the parallel regression for India, strength of the rupee has a significant positive effect (a 1% increase is linked to a 0.844% price increase), inflation expectations have a significant positive effect (a 1% increase in inflation is associated with a 1.491% increase in gold price), and 10-year Treasury return has a significant positive effect on gold price (a 1% increase in returns is linked to a 1.817% increase in price). When Chinese and Indian data is combined, rupee strength has a significant positive effect (a 1% increase is correlated with a 0.794% gold price increase in dollars), inflation expectations have a positive significant effect (a 1% increase in expectations has a 1.688% increase in price), and 10-year American Treasury return has a positive significant effect on gold price (a 1% return increase has a 1.8% increase in dollar-denominated gold price).

Conclusion

When the full set of variables with the logarithms are applied, the results appear to confirm accepted economic theories. On one hand, the inflation expectations have a positive effect on

gold price across the board. This supports the theory that gold is a store of value and a hedge against inflation; when the markets anticipate higher inflation in the near future, demand for gold increases, driving up its price. Second, the fact that a stronger rupee is positively correlated with gold prices would be expected. Given that India imports almost all of its gold, a stronger rupee would make these gold imports cheaper, driving up demand in India and causing price increases due to the simple rules of supply and demand. Chinese demand has a statistically significant negative correlation with price, which is expected. This finding is consistent with the results of Immanuvel and Lazar (2022), which finds that changes in gold demand, particularly in China and India, significantly affect its price. This would be a shift from a Khannan and Dhal (2008) paper they cite that finds India is a price taker in gold markets in spite of its outsized portion of worldwide demand. Additionally, U.S. Treasury returns and gold price are positively correlated at a statistically significant level. This makes sense considering how investors consider both U.S. Treasuries and gold extremely safe investments, so they are likely to behave in the same way in varying market conditions.

If gold's attractiveness for investors was the main driver of gold price, one would expect significant results for the external factors. In the combined logarithmic regression, this is affirmed as inflation expectations and American Treasury returns have significant effects, indicating gold's place as a safe haven asset as prevailing market sentiments and profitability of other investments have an influence on gold's desirability as an investment opportunity. Yet, if widespread demand for gold jewelry among individuals and households is such an important source of demand, one would expect larger shifts in gold price to arise from changes in demand than what is seen in the results of this paper. Potentially distorting the results somewhat in the case of China is that consumer spending on gold jewelry is highest in the first quarter of the year. This is because the Chinese New Year (the country's longest holiday) happens during this time, making it a popular time for weddings, a key motivation to purchase gold (World Gold Council, 2021). Secondly, most workers receive their end of year bonuses in the first quarter, so consumers overall have more money on hand to buy consumer goods such as gold jewelry.

Further studies could advance in different directions. First, from a data collection perspective, one could attempt to estimate gold jewelry demand in China and India going farther back than 2010 to increase the length of the series and effectively increase sample size to acquire more robust findings. Second, one possible avenue would be to acquire data concerning, or to estimate, demand for gold in the secondary market in China and India. As explained in the methodology section, the gold demand numbers do not include used jewelry, only new. If demand for second hand gold is sufficiently strong, then the effects of demand on price will be overestimated, as the true values will not be underestimated and the real demand not captured. In India, for example, almost ten percent of gold supply comes from individuals selling their old jewelry to jewelers, or from retailers (such as jewelers) who sell their unsold gold products to be melted down at refineries (World Gold Council, 2021). The same effect can be applied to China as well, whose gold supply also has an important share coming from recycled gold jewelry. While accurate data collection is difficult, such a study could help shed some light on whether the gold market in its entirety affects gold prices, and how gold prices affect demand in the market for gold recycling and second-hand jewelry, not just for new products that are almost entirely made from imported gold. Third, beyond the data and technical aspects, one

could investigate why Indian demand neither shows Granger causality on gold price (nor vice versa), and why its coefficients in the regressions are not larger, as one would expect from the world's largest importer of gold. This finding is particularly surprising and merits a more detailed analysis.

Appendix

Table 1: Combined China and India regressions

	Dependent variable:	
	Log(Gold Price)	
	(1)	(2)
Log(Chinese Demand)	-0.307**	-0.042
	(0.107)	(0.066)
Log(Renminbi Exchange Rate)	-1.403*	0.689
	(0.626)	(0.440)
Log(Indian Demand)	-0.100	-0.041
	(0.078)	(0.046)
Log(Rupee Exchange Rate)	0.262*	-0.794***
	(0.152)	(0.173)
FED Inflation Expectations		1.688***
		(0.226)
Log(10 Year Treasury Return)		1.800***
		(0.238)
Log(Uncertainty Index)		0.027
		(0.040)
Constant	10.842***	-5.221**
	(1.449)	(1.778)
Observations	50	50
R^2	0.287	0.794
Adjusted R^2	0.223	0.759
Residual Std. Error	0.146 (df = 45)	0.081 (df = 42)
F Statistic	4.525*** (df = 4; 45)	23.079*** (df = 7; 42)
Note:	*p<0.05; **p<0.01; ***p<0.001	

Table 2: China regressions

	Dependent variable:	
	Log(Gold Price CNY)	
	(1)	(2)
Log(Chinese Demand)	-0.291**	-0.174*
	(0.100)	(0.070)
Log(Renminbi Exchange Rate)	0.106	1.222*
	(0.622)	(0.526)
FED Inflation Expectations		1.653***
		(0.276)
Log(10 Year Treasury Return)		0.942***
		(0.133)
Log(Uncertainty Index)		0.023
		(0.049)
Constant	10.400***	-1.726
	(1.516)	(1.882)
Observations	50	50
R^2	0.221	0.703
Adjusted R^2	0.188	0.670
Residual Std. Error	0.157 (df = 47)	0.100 (df = 44)
F Statistic	6.683*** (df = 2; 47)	20.865*** (df = 5; 44)
Note:	*p<0.05; **p<0.01; ***p<0.001	

Table 3: India regressions

	Dependent variable:	
	Log(Gold Price INR)	
	(1)	(2)
Log(Indian Demand)	-0.179*	-0.065
	(0.074)	(0.046)
Log(Rupee Exchange Rate)	1.064	0.156

	(0.147)	(0.173)
FED Inflation Expectations		1.490***
		(0.198)
Log(10 Year Treasury Return)		1.819***
		(0.248)
Log(Uncertainty Index)		0.053
		(0.040)
Constant	7.868***	-3.785**
	(0.815)	(1.252)
Observations	50	50
R^2	0.636	0.895
Adjusted R^2	0.621	0.883
Residual Std. Error	0.157 (df = 47)	0.087 (df = 44)
F Statistic	41.073*** (df = 2; 47)	75.151*** (df = 5; 44)
Note:	*p<0.05; **p<0.01; ***p<0.001	

Table 4: Granger causality test, gold price on Chinese demand

Statistic	N	Mean	St. Dev.	Min	Max
Res.Df	2	46.500	0.707	46	47
Df	1	-1.000		-1	-1
F	1	0.398		0.398	0.398
Pr(> F)	1	0.531		0.531	0.531

Table 5: Granger causality test, Chinese demand on price

Statistic	N	Mean	St. Dev.	Min	Max
Res.Df	2	46.500	0.707	46	47
Df	1	-1.000		-1	-1
F	1	4.689		4.689	4.689
Pr(> F)	1	0.036		0.036	0.036

Table 6: Granger causality test, price on Indian demand

Statistic	N	Mean	St. Dev.	Min	Max
Res.Df	2	46.500	0.707	46	47
Df	1	-1.000		-1	-1
F	1	2.952		2.952	2.952
Pr(> F)	1	0.093		0.093	0.093

Table 7: Granger causality test, Indian demand on price

Statistic	N	Mean	St. Dev.	Min	Max
Res.Df	2	46.500	0.707	46	47
Df	1	-1.000		-1	-1
F	1	0.306		0.306	0.306
Pr(> F)	1	0.583		0.583	0.583

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