The Effect of Price Risk on Mongolian Copper Exports

by

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Abstract

Mongolia has copious mineral deposits. Copper ore is the major commodity of the mineral industry and is also Mongolia's main export item. China is the largest destination for Mongolia's copper exports. To analyze the price risk effects on Mongolia's export and the import demand of China, the differential import allocation model is applied to estimate the import demand of China. The model data for China's imports of copper come from Mongolia, Peru, Chile, Australia, and the rest of the world (ROW). The results show Chile is the only exporter that would be affected by its own price risk. Chile's import would increase by 5.76 percent when the price risk increases by 1 percent. The risk premium of Chile indicates that to maintain a constant import quantity, the price would increase 1.39 percent following a price risk increase of 1 percent. Changes in Peru's and Chile's pricing and the price volatility of Chile have positive effects on Mongolia's copper exports. China's demand for copper from Mongolia differs from its demand for copper from other sources in that it is price inelastic. One implication of a price inelastic demand is that Mongolia could improve its national welfare by imposing an export tax on copper destined for China. The tax would be welfare decreasing for Mongolia's copper producers, but because most of the tax would be borne by Chinese consumers, the government could use the tax revenue to compensate domestic producers for their losses and still have money left over to fund public works such as grassland protection.

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List of Abbreviations

DIA Differential Import of Allocation

GDP Gross Domestic Product

M-ARCH Multivariate Autoregressive Conditional Heteroskedasticity

ROW Rest of the World

The Effect of Price Risk on Mongolia Copper Export

Introduction

Mongolia, a country located in north-central Asia, has copious natural mineral deposits. Over the last several decades, Mongolia's national economy has become more reliant on the mining industry. According to the Mineral Resources Authority of Mongolia, the mining industry represented 20 percent of Mongolia's gross domestic product (GDP) between 2003 and 2011. Figure 1 shows the proportion of minerals exported of total exported products and that this has increased from 57.5 percent to 78.8 percent.

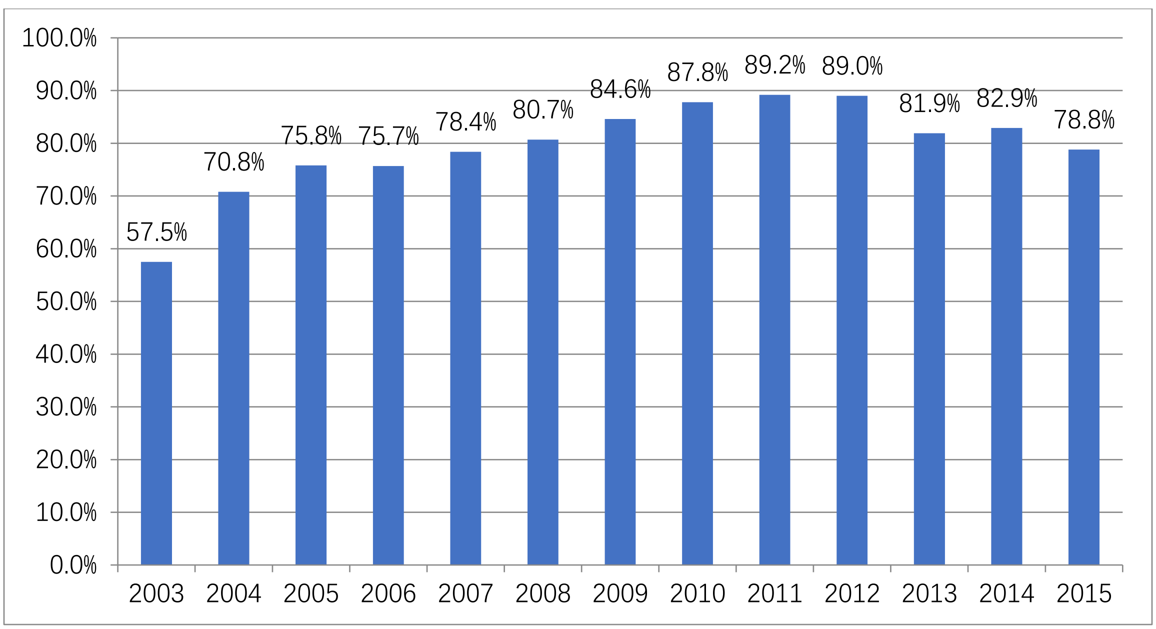

Figure 1. Share of mineral products in Mongolian exports (Source: Mineral Resources Authority of Mongolia: https://cmcs.mram.gov.mn)

The main mineral exports of Mongolia are copper ore, coal briquettes, iron ore, and crude petroleum. Copper ore is not only the major sector of mineral exports, but also has grown to lead the total exports of Mongolia. In 2015, Mongolia exported US$2.31 billion copper ore, which accounted for 45 percent of the total exports. Figure 2 describes the change of the value of copper exports and the proportion of copper exported of the total exports of Mongolia. There has been an overall rise in the value of copper exports between 2002 and 2015.

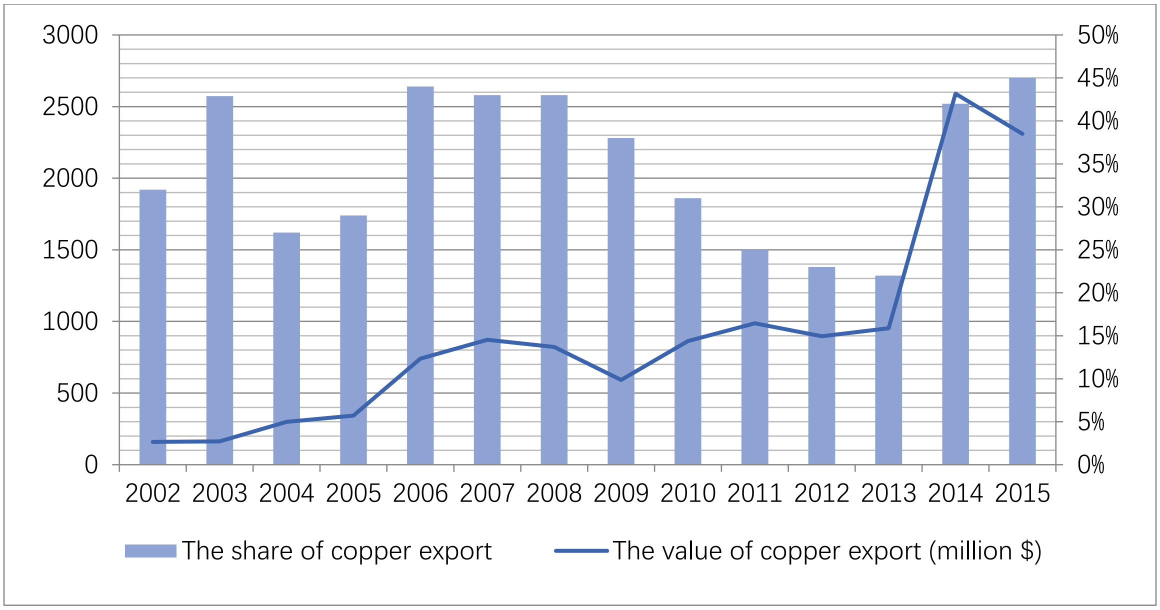

Figure 2. Share and value of copper exports from Mongolia (Source: The Observatory of Economic Complexity: http://atlas.media.mit.edu)

As the greatest importer of copper ore in the world, China is also the top export destination of Mongolia. Imports of copper account for about two thirds of the total demand of copper in China's market. The value of copper ore exports to China increased from US$162 million in 2001 to US$2.31 billion in 2015 in Mongolia. Mongolia, Peru, Chile, and Australia are major copper exporters for China. Figure 3 shows Chile is the largest exporter of copper to China, and also the top exporter in the world. Because Mongolia is geographically near to China, Mongolia has become an important copper exporter to China.

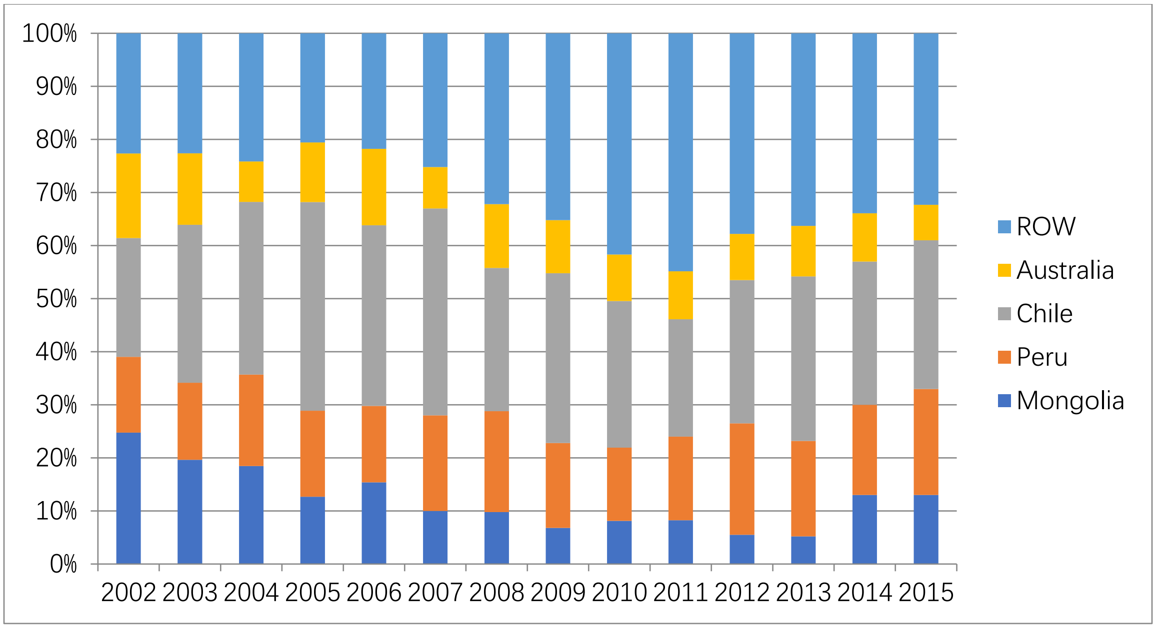

Figure 3. Source of Chinese copper imports (Source: The Observatory of Economic Complexity: http://atlas.media.mit.edu)

The study of the price risk effects on Mongolian copper exports is important for several reasons. First, as copper export plays an important role in the Mongolian economy, the global copper price would probably influence, and possibly hurt, the trade balance of Mongolia (Batchuluun, 2010). Figure 4 supports this assumption. The increasing rates of GDP and total exports were negative along with the global copper price in 2009. Then, the rates grew rapidly with the copper price in 2010 and 2011. The total demand for copper in China is another major factor affecting Mongolian copper exports. In turn, this would also be influenced by the price volatility of copper.

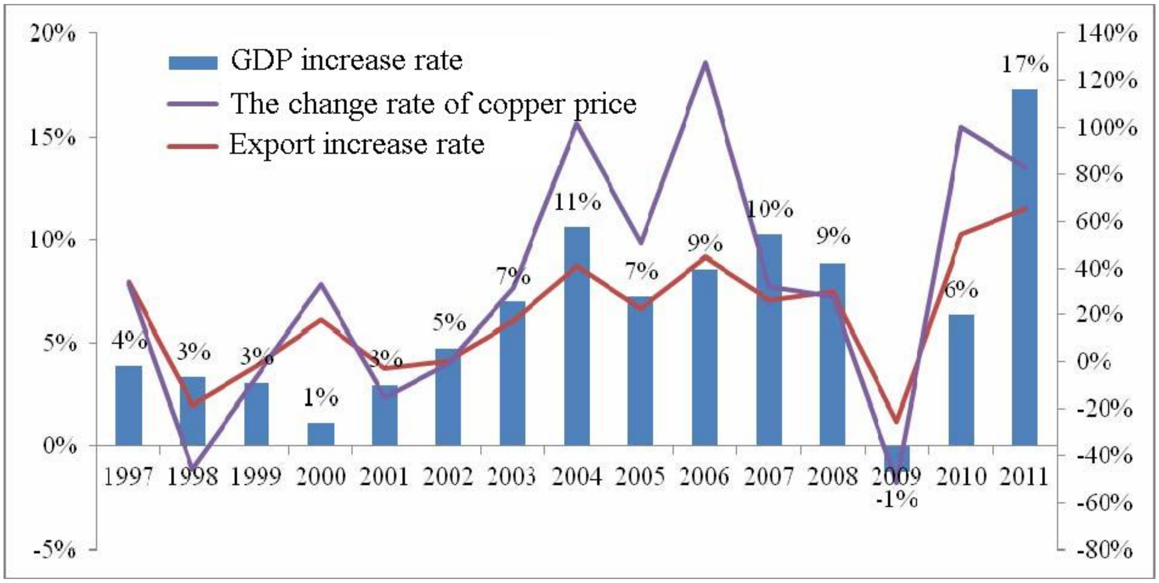

Figure 4. Changing of GDP, export and copper price (Source:Basang 2013)

Literature Review

Armington (1969) proposes analyzing the import of homogenous products across different countries. The primary assumption of Armington's study is that commodities from different exporters competing in the same destination are imperfect substitutes. This assumption allows for evaluating the competition between the major exporters and evaluating the source-specific price effects on the total demand of the importer. Shiells and Reinert (1993) estimates the elasticities of substitution between different exporters, Mexico, Canada, the rest of the world, and domestic production in U.S. market. Most elasticities are positive and low.

Agricultural commodities are the main objects of studies about import demand by source, such as meats, fruits, cotton, and wine. These researches always use the Almost Ideal Demand System (AIDS) and Rotterdam model to analyze import demand. Yang and Koo (1994) estimate the import demand of meat products using small samples and indicate that the U.S. has the largest potential in the beef market of Japan according to the AIDS model. Mutondo and Henneberry (2007) describe different exporter performances in the U.S. meat market and the influences of animal disease on the market. Seale, Marchant, and Basso (2003) use the AIDS model to estimate the import demand in the U.S. wine market. Muhammad (2011) analyzes the U.K. import market for wine using the Rotterdam model. French wine has same performance in U.S. and U.K. markets, which would attract more revenue with price increases.

Some studies have also focused on the import demand patterns in China. Muhammad, McPhail, and Kiawu (2012) estimate the import demand of cotton in China and suggest that if the U.S., as a cotton exporter, increases cotton subsidies it could earn more market share in the Chinese market. Niquidet and Tang (2013) analyze log and lumber import demands using the AIDS model and show that the price elasticity of demand is elastic. Sun (2014) employs the Rotterdam model to assess China's roundwood import market and finds there is no obvious competition between the foreign exporters but that a substitute situation exists. Therefore, research has mostly focused on agricultural and forestry products. The source diversification analysis of mineral products has received less attention than other fields.

Nevertheless, the consumption of copper cannot avoid the problem of price risk. The major factors causing copper price volatility are demand and supply, production costs, market power, and the forecast of supply and demand (Rosenau-Tornow, Buchholz, and Riemann 2009). Wolak and Kolstad (1991) indicate that producers attempt to reduce cost risk by using diversified suppliers. Because mineral products are always treated as inputs in domestic industry, producers always purchase commodities from different exporters to avoid price risk. This study presents a model to examine the price risk's effect on import allocation across different exporters. Does the price risk of foreign copper affect the allocation of the import market? This is the key problem to figure out in my study.

In previous studies, the impact of price risk on the allocation of the import market has been estimated. Cavalcanti, Tiago, and Mohaddes (2015) estimates the price volatility of commodity terms of trade has a significant negative effect on output growth of product exporters. However, most of studies usually focus on agricultural products. Muhammad (2015) analyzes the price risk effects on competition in China's soybean market. The study indicates that price risk plays an important role in the soybean import market. Zhang and Zheng (2016) estimate the impact of price risk on the allocation of U.S. import demand. The study shows that most exporters have significant and negative risk elasticities, and price stability is important for trade from developing countries to developed countries. There is an absence of research on the effects of price risk on the allocation of copper demand. The above studies suggest that the price volatility of import copper might decrease the trade from exporters.

Model

This study uses Muhammad's (2012) differential import allocation (DIA) model, which is derived from the theory of expected utility maximization (Wolak and Kolstad 1991). The DIA model treats foreign price risk as a factor affecting the optimal allocation of import across different sources.

Assuming copper is an intermediate good for a firm, the optimal allocation of import input would be decided in the first stage of a two-stage profit maximization, according to

Wolak and Kolstad's (1991) theory. A firm would decide the output level and domestic resources for production in the second stage, if the prices of domestic resources and the amounts of output and import resources have already been known.

R defines the net revenues obtained from outputs and domestic inputs during the production. q_i and p_i represent the quantity and price of import copper from the *i*th country (*i=1,2…n*). The optimal allocation of import demand **q** would be obtained by the utility maximization problem:

$$\underset{q}{\text{Max}}\, U[R_t - E(\mathbf{p}_t'\mathbf{q}_t), V(\mathbf{p}_t'\mathbf{q}_t)]$$

$$s.t. \qquad Q_t = \iota'\mathbf{q}_t, \mathbf{q}_t \geq 0 \qquad (1)$$

E and *V* represent the function of expectation and variance. ***p*** and ***q*** are n-dimensional vectors of the price and quantity of copper import from each exporter. Q is the quantity of total copper imports and ι is a unit vector. The Lagrangian of (1) is

$$L = U(R_t - \tilde{\mathbf{p}}'\mathbf{q}, \mathbf{q}'\boldsymbol{\Omega}\mathbf{q}) + \lambda(Q - \iota'\mathbf{q}) \qquad (2)$$

where $\tilde{p} = E(p)$ and $\Omega = E\{(p-\tilde{p})(p-\tilde{p})'\}$, $\tilde{\mathbf{p}}$ and $\boldsymbol{\Omega}$ represent the conditional expectation and variance of import price **p**. λ is Lagrange multiplier on the constraint. The first order condition from equation (2) with respect to the *i*th copper import is:

$$L_i = \frac{\partial L}{\partial q_i} = -U_1\tilde{p}_i + 2U_2\left(q_i\sigma_i^2 + \sum_{j\neq i} q_j\sigma_{ij}\right) - \lambda = 0 \qquad (3)$$

Where the derivatives of maximum utility *U* with respect to the *i*th argument are represented by U_i. σ_i^2 means conditional variance and σ_{ij} means conditional covariance of import price. Equation (4) is the fundamental mode of total import demand function.

$$q_i^* = q_i(Q, \tilde{p}_1, \tilde{p}_2, \dots, \tilde{p}_n, \sigma_1^2, \sigma_2^2, \dots, \sigma_n^2,$$
$$\sigma_{12}, \dots, \sigma_{1,n}, \sigma_{23}, \dots, \sigma_{2,n}, \dots, \sigma_{n-1,n}). \quad (4)$$

For example, if n=5 this means each equation in the system contains 10 covariance variables as follows $\sigma_{12}, \sigma_{13}, \sigma_{14}, \sigma_{15}, \sigma_{23}, \sigma_{24}, \sigma_{25}, \sigma_{34}, \sigma_{35}, \sigma_{45}$.

Following Theil's (1977,1980) studies, the differential approach is used to derive the import demand model. The total differential of equation (4) is:

$$dq_i = \frac{\partial q_i}{\partial Q} dQ + \sum_{j=1}^{n} \frac{\partial q_i}{\partial \tilde{p}_j} d\tilde{p}_j + \sum_{j=1}^{n} \frac{\partial q_i}{\partial \sigma_j^2} d\sigma_j^2 + \sum_{g \neq h} \sum_{\substack{h \neq g \\ h > g}} \frac{\partial q_i}{\partial \sigma_{gh}} d\sigma_{gh} \quad (5)$$

After some transformation steps from equation (5), the DIA model in logarithmic-differential form is obtained:

$$s_i d \log q_i = \frac{\partial q_i}{\partial Q} d \log Q + s_i \sum_{j=1}^{n} \frac{\partial \log q_i}{\partial \log \tilde{p}_j} d \log \tilde{p}_j + s_i \sum_{j=1}^{n} \frac{\partial \log q_i}{\partial \log \sigma_j^2} d \log \sigma_j^2$$
$$+ s_i \sum_{g \neq h} \sum_{\substack{h \neq g \\ h > g}} \frac{\partial \log q_i}{\partial \log \sigma_{gh}} d \log \sigma_{gh} \quad (6)$$

where $s_i = q_i/Q$ is the share of total imports from country *i*. $\partial q_i/\partial Q>0$ is expected, which implies increasing in total imports would increase the imports from exporter *i*. $s_i \partial \log q_i / \partial \log \tilde{p}_i$ should be negative, which are consistent with the demand theory. When $\neq j$, the positive sign of $s_i \partial \log q_i / \partial \log \tilde{p}_j$ would represent the imports from exporter *i* and *j* are substitutes. In contrast, the imports are complements. $s_i \partial \log q_i / \partial \log \sigma_j^2$, which represents the variance effect, could be positive or negative depending on the importers' response of price risk. $s_i \partial \log q_i / \partial \log \sigma_{gh}$ reflects the competitive relationship between the any two importers and they are possible to be negative or positive.

Empirical Model

The DIA model contains five equations as follows:

$$\bar{s}_{i,t}\Delta q_{i,t} = \theta_i \Delta Q_t^* + \sum_{j=1}^{5} \pi_{ij}\Delta\tilde{p}_{j,t} + \sum_{j=1}^{5} v_{ij}\Delta\sigma_{j,t}^2 + \sum_{g\neq h}\sum_{\substack{h\neq g\\ h>g}} \omega_{igh}\Delta\sigma_{gh,t} + \varepsilon_{i,t} \qquad i = 1, \ldots, 5 \qquad (7)$$

The matrix of coefficients corresponding to the price and variance terms are 5x5 while the matrix of coefficients corresponding to the covariance terms is 5x10. For easily estimating the log change, first differences are used where for any variable x, $d\,log\,x_t \approx \Delta x_t = ln(x_t) - ln(x_{t-1})$. The variable of market share is estimated by the average of two sequential periods, $\bar{s}_{i,t} = 0.5(s_{i,t} + s_{i,t-1})$. To ensure the import constraints $\sum_{i=1}^{n} s_i d\log q_i = d\log Q$ are satisfied in empirical procedure, $\Delta Q_t = ln(Q_t) - ln(Q_{t-1})$ is replaced by $\Delta Q_t^* = \sum_{i=1}^{n} \bar{s}_{i,t}\Delta q_{i,t}$.

θ_i represents the marginal market share effects on copper import from country i. π_{ij} reflects the price effects on copper import from country i. It reflects the own price effect when $i = j$ and the cross price effect when $i \neq j$. v_{ij} shows the variance effect. ω_{igh} means the covariance effect. The general restrictions of demand theory are assumed to be satisfied in the DIA model. These restrictions are the following conditions: $\sum_{i=1}^{n} \theta_i = 1$; $\sum_{i=1}^{n} \pi_{ij} = 0$; $\sum_{i=1}^{n} v_{ij} = 0$; $\sum_{i=1}^{n} \omega_{igh} = 0$; $\sum_{j=1}^{n} \pi_{ij} = 0$; and $\pi_{ij} = \pi_{ji}$.

To derive the specific total import, price, risk and covariance elasticities from equation (7), these following methods are applied:

$$\eta_i = d\log q_i / d\log Q = \theta_i / \bar{s}_i \tag{8}$$

$$\eta_{\mathrm{ij}} = d\log q_i / d\log \tilde{p}_i = \pi_{ij} / \bar{s}_i \tag{9}$$

$$\eta_{ij}^{\sigma} = d\log q_i / d\log \sigma_i^2 = v_{ij} / \bar{s}_i \tag{10}$$

$$\eta_{igh}^{\sigma} = d\log q_i / d\log \sigma_{gh} = \omega_{igh} / \bar{s}_i \tag{11}$$

In Wolak and Kolstad's (1991) study, the risk premium is defined as the negative value of the risk elasticity of copper imports with respect to price elasticity:

$$RP_i = -d\log \tilde{p}_i / d\log \sigma_i^2 = -v_{ij} / \pi_{ij} \tag{12}$$

Risk premium is used to estimate the impact of price risk on the price change under the consistent import allocation, which measures the exporter i seems willing to pay how much higher above the current price for the import of copper having no price risk. According Wolak and Kolstad (1991), the expected sign of risk premium is positive.

Estimation and Results

This paper uses the monthly data (January 2000–December 2006 and January 2010–September 2012) provided by the General Administration of Customs of the People's Republic of China and defined according to the HS classification 2603: copper ores and concentrates. The following exporting countries are considered for the analysis: Mongolia, Peru, Chile, Australia, and the rest of the world (ROW). The ROW is an aggregation of all countries not specified.

To obtain the conditional expectation, variance, and covariance of copper import prices, the following autoregressive equation is estimated assuming a multivariate GARCH (1,1) process (Appelbaum and Woodland 2010):

$$\Delta \mathbf{p}_t = \propto_0 + A_1 \Delta p_{t-1} + A_2 \Delta z_t + \varepsilon_t \tag{12}$$

$$\widehat{\Omega}_t = B_0 + B_1 \varepsilon_{t-1} \varepsilon_t' B_1 + B_2 \widehat{\Omega}_{t-1} B_2 \tag{13}$$

where Δp_t represents the first difference of the logarithm of the import price. $\widehat{\Omega}$ defines the estimated variance and covariance matrix. In this model, equation (12) and (13) are the mean equation and variance equation for price change. The conditional variance estimates of equation (13) are presented in Figure 5.

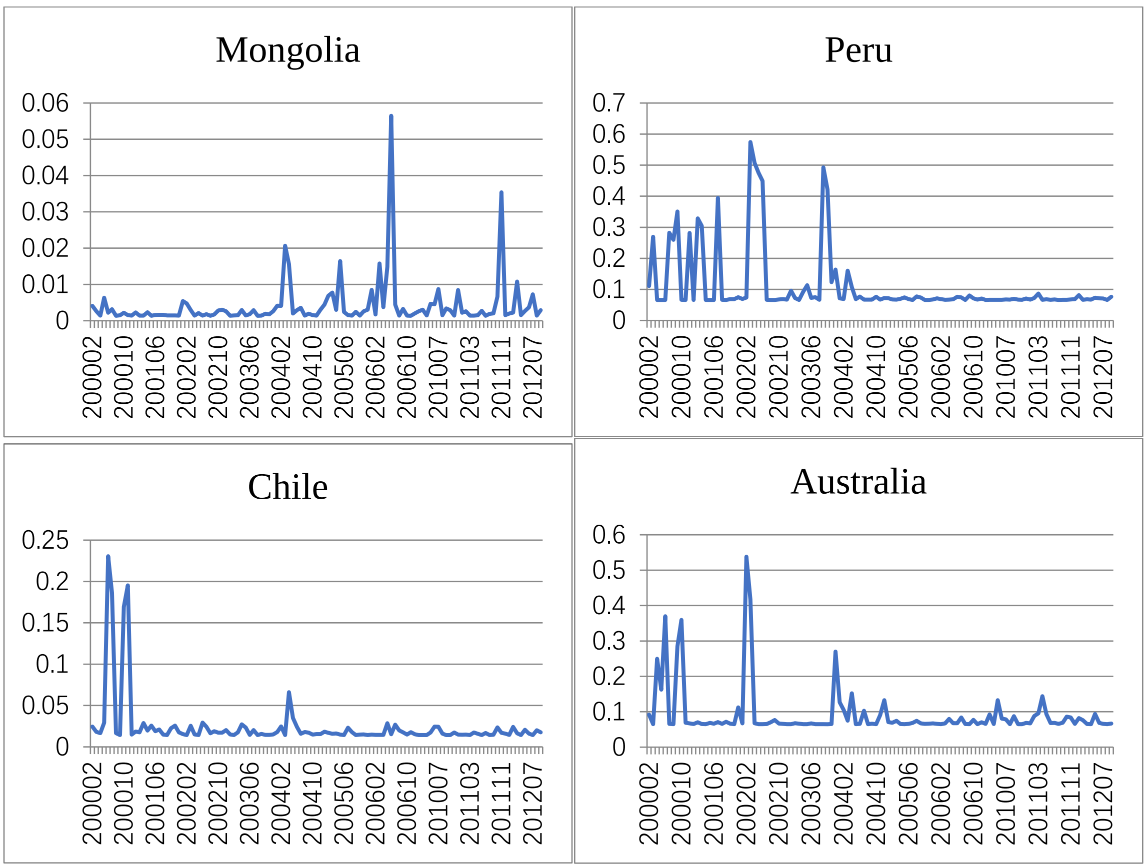

Figure 5. M-GARCH variance estimates: January 2000-September 2012, exclusive of 2007-2009.

Figure 5 shows the prices of Peru and Australia were more volatile than Chile and Mongolia. Peru and Australia had similar volatilities that were more erratic in 2000–2004 and peaked in March 2002. Mongolia's price was more stable than other countries, but it was stable until 2003 and more volatile in recent years. Table 1 reports the summary statistics for all variables of the DIA model.

Table 1. Summary Statistics for Model Variables: January 2000-September 2012

Monthly quantity (100 kg)	Mean	SD	Min	Max
Total	322,772,419	165,793,546	78,129,510	704,323,595
Mongolia	41,740,717	9,592,176	7,075,208	74,120,580
Peru	53,252,635	35,391,775	4,597,817	194,756,400
Chile	94,050,135	49,137,861	7,685,700	243,247,648
Australia	38,631,717	21070647	789,200	97,865,334
ROW	104,584,481	91201780	3,686,726	359,461,491
Quantity share				
Mongolia	0.164	0.086	0.042	0.407
Peru	0.133	0.079	0.028	0.352
Chile	0.295	0.110	0.051	0.562
Australia	0.124	0.082	0.003	0476
ROW	0.284	0.124	0.038	0.534
Price (¥/100kg)				
Mongolia	0.942	0.640	0.329	2.167
Peru	1.261	0.823	0.310	2.740
Chile	1.230	0.841	0.340	2.871
Australia	1.254	0.989	0.238	3.501

ROW	1.105	0.696	0.164	2.583
Variance of price				
Mongolia	0.0034	0.0033	0.0017	0.0271
Peru	0.1210	0.1377	0.0603	0.6883
Chile	0.0184	0.0311	0.0095	0.2735
Australia	0.0917	0.0739	0.0641	0.5426
ROW	0.0341	0.0361	0.0229	0.2960
Covariance of price				
Mongolia–Peru	0.0064	0.0088	-0.0113	0.0442
Mongolia–Chile	0.0009	0.0020	-0.0003	0.0119
Mongolia–Australia	-0.0018	0.0074	-0.0580	0.0175
Mongolia–ROW	0.0019	0.0029	-0.0033	0.0193
Peru–Chile	-0.0003	0.4007	-0.0639	0.3377
Peru–Australia	-0.0234	0.0757	-0.5534	0.0079
Peru–ROW	-0.0162	0.0724	-0.4751	0.0722
Chile–Australia	-0.0020	0.0306	-0.1824	0.0094
Chile–ROW	-0.0053	0.0172	-0.1313	0.0201
Australia–ROW	-0.0005	0.0131	-0.0607	0.0757

The tests for homogeneity and symmetry show they cannot be rejected in Table 2. These restrictions will be imposed in all results by default.

Table2. Wald Test for General Restrictions

Model	Wald Statistic	Restricted Parameters	*P*-value
Homogeneity ($\sum_{j=1}^{n}\pi_{ij}=0$)	1.68	2	0.6118
Symmetry ($\pi_{ij}=\pi_{ji}$)	8.17	1	0.8917

Table3. Wald Test for Variance and Covariance Restrictions

Model	Variance	Covariance	Wald Statistic	Restricted parameters	P-value
1	unrestricted	unrestricted			
2	unrestricted	restricted	30.07	30	0.4621
3	unrestricted	=0	65.90	20	0.0653
4	restricted	=0	35.41	20	0.0180
5	=0	=0	113.2	5	0.0029

The Wald test in Table 3 is used to check whether restrictions on the risk variables are compatible with the data. Model 2 imposes the restriction that import demand is unresponsive to cross-effects corresponding to the covariance variable, i.e., $\omega_{igh}=0\forall g\neq i, h\neq i$. Model 3 imposes the restriction that import demand is unresponsive to

Table 4. Demand Estimates for China Copper Ore Imports.

Country	Marginal Share (θ_i)	Price Effects (π_{ii})					Risk Effects (v_{ij})				
		Mongolia	Peru	Chile	Australia	ROW	Mongolia	Peru	Chile	Australia	ROW
Mongolia	0.020 (0.012)*	-0.115 (0.078)	0.075 (0.022)***	0.200 (0.054)***	-0.008 (0.024)	-0.151 (0.036)***	-1.973 (1.596)	-0.050 (0.069)	0.419 (0.237)*	-0.013 (0.134)	0.141 (0.202)
Peru	0.188 (0.029)***		-0.688 (0.053)***	0.389 (0.052)***	0.200 (0.038)***	0.025 (0.038)	2.084 (2.71)	0.111 (0.213)	-3.782 (0.701)***	0.553 (0.308)*	0.455 (0.649)
Chile	0.622 (0.032)***			-1.224 (0.096)***	0.628 (0.052)***	0.008 (0.059)	1.601 (2.979)	-0.108 (0.235)	1.700 (0.783)**	-0.096 (0.496)	-0.728 (0.696)
Australia	0.147 (0.028)***				-0.693 (0.051)***	-0.127 (0.037)***	-3.102 (2.674)	0.0125 (0.261)	0.868 (0.642)	-0.139 (0.464)	0.109 (0.570)
ROW	0.023 (0.021)					0.246 (0.067)***	1.385 (1.879)	0.035 (0.129)	0.795 (0.442)**	-0.305 (0.190)	0.023 (0.525)
	R^2	0.068	0.714	0.840	0.669	0.204					

*Note: Standard errors are in parentheses. ROW represents the rest of the world. *, **, and *** denote the 0.10, 0.05 and 0.01 significance levels.*

the covariance term into neither the cross nor the direct effects matter, i.e., $\omega_{igh} = 0 \forall g \ \ and \ \ h$. Model 4 constrains the cross-variance effects, $v_{ij} = 0 \forall i \neq j$. Model 5 represents that the importer is risk neutral, $v_{ij} = \omega_{igh} = 0 \forall g, h, i \ \ and \ \ j$. It means the price risk has no influence on import demand. The results indicate that Model 2 is statistically equivalent to Model 1. However, the hypotheses that Models 3, 4, and 5 are equivalent to Model 2 are rejected. These represent that the exporter would be influenced by own price instability and price instability of its international competitors. The hypothesis the price risk plays no role in China's import demand for copper ore is firmly rejected, because the p-value for Model 5 against Model 1 is 0.0029. The price risks indeed influence import demand. In the following discussion, Model 3 is chosen as the preferred model.

Table 4 reports the marginal share, price effects, and risk effects estimates. The marginal share estimates are all positive and significant. This means that the quantities of copper import from each source will increase following the total imports increasing. The copper imports of Mongolia, Peru, Chile, Australia, and the ROW will increase 0.02, 0.19, 0.62, 0.15, and 0.02 kg, respectively, as the responses to the 1 kg increase in total import. The Mongolian response level is lower than the other countries.

The own price estimates of Peru, Chile, and Australia are all negative, significant, and consistent with the demand theory. The estimate of Mongolia (-0.115) is negative but insignificant. However, the ROW's own price estimate is positive and significant, which is 0.246. Copper not only is treated as the input of production, but also is one method of investment in the finance market. Maybe this is the reason why the unexpected value appeared on the price estimate of the ROW.

Cross-price estimates that are significant are all positive except for Mongolia and the ROW (-0.151) and Australia and the ROW (-0.127). The estimates of Mongolia and Chile, Mongolia and Australia, Peru and the ROW, and Chile and the ROW are insignificant. Chile is the only country that has a significant own risk estimate (1.700). The value of Chile's own risk estimate exceeds the absolute value of Chile's own price estimate. This means imports from Chile would have more response to price risk.

Only four of all cross-price risks estimates are significant. They are the coefficients of Chile with respect to Mongolia (0.419), Peru (-3.782), and the ROW (0.795), and Australia with respect to Peru (0.553). This means the imports from Mongolia and the ROW will increase when the import price of Chile becomes more volatile, but the imports from Peru will decrease. Imports from Peru have an inverse effect on Australia's price.

The elasticities of total import, own price, and own risk are presented in Table 5. Total import, own price, and own risk elasticities come from their estimates divided by market share, $\eta_i = \theta_i/\bar{s}_i$, $\eta_{\mathrm{ij}} = \pi_{ij}/\bar{s}_i$, $\eta_{ij}^{\sigma} = v_{ij}/\bar{s}_i$. Risk premium is the negative value of own risk elasticities divided by own price elasticities, $RP_i = -v_{ij}/\pi_{ij}$.

Table 5. Demand Elasticities China Copper Ore Imports.

Country	Total Import (η_i)	Risk Premium (RP_i)	Own Price (η_{ii})	Own Risk (η_{ii}^{σ})
Mongolia	0.124	-17.431	-0.699	-12.036
	(0.074)*	(14.242)	(0.475)	(9.732)
Peru	1.412	0.166	-5.159	0.833
	(0.215)***	(0.311)	(0.398)***	(1.594)
Chile	2.107	1.389	-4.148	5.760
	(0.109)***	(0.676)**	(0.326)**	(2.653)**
Australia	1.187	-0.178	-5.599	-1.122

	(0.223)***	(0.673)	(0.416)***	(3.752)
ROW	0.079	-0.115	0.868	0.080
	(0.076)	(2.142)	(0.236)***	(1.849)

*Note: Standard errors are in parentheses. ROW represents the rest of the world. *, ** and *** denote the 0.10, 0.05, and 0.01 significance levels.*

The most responsive effect is the total import to Chile's copper import, in which Chile's import will increase 2.107 percent with respect to a total 1 percent increase. Mongolia, Peru, and Australia's responses are 0.124 percent, 1.412 percent, and 1.187 percent, respectively. Mongolia has the least impact by the total import of copper. The own price elasticities are highly elastic in Peru (-5,16), Chile (-4.15), and Australia (-5.60). The ROW has a special situation in own price elasticity, which has positive response for price change; but it has the least reflection (0.87) on own price. Chile is the only country that has a significant own risk effect on own copper imports. It means that Chile is a risk-preferred exporter in the China copper market. The imports from Chile will increase 5.76 percent following the price risk of Chile's imports increasing by 1 percent. The risk premium of Chile is 1.39, describing a situation in which when price risk increases by 1 percent, the price would increase 1.39 percent to hold the constant import from Chile. Other countries' price risks do not have notable influences on their own copper export.

Table 6. Demand Elasticities for Mongolia Copper Ore Exports

Mongolia Country	Price Elasticity (η_{ij})	Risk Elasticity (η_{ij}^{σ})
Mongolia	-0.699	-12.036
	(0.475)	(9.732)
Peru	0.455	-0.308
	(0.135)***	(0.418)

Chile	1.217	2.554
	(0.330)***	(1.444)*
Australia	-0.050	-0.079
	(0.145)	(0.818)
ROW	-0.823	0.862
	(0.219)***	(1.233)

*Note: Standard errors are in parentheses. ROW represents the rest of the world. *, **, and *** denote the 0.10, 0.05 and 0.01 significance levels.*

Table 6 shows the performance of Mongolian copper exports with respect to the other exporters. Mongolia's own price elasticity is insignificant, but the value is negative and consistent to demand theory. The cross-price elasticities of Mongolia and Peru (0.46), and Mongolia and Chile (1.22) are positive. This denotes that the import copper of Mongolia and Peru, and Chile are substitute. The copper price of Mongolia is more sensitive with the price of Chile than with the price of Peru. The import copper of Mongolia and the ROW are complementary goods. Chile is the only exporter whose price risk has positive and significant effects on the copper imports from Mongolia. The imports from Mongolia would change 2.55 percent in the same trend while Chile changes 1 percent. The impact of Chile's price risk also exceeds Chile's price effect.

Summary and Conclusion

This study uses the source disaggregated demand system to analyze the price risk effects on the import market. As a great part of Mongolia's national economy, it is valuable to gain insight into copper export's condition. Because most of Mongolia's copper is exported to the Chinese market and Mongolia also is one of the major exporters in this market, the import demand of China is used to apply the source disaggregated demand model. Following Muhammad's (2012) DIA model and evaluating the data of other main exporters in China's copper market, the conditional variances and covariances that represent the variables of price risk are obtained through the multivariate GARCH (1,1) process. Then Wald tests are used to determine the best model fitting the data. The test results show that unrelated covariate effects on copper imports from each source are insignificant. Finally, the elasticities of total import quantity, price, price risk, and risk premium are reported in the results.

In the Chinese market, Peru, Chile, and Australia are highly sensitive to own prices on their copper export quantities. As the top copper exporter for China and the world, Chile also has the characteristics that will be most affected by the total imports of China and prefers more price volatility. The only significant risk premium is for Chile's copper exports. The positive value 1.39 shows that the copper imports from Chile are more sensitive to price risk than the change of copper price. Mongolia is a relatively stable source for the copper imports of China.

The demand of Mongolian copper import is highly price inelastic, which might be caused by policy instability, unpredictability, and non-transparency in Mongolia. The changes of Peru, Chile, and the ROW's price and Chile's price volatility are the significant factors for Mongolia's copper ore export. The relations between Mongolia's copper and Peru and Chile's copper are substitutes. Chile's volatility would encourage the copper export of Mongolia. Own price change and own price risk do not have powerful impacts on Mongolia's copper export.

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