Location Factors for Non-Ferrous Exploration Investments

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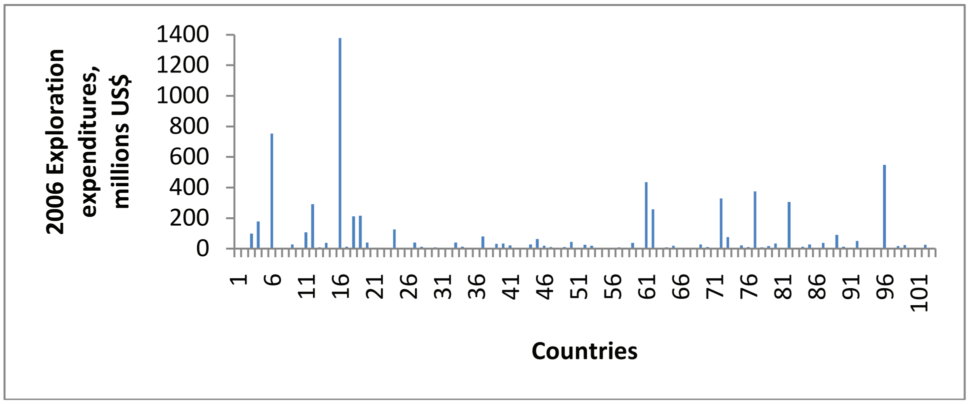
This paper analyzes the relative importance of geological potential and investment climate for non-ferrous minerals exploration investments. The analysis is based on log-linear and truncated models of exploration funding with geological potential and investment environment as location factors. In order to account for countries sizes, we include the population variable. Models are estimated using the Metals Economics Group's exploration expenditures data, one measure of geological potential, and one indicator of investment climate. Our analysis shows that exploration does not simply follow geological potential. The investment environment plays a significant role in allocating exploration budgets by mining companies. This result confirms that a mineral rich country cannot expect large amounts of exploration money without establishing a favorable investment climate.

INTRODUCTION

This paper analyzes the relative importance of geological potential and investment climate for non-ferrous exploration investments. Many metals, coal, and uranium producing countries resort to private companies to explore and mine their mineral deposits (Jara, Lagos, and Tilton, 2008). Because the minerals projects require lump sum investments under considerable uncertainty, the companies are reluctant to invest unless they are guaranteed generous terms (Buckley, 2008). The high fixed costs are an important aspect of companies' bargaining power. Once the uncertainty fades away and the minerals developments begin to operate profitably, the significant fixed costs turn into a liability. The companies cannot simply abandon projects if the host countries impose harsher terms. This progression is recurring. In order to bring new investments or expand existing projects, the countries have to improve investment climate and offer better conditions. However, the new deals become obsolete. Such an interaction between natural resource investors and a host country Raymond Vernon (1971) described as the "obsolescing bargaining". The obsolescing bargain model explains a cyclical shift of bargaining power from the foreign investor to the host country and back. This paper attempts to analyze how much bargaining power mineral producing countries have. If public policy takes a good portion of any rents associated with new discoveries, will this or will this not cause exploration to move elsewhere?

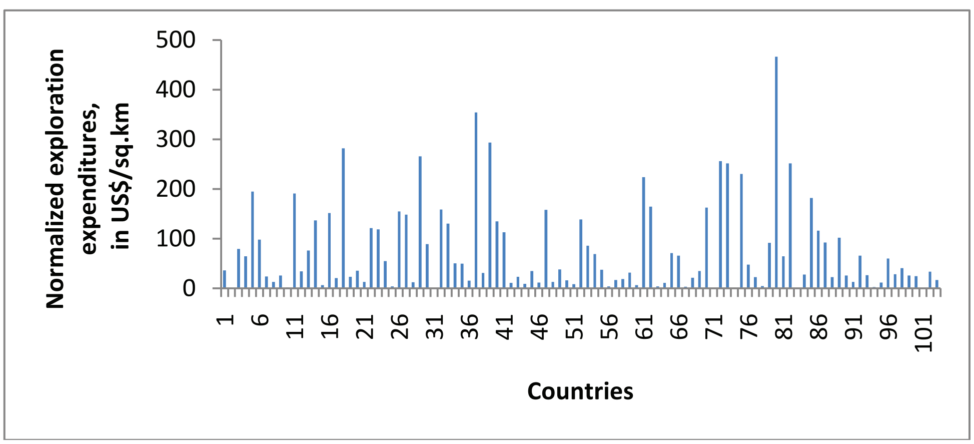
Figure 1 shows how exploration spending varies among countries.[1] Some of the differences among countries are simply due to differences in size what can be associated with land areas - mineral potential (Johnson, 1990). But large intercountry variations remain even after controlling for land areas, see Figure 2. These variations could be influenced by variations in mineral investment policy. The central question then is how much of the differences in country exploration investments are due to country differences in geological potential and to differences in country mineral policies?

FIGURE 1
THE 2006 EXPLORATION EXPENDITURES



We are not aware of studies, which conduct econometric analysis of location factors of non-ferrous exploration spending. Our study is one of the first attempts to model countries' non-ferrous minerals exploration investments and to estimate the relative importance of geological potential and investment environment. The analysis draws upon works by Johnson (1990), Eggert (1992 and 2008), Otto (1992a and 1992b), the Fraser Institute (2006), and Jara, Lagos, and Tilton (2008). These papers point to the two dominant groups of location factors of exploration investments: geological potential and investment climate. Similarly, Dunning (1998), Billington (1999), Campos and Kinoshita (2003), Buckley et al (2007), and UNCTAD (2007) emphasize importance of availability of natural resources and investment conditions for resource seeking Foreign Direct Investment.

FIGURE 2
THE 2006 EXPLORATION EXPENDITURES DIVIDED BY LAND AREAS



The paper builds two models of exploration investments: log-linear and truncated. In the models, the log-transformed exploration expenditures are the dependent variable; geological potential, investment climate, and population are explanatory variables. The population factor is included to account for economies' sizes.[2] The countries' exploration investments data were kindly provided by the Metals Economics Group (MEG). MEG reports exploration expenditures of at least $100,000. It order to take into account effects of this truncation, we consider a one-limit truncated regression model for exploration expenditures. We estimated models using one indicator of geological potential (land areas) and one measure of investment climate (Index of Economic Freedom of the Heritage Foundation and the Wall Street Journal).

The paper is structured as follows. The second section describes the data. The third section presents models of exploration investments. It derives estimates of the relative importance of geological potential and investment climate for exploration spending. The forth section summarizes main findings and conclusions.

DESCRIPTION AND STATISTICS OF DATA SERIES

This section describes the data on exploration expenditures, measures of the geological potential and investment climate, and population. It also presents statistics for the data series.

Exploration investments data are from the Corporate Exploration Strategies 2006 Study of the Metals Economics Group (MEG, 2006). The data include the 2006 budgets of mining companies for exploration of nonferrous metals and diamonds. The compiled series are based on surveys of 1,624 companies, which budgeted $100,000 or more on the 2006 exploration. Total exploration budgets of surveyed companies add to $7.13 billion - approximately 95% of worldwide exploration investments (MEG, 2006). The expenditures are reported for the following exploration targets: gold; base metals – copper, zinc, lead, nickel (does not include aluminum); diamonds; platinum; and other metals or minerals. The MEG Corporate Exploration Strategies Study has the 2006 exploration data for 124 countries and regions. In our regressions analysis, we examine 103 countries. Several countries were not included in the analysis mainly because of lack of the investment climate data for them. Total exploration expenditures of the 103 included countries constitute around 98% of the 2006 exploration spending of surveyed companies. Table 1 contains statistics of exploration expenditures for the analyzed countries. Figure 3 shows a histogram of the 2006 total exploration spending. The range of countries' total exploration investments is between $100,000 and $1,378 million.

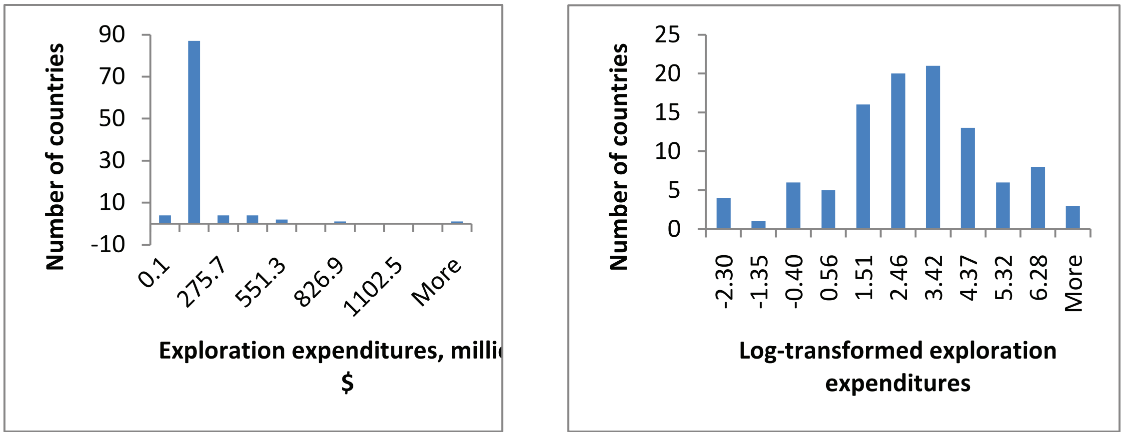
TABLE 1
STATISTICS OF THE 2006 EXPLORATION EXPENDITURES

Number of countries with exploration expenditures in ranges			Statistics, in millions $ (M $)			
0.1- 138 M $	139 - 276 M $	276 - 1,378 M $	Mean	Max	Min	St.Dev
91	4	8	67.62	1,378.10	0.1	176.84

Figure 3 illustrates that exploration expenditures differ significantly across countries: in 91 out of 103 countries total exploration expenditures are between $100,000 and $138 million, while in four countries exploration spending is between $139 million and $276 million, in 8 countries – above $276 million. To reduce non-homogeneity of the data, we take logarithms of the original series. Such logarithmic transformation has been employed in an analysis of foreign direct investments by Bullington, 1999; Cheng and Kwan, 2000; and Wei, 2000. A histogram of the log-transformed total exploration expenditures is also provided in Figure 3.

In our analysis, we examine one measure of geological potential - land areas[3]. Land measures were used as indicators of mineral and resource indicators in Johnson, 1990; Sachs and Warner, 1995; Stijns, 2005; Birdsall et al, 2001. The data on countries' land areas is from the World Bank's database "World Development Indicators 2005" (World Bank, 2005). For a few countries, the land areas data are from the Central Intelligence Agency's (CIA) publication "The World Factbook 2005" (CIA, 2005). Table 2 reports statistics for geological potential and investment environment indicators.

FIGURE 3
HISTOGRAMS OF THE 2006 TOTAL EXPLORATION EXPENDITURES



We use one indicator of investment climate - the Index of Economic Freedom, published by the Heritage Foundation and the Wall Street Journal. The index reflects countries' economic conditions. It is calculated as an equally weighted average of scores for 10 indicators of economic freedom: business freedom, trade freedom, fiscal freedom, government size, monetary freedom, investment freedom, financial freedom, property rights, freedom from corruption, and labor freedom (Heritage Foundation and the Wall Street Journal, 2009). The index values vary between 0 and 100. The higher score indicates economic conditions or policies more favorable to economic freedom. Values of the 2005 index of economic freedom reveal that New Zealand had the most favorable economic environment among analyzed countries. Its score of economic freedom was the highest (82.3). Angola had the lowest index level (24.3). The mean and the median values of the index are almost the same: the mean equals 58.0 and the median equals 56.6. Bolivia has the index value (58.4) closest to the mean. In our analysis, we use the scores of the index of economic freedom for the year 2005.

TABLE 2
STATISTICS FOR MEASURES OF GEOLOGICAL POTENTIAL AND INVESTMENT CLIMATE

Measures	Statistics^				
	Mean	Median	Maximum	Minimum	St. dev
Land areas, in 2005, in thousand sq. km	1,108 (Colombia)	305 (Vietnam)	16,381 (Russia)	9 (Cyprus)	2,425
Index of Economic Freedom, 2005	58.0 (Bolivia)	56.6 (Tanzania)	82.3 best score (New Zealand)	24.3 worst score (Angola)	9.6

^Below statistics we provide names of representative countries.

A significant difference between the mean and median values of land areas in Table 2 suggests a highly skewed distribution: there are only a few countries with largest levels of land areas, while the majority of countries have smaller territories. To reduce variations of the land areas across countries, we use logarithms of the land areas in our models.

We include in models the population factor to control for countries' sizes. Most of the data on countries' population is from the World Bank's database "World Development Indicators 2005" (World

Bank, 2005). For a few countries, the population data are from the Central Intelligence Agency's (CIA) publication "The World Factbook 2005" (CIA, 2005).

CROSS-COUNTRY MODELS OF EXPLORATION INVESTMENTS

In this part we analyze the relative importance of geological potential and investment climate for exploration spending. We build two models: log-linear and truncated. In the models, the log-transformed exploration expenditures are the dependent variable; geological potential, investment climate, and population are explanatory variables. We use logarithms of exploration expenditures to reduce their significant variations across countries (to reduce heteroskedasticity of models' errors terms) and to model non-linear associations of variables. Such logarithmic transformation has been employed in an analysis of foreign direct investments by Bullington, 1999; Cheng and Kwan, 2000; Wei, 2000; Buckley et al, 2007. In the models we analyze total exploration expenditures, which include exploration expenditures by major, intermediate, and junior mining companies.

Log-Linear Model of Exploration Investments

In this section we estimate the log-linear model of exploration investments:

$$lexploration_i = c + b_1 geology_i + b_2 investment_i + b_3 lpopulation_i + \varepsilon_i, \qquad (1)$$

where *lexploration* is the log-transformed total exploration expenditures, $lexploration_i = ln(exploration_i)$, *exploration* is the total exploration expenditures (includes exploration expenditures of major, intermediate, and junior mining companies); *geology* is the geological potential indicator; *investment* is the investment climate indicator, *lpopulation* is the log-transformed population, $lpopulation_i = ln(population_i)$, $\varepsilon_t \sim N[0, \sigma^2]$, i denotes a country, $i = 1, \ldots, 103$. We estimate model (1) for one measure of geological potential (log-transformed land areas – *lland*) and one investment climate indicator (the index of economic freedom - *econfreedom*):

Regression 1:

$$lexploration_i = c + b_1 lland_i + b_2 econfreedom_i + b_3 lpopulation_i + \varepsilon_i$$

Regression 1 results are reported in Table 3. The adjusted R^2 value of 0.48 in Regression 1 is relatively high for cross-country models. In Regression 1, coefficients of geological potential (land areas) and investment climate (index of economic freedom) have expected positive signs and are significant. The geological potential coefficient implies that, if geological potential improves by 1%, then exploration investments grow by1.01%. The investment climate coefficient shows that, if the index of economic freedom goes up by 10 units, then exploration investments rise by 0.31%. For example, if Russia's score of the 2005 index of economic freedom were at the Bulgaria's index level of 62.3, Russia could have seen an exploration spending increase of about 0.31%.

Truncated Model of Exploration Investments

MEG reports exploration expenditures of at least \$100,000. In order to take into account this truncation[4], we estimate a one-limit truncated regression model:

$$lexploration_i{}^* = b' X_i + \varepsilon_i \qquad (2)$$

$$lexploration_i = lexploration_i{}^* \quad \text{if} \quad lexploration_i{}^* > -2.3$$

$$(exploration_i{}^* > \$100{,}000),$$

where *exploration*$_i$* is the latent exploration expenditures variable, *lexploration*$_i$* is log-transformed latent exploration expenditures, *lexploration*$_i$* = ln(*exploration*$_i$*), *lexploration*$_i$ =ln(*exploration*$_i$), *exploration*$_i$ is a truncated (observed) exploration expenditures variable, X_i is a vector of explanatory variables, X_i = (1, *geology*$_i$, *investment*$_i$, *lpopulation*$_i$)', *geology*$_i$ is an geological potential indicator, *investment*$_i$ is an investment climate indicator, *i* denotes country *i*, $\varepsilon_i \sim N[0, \sigma^2]$, $i = 1, \ldots, 103$. We estimate model (2) for one measure of geological potential and one measure of investment climate: *geology* = *lland*, *investment* = *econfreedom*.

Regression 2:

$$lexploration_i{}^* = c + b_1 lland_i + b_2 econfreedom_i + lpopulation_i + \varepsilon_i \,.$$

Maximum likelihood estimation results for Regression 2 are given in Table 3. Magnitudes of coefficients of explanatory variables and the significance statistics in regressions 1 and 2 are close. It appears that truncation at $100,000 does not significantly change importance of geological potential and investment environment for exploration investments, comparing to model (1).

TABLE 3
ESTIMATION RESULTS FOR THE LOG-LINEAR MODEL (1) AND THE TRUNCATED MODEL (2)

Variables	Model 1*	Model 2**
Constant	-11.724 (-7.750)	-10.300 (-7.187)
lland	1.010 (7.966)	0.903 (7.941)
econfreedom	0.031 (2.210)	0.029 (2.214)
lpopulation	-0.185 (-1.390)	-0.141 (-1.160)
Adjusted R^2	0.48	
Log-likelihood	-185.84	-171.62

* t-statistics of the model (1) coefficients estimates are given in parentheses. The t-statistics were derived using the White heteroskedastisity consistent standard errors.
** z- statistics of the model (2) coefficients estimates are given in parentheses. The z- statistics are derived using the Huber/White standard errors

CONCLUSIONS

This work studies variations in countries' non-ferrous minerals exploration investments. It also analyzes the relative importance of geological potential and investment climate for attracting exploration funding. The analysis is performed using cross-country models of exploration investments.

We construct two models of exploration expenditures: log-linear and truncated. In the models we consider two location factors: geological potential and investment climate. An estimation of models is based on the Metals Economics Group's exploration expenditures data, one measure of geological potential, and one indicator of investment climate.

The models quantify the relative importance of geological potential and investment climate and show that both factors influence exploration funding. Exploration does not simply follow geological potential. In order to attract exploration investments, countries rich with natural resources need to work on forming competitive investment environments.

The performed study is based on the exploration expenditures in one year - 2006. In a follow-up paper we will look at changes of the countries' exploration investments over time and factors leading to these changes.

ENDNOTES

1. The horizontal axis of Figure 1 shows countries by their numbers in our sample.
2. We estimated a model with an interaction term between geological potential and investment climate to test whether significance of geological potential for exploration investments depends on investment environment. We found that the interaction term was an insignificant factor.
3. We do not consider mineral reserves estimates as measures of the geological potential because of lack of the data for some analyzed countries. Another measure of geological potential is the Fraser Institute index of mineral potential (Fraser Institute, 2006). In 2006, the index covered only 36 countries. For this reason, we do not use the Fraser Institute index of mineral potential.
4. Truncation results in lower variance than the variance on the original variable. Truncation from below, as in our sample, produces the higher mean than the mean of the original variable.

REFERENCES

Billington, N. (1999). The Location of Foreign Direct Investment: An Empirical Analysis. Applied Economics, 31, 65-76.

Birdsall, N., Pinkney, T. & R. Sabot, R. (2001). Natural Resources, Human Capital, and Growth. Resource Abundance and Economic Growth, R. Auty ed., Oxford University Press.

Buckley, P.J. (2008). Do We Need a Special Theory of Foreign Direct Investment for Extractive Industries? Journal of Chinese Economic and Foreign Trade Studies, 1, (2), 93-104.

Buckley, P.J., Clegg, L.J., Cross, A.R., Liu, X., Voss, H. & Zheng, P. (2007). The Determinants of Chinese Outward Foreign Direct Investment. Journal of International Business Studies, 38, 499-518.

Campos, N. F. & Kinoshita, Y. (2003). Why Does FDI Go Where it Goes? New Evidence from the Transition Economies. IMF Working Paper, WP/03/28.

Central Intelligence Agency. (2005). The World Factbook 2005. Washington, DC, http://www.cia.gov/cia/publications/factbook/

Cheng, L. K. & Kwan, Y.K. (2000). What Are the Determinants of the Location of Foreign Direct Investment? The Chinese Experience. Journal of International Economics, 51, 379-400.

Dunning, J. H. (1998). Location and the multinational enterprise: a neglected factor. Journal of International Business Studies, 29, (1), 45-66.

Eggert, R.G. (1992). Exploration. In: Peck, M.J., Landsberg H.H., Tilton, J.E. (Eds), Competitiveness in Metals – the Impact of Public Policy. London: Mining Journal Books, 21-67.

Eggert, R. G. (2008). Trends in Mineral Economics: Editorial Retrospective, 1989-2006. Resources Policy, 33, 1-3.

Fraser Institute. (2006). Survey of Mining Companies: 2005/2006, Vancouver, Canada.

Heritage Foundation and Wall Street Journal. (2009). 2009 Index of Economic Freedom, Washington, DC.

Jara J.J., Lagos, G. & Tilton, J.E. (2008). Using Exploration Expenditures to Assess the Climate for Mineral Investment. Resources Policy 33, 179-187.

Johnson, C. J. (1990). Ranking Countries for Minerals Exploration. Natural Resources Forum, August 1990, 178-186.

Metals Economics Group. (2006). Corporate Exploration Strategies 2006, Halifax, Canada.

Otto, J. M. (1992a). Results of a Survey of Mineral Investment Preferences. Mineral Investment Conditions in Selected Countries of the Asia-Pacific Region, United Nations, 330-342.

Otto, J. M. (1992b). Criteria for Assessing Mineral Investment Conditions, Mineral Investment Conditions in Selected Countries of the Asia-Pacific Region, United Nations, 1992, 6-34.

Sachs, J. D. & Warner, A.M. (1995). Natural Resource Abundance and Economic Growth, NBER Working Paper Series, Working Paper 5398, Cambridge, Massachusetts.

Stijns, J.-P. C. (2005). Natural Resource Abundance and Economic Growth Revisited. Resource Policy, 30, 107-130.

United Nations Conference on Trade and Development (UNCTAD). (2007). World Investment Report: Transnational Corporations, Extractive Industries and Development.

Vernon, R. (1971). Sovereignty at Bay, Harmondsworth: Penguin.

Wei, S.-J. (2000). How Taxing is Corruption on International Investors? The Review of Economics and Statistics, 82(1), 1-11.

World Bank. (2005). World Development Indicators 2005.