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Export Restrictions in Minerals and Metals

Trade and Prediction of Policy Change

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1. INTRODUCTION

During the past decades, global minerals and metals trade has expanded tremendously with emerging markets such as China and India playing a growing significant role. Countries have become more specialized in producing certain minerals and metals and more reliant on other raw materials from foreign resources. As the global market for commodities grew tighter, the prices for raw materials and their volatility rocketed. Export restrictions[1] on minerals and metals have since become increasingly frequent[2]. The phenomenon consists bursts of escalating but relatively short-lived interventions, medium-to-long-term fiscal adjustments as well as creeping protectionism. Export restrictions are broadly applied across almost all minerals and metals to various extents largely by emerging and developing countries and with different rationales[3]. According to OECD Inventory of Restrictions on Trade in Raw Materials[4] (hereafter called OECD Inventory) (OECD, 2014), 57 out of 72 countries with available data have imposed at least one export restriction on minerals and metals or their wastes and scraps during the period 2009 to 2012. There was a drastic surge of export restrictions usage since about a decade ago – over 50 percent of the restrictions effective in 2012 were enacted after 2009 and 466 out of over 2000 measures were introduced in 2012 itself. The export restrictions have, to various extents, led to global supply shortages and increased volatilities in commodity prices[5]. Accusations that these restrictions have contributed to the frictions and the public trade disputes among governments and their trading partners are not uncommonly seen. In addition, there are further confusion and uncertainty

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[1] Appendix A provides a more comprehensive list of export restriction measures and their definitions.

[2] Appendix B provides a list of countries that impose export restrictions.

[3] The evolution of use of export restrictions saw a pattern shift from an objective which was largely revenue generation centric and to a lesser extent fulfilling domestic obligations (prior to 19th century) to an increasingly diversified objectives of governments besides revenue generation, mainly: 1) to indirectly subsidize downstream industries; 2) to continue generating government revenue; 3) to use natural resources more sustainably; 4) to monitor export activities and combat illegal; 5) to intervene flows of foreign capital and the exchange rate setting mechanism (21st Century) (Goode et al.,1966; Fung and Korinek, 2014).

[4] OECD Inventory is a database established since 2009 to provide systematic track of export restrictions supported by surveys of a great number of counties and raw materials, covering both industrial raw materials and primary agricultural and food commodities. The inventory tracks restrictive trade measures for over 80 industrial raw materials in a various forms: primary and semi-refined/ processed state or in waste and scrap form. It records data for 72 countries (EU as a single region) and for the entire period from 2009 to 2012. The focus of this thesis is on the use of data related to minerals and metals trade and will utilize this database as a starting point for sampling.

[5] This is partially due to the fact that the minerals production is high-concentrated and in a short-term some of the minerals cannot be substituted in industrial production.

caused by these restrictive policies in the global marketplace due to the fact that most of the governments of mineral and metal exporting countries, if not all, announce such policies without advance notice. These could lead to devastating situations for some, be it a country that relies heavily on certain strategic raw materials, a mining company with concentrated productions or a commodity trader with geographically concentrated supply, not only because of the adversely affected access to raw materials but also because of the short turnaround time to adjust their position. As a result, with the prospect of more restrictive export policies, governments of minerals and metals importing countries, multinational mining companies and global commodity traders have begun to incorporate in their business strategies the risk of potential inaccessibility to raw materials. However, there seem to be rare, if not at all, researches into the risk management arena with regard to the export restrictions. Therefore, to establish a groundbreaking risk management tool of such kind suddenly becomes an interesting topic to explore.

This thesis pioneers into the risk management arena from the perspective of the stakeholders of the export restrictions other than the restriction-imposing country. It sets out to establish a useful statistical model to predict whether a given country is going to implement new export restriction policies or tighten the existing policies for a particular type of minerals or metals[6] one year before these measures take place. This model serves as an alert to potential adverse policy changes and allows respective stakeholders of export restrictions to prepare their government policies or business strategies with the one-year lead-time under the proposed model in this thesis. Consequently, the global market will perform more effectively and more efficiently when decisions of traders and end users are based on rational evaluations of potential costs, risks and market opportunities. Furthermore, by developing the statistical model, the thesis also sheds some lights into the influence of each variable on the export restriction policymaking. From the research perspective, this thesis also enriches the literature of export restrictions by bringing in some new variables that seem to have never been statistically tested.

The rest of the thesis is structured as follows. Section 2 introduces the linear multiple discriminant analysis (LMDA) and its usefulness in developing the export restriction policy prediction model. The discriminant model is developed in Section 3, where an initial sample of seventy incidents with a combination of different countries and different minerals or metals is used to establish a function which best discriminates

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[6] The scope of the minerals and metals covered under this study incorporates aluminum, antimony, chromium, cobalt, copper, gold, iron, lead, lithium, nickel, palladium, platinum, rare-earths, tin, titanium, tungsten, zinc. Both primary and secondary (refined metals) are covered.

between incidents in two mutually exclusive groups: policy-tightening incidents and non-policy-tightening incidents. Section 4 reviews empirical results obtained from the initial sample and utilizes a variety of techniques to examine the reliability of the model for its predicting power. In Section 5 the model's adaptability to practical decision situations and its potential benefits in a variety of situations are suggested. A case study on Indonesia's recent export ban on raw materials export is also exemplified in this section. The final section summarizes the findings and conclusions of the study, and proposes some further areas for research.

2. MULTIPLE DISCRIMINANT ANALYSIS

Multiple discriminant analysis [7] (MDA) is a statistical tool, which undertakes to investigate the most significant differences between groups on the basis of the attributes of the cases and to classify an observation into one of several *priori* groupings dependent on the observation's individual attributes. It is used primarily to classify and/or make predictions in problems where the dependent variable appears in qualitative form, e.g. male or female, tightening of export restrictions or not tightening export restrictions. Since the development of MDA by two different researchers, Fisher [8] (1936) and Mahalanobis [9] (1936), who started with different approaches to the problem of discriminating groups, MDA has been applied in a variety of fields such as biological and behavioral sciences (Cohran, 1964), finance studies[10] and face recognition (Etemad and Chellappa, 1997). Unlike multiple logistic regression[11], MDA does not require its dependent variable to be dichotomous. MDA appears in both linear and quadratic forms. Mathematically, linear multiple discriminant analysis (LMDA) is a simplified version of quadratic multiple discriminant analysis (QMDA). For this thesis, whenever MDA is mentioned, it refers to LMDA.

The MDA technique starts with establishing explicit group classifications. The original groups can be two or more. Once groups are established, data are collected for the

[7] Discriminant (Function) Analysis (DA) undertakes the same task as multiple linear regressions by predicting an outcome. However, multiple linear regression is limited to cases where the dependent variable on the Y axis is an interval variable so that the combination of predictors will, through the regression equation, produce estimated mean population numerical Y values for given values of weighted combinations of X values (Agresti, 1996). DA, on the other hand, can be applied to solve this problem by allowing dependent variable be a categorical variable.

[8] Maximal separation is determined from an eigen analysis of $W^{-1}B$, where B is the between-group sum-of-squares and cross-products (SSCP) matrix, and W is the within-group SSCP matrix. Fisher (1936) attempts to maximize the $W^{-1}B$ to achieve optimal discrimination between groups. This thesis is based on the Fisher's approach.

[9] For Mahalanobis (1936), an observation with unknown group membership is classified as belonging to the group with smallest Mahalanobis distance between the observation and group mean.

10 Examples of applications of MDA in finance include: credit evaluation (Durand, 1941), classification of firms with high and low price earnings ratios (Walter, 1959), investment classification (Smith, 1965) and bankruptcy prediction (Altman, 1968).

[11] Logistic regression is a similar statistical tool to DA, as it also explains a categorical variable by the values of continuous independent variables. However, it only allows its dependent variable to represent two categories.

items in the groups. MDA then attempts to derive a linear combination of these attributes which best discriminates between the groups:

$$W = \sum_{i=1}^{n} (V_i * X_i) + a$$

where W = Discriminate function

V = Unstandardized discriminant coefficient

X = Independent variables

a = A constant

i = Number of predictor variables

The resulting function optimizes coefficients V's to maximize the distance between the means of the dependent variable. Large weights (i.e. bigger absolute value of V's) are usually associated with good predictors. Once discriminant function(s) is generated, according to the scores calculated for the new cases, one can predict which group each case belongs to. The number of discriminant functions is one less the number of groups. There is only one function for the basic two-group discriminant analysis.

After careful consideration over the nature of the problem this thesis attempts to resolve, MDA is selected as the most appropriate statistical tool to undertake this task. The MDA technique considers an entire profile of attributes common to the relevant countries and minerals or metals, as well as the interaction of these properties simultaneously, giving it an edge over other univariate statistical analyses. Another advantage of MDA is the reduction of the dimensionality, i.e. from the number of different independent variables to g-1 dimension(s), where g equals to the number of original *a priori* groups. This thesis is concerned with two groups, consisting of export restrictions tightening incidents and export restrictions not tightening incidents. Thus, the analysis is transformed to the simplest form: one dimension.

A couple of assumptions are needed for the MDA technique. First of all, the observations should be a random sample and each predictor variable is normally distributed. Secondly, the covariance matrices should be the same (or very similar) for all groups. These barriers are considered quite high. Nevertheless, past literatures show, in spite of the shortcomings, MDA methods are still widely used among academic researches and business practices. However, there is always a potential problem of high degree of correlation or collinearity among variables when assessing a country's tendency on tightening its export restrictions on a particular mineral or metal using a comprehensive list of parameters. For Altman (1968), although this aspect necessitates careful selection of the predictive variables, it also has the advantage of yielding a model with a relatively small number of selected measurements that will potentially convey a great deal of information.

3. DEVELOPMENT OF THE ERPP MODEL

3.1. Sample Selection

The initial sample is composed of seventy observations, half of which relates to a country tightening export restrictions and the other half relates to a country not tightening export restrictions. It is generally held that the group sizes of the dependent should not be grossly different and should be at least five times the number of independent variables. In our case, the ERPP model is composed of thirteen independent variables, and the entire population of the training sample is more than five times of the number of the independent variables. OECD Inventory contains data for export restrictions from 2009 to 2012. The data for each year is summarized in **Table 3.1**. Year 2010 stands out immediately because it has a larger sample size, more (+) observations, more (+) countries and more countries that have both tightening of policies on some minerals or metals and non-tightening policies on the others. Meanwhile, it is not disadvantaged in the rest of the aspects.

Table 3.1 Summary of OECD Inventory Database for Minerals and Metals by Year[12]

Year	Sample Size	No. of (+) Obs	No. of (+) Ctry	No. of (-) Obs	No. of (-) Ctry	(+) vs (-) Ctry
2009	788	125	9	663	46	5
2010	819	170	17	649	46	12
2011	796	70	13	726	45	8
2012	795	38	9	757	48	9

Source: Author's investigation.

Therefore, 2010 is selected as the year that the training sample is built on. As the number of the countries that tightened their export restrictions is limited to only seventeen in that year, in order to achieve broader representativeness, all seventeen countries are covered under the initial sample. The selection of minerals or metals covered for each country is as follows: firstly, based on the existing records in the OECD Inventory, top-ranked minerals or metals in terms of total productions or total exports are selected; secondly, a filter is applied to all these domestically important observations to obtain those with relative importance in the global markets. It is

[12] (1) (+) represents export restrictions tightening while (-) represents policy not tightening. (2) Each observation above corresponds to an observation in OECD Inventory on a HS6 level for every type of export restrictions. Thus the number of observations is inflated in the table because even when, for instance, six export restrictions are tightened during the year for one mineral or metal, it will be counted as one single entry into author's database to represent a tightening of policy on one particular mineral or metal in one country during that year.
(3) (+) vs (-) represents the number of countries who have both tightening of policies on some minerals or metals and non-tightening policies on the others. The more these types of countries, the more insightful a training sample can be constructed.

easily envisaged that some smaller countries have limited influence on the global markets, and thus will be filtered out from this process. Nevertheless, the top one or two minerals or metals are kept for smaller countries in the initial sample in order to maintain broader country coverage, increasing the model's robustness[13]. Finally, a random selection is conducted among those countries that have quite a few internationally significant minerals or metals.

A paired thirty-five observations are selected to formulate the second group in which the export restrictions were not tightened during 2010. The same sampling process as described above is applied for group two as well. The sampling for group two is less difficult compared with that for group one as there were many more countries that did not tighten its export restrictions on a mineral or metal than those that did.

3.2. Choice of Variables

The literatures on predictors of export restrictions policy change is very limited. Therefore, most of the variables used in the ERPP model are initiated in this thesis based on the potential relevancy to the study. A list of twenty-one potentially useful variables is compiled for the evaluation (see **Appendix C**). From the original list of variables, thirteen are selected as doing the best overall job together in the prediction of policy tightening. In order to reach the final profile of the ERPP model, the following aspects were considered by the author: 1) statistical significance of various alternative functions including determination of relative contributions of each independent variable; 2) inter-correlation between relevant variables; and 3) observation of the predictive accuracy of the various profiles. The final profile of variables includes:

$Prod$ – Current indirect market power. This is measured by the significance of a country's production volume of a mineral or metal to the world's production volume of that mineral or metal. It is hypothesized that the larger the market power of global supply a country possesses, the more likely it is to strengthen the export restrictions.

$Econ$ – The significance of a mineral or metal towards a country's GDP. If a country's economy is significantly contributed by the industry of a particular type of mineral or metal, the government tends to impose or tighten export policies, especially export taxes, on this mineral or metal to collect more revenues. Thus, it is hypothesized that the higher the contribution, the more likely the export restrictions will be tightened. Ideally, the mineral-based economic contribution shall be used. However, due to lack

[13] By including observations related to smaller countries whose minerals and metals do not have most significant influence in the global market place, the discriminant functions generated under the ERPP model will hopefully become more versatile, thus can be applied for prediction of export restrictions policy change for new cases of smaller countries.

of data, the mining and quarrying industry data is used as a proxy to the economic contribution of a particular mineral or metal.

$Govrev$ – Growth of government revenue. This is measured by the change of a country's government revenue from two-year before the year in concern to one-year before the year in concern. In our case, the government revenue of 2009 and 2008 are compared. It is hypothesized that the more the government revenue increases, the less likely the government will tighten the export restrictions, especially export taxes, to collect revenue. On the other hand, if revenue decreases, a government is much more likely to increase taxes to compensate revenue loss in other areas.

GDP – Strength of economy. This is measured by the growth of a country's GDP from two-year before the year in concern to one-year before the year in concern. In our case, the country GDP of 2009 and 2008 are compared. It is hypothesized that if the economy becomes better, a government would have better revenue as well. Therefore, the higher the GDP ratio, the less likely the export restrictions are to be strengthened.

FX – Strength of local currency against dollars. This is measured by the change of a country's FX (denominated as local currency per USD) from two-year before the year in concern to one-year before the year in concern. In our case, the FX of 2009 and 2008 are compared. The reason that USD is used as a currency benchmark is that most of the global commodities, including minerals and metals, are traded in USD. It is hypothesized that if the local currency of a country depreciates, the overall extracting and production costs become relatively low compared with other producing countries, *ceteris paribus*, while the USD-denominated world price for the mineral or metal does not change. This will encourage exports. Therefore, the government's revenue collection target is easier to be achieved and consequently it is less likely to tighten the export restrictions.

$Struc$ – Strength of downstream industry. This is represented by the ratio of the production volume of the processing industry over the production volume of both the upstream and downstream industries. A positive correlation is hypothesized to exit between the strength of downstream industry and the probability of stricter policy. In order to retain the minerals and their subsequent downstream smelting and refining domestically, governments tend to tighten the export policy. This can be evidenced by the measures in many countries where "protecting downstream industries" is used as an excuse for imposing or tightening export measures. As a result, the local downstream industries benefit from lower mineral prices compared with their international counterparts.

$Reserve$ – Potential indirect market power. This is modeled by the proportion of the world's mineral deposit that a country has. The measurement of deposits is either by volume of raw materials or by volume of metal contents these raw materials contain, depending on different cases. The hypothesis of the relationship between this factor and the likelihood of tightening export restrictions is difficult to make—there is a tendency of reserve-rich countries to exert their potential market power to generate more revenue in some cases while in other cases the countries with a low reserve-to-production ratio [14] might want to take their opportunities while reserves still last.

$Owner$ – Level of privatization. This is measured by the share of the total production capacity for a mineral or metal in a country that private sector[15] possesses. In a country that both private sector and state owned companies (SOEs) export raw materials, it is hypothesized that the higher the proportion of private sector, the more likely the government will impose stricter export policies. The underlying assumption is that levying heavier taxes in a scenario that SOEs export the majority of raw materials would not provide the government a significant amount of extra money because SOEs will ultimately remit the profits back to the state in a form of dividends. One caveat for the significance of $Owner$ factor is that it is subject to the influence of royalties or mining taxes used by some governments. When a government collects revenue mainly through royalties or mining taxes, the level of privatization is expected to become insignificant toward the probability of tightening export restrictive measures.

Exp – Current dynamic (direct) market power. This is measured by the significance of a country's export of a mineral or metal to the world's total export of that mineral or metal. The hypothesis on this variable is undetermined. A higher significance of a country's export may lead to more likely tightening of export restrictions due to a government's tendency to take advantage of its market power. On the other hand, it may well be the opposite situation. The high proportion of the supply to the global market may represent that a government has already generated enough revenue out of the existing export taxes and thus less willing to harm the exports by imposing stricter export policies.

$Smug$ – Extent of illegal activities in exporting minerals or metals. This is approximated by the value of the black market of a country as a proportion of the

[14] A low reserve-to-production ratio can be associated with either reserve-rich countries or countries whose reserves are not among the top. Thus, it is not clear if a higher reserve will correlates with higher probability of stricter export policies. For instance, Guinea is one of the top producer of bauxite while it does not possess the largest reserves. Despite that the direction of influence is unclear, *Reserve* factor increases the accuracy of the ERPP model, which measures "collective" explanatory power of the independent variables.

[15] Private sector refers to local private businesses and multinational mining companies.

total value of the world's black market due to lack of precise data on the subject. One of the popular arguments government put forward to impose or tighten the export restrictions is the loss of control over export activities and revenue loss due to illegal exports. Thus, it is hypothesized that the higher the black market value of a country, the more likely the government will take stricter measures in the exports.

Bud – Balance of budget of a government. This is measured by the ratio of government expenditure over government revenue with one-year lead time. This variable supplements $Govrev$ and provides additional information on how short of money the government is in attempting to fulfill its ambition. It is hypothesized that the more deficit the budget is, the more likely the government is going to tighten the export restrictions.

$Unempl$o – Job market performance of a country. Economic success is not the only goal of a government. It is said that in the minerals and metals industry, the more downstream along the value chain the business is, the more labor-intensive it is. It is hypothesized that a higher unemployment rate would stimulate a government's desire to improve the employment by protecting downstream industries, which consequently increases the likelihood of tightening export restrictions.

$Price$ – Value of mineral or metal commodities. This is measured by the change of USD price of the material from two-year lead time before the year in concern to one-year lead time. In our case, the commodity prices of 2009 and 2008 are compared. It is hypothesized that the higher the price of the commodity, the more likely governments will tighten the export restrictions as they also want to take a share out of this commodity boom together with its local mining industries.

Table 3.2 Data Summary of Individual Variables

Variable	Obs	Mean	Std. Dev	Min	Max	F Ratio	P-Value
Prod	70	12.948	20.274	-	97.929	0.014	0.907
Econ	70	7.334	7.683	0.032	44.800	7.478	0.008
Govrev	70	0.983	0.222	0.560	1.850	10.008	0.002
GDP	70	1.013	0.149	0.740	1.850	5.143	0.027
FX	70	2.901	15.177	0.970	128.068	1.005	0.320
Struc	70	33.797	29.075	-	100.000	1.688	0.198
Reserve	70	8.726	13.636	0.000	73.171	2.765	0.101
Owner	70	73.743	38.019	-	100.000	0.947	0.334
Exp	70	7.352	16.274	-	97.300	1.363	0.247
Smug	70	3.251	6.178	0.020	34.530	0.650	0.423
Bud	70	1.112	0.373	0.713	3.034	2.825	0.097
Unemplo	70	10.639	13.640	0.600	80.000	0.930	0.338
Price	70	0.862	0.242	0.461	1.299	0.196	0.659

Source: Author's investigation.

F-test is used to examine the individual discriminating ability of the variables. This test relates the difference between the average values of the predictor in each group to the variability of values of the predictor within each group. Results are summarized in **Table 3.2** above. It is observed that only *Econ*, *Govrev*, *GDP* and *Bud* are significant at a relatively low significance level, indicating significant differences in these variables between groups. The rest of the variables do not seem to have a significant discriminating power at 10 percent significance level. However, the inter-correlations between these non-significant variables display some negative correlations (shown in **Appendix D**), which are considered good by the literature to add extra information to the discriminant function (Cochran, 1964). Indeed, as the empirical test will show, these individually not very significant variables contribute significantly to the classification collectively.

Table 3.3 Relative Contribution of The Variables[16]

	Scaled Vector (Descending Significance)	Individual Significance Ranking
Prod	1.47	13
Govrev	0.95	1
GDP	0.92	3
Econ	0.87	2
FX	0.76	8
Reserve	0.74	5
Exp	0.59	7
Bud	0.54	4
Struc	0.49	6
Unemplo	0.39	10
Smug	0.33	11
Owner	0.30	9
Price	0.17	12

Source: Author's investigation.

Because the actual variable measurement units are not all comparable to each other, the relative contribution of each variable is different than the coefficient to be generated in the ERPP model. The relevant statistic is observed as a scaled vector, which is computed by multiplying corresponding elements by the square roots of the diagonal elements of the variance-covariance matrix. For instance, the square root of the appropriate variance-covariance figure (standard deviation) for *Prod* is approximately 20.274 (see **Table 3.2**) and when multiplied by the variable's

[16] The resulting scaled vector is taken from the standardized canonical discriminant function coefficients. These coefficients indicate the relative importance and relationship between the discriminating variables and the discriminant functions. The difference from the manual calculations is due to rounding.

coefficient 0.072 yields a scaled vector of about 1.46. This standardization is applied to all the variables and the results are summarized in **Table 3.3** with descending order.

Section 2 mentions that collinearity or multi-collinearity is a potential issue that would deteriorate the predictability of the MDA technique. According to Neos and Mevik (2001), collinearity in a discriminant function will lead to instability of eigenvalues and eigenvectors, which may affect the sign of resulting discriminant function coefficients and the relative contribution of each independent variable. The noises created may reduce the predictive power of the model for future applications. After reviewing correlations between every two independent variables, author identified two pairs of correlation that might cause muilti-collinearity, i.e. *GDP-Govrev* and *Reserve-Prod*, both of which have a correlation above 0.75. Variance Inflation Factor (VIF) is therefore applied to all the variables to verify the above suspicion. There are two variables that have a VIF value greater than 10, which is the threshold that merits further examinations or/and adjustments. *Govrev*, with a VIF value of 14.03, is one of the two variables. The other one is *GDP*, which is associated with a VIF value of 12.38.

To assess whether this collinearity will harm the validity of the model, the following aspects have been carefully studied: 1) whether multi-collinearity fundamentally changes the sign of some coefficients; 2) whether multi-collinearity changes the relative contribution of each variable; 3) whether multi-collineraity reduces classification accuracy for the initial dataset; and finally 4) whether multi-collinearity adversely affected the predictability of the ERPP model when applying to new cases[17]. It is found that the collinearity does not change the sign of any coefficients in our case. However, it changes the ranking order of relative contribution per variable. For example, either *GDP* or *Govrev* is of relative low contribution to the predictability, ranking the tenth in the model without variable *Govrev* and the eleventh in the model without variable *GDP* respectively. However, the ERPP model, which is identified with collinearity, ranks *Govrev* and *GDP* at the top (see **Table 3.3**). Another major difference between the ERPP model and the two testing models is the relative contribution of *Bud*. In the testing models, *Bud* is ranked second and fourth while in the ERPP model it is ranked only eighth. It is argued that the ERPP model, nevertheless, is still superior model as it performs better in both step three and step

[17] Three models, the ERPP model, the model without *GDP* variable and the model without *Govrev* variable, are tested following these four-step procedure. In the fourth step, all data are applied to a secondary dataset to assess their performance in predicting new cases. More details about the secondary dataset please refer to Section 4.3.

four, which are the main focus of this thesis—finding a useful prediction tool for export restrictions.

3.3. The ERPP Model

After numerous computer runs analyzing different variables combination, below presents the final discriminant function that best discriminates between groups.

$W = 0.072Prod - 0.118Econ + 4.556Govrev - 6.373GDP + 0.05FX + 0.017Struc - 0.055Reserve + 0.008Owner - 0.036Exp - 0.053Smug + 1.475Bud - 0.029Unemplo + 0.701Price - 0.413$ .... (I)

where

$Prod$ = [Country production of a material]/ [World production of that material]

$Econ$ = [GDP of the mining & quarrying industry in one country]*100/ [Country GDP]

$Govrev$ = [Government revenue]/ {Government revenue}

GDP = [Country GDP]/ {Country GDP}

FX = [Equivalent country currency per USD]/ {Equivalent country currency per USD}

$Struc$ = [Downstream production]*100/ ([Primary production]+ [Downstream production])

$Reserve$ = [Country reserve of a mineral]*100/ [World reserve of that mineral]

$Owner$ = [Private sector production capacity]*100/ ([Private sector production capacity]+ [Public sector production capacity])

Exp = [Country mineral or metal export]*100/ [World export of that mineral or metal]

$Smug$ = [Country black market value]/ [World black market value]

Bud = [Government expenditure]/ [Government revenue]

$Unemplo$ = [Country unemployment rate]*100

$Price$ = [Price of the material in USD]/ {Price of the material in USD}

Notes: [] means that it is one-year-lead-time data taken from one-year before the year in concern; {} that it is two-year-lead-time data taken from two-year before the year in concern.

The final model reveals the correlation between each independent variable and the decision a government makes regarding whether to tighten the export restrictions on a particular type of mineral or metal produced in its country. Reviewing the hypotheses made in Section 3.3 on each variable, all of them are as expected apart from those for *Unemplo* and *Exp*. For *Unemplo*, it goes the other way by indicating that the higher the unemployment rate, the less likely that government will impose stricter rules. A possible explanation could be that although mining industry is integral to a country's economy, it is not the most significant in terms providing employment opportunities compared with other industries such as most labor-intensive services industries. On the other hand, for *Exp*, the model confirms that governments are more concerned about losing the existing export revenues than generating more revenues by taxing more. As discussed previously, due to the multi-collinearity between the *Govrev* and *GDP* factors, the relative contribution among variables are slightly distorted. Nevertheless, the signs and overall predictive power remains valid.

F-test is employed here to determine the overall discriminating power of the model. It calculates the ratio of sums-of-squares between groups to the sums-of-squares within groups. The equation is shown below. When the ratio is maximized, it effectively separates apart the group means of G groups to the maximum while simultaneously pulling individual points within the group together to the best of its ability.

$$F = \frac{\sum_{g=1}^{G} N_g(\mu_g - \mu)^2}{\sum_{g=1}^{G}\sum_{p=1}^{Ng}(i_{pg} - \mu_g)^2}$$

where

G = Number of groups

g = Group g, g = 1 … G

N_g = Number of observations in group g

i_{pg} = Observation p in group g, p = 1 … N_g (in this case the W-score as per equation (I))

μ_g = Group mean

μ = Overall sample mean

The group means for the group with tightening export restrictions and the group without tightening export restrictions are 0.7703 and -0.7732 respectively. The F-ratio for the test stands at 2.6412 with a p-value of 0.006, meaning that a *priori* groups are significantly different at 1% significance level and thus the null hypothesis that the observations come from the same population is rejected.

Therefore, new cases can be assigned to one of the two groups once their W-scores are calculated. The idea is to compare the profiles of the new cases against those of the existing two mutually exclusive groups and assign them to the group they resemble more closely. In our case, the cutoff point for the classification is the mean of the two group means of W-scores, -0.0015. In another word, a new case with a calculated W-score greater than -0.0015 will be assigned to export restrictions tightening group while a new case with a W-score less than -0.0015 will be categorized into the group without stricter export restrictions.

4. EMPIRICAL RESULTS

4.1. Initial Sample

The initial sample of thirty-five observations in each of the two groups is classified in accordance to the classification rule generated under ERPP model. A summary of the classification is presented under the below re-substitution table, **Table 4.1**. The word re-substitution is used because the same observations that built the model are being classified by the model. As a result, a high accuracy rate is expected. In the table, the classification is displayed with *a priori* groupings on the side while the predicted groupings are at the top. The misclassification of a (+) group into (-) group represents the *Type I error* and the misclassification of a (-) group into (+) group represents the *Type II error*. Correct percentages shown in the table are considered analogies to the coefficient of determination (R^2) in regression analysis, which measures the explanatory power of an independent variable in percentage over the total variation of the dependent variable.

Indeed, an overall high accuracy rate of classification at 86 percent is achieved. *Type I error* is extremely low, at only 6 percent, while *Type II error* is far bigger, at 23 percent. This means that if the ERPP model indicates that in a new case, the government is not going to tighten its export restrictions on a mineral or metal, it is probably right; on the other hand, if the ERPP model suggests that in a new case, the government is going to tighten its export restrictions on a mineral or metal, it is more likely right than wrong. It is noted that this classification with initial sample is embedded with an upward bias and should be further validated using various techniques.

Table 4.1 Re-substitution Classification Summary[18]

Actual	Predicted (+)	(-)	Total
(+)	33	2	35
Type I	0.94	0.06	1.00
	Correct	Error	
(-)	8	27	35
Type II	0.23	0.77	1.00
	Error	Correct	
Total	41	29	70
	0.59	0.41	1.00
Priors	0.50	0.50	1.00

Source: Author's investigation.

4.2. Potential Bias And Validation Techniques

According to Altman (1968), the upward bias is caused by 1) sampling errors in the initial sample; and 2) search bias when reducing the initial twenty-one potential variables to the current thirteen. He maintains that "the probability of bias due to intensive searching is inherent in any empirical studies". To assess the bias, the author implements the leave-one-out (LOO) cross validation method, which provides a more realistic assessment of the classification success. The idea of the leave-one-out cross validation (LOOCV) is to use a subset of the initial sample, sixty-nine in our case, as the training sample to formulate a discriminant function and predict the classification of the remaining one observation. The iterative process is run seventy

[18] (+) represents export restrictions tightening while (-) represents policy not tightening.

times over every single observation by the computer to assess the accuracy of the classifications. The graphical illustration of the LOOCV process is presented in **Figure 4.1** and the result of LOOCV is shown below in **Table 4.2**. A 70 percent overall accuracy is achieved after considering the search bias present in the initial sample, down quite a significant 16 percent. However, it does not invalidate the ERPP model as a useful tool in predicting export restriction policy change.

Table 4.2 Leave-one-out (LOO) Classification Summary[19]

	Predicted			
Actual	(+)	(-)	Unclassified	Total
(+)	24	10	1	35
Type I	0.69	0.29	0.03	1.00
	Correct	Error		
(-)	10	25	-	35
Type II	0.29	0.71	-	1.00
	Error	Correct		
Total	34	35	1	70
	0.49	0.50	0.01	1.00
Priors	0.50	0.50		1.00

Source: Author's investigation.

4.3. Secondary Sample

To further assess the predictive power of the ERPP model, a secondary sample consisting of ten exporting restriction tightening observations and ten exporting restriction non-tightening observations is prepared based on the data of year of 2012 in OECD Inventory (2014) (see **Appendix H**). The summary of classification result is presented in **Table 4.3** below.

It is very encouraging that for the secondary dataset the Type I error is as low as 10 percent. Normally, higher error percentage is expected for new cases. Type II error, nonetheless, rockets to 50 percent, meaning half of the export policy tightening predictions are not correct, i.e. the ERPP model overestimates the probability of tightening in general. Regardless, the overall accuracy is 70 percent, which is pretty

[19] 1) The true error is estimated as the average error rate on all test examples.

$$E = \frac{1}{N}\sum_{i=1}^{N} E_i$$

2) There is one observation that is not classified in this LOOCV process due to a tie in classification. This is also a great illustration of data sensitivity of the discriminant analysis. Imagine that the data of one of the relatively more significant independent variable changes, the accuracy rate will be affected immediately. To be conservative, this unclassified observation is deemed as false classification in calculating the accuracy rate.

consistent with the LOOCV result, suggesting that ERPP model is still a good tool to have in predicting policy change.

Table 4.3 Secondary Dataset Classification Summary

Actual	Predicted (+)	(-)	Total
(+)	9	1	10
Type I	0.90	0.10	1.00
	Correct	Error	
(-)	5	5	10
Type II	0.50	0.50	1.00
	Error	Correct	
Total	14	6	20
	0.70	0.30	1.00
Priors	0.50	0.50	1.00

Source: Author's investigation.

5. APPLICATIONS

5.1. Practical Suggestions of ERPP Model

The ERPP model could be useful to six different parties in today's global minerals and metals trade business, namely the raw materials importing countries, mining MNCs, global commodity traders, shipping lines and ship owners, mineral or metal exporting countries other than the one(s) tightening the export restrictions, and investment/ financial analysts.

For raw material importing countries, there is a necessity to securely source commodities that have strategic industrial and military value to their respective industry sectors from international markets. ERPP model allows them to keep a good monitor over their trading partners to assess the foreign supply risks and reduce supply chain vulnerabilities. Should there be any indication that a major trading partner is likely to strengthen its policy on a particular material, the government of the importing country must have a contingent plan and do three things: 1) importing as much as possible until enough from this trading partner before the implementation of the stricter policy; 2) developing new relationship with or enhancing existing relationship with other exporting countries (of the same material) to diversify supplies while importing more tonnages from them; 3) investing into countries with less likelihood of tightening policies in the long-term to secure more resources.

For global commodity traders, in terms of securing supplies to fulfill their short positions, they work similarly as raw material importing countries. Meanwhile, ERPP model provides insights into potential change in fundamentals of supply and demand on certain materials by assessing the export policies of some major exporting countries. If there is indication that the market is getting tighter on certain materials due to the potential policy change, then traders can increase their long position and store the materials in warehouse and sell at a higher price later on. In this sense, ERPP is not only a risk management tool, but to some extent, an opportunity identifier.

For global mining companies, ERPP model is a good tool to assess the political risk when making new investments. Among the equally attractive mining projects, they might want to select the one with less likelihood of stricter export policies unless they are sure that the final products after extracting and processing are not going to suffer from such restrictions. In addition, for the existing projects, by assessing the hosting countries' likelihood to tighten export policies, these MNCs can adjust their business plans accordingly to increase production from mine sites in countries without stricter export policies to fulfill the delivery obligations[20]. In the business plan, mining companies can also schedule shipments better to avoid demurrages due to unable to or short ship exporting materials; they can also study the probability of domestic downstream business if the primary production cannot be or is hard to be exported.

For the ship owners and shipping lines, ERPP model indicates to them a potential loss of opportunity. Regardless of a country tightening or banning its export on certain minerals or metals, by basic economics, the quantity of the materials out of that country drops. The size of the drop depends on the elasticity of the supply. If this country is of great significance by supplying that material into the global market, shipping lines or ship owners will find themselves operating on a less exciting route, making them earn much less comparing to another route, for example, the one from another major country that supplies similar material to the consuming markets. Nonetheless, with accurate prediction, they could well avoid this from happening.

For other exporting countries that supply similar materials as those who potentially will impose tighter export restrictions, the companies and government of that exporting country can carefully study the best actions to take to increase their welfare, for example, increasing the production to obtain bigger market share if the demand elasticity is low. It might prepare the local government better in terms of attracting long-term investment into the country's mining sector.

For investment/ financial analysts, ERPP model can be helpful in assessing the risks that a mining sector company is facing and thus affecting the evaluation of that company. If the stocks of the mining company is floated, investors could short sale

[20] In case of export taxes increase, the delivery obligation will adversely impact companies' profits. However, in case of export ban, the incident is normally regarded as a force majeure event thus the mining countries can walk away or deliver the quantities later on when the problems are resolved.

the stocks and buy back later to pocket some profits given that the tightening of policies will indeed happen. On the other hand, if one mineral or metal from one country is predicted to be affected by the tightening policies, investors could potentially invest into the stocks of companies producing such mineral or metal in a substituting country in anticipation that, when the market gets tighter, the stocks will become bullish.

Although the ERPP model is generated from a small sample featuring on certain countries, certain minerals and metals, the potential usefulness is of great interest to the abovementioned parties. It is simple and low cost compared with other possible approaches. However, this thesis does not claim that the risk management decision with regards to stricter export policies should rely solely on this method. Rather contrarily, it should serve complementarily to the existing risk management mechanisms. Below a case study on Indonesia in 2014 is presented to spot some usefulness of the ERPP model in a real situation.

5.2. Case Study: Indonesia in 2014

5.2.1. A Brief Overview of Indonesia's Mining Industry

Indonesia is among the top ten countries in the world for proven reserves of copper, nickel, tin, bauxite and gold. It accounts for 29-30 percent of global nickel supply, 9-10 percent of aluminum and three percent of copper (Rusmana and Chatterjee, 2014; Sanderson and Hume, 2014). Driven by historically high commodity prices and surging production, Indonesia's total mineral export value rocketed from USD 3 billion to USD 11.2 billion during the period 2001-2013 (World Bank, 2014).

On 11 January 2014, the Indonesian government enacted a ban on unprocessed mineral exports after the postponement from 2012 when the regulation was initially issued. This regulation dates back to 2009 when the Mining Law established the policy of adding value in the mineral sector through domestic processing (World Bank, 2014). However, in the last minute, the government revised its decision by exempting certain semi-processed concentrates, including copper, iron ore, manganese, lead, zinc and ilmenite, and imposing an unexpected export tax on them instead[21] (ICTSD, 2014).

Immediately after the levy of export restrictions, the global market witnessed that nickel price soared over 50 percent to a two-year high of USD 22,000 per tonne between January and mid-May 2014 and since then it has retreated (Sanderson and Hume, 2014). The market power Indonesian nickel has on the global market is said to be the main drive. MNCs such as Freeport McMoRan Inc. and Newmont Mining

[21] The scheme of this extra export duty is summarized in Appendix G.

Corp., which together produce 97 percent of Indonesia's copper, stopped capital expenditure into their assets and halted their copper and gold mine productions once the storage facilities were full (Vella, 2014). Stricter export policies in 2014 have led to a 25 percent and 40 percent drop in copper production of Freeport's and Newmont's Indonesian subsidiaries respectively (Freeport Annual Report 2014; Newmont Annual Report 2014). Country wise, China was the biggest victim of Indonesia's export ban on raw materials, especially for nickel concentrates and bauxite. In 2013, 68 percent of the bauxite and 60 percent of the nickel ores China imported came from Indonesia (Maverick, 2014; Berry, 2014).

5.2.2. Using ERPP Model To Predict Adverse Policy Change

By plugging in the necessary data (i.e. 2012 and 2013 data) required for the ERPP model, we calculate W-scores for Indonesian unprocessed nickel, bauxite and unprocessed copper and reach 0.4514, 0.1216 and 0.7359 respectively. According to the classification rule, export policies on all these minerals are predicted to be tightened during 2014, which was in line with reality. Given that the model could have predicted correctly in Indonesia's case at the end of 2013, what can various parties do to strive for a better outcome?

For raw material importing countries such as China, they could strategically build up stockpile of affected materials, invest and diversify into alternative supplying countries before the actual tightening of export policies. China may not be the most appropriate example as it is known for stockpiling strategic commodities ranging from energy, minerals and metals to agricultural products even without a clear threat in the global market place. Nevertheless, ERPP model can still be useful in providing a tightening signal so that China can adjust the scale and scope of its stockpiling activities accordingly. For other raw material importing countries which do not have a habit of stockpiling, the ERPP model could be of a greater use.

For global mining corporations such as Freeport and Newmont, should they knew that the copper concentrate exports would be tightened, they would have scheduled their shipments or delivery plans more carefully to avoid big sum of demurrage costs. The productions of both companies decreased in 2014 compared with those in 2013. Admittedly this is partially due to the sluggish copper price in 2014, if a strategic plan was built well before the stricter policies, they might have produced more materials form some other assets.

International commodity traders can also benefit from the ERPP model if they knew that they had to secure some alternative supplies from alternative countries—for example, copper from Chile, Peru, Zambia and Democratic Republic of Congo, nickel from Canada, the Philippines and Australia, bauxite from Guinea, Jamaica and

Australia. They can use ERPP model as one of the useful tools to assess the overall market outlook by examining the extent of tightening policies by other major exporting counties.

Other raw materials exporting countries such as the Philippines and Australia, with advance notice from the ERPP model, could take advantage of Indonesia's tighter export policies. It was a trade-off between selling the same or similar quantity of minerals at higher prices and selling more quantity (given that the production can be increased) at not so high prices. In the case of nickel ores or concentrates, Nickel Asia Corp., which accounts for about a third of Philippines' nickel output reported that they could not take new orders as the demand from the market outstripped their capacity (Chen, 2014). If Nickel Asia Corp. knew in advance about the Indonesia's potential export ban, they could have taken some measures to temporarily increase their production capacity if that was more profitable.

For ship owners and shipping lines, with reliable forecast, they could have deployed their vessels on routes that were not affected by Indonesia's export ban. According to Stackhouse (2014), Indonesia accounts for 60 percent of the global seaborne trade of bauxite and nickel. The first half of 2014 saw significant shocks to dry bulk shippers such as DryShips Inc. (DRYS), Diana Shipping Inc. (DSX), Navios Maritime Holdings Inc. (NM) and Safe Bulkers Inc. (SB) (Mao, 2014).

Investors and financial analysts, with careful considerations, could have short sold Freeport McMoRan Inc. (FCX) close to the end of 2013 at a recent peak of USD 37.68 per share and buy back later on when price drop (Yahoo Finance, 2014). The trough before the stock price resumed was USD 30.64 per share (*ibid*). However, the ERPP model only provides some insight into a single aspect of the stock thus should never be considered as a perfect tool to making trading or investment decisions. If for the same reason as FCX, one shorted Newmont Mining Corp. (NEM), he would have lost some money during the same period. Other reported opportunities were: PT Vale Indonesia and PT Aneka Tambang, which mine nickel and have some processing facilities in Indonesia, climbed 5.4 percent and 1 percent on 13 January, two days after the official announcement; on the same date, in Sydney trading, Alumina Ltd. jumped 3.6 percent on prospects for increased demand after the ban went into effect (Rusmana and Chatterjee, 2014).

6. CONCLUDING REMARKS

This thesis pioneers into the export restriction policy prediction avenue by establishing an MDA model which encompasses a number of macro economic indicators as well as variables that are specific to global minerals and metals trade. The resulting ERPP model proves to be fairly successful in predicting the tightening of export restrictions with accuracy rate of 86 percent and 70 percent for the initial sample and the secondary sample respectively. Several practical applications of the model, such as supply risk monitoring, investment appraisal and fundamental analysis are suggested. This study can potentially contribute to academic research, policymaking and global minerals and metals trading business.

A couple of limitations of the study exist: 1) the ERPP model does not specify which export restriction is likely to be tightened; 2) the model is based on annual data, thus does not capture the variability during the year and consequently cannot pinpoint the exact time the export restrictions are to be tightened within the year; 3) the model focuses on the potential risks over export policies while does not indicate opportunities when restrictions are lessened; 4) country macro indicators tend to decrease the accuracy of the model when one would like to use the model to differentiate between tightening and non-tightening policy change on minerals or metals of the same country; 5) the lead time for the model is limited to one year; 6) not all forty commonly used minerals and metals[22] are covered by the ERPP model; and 7) samples and data are limited due to lack of documentation and research and thus need estimations. The abovementioned limitations require further investigations in this field. Another area for future research could be to extend the methodologies of developing the ERPP model into predicting export restriction policy change for energy and agricultural commodities.

[22] According to NMA (2014), there are forty most commonly used minerals and metals.

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APPENDICES

Appendix A: Definitions of Export Measures

Export Restriction	Definition*
Export tax	A tax collected on goods or commodities when they leave a customs territory. This tax can be set either on a per unit basis or an ad valorem (value) basis. Other terminology equivalent to export tax: export tariff, export duty, export levy, export charge. In some countries the term 'cess' is used.
Fiscal tax on exports	A tax not paid at the border, but that only applies to, or discriminates against, goods or commodities intended for export. An example is when the sales tax that a government charges is higher for goods or commodities intended for export than when these goods or commodities are offered for sale in the domestic market. Other terminology equivalent to fiscal tax on exports: export royalty.
Export surtax	A tax collected on goods or commodities when they leave a customs territory, and which is applied in addition to the normal export tax rate. It can be part of a progressive tax system or can be triggered by a price threshold, and so be of a temporary nature. Example: a USD 10 surcharge is applied on each ton of a commodity exported when the world price of this commodity exceeds USD 900/ton. Other terminology equivalent to export surtax: export surcharge.
Export quota	A prescribed maximum volume of exports.
Export prohibition	An absolute restriction on exports, i.e. zero exports. Other terminology equivalent to export prohibition: export ban, export embargo.
Export license/ Licensing requirement	The requirement to obtain prior approval, in the form of a license, to export a good or commodity. There are two types of licensing requirements: (1) Non-automatic export licensing: Exporters must obtain prior approval, in form of a license, to export a good or commodity. This practice requires submission of an application or other documentation as a condition for being authorised to export. Export licenses are often used in conjunction with export quotas. Apart from economic reasons, licensing can be applied for non economic reasons: national security, protection of health, safety, the environment, morality, religion, intellectual property, or compliance with international obligations. Licensing schemes can operate on the basis of product lists, such as lists of banned products or of restricted products that require licences, or be applied to restrict exports by destination (e.g. specific countries), or have other conditions attached, such as that export may be used for a specified purpose only. Other terminology equivalent to non-automatic licensing: export permit. (2) Automatic export licensing: Approval for export is granted in all cases, usually immediately upon a standardised application. This kind of measure usually only assists in the compilation of statistics, does not create burdens or extra transaction costs for exporters and is not recorded in the Inventory.

Export Restriction	Definition*
Minimum export price/ price reference for exports	A minimum permitted price for a good being exported. This practice is often used in conjunction with export taxes because it can facilitate customs procedures by preventing under-invoicing, and can be used as a base for calculating export taxes. In some cases, minimum export prices are not binding but are used as reference prices. Other terminology equivalent to minimum export price: administered pricing.
Dual pricing scheme	The government applies different prices to a product when it is exported than when the same product is sold in the domestic market.
VAT tax rebatereduction/ withdrawal	Most countries with a VAT system will rebate the VAT on exports. By denying VAT reimbursement in whole or part, it is less advantageous to export a product than to sell it domestically. This in turn encourages exports of products produced locally that use the input to produce downstream products. A variant is the removal or reduction of rebate from other sales taxes on exports of a product.
Restriction on customs clearance point for exports	The government specifies ports/entry points through which export of a good or commodity is to be channelled.
Qualified exporters list	The rights to export a certain commodity are allocated to specific companies by the government, through a process of application and registration.
Domestic market obligation (DMO)	The requirement for producers of coal and other minerals to allocate a proportion of their annual production output to the domestic market. (The term “domestic market obligation” appears to be specific to Indonesia, which introduced this measure as an integral part of production-sharing contracts to ensure that foreign contractors were also held responsible for fulfilling the domestic needs of its people.)
Captive mining	When a processing company is required to own the mine that produces its inputs, or has been awarded mining rights with the intention that the company will mine the commodity for use in its own domestic processes and not trade it. Captive mining is a form of government support for firms with access to captive supplies, as well as a means of controlling the price and availability of a commodity. When captive mining concessions increase (as a share of production), exports are likely to fall.
Other export measures	Measures not elsewhere specified, but which influence de jure or de facto the level or direction of exports of goods or commodities.

* Guidance for these definitions of export measures has been provided by the following: OECD (2003), p.8; Bonnariva et al. (2009), p.2; Kim (2010), p.6 and 12 ; Goode (1998).

Source: OECD (2014).

Appendix B: Countries Using Export Restrictions

Country	Minerals and Metals	Waste and Scrap
Afghanistan	X	X
Algeria		X
Argentina	X	X
Australia		
Azerbaijan	X	X
Belarus	X	X
Benin	X	
Bolivia	X	X
Brazil	X	X
Canada		
China	X	X
Colombia	X	X
Cote d'Ivoire		X
Dominican Republic	X	X
Egypt		X
Fiji	X	
Gabon	X	
Gambia	X	X
Ghana	X	X
Grenada	X	
Guinea	X	X
Guyana		X
India	X	X
Indonesia	X	X
Jamaica		X
Japan		X
Kazakhstan	X	X
Kenya		X
Kuwait		X
Kyrgyz Republic		
Former Yugoslav Republic of Macedonia		
Malaysia	X	X
Mali	X	
Mauritius	X	X
Moldova		
Morocco		X
Myanmar		
Namibia	X	
Nigeria		X
Pakistan		X
Paraguay	X	X
Philippines	X	
Russia	X	X

Country	Minerals and Metals	Waste and Scrap
Rwanda	X	X
Senegal	X	
Sierra Leone	X	
South Africa	X	X
Sri Lanka	X	X
Syria	X	
Tajikistan	X	X
Tanzania		X
Thailand	X	
Trinidad and Tobago		X
Tunisia		X
Turkmenistan	X	X
Uganda	X	X
Ukraine	X	X
United Arab Emirates		X
United States		
Uruguay	X	X
Venezuela		X
Vietnam	X	X
Zambia	X	X
Zimbabwe	X	
Column Totals	41	45

Note: For industrial materials records relate to the period 2009-2012.

Source: adapted from OECD (2014).

Appendix C: A Full List of Independent Variables

Variables	Measurement	Notes
Prod	Country production of a particulare mineral or metal as percentage of the world's production	Selected in the final model
Govrev	Growth of government revenue in the past two years	Selected in the final model
GDP	Growth of total GDP in the past two years	Selected in the final model
Econ	Economic contribution of a particular mineral or metal to overall country GDP	Selected in the final model
FX	Change of FX in the past two years	Selected in the final model
Reserve	Country reserve of a particulare mineral or metal as percentage of the world's total reserve	Selected in the final model
Exp	Country export of a particulare mineral or metal as percentage of the world's total export	Selected in the final model
Bud	Government budget deficit/ surplus for the past year	Selected in the final model
Struc	The proportion that downstream industry produciton has compared with county total production	Selected in the final model
Unemplo	Unemployment rate of the country	Selected in the final model
Smug	Level of minerals or metals activities in one country	Selected in the final model
Owner	The ownership of mining secto: private ownership proportion	Selected in the final model
Price	Change of commodity price for a mineral or metal during the past two years	Selected in the final model
RTA	Number of memberships to any global or reginal trade agreements (it is hypothesized that the more membership a country has, the less likely it will tighten the export restrictions)	Tested but not significant
Water	Change of renewable water resource per capita during the past two years (as a proxy towards environment protection; it is hypothesized that the worse deterioration, the more likely the export restrictions will be tightened)	Tested but not significant
Retarliation	Recent trade wars with trading partners	Data deficiency
Habit	How many times the export policy has been tightened during the past five years	Data deficiency
Volatility	Volatility of commodity prices during the past five years	Not considered
Royalty	Royalty or other profit tax etc. which replaces the function of export taxes to generate government revenue	Data deficiency
Stability	Stability of government revenue generation	Not considered
Election	Is the tightening of export restrictions pertaining to a potential election?	Data deficiency

Appendix D: Correlation Matrix for Thirteen Final Independent Variables

	Prod	Econ	Govrev	GDP	FX	Struc	Reserve	Owner	Exp	Smug	Bud	Unemplo	Price
Prod	1.00												
Econ	0.04	1.00											
Govrev	0.01	-0.05	1.00										
GDP	0.05	-0.09	0.90	1.00									
FX	-0.07	0.08	0.47	0.68	1.00								
Struc	-0.15	0.00	-0.14	-0.19	-0.14	1.00							
Reserve	0.76	0.11	-0.15	-0.09	-0.08	-0.20	1.00						
Owner	-0.26	0.21	-0.24	-0.17	0.09	-0.06	-0.06	1.00					
Exp	0.67	0.04	-0.12	-0.04	-0.05	-0.19	0.42	-0.05	1.00				
Smug	0.47	-0.10	0.17	0.11	-0.06	0.09	0.20	-0.30	0.13	1.00			
Bud	-0.27	0.22	0.59	0.36	0.02	-0.12	-0.28	0.03	-0.18	-0.12	1.00		
Unemplo	-0.14	0.09	0.44	0.50	0.62	-0.00	-0.12	0.25	-0.06	-0.20	0.40	1.00	
Price	0.02	0.18	0.09	0.08	0.02	-0.12	-0.04	-0.08	0.07	-0.05	0.20	-0.02	1.00

Note: High correlation is observed in two pairs: GDP-Govrev and Reserve-Prod.
A rule of thumb is that for any correlation greater than 0.75, further investigation over collinearity is merited.

Source: Author’s investigation.

Appendix E: Data Sources for Each Independent Variable

Variable	Data Source
Prod	Most of the data comes from British Geological Survey (2009) and British Geological Survey (2011; 2013). Chile data in 2009 comes from Geological Survey (2009). US Afganistan data in 2009 estimated based on US Geological Survey (2009). Belarus data in 2009 estimated based on: http://www.guenther-tore.de/articles/a-technical-leader-in-aluminium and http://www.alutech-group.com/en/company/history. Morocco data in 2009 estimated based on https://www.lightmetalage.com/producers.php. Kenya data in 2009 estimated based on http://www.acaciamining.com/~/media/Files/A/Acacia/reports/2011/abg-annual-report.pdf.
Govrev	Most of the data comes from World Bank (2008; 2009; 2010; 2011). Rest from CIA Factbook (2008; 2009; 2010; 2011).
GDP	All data comes from World Bank (2008; 2009; 2010; 2011; 2012; 2013).
Econ	Most of the data comes from US Geological Survey (2009; 2011). China data in 2011 comes from AWIC report (2014). China data in 2009 estimated based on US Geological Survey (2009). Zimbabwe data interpolated based on http://www.theindependent.co.zw/2014/10/24/recovery-mining-sector-key-long-term-growth/. Guyana and Tajikistan data estimated based on UN Comtrade (2009).
FX	All data comes from World Bank (2008; 2009; 2010; 2011; 2012; 2013).
Exp	All data comes from UN Comtrade (2009; 2011; 2013). China data in 2011 based on http://www.bbc.com/news/business-13465478. China data in 2009 based on http://www.statista.com/statistics/215979/major-aluminium-exporters/. South Africa and Tajikistan data in 2009 esimated based on US Geological Survey (2009). Phillipines data in 2009 from http://www.victorynickel.ca/projects/minago/. Rwanda data in 2009 from http://en.wikipedia.org/wiki/Mining_in_Rwanda. Russia data in 2009 comes from http://www.zerohedge.com/contributed/2014-03-06/palladium-surges-55-5-days-russia-supply-concerns and http://www.wsj.com/articles/SB10001424052702304256404579453181120437764. Tanzania data in 2009 from http://unctad.org/en/Docs/aldcmisc2011d7_en.pdf. Afganistan data in 2009 estimated base on http://www.unescap.org/sites/default/files/Trade%20Insights%20No.%206.pdf. Global export of platinum, palladium and rare earth in 2009 come from http://www.indexmundi.com/en/commodities/minerals/platinum-group_metals/platinum-group_metals_t5.html, http://www.indexmundi.com/en/commodities/minerals/platinum-group_metals/platinum-group_metals_t5.html and http://fas.org/sgp/crs/row/R42510.pdf.
Bud	All data comes from CIA Factbook (2009; 2011; 2013) or respective government websites, including statistic bureaus or central banks.
Unemplo	Most of the data comes from World Bank (2009; 2011; 2013). Rest from CIA Factbook (2009; 2011; 2013).
Smug	Most of the data comes from Havscope (2014) at http://www.havocscope.com/country-profile/. Rest estimated based on regional shawdow economy percentage from http://www.voxeu.org/article/shadow-economies-around-world-model-based-estimates.
Reserve	Most of the data comes from US Geological Survey (2009; 2011). Belarus, Kenya and Rwanda data in 2009 estimated based on US Geological Survey (2009) on a 10-year mine life basis. Pakistan data in 2009 from http://www.thenational.ae/business/economy/pakistans-500bn-gold-mine-kept-under-wraps and http://www.dawn.com/news/1162943. Sri Lanka data in 2009 comes from http://www.dailynews.lk/?q=business/lankas-iron-ore-needs-innovation-regain-past-glory and http://www.island.lk/index.php?page_cat=article-details&page=article-details&code_title=46462. Tanzania data in 2009 comes from http://thecontinentobserver.com/energy/09/22/tanzania-projected-to-become-leading-iron-producer-in-africa/ and http://www.reuters.com/article/2011/09/22/tanzania-china-mining-idUSL5E7KM1HU20110922. Tunisia data in 2009 comes from http://www.onm.nat.tn/en/index.php?p=indminier. Uganda data in 2009 comes from http://www.uganda-mining.go.ug/magnoliaPublic/en/GeologyMining.html and http://newscastmedia.com/uganda-minerals.pdf. Vietnam data in 2009 comes from http://www.thanhniennews.com/business/vietnam-loses-168-mln-to-illegal-iron-ore-exports-industry-1998.html, http://actamont.tuke.sk/pdf/2000/n2/10kusnir.pdf, http://en.people.cn/200604/26/eng20060426_261383.html and http://actamont.tuke.sk/pdf/2000/n2/10kusnir.pdf. Argentina data in 2009 comes from http://lithiuminvestingnews.com/7418/lithium-in-argentina/. Azerbaijan data in 2009 from

	http://www.azerbaijan.az/_Geography/_Geostructure/geostructure_02_e.html. Chromite reserve in 2011 estimated based on US Geological Survey (2014). For Argentina, Uruguay, Ukraine (2011) which we do not have data, we multiply the current country production with the avg lifespan of the mine. Argentina bauxite mine lifespan is estimated to be 37 years based on http://bauxite.world-aluminium.org/uploads/media/IV_Sustainable_Bx__Mining_Report.pdf. http://www.miningaustralia.com.au/features/on-the-road-for-a-massive-new-iron-ore-mine and http://www.mining-technology.com/projects/mary-river-iron-ore/ indicate 20+ years of iron ore mine. Conservetively, 20 years were taken. South Africa data in 2011 estimated based on https://books.google.ch/books?id=DVdCqL9NbOcC&pg=PA663&dq=chromium+world+reserve&hl=en&sa=X&ei=BLg2Va7aEIG0sgGAr4GQAw&ved=0CB4Q6AEwAA#v=onepage&q=chromium%20world%20reserve&f=false.
Struc	Most of the data comes from British Geological Survey (2009) and British Geological Survey (2011; 2013). Rest based or estimated based on Geological Survey (2009; 2011; 2013) and UN Comtrade (2009; 2011; 2013). Kenya data in 2009 estimated based on http://www.oecd.org/environment/waste/46194971.pdf and http://www.ntv.co.ug/news/business/23/feb/2015/kilembe-copper-smelters-accuse-telkom-kenya-contract-abuse#sthash.2K2g0Cz9.dpbs. Russia data in 2009 esitmated on http://www.goldbarsworldwide.com/PDF/RU_NR_Composite.pdf. Tanzania data in 2009 estimated based on http://www.unitedworld-usa.com/usatoday/tanzania/18energy_trade_industry.htm and http://eonyango.blogspot.ch/2010/04/championing-steel-manufacturing.html. Sri Lanka data in 2009 comes from http://www.worldsteel.org/dms/internetDocumentList/statistics-archive/yearbook-archive/Steel-Statistical-Yearbook-2013/document/Steel-Statistical-Yearbook-2013.pdf.
Owner	Most of the data comes from US Geological Survey (2009; 2011). China data in 2011 comes from AWIC report (2014). Pakistan data in 2009 from http://en.wikipedia.org/wiki/Saindak_Copper_Gold_Project and http://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapid=12964002. China data in 2009 comes from http://zhidao.baidu.com/link?url=Qe9cbR7Liyh3bT1FTy1x0u2G3u6eUk5rz7Y-9MWcof7UdiVrDWRxtiYl5O4N_-BUzCL48KI0gIV5mJahQLt4Aa.
Price	Commodity Price for Al, Cu, Fe, Pb, Ni, Sn, Zn from IMF Commodity Price database (2008; 2009; 2010; 2011; 2012; 2013). Rest based on US market price from US Geological Survey (2009; 2010; 2011; 2012; 2013). Lithium price from http://www.lithiumsite.com/market.html.

Notes to Methodology of Data Collection

This section briefly mentions some of the methodologies used in this thesis in estimating data when they are not readily available. Independent variables that enjoy sufficient data availability, i.e. directly quotable, will not be mentioned below. One caveat to note for the utilization of data is that, for each required data, there could be many inconsistent data presented in different databases or documents. It is inevitable that there might be some omissions regarding overall data consistency when choosing a particular piece of information. Therefore, researchers should bear in mind the potential data sensitivity issue with the resulting ERPP model.

$Prod$ – Majority of the production data comes from British Geological Survey (2014; 2015) or other directly quotable resources. Rest data is estimated by identifying the major players in one country for that particular mineral or metal, finding the production volume, value or capacity and estimating based on these facts. For example, in Afghanistan, the capacity for copper concentrates production is said to be 180,000MT per annum according to US Geological Survey (2009), assuming an average 25 percent copper content of those concentrates, it results 45,000MT annual production of copper.

$Econ$ – Majority of the data comes from US Geological Survey (2009) in a form of percentage the mining and quarrying industry contributes towards a country's total GDP. In cases of Guyana and Tajikistan, the export value of a particular mineral or metal is used to estimate the contribution. In Zimbabwe's case, interpolation is used based on existing 1999 and 2014 data.

$Struc$ – Majority of the data comes from British Geological Survey (2014; 2015) or other directly quotable resources. In cases of Russia and Tajikistan, the smelting capacity of major industry players for a particular metal, quoted in US Geological Survey (2009), is used as refined metal production in that year. Rest estimated based on UN Comtrade (2009) export data following that, for primary raw materials, the minimum production a country has should equal to what it exports. It is, however, not the case for refined metal as a country can import raw materials, smelt them and export some.

$Owner$ – Calculations are based on the structure of the mining industry section in US Geological Survey (2009). Major industry players for each mineral or metal that is significant to a country are listed with capacity of production. A typical calculation of government ownership is illustrated with Zambian copper industry in **Table I** below.

$Smug$ – No smuggling data per country per mineral or metal available. Havoscope (2014) black market value per country over world's total black market percentage is used as a proxy. For a handful countries that are not covered, the black market value in the country is estimated based on Elgin and Oztunail (2012) GDP-weighted shadow economy percentages.

$Price$ – Taken from IMF Commodity Price database for Al, Cu, Fe, Pb, Ni, Sn and Zn. For the rest minerals or metals whose international prices are not standardized in major exchanges, the US market price for the year is used (US Geological Survey, 2009).

All data collected is based on the entirety of one of the three possibilities – export restrictions on primary mine productions or export restrictions on processed materials or both – for a particular material in a particular country. This means, for example, if there is a stricter export policy in one of the many types of processed materials in one country, the data with regards to the whole universe[23] where the processed material belongs to will be collected and used. **Appendix F** displays the final processed data for the model run.

[23] If a country tightens copper blister exports, the whole universe of processed copper, including copper cathodes, copper mattes and so forth, is considered as being tightened in terms of exports. Therefore data is collected accordingly. Although this aggregation reduces the precision per type of product, this seems to be a compromise that has to be made due to data availability issue.

Table I. Zambian Government Ownership in Copper Industry

Production Capacity per Type of Materials	% Ownership	Cu Content (MT)
Ores		
20,000,000	-	-
18,000,000	20.60	5,191.20
4,500,000	20.60	1,297.80
2,800,000	20.60	807.52
2,400,000	20.60	692.16
5,500,000	10.00	770.00
2,500,000	10.00	350.00
1,800,000	-	-
800,000	15.00	168.00
600,000	15.00	126.00
1,200,000	-	-
Concentrates		
50,000	15.00	1,875.00
16,000	15.00	600.00
Cathodes		
80,000	20.60	16,315.20
180,000	20.60	36,709.20
17,000	10.00	1,683.00
27,000	10.00	2,673.00
52,000	-	-
14,000	-	-
8,000	-	-
Blisters		
311,000	20.60	56,378.08
240,000	20.60	43,507.20
200,000	10.00	17,600.00
275,000	10.00	24,200.00
15,000	10.00	1,320.00
150,000	10.00	13,200.00
Total Cu Metal Content Owned by Government		225,463.36
Total Cu Metal Content		1,522,940.00
Government Ownership		14.80%

Source: calculated based on US Geological Survey (2009).

Appendix F: Processed Data of Initial Sample

Country	Minerals or Metals	*GDP*	*Econ*	*Bud*	*Govrev*	*Prod*	*Exp*	*Struc*	*Owner*	*Unemplo*	*FX*	*Price*	*Smug*	*Reserve*	*Priori*	Hit
Afghanistan	Copper	1.23	20.00	3.03	1.61	0.36	0.01	0.00	95.24	40.00	1.00	0.74	0.40	0.03	(+)	Yes
Afghanistan	Iron & Steel	1.23	20.00	3.03	1.61	0.00	0.08	4.58	100.00	40.00	1.00	1.30	0.40	0.04	(+)	Yes
Argentina	Copper	0.93	3.50	0.93	0.93	1.14	0.01	10.06	100.00	7.80	1.18	0.74	0.06	1.46	(+)	Yes
Belarus	Aluminum	0.81	3.30	1.03	0.73	0.11	0.05	50.00	0.00	1.60	1.31	0.65	0.98	0.00	(+)	Yes
China	Iron & Steel	1.10	6.03	0.98	1.17	46.48	4.04	39.40	3.44	4.00	0.98	1.30	14.40	4.38	(+)	Yes
China	Copper	1.10	6.03	0.98	1.17	21.38	2.27	71.72	23.80	4.00	0.98	0.74	14.40	5.45	(+)	Yes
China	Lead	1.10	6.03	0.98	1.17	41.46	1.34	78.00	55.07	4.00	0.98	0.82	14.40	13.92	(+)	Yes
China	Zinc	1.10	6.03	0.98	1.17	37.60	0.71	56.32	35.31	4.00	0.98	0.88	14.40	18.33	(+)	Yes
China	Tin	1.10	6.03	0.98	1.17	42.40	1.60	52.31	47.98	4.00	0.98	0.74	14.40	29.75	(+)	Yes
China	Rare-earth	1.10	6.03	0.98	1.17	97.93	97.30	0.00	2.11	4.00	0.98	1.00	14.40	30.68	(+)	Yes
China	Tungsten	1.10	6.03	0.98	1.17	78.22	14.90	5.82	0.00	4.00	0.98	0.82	14.40	60.00	(+)	Yes
China	Cobalt	1.10	6.03	0.98	1.17	6.90	2.40	80.97	23.08	4.00	0.98	0.46	14.40	1.01	(+)	Yes
Guyana	Aluminum	1.05	0.03	1.16	1.05	4.00	0.00	0.00	82.50	11.00	1.00	0.65	0.04	2.93	(+)	Yes
India	Iron & Steel	1.12	1.91	1.34	1.00	9.59	10.22	22.52	44.77	6.80	1.11	1.30	3.79	2.63	(+)	Yes
Kenya	Aluminum	1.03	0.50	1.24	1.02	0.02	0.01	100.00	100.00	40.00	1.12	0.65	0.05	0.00	(+)	Yes
Kenya	Copper	1.03	0.50	1.24	1.02	0.02	0.02	66.08	100.00	40.00	1.12	0.74	0.05	1.82	(+)	Yes
Kenya	Lead	1.03	0.50	1.24	1.02	0.01	0.02	95.24	100.00	40.00	1.12	0.82	0.05	0.01	(+)	Yes
Morocco	Aluminum	1.02	6.00	1.06	0.94	0.03	0.03	69.23	100.00	10.00	1.04	0.65	0.70	0.00	(+)	Yes
Pakistan	Copper	0.99	2.90	1.45	1.03	0.14	0.36	47.58	0.00	7.40	1.16	0.74	0.36	2.12	(+)	Yes
Russian	Gold	0.74	8.00	0.71	0.56	8.21	0.36	47.27	100.00	6.20	1.28	1.09	2.71	12.77	(+)	No
Russian	Palladium	0.74	8.00	0.71	0.56	24.48	14.48	42.38	100.00	6.20	1.28	0.72	2.71	8.73	(+)	Yes
Russian	Platinum	0.74	8.00	0.71	0.56	5.28	10.22	46.26	100.00	6.20	1.28	0.75	2.71	8.73	(+)	No
Rwanda	Tungsten	1.11	1.00	1.14	1.11	0.95	14.90	0.00	100.00	0.60	1.04	0.82	0.12	1.00	(+)	Yes
Sri Lanka	Iron & Steel	1.03	1.50	1.41	1.01	0.01	0.00	41.67	100.00	5.20	1.06	1.30	0.46	0.00	(+)	Yes
Tanzania	Cobalt	1.03	2.60	1.10	1.03	0.32	0.30	0.00	100.00	2.50	1.10	0.46	0.46	1.58	(+)	Yes
Tanzania	Copper	1.03	2.60	1.10	1.03	0.02	0.02	0.00	100.00	2.50	1.10	0.74	0.46	0.02	(+)	Yes
Tanzania	Nickel	1.03	2.60	1.10	1.03	1.09	0.00	0.00	100.00	2.50	1.10	0.69	0.46	2.58	(+)	Yes
Tanzania	Iron & Steel	1.03	2.60	1.10	1.03	0.01	0.00	64.38	100.00	2.50	1.10	1.30	0.46	0.75	(+)	Yes
Tunisia	Iron & Steel	0.97	1.00	1.14	0.95	0.01	0.02	39.69	46.64	14.00	1.10	1.30	0.94	0.07	(+)	Yes
Uganda	Cobalt	1.04	2.02	1.12	0.99	0.98	0.88	50.00	75.00	4.20	1.18	0.46	0.32	0.09	(+)	Yes
Uganda	Copper	1.04	2.02	1.12	0.99	0.00	0.00	100.00	100.00	4.20	1.18	0.74	0.32	0.01	(+)	Yes

Country	Minerals or Metals	GDP	Econ	Bud	Govrev	Prod	Exp	Struc	Owner	Unemplo	FX	Price	Smug	Reserve	Priori	Hit
Uganda	Iron & Steel	1.04	2.02	1.12	0.99	0.01	0.01	0.00	100.00	4.20	1.18	1.30	0.32	0.03	(+)	Yes
Vietnam	Iron & Steel	1.07	4.40	1.08	1.07	0.08	0.03	58.64	0.00	4.90	1.05	1.30	0.05	0.60	(+)	Yes
Vietnam	Titanium	1.07	4.40	1.08	1.07	12.97	0.67	0.00	91.23	4.90	1.05	1.01	0.05	0.11	(+)	Yes
Zimbabwe	Chromium	1.85	12.50	1.17	1.85	0.96	0.80	0.00	100.00	80.00	128.07	0.90	0.06	0.10	(+)	Yes
China	Aluminum	1.10	6.03	0.98	1.17	34.75	1.05	30.62	52.39	4.00	0.98	0.65	14.40	2.86	(-)	No
China	Titanium	1.10	6.03	0.98	1.17	16.67	0.57	6.40	43.14	4.00	0.98	1.01	14.40	14.18	(-)	Yes
India	Chromium	1.12	1.91	1.34	1.00	17.04	5.96	9.85	100.00	6.80	1.11	0.90	3.79	11.25	(-)	No
Morocco	Lead	1.02	6.00	1.06	0.94	0.22	0.49	36.80	100.00	10.00	1.04	0.82	0.70	0.63	(-)	Yes
Pakistan	Iron & Steel	0.99	2.90	1.45	1.03	0.07	0.05	71.41	0.00	7.40	1.16	1.30	0.36	0.19	(-)	No
Russian	Nickel	0.74	8.00	0.71	0.56	18.74	1.56	48.31	100.00	6.20	1.28	0.69	2.71	9.43	(-)	No
Russian	Tungsten	0.74	8.00	0.71	0.56	8.70	14.66	0.00	100.00	6.20	1.28	0.82	2.71	8.33	(-)	Yes
Sri Lanka	Titanium	1.03	1.50	1.41	1.01	1.15	0.47	0.00	0.00	5.20	1.06	1.01	0.46	1.77	(-)	No
Vietnam	Aluminum	1.07	4.40	1.08	1.07	0.22	0.02	0.00	0.00	4.90	1.05	0.65	0.05	7.24	(-)	Yes
Vietnam	Copper	1.07	4.40	1.08	1.07	0.15	0.08	31.69	0.00	4.90	1.05	0.74	0.05	0.04	(-)	Yes
Vietnam	Zinc	1.07	4.40	1.08	1.07	0.24	0.11	30.91	9.09	4.90	1.05	0.88	0.05	1.28	(-)	Yes
Azerbaijan	Iron & Steel	0.91	44.80	1.08	0.75	0.01	0.01	83.36	100.00	0.80	0.98	1.30	0.88	0.19	(-)	Yes
Bolivia	Antimony	1.04	8.00	0.91	1.04	2.28	0.22	43.90	100.00	7.50	0.97	0.82	0.02	15.00	(-)	Yes
Bolivia	Tin	1.04	8.00	0.91	1.04	5.42	6.21	42.91	40.84	7.50	0.97	0.74	0.02	7.00	(-)	Yes
Indonesia	Copper	1.06	10.50	1.00	0.83	2.35	1.25	22.91	94.28	8.40	1.07	0.74	1.27	6.55	(-)	Yes
Indonesia	Tin	1.06	10.50	1.00	0.83	16.04	30.73	37.71	50.96	8.40	1.07	0.74	1.27	14.00	(-)	Yes
Kazakhstan	Copper	0.86	32.30	1.34	0.86	2.93	1.36	44.73	100.00	6.90	1.23	0.74	2.29	3.27	(-)	Yes
Kazakhstan	Iron & Steel	0.86	32.30	1.34	0.86	0.18	0.56	8.23	100.00	6.90	1.23	1.30	2.29	2.06	(-)	Yes
Malaysia	Tin	0.88	13.00	1.24	0.94	5.98	10.28	93.66	100.00	3.70	1.06	0.74	0.17	8.75	(-)	No
Phillipines	Nickel	0.97	2.00	1.05	0.89	10.08	12.79	0.00	100.00	7.40	1.08	0.69	0.95	1.34	(-)	No
South Africa	Antimony	1.04	8.80	0.99	0.96	1.60	0.00	12.92	100.00	21.70	1.03	0.82	0.22	2.10	(-)	Yes
South Africa	Chromium	1.04	8.80	0.99	0.96	34.15	0.00	0.00	100.00	21.70	1.03	0.90	0.22	41.67	(-)	Yes
Tajikstan	Antimony	0.96	12.13	1.02	0.96	3.21	0.19	10.64	100.00	2.30	1.21	0.82	0.10	2.38	(-)	Yes
Zambia	Copper	0.86	8.90	1.09	0.74	7.42	3.90	35.71	85.20	50.00	1.35	0.74	0.33	3.45	(-)	Yes
Australia	Cobalt	0.88	8.80	0.99	0.81	10.82	7.39	43.02	100.00	5.70	1.08	0.46	0.81	21.13	(-)	Yes
Australia	Iron ore	0.88	8.80	0.99	0.81	17.70	37.70	2.36	100.00	5.70	1.08	1.30	0.81	17.50	(-)	Yes
Australia	Nickel	0.88	8.80	0.99	0.81	10.98	1.94	44.11	100.00	5.70	1.08	0.69	0.81	37.14	(-)	Yes
Chile	Copper	0.96	15.60	0.81	0.74	54.89	21.02	22.01	59.98	10.00	1.07	0.74	0.02	29.09	(-)	Yes
Chile	Lithium	0.96	15.60	0.81	0.74	73.62	43.03	0.00	100.00	10.00	1.07	0.99	0.02	73.17	(-)	Yes
Peru	Copper	1.00	8.20	0.91	0.90	12.71	12.88	20.34	100.00	9.00	1.03	0.74	0.37	10.91	(-)	Yes
Peru	Tin	1.00	8.20	0.91	0.90	5.92	6.50	47.83	100.00	9.00	1.03	0.74	0.37	12.43	(-)	Yes

Country	Minerals or Metals	*GDP*	*Econ*	*Bud*	*Govrev*	*Prod*	*Exp*	*Struc*	*Owner*	*Unemplo*	*FX*	*Price*	*Smug*	*Reserve*	*Priori*	Hit
United States	Copper	0.98	1.31	1.18	0.89	14.11	11.75	33.61	100.00	9.30	1.00	0.74	34.53	6.36	(-)	Yes
Canada	Nickel	0.89	0.60	1.00	0.88	9.29	0.88	46.22	100.00	6.10	1.07	0.69	4.30	7.00	(-)	No
Brazil	Iron ore	0.98	2.40	0.90	0.88	16.78	28.66	13.50	100.00	7.40	1.09	1.30	0.94	10.63	(-)	Yes
South Africa	PMG	1.04	8.80	0.99	0.96	46.75	72.29	50.00	100.00	21.70	1.03	0.75	0.22	8.73	(-)	Yes

Notes:
1) All data are shown in two decimals due to presentation. Data collected from various sources, details see **Appendix E**.
2) (+) represents export restriction tightening observations while (-) stands for non-tightening incidents.

Source: Author's investigation.

Appendix G: Indonesia's Unexpected Export Tax Scheme

Mineral	Unprocessed exports banned?	Export tax on unprocessed exports?	Export tax on unprocessed exports as percent of sales revenue					
			2014		2015		2016	
			H1	H2	H1	H2	H1	H2
Nickel	Yes	n.a. as exports banned	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bauxite	Yes	n.a. as exports banned	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Copper	No	Yes, for IUP and CoW	25	25	35	40	50	60
Iron Ore	No	Yes, for IUP and CoW	20	25	35	40	50	60
Lead	No	Yes, for IUP and CoW	20	25	35	40	50	60
Zinc	No	Yes, for IUP and CoW	20	25	35	40	50	60
Tin	n.a. as all Indonesian tin exports are currently processed		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: GoI Regulations (GR 1/2014, MoF 6/2014); World Bank Staff Summary.

Source: World Bank (2014).

Appendix H: Processed Data of Secondary Sample

Country	Minerals or Metals	*GDP*	*Econ*	*Bud*	*Govrev*	*Prod*	*Exp*	*Struc*	*Owner*	*Unemplo*	*FX*	*Price*	*Smug*	*Reserve*	*Priori*	Hit
China	Antimony	1.23	6.00	1.11	1.25	82.60	25.37	57.14	30.49	4.30	0.95	1.71	14.40	0.05	(+)	Yes
China	Rare-earth	1.23	6.00	1.11	1.25	95.13	97.00	0.00	18.59	4.30	0.95	3.10	14.40	50.00	(+)	Yes
China	Tin	1.23	6.00	1.11	1.25	44.00	1.29	54.97	47.98	4.30	0.95	1.28	14.40	31.25	(+)	Yes
India	Chromium	1.08	2.63	1.51	0.95	14.20	1.17	2.23	100.00	3.50	1.02	1.28	3.79	10.59	(+)	Yes
Indonesia	Nickel	1.15	9.30	1.09	1.40	1.21	5.69	8.00	72.07	6.60	0.96	1.05	1.27	4.88	(+)	No
Indonesia	Tin	1.15	9.30	1.09	1.40	15.62	18.43	40.65	28.43	6.60	0.96	1.28	1.27	16.67	(+)	Yes
Ukraine	Aluminium	1.20	7.00	1.21	1.43	0.02	0.03	0.44	100.00	7.90	1.00	1.10	0.24	0.00	(+)	Yes
Ukraine	Iron	1.20	7.00	1.21	1.43	2.41	6.94	44.32	100.00	7.90	1.00	1.14	0.24	2.63	(+)	Yes
Uruguay	Iron	1.21	0.80	1.04	1.20	0.00	0.01	35.06	100.00	6.30	0.96	1.14	0.94	2.03	(+)	Yes
Zambia	Copper	1.17	8.80	1.17	1.41	3.87	3.67	40.86	13.24	13.20	1.01	1.17	0.51	2.90	(+)	Yes
Bolivia	Antimony	1.22	9.60	1.01	1.01	2.63	3.10	8.61	65.91	2.70	0.99	1.71	0.02	17.22	(-)	Yes
Canada	Nickel	1.10	0.70	1.08	1.09	10.49	0.45	39.34	100.00	7.40	0.96	1.05	4.30	4.13	(-)	No
China	Cobalt	1.23	6.00	1.11	1.25	4.85	6.71	83.63	23.08	4.30	0.95	0.86	14.40	1.07	(-)	Yes
Kazakhstan	Iron	1.27	18.20	1.13	1.15	0.29	1.61	13.16	100.00	5.40	1.00	1.14	3.73	1.25	(-)	Yes
Kazakhstan	Copper	1.27	18.20	1.13	1.15	2.85	1.74	47.41	100.00	5.40	1.00	1.17	3.73	1.01	(-)	Yes
Kazakhstan	Aluminium	1.27	18.20	1.13	1.15	0.55	0.11	12.98	100.00	5.40	1.00	1.10	3.73	0.55	(-)	Yes
Malaysia	Aluminium	1.17	6.30	1.27	1.30	0.06	0.13	0.00	100.00	3.10	0.95	1.10	0.17	0.02	(-)	No
South Africa	Chromium	1.11	8.80	1.22	1.12	40.46	0.13	32.26	100.00	24.70	0.97	1.28	0.22	26.67	(-)	No
Russian	Copper	1.25	10.70	1.30	1.43	4.64	2.72	47.77	100.00	6.50	0.99	1.17	2.71	4.35	(-)	No
Dominican Republic	Nickel	1.10	0.40	1.21	1.10	0.74	0.00	50.00	90.00	14.70	1.02	1.05	0.01	1.25	(-)	No

Notes:
1) All data are shown in two decimals due to presentation. Data collected from various sources, details see **Appendix E**.
2) (+) represents export restriction tightening observations while (-) stands for non-tightening incidents.

Source: Author's investigation.