OECDpublishing

Please cite this paper as:

Fung, K. and J. Korinek (2013-05-14), "Economics of Export Restrictions as Applied to Industrial Raw Materials", *OECD Trade Policy Papers*, No. 155, OECD Publishing, Paris.
http://dx.doi.org/10.1787/5k46j0r5xvhd-en

OECD Trade Policy Papers No. 155

Economics of Export Restrictions as Applied to Industrial Raw Materials

K.C. Fung,

Jane Korinek

OECD TRADE POLICY PAPERS

The OECD Trade Policy Paper series is designed to make available to a wide readership selected studies by OECD staff or by outside consultants. This series continues that originally entitled OECD Trade Policy Working Papers.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

This document has been declassified on the responsibility of the Working Party of the Trade Committee under the OECD reference number TAD/TC/WP(2012)23/FINAL.

Comments on the series are welcome and should be sent to tad.contact@oecd.org.

OECD TRADE POLICY PAPERS

are published on www.oecd.org/trade

Abstract

ECONOMICS OF EXPORT RESTRICTIONS AS APPLIED TO INDUSTRIAL RAW MATERIALS

Governments intervene in non-renewable natural resources sectors more than in many others, including through the use of export taxes and quotas. Industrial raw materials sectors are characterized by a number of specificities: production is often geographically concentrated, firms are often large with substantial market power, production processes are highly capital intensive, products are relatively homogeneous and potentially substantial differences in costs of production are prevalent. This paper aims to increase understanding of the economic effects of export restrictions, in particular as they apply to the mining sector. It ascertains the prevalence of export restrictions on metals and minerals, proposes a Cournot-Nash model of export restrictions, suggests some of the economic effects due to the presence of export restrictions, and draws some implications for trade policy among producing and consuming countries of non-renewable natural resources.

Keywords: Export restrictions, export tax, export quota, export prohibition, export ban, industrial raw materials, extractive industries, mining sector, Cournot-Nash model.

JEL Classification: F12, F13, L72, Q37

ACKNOWLEDGEMENTS

This paper was authored by K.C. Fung, Professor of Economics at University of California at Santa Cruz and Jane Korinek of the OECD Secretariat. Statistical assistance and advice on use of the OECD export restrictions database was provided by Tarja Mard. The authors are grateful for comments and discussions on earlier versions of this paper by Frank van Tongeren of the OECD Secretariat, Roberta Piermartini of the WTO Secretariat and Tim Josling, Professor Emeritus of Stanford University. The final report benefitted from discussions in the OECD Working Party of the Trade Committee, which has agreed to make the study more widely available through declassification on its responsibility.

Table of contents

Tables

Figures

Boxes

Executive Summary

This paper aims to increase understanding of the economic effects of export restrictions, in particular as they apply to industrial raw materials. Existing studies on the economic consequences of export restrictions are relatively limited, particularly compared to existing analysis on import taxes and quotas. Industrial raw materials sectors are characterized by a number of specificities: geographically concentrated production, large firms with substantial market power, highly capital intensive, relatively homogeneous products and potentially substantial differences in costs of production. In particular, government interventions in these sectors are more prevalent than in many others, including through the use of export taxes and quotas.

A theoretical model has been developed to represent interactions in industrial raw materials markets. The model permits a clearer understanding of the economic impacts of export taxes and quotas on raw materials market participants. An export tax or quota in a large raw materials producing country implies a shift in welfare and in profits from domestic raw materials producers and foreign downstream producers to domestic downstream producers and foreign raw materials producers. Raw materials producing firms subject to export restrictions will move to lower production levels and therefore lower employment. Lower profit levels will also imply that domestic raw materials firms will decrease their investment. In some raw materials sectors, the technology input in the downstream sector is significant. In mining, the downstream sector is generally more labour intensive. Therefore a net shift within the country imposing the restriction will occur toward greater investment in the downstream technology and toward job creation in the labour intensive industry.

Abroad, raw materials producers gain from higher world prices and lower exports of the firm(s) in the country that is subject to a tax or quota. Raw materials producers in countries that are not subject to the export restriction will therefore increase production. Higher world prices for their goods will increase their profits. Foreign downstream producers will lose out because of higher prices for their inputs. They will invest and produce less due to their lower profit margins. There will be a tendency toward a net decrease in jobs in countries not subject to the export restriction since the downstream industries tend to be more labour intensive.

In some cases, the downstream industry in the country imposing the export restriction is not able to avail itself of the more favourable market conditions. It will therefore look to foreign investment and transfers of technology in order to expand or initiate production. Downstream foreign firms (i.e., firms outside the country imposing the export restriction on raw materials), hit by higher prices of inputs, may be willing to outsource some of their production to firms in the country where the export restriction is imposed. They may also be willing to sell some of their know-how or proprietary processes if they can no longer produce profitably. The government imposing the export restriction may

attempt to create an incentive for greater investment in its downstream industry by competing foreign firms.

In the longer term, however, technological innovation will tend to suffer. This is due to the fact that the returns to innovation in the downstream sectors have fallen in all countries outside the one imposing the export restriction. One area in which technological innovation will be fostered however is finding alternative materials to the one on which the restriction is placed. If such a break through happens, the export restrictive policy will have been self-defeating.

The industrial raw materials that are produced from extractive industries are by nature non-renewable. Their supply however is not fixed in the medium term, nor is it always known. In many countries, new deposits are found regularly and new information concerning existing deposits is compiled. Imposing an export tax, and to an even greater extent an export quota, will negatively impact future production by reducing firms' incentives to undertake new exploration in the country imposing the restriction. Firms will reduce their exploration activities when facing export restrictions which strongly compromises future production possibilities. Given that exploration is a necessary component in the extractive industries, the negative effects of export restrictions could be felt for many years.

A strong incentive for governments in some countries to impose export taxes is to collect revenue. In the case that the revenue from export taxes represents a significant share of total government revenue, governments will attach a high level of importance to them. In these countries, taxes will be a trade policy instrument of choice as opposed to quotas since they create a direct source of revenue for the public sector.

This policy research shows that some of the impacts of export restrictions are potentially stronger in the case of an export quota as compared with an export tax although production levels and changes in world prices may be similar. Firstly, in the event that there is an increase in the demand for the raw material in the importing country, an export tax will allow an increase in exports, albeit at a higher price level. In the case of a binding export quota, however, there will be no change in exports thereby creating further market distortions. Additionally, there is a strong incentive in the case of an export quota for firms to engage in more collusive behaviour in some market configurations – and governments considering implementing export quotas may need to guard against such negative effects.

Introduction

This paper aims to increase understanding of the economic effects of export restrictions, in particular as they apply to industrial raw materials.[1] Industrial raw materials sectors are characterized by a number of specificities. In particular, government interventions in these sectors are more prevalent than in many others, including through the use of export taxes and quotas.

The existing literature on the economic consequences of export restrictions is relatively limited, particularly in comparison to the existing analysis on import taxes and quotas. In addition, much of the relevant analysis is undertaken in the context of the agriculture sector. The agriculture sector has its own specificities – supply (planting) decisions at fixed times, uncertainties linked to climate, price volatility, etc. – that are not necessarily replicated elsewhere. This paper aims to make a contribution to the existing analysis on export restrictions using some of the characteristics of industrial raw materials sectors as a backdrop to model specifications.

Industrial raw materials sectors exhibit their own particularities. Firstly, natural resources in the extractive industries are often geographically concentrated. In some cases, a majority of minerals or metals are found in one or two countries. Moreover, for some mineral exporting countries, a few products from the extractive industries make up a large share of their total exports. Thus, export diversification is sometimes low, and domestic income, employment and government revenue are often quite dependent on the value generated by a single industry.

Firms in extractive industries are often multinationals based outside the country where they are operating and that have sizeable market power. The relative scarcity of technical skills, access to funding and the ability to assume risk over the long term implies that few firms worldwide are able to compete in large mining ventures (Broadway and Keen, "Perspectives on resource tax design", in Daniel et al., 2010). At the same time, these firms sometimes represent formidable potential for wealth generation in the countries in which they operate. In some countries, a large mining or refining firm is state-owned.

Extractive industries are generally characterised as highly capital-intensive with low levels of employment creation. Downstream industries are those industries located along the chain of processing as the product is transformed from ore to concentrate to powder, mineral to metal, and finally to finished products. As the downstream processing industries are farther from the mineral extraction, they tend to require more sophisticated technological inputs and knowhow and create more jobs, i.e., a refining or smelting plant tends to be more labour intensive than a mine; a plant producing semi-finished goods tends to be more labour intensive than a smelter; and a factory producing finished manufactures tends to be still more labour intensive.

Mineral resources are, generally speaking, relatively homogeneous goods. Although the quality and grade of extracted ores can vary, in processed form metals are relatively

[1] Industrial raw materials are defined here are the unprocessed or minimally processed products of the mining sector. "Industrial raw materials" and "products of the mining sector" are used interchangeably. Not included in this definition are agricultural raw materials, fossil fuels or natural resources from the forestry sector.

homogeneous across different producers. This implies that the cost of extraction may vary considerably but the price of the final good is similar across producing firms.

A particular characteristic of the extractive industries is the exhaustibility of the non-renewable natural resources. This does not mean that new deposits are not found; and the extent to which deposits are exploited depends on confluent factors. It means, however, that optimal extraction rates calculated at present are a function of optimal extraction rates in future: there is a trade-off between present and future production and consumption.

This paper takes into account all of these specificities of the extractive industries sector in informing the choice of theoretical model used to examine the economic effects of export restrictions. The Cournot-Nash oligopolistic model with imperfect competition most closely describes the raw materials sector. This model exercise is unique in the type of model used in the context of export restrictions in the extractive industries sector. The model will be used to shed light on the impacts of export taxes and quotas on domestic and foreign producers and consumers, governments in terms of the revenue they collect and on their countries' welfare, and global prices and availability.

This paper is organized in the following way. The next section reviews the frequency and extent to which export taxes and quantitative restrictions are used in the minerals sector. The following section reviews the existing literature on impacts of export restrictions. Section four outlines the Cournot-Nash oligopolistic model. Section 5 draws conclusions for policymakers regarding the industrial raw materials sector.

Use of export restrictions on industrial raw materials

Before examining the economic effects of export restrictions, this section outlines the frequency and extent of use of export restrictions in industrial raw materials. Export restrictions are used more readily on some products such as metals and minerals, agricultural products and wood, as compared to manufactures. The industrial raw materials sectors are characterized by relatively low import restrictions but higher than average export restrictions. Tariff escalation, i.e., import tariffs that are higher on semi-processed and final products than on raw materials and inputs, can also be found in these sectors.

The OECD has compiled data on export taxes, export quotas and bans that are used by major exporters of industrial raw materials. For each material, official government data were collected and verified for the five leading countries in terms of share of global production in 2009.[2] [3] The database records export restrictions that governments have

[2] Information used here refers to export restrictions on metals and minerals (Harmonized System 2007 codes HS26, HS28 and HS71-74 and 76-81). Information used in this analysis excludes waste and scrap except when otherwise indicated.

[3] Not included in the inventory are regulatory measures which countries apply to honour multilateral conventions such as the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Kimberley Process and existing conventions on the non-proliferation of weapons. These export controls are monitored and documented by the respective regimes. A methodological note outlining the criteria used to compile the data, product and country coverage, etc. can be found at: /www.oecd.org/tad/non-tariffmeasures/methodologyinventoryexportrestrictionsrawmaterials09102012.pdf. A preliminary analysis of the dataset is available in Fliess and Mard (2012).

applied during the period of 2009-2010. 100 countries that produce industrial commodities are covered, including 28 OECD countries. In addition to the five largest producers of each product, information on export restrictions was included for smaller producers in the case that it was known and could be well documented and verified. Given the non-comprehensive nature of information regarding smaller producers, however, it was not used systematically throughout the analysis here and care was taken to compare across products when using it.

There is a great diversity in the use of export taxes and export quotas and prohibitions across countries and across products. Export taxes are used much more frequently than export quotas or prohibitions. Large exporters use export taxes frequently on some products. Export taxes are most used on iron and steel, followed by aluminium, copper, cobalt, precious metals (i.e. silver, gold, platinum, iridium, osmium, palladium, rhodium and ruthenium), molybdenum, manganese and diamonds (Figure 1). At least two of the main global suppliers use export taxes on a substantial number of the industrial raw materials examined. Only eight of the 47 products examined are not subject to export taxes.[4]

Export quotas are used more infrequently than export taxes on industrial raw materials. The product which is most frequently subject to quantitative export restrictions is iron and steel (by two major exporters). Products on which quantitative export restrictions are placed by one major exporter are: indium, cerium, other rare earth elements, antimony, pig iron, silver, tin, tungsten, molybdenum and aluminium (Figure 1). Thirty-one of the 47 products are not subject to quantitative restrictions by any of the exporters examined.[5]

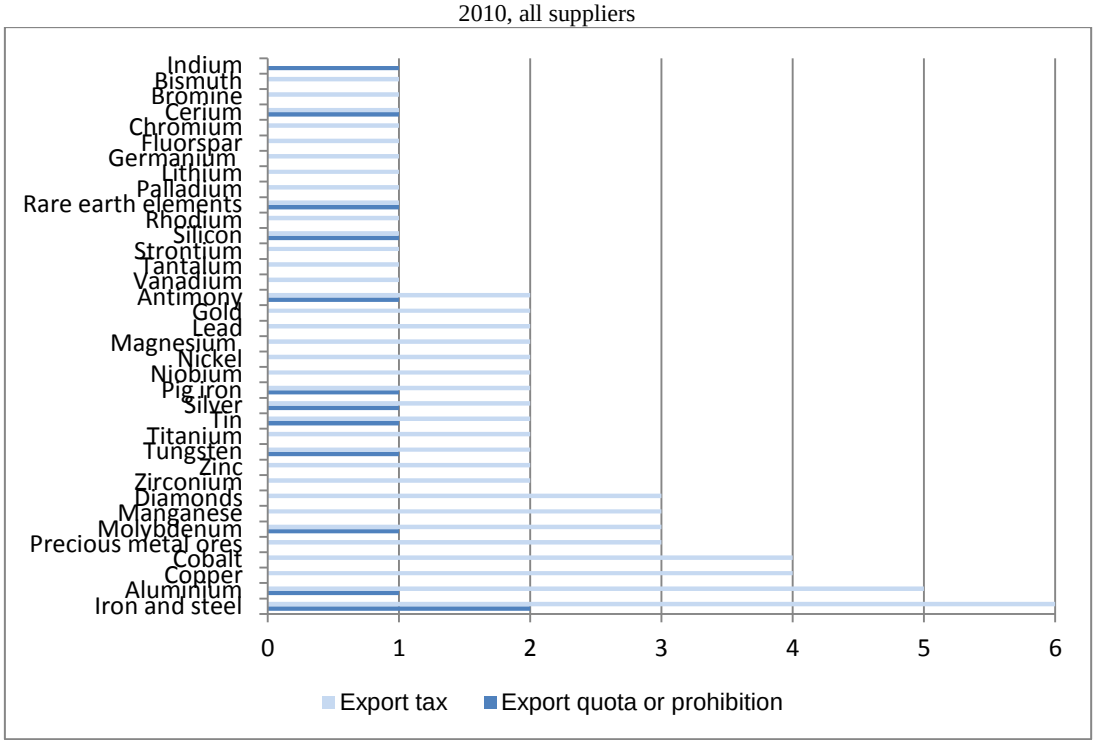
There is a large difference between the countries examined in their use of export restrictions. In some countries, export restrictions are very widely used on exports of metals and minerals. Argentina uses export taxes the most often by far, with 210 products (Harmonized System 6-digit level) subject to the tax; China resorts to using export taxes on 107 products (HS 6-digit), followed by India (74 products), Vietnam (35 products) and Russia (27 products). Export quotas are used only by China in the dataset, which quantitatively restricts exports of 31 (HS 6-digit) products. Export bans or prohibitions are rarely used: Uruguay imposes an export ban on three products, and Azerbaijan places a ban on one product. A large number of countries examined do not use export taxes, quotas or prohibitions on any exported metals and minerals. No taxes or quotas are used on exports from Australia, Bolivia, Brazil, Canada, Central African Rep., Chile, Dem. Rep. of Congo, Finland, France, Gambia, Ghana, Grenada, Israel, Japan, Jordan, Kenya, Korea, Kuwait, Kyrgyzstan, Malaysia, Mali, Mauritius, Mexico, Mongolia, Morocco, Mozambique, New Caledonia, Paraguay, Peru, Philippines, Rwanda, Senegal, Surinam, Tanzania, Turkmenistan, Turkey, Uganda and United States.

4 These are: Arsenic, Beryllium, Cadmium, Iodine, Mercury, Sulphur, Tantalum, and Thallium.

5 These are: Arsenic, Beryllium, Bismuth, Borates, Cadmium, Chromium, Cobalt, Copper, Diamonds, Fluorine/bromine, Gold, Iodine, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Niobium, Ruthenium, Palladium, Phosphates, Rhodium, Strontium, Sulphur, Tantalum, Thallium, Titanium, Vanadium, Zinc, and Zirconium.

Figure 1. Number of countries with at least one export measure in force

2010, all suppliers



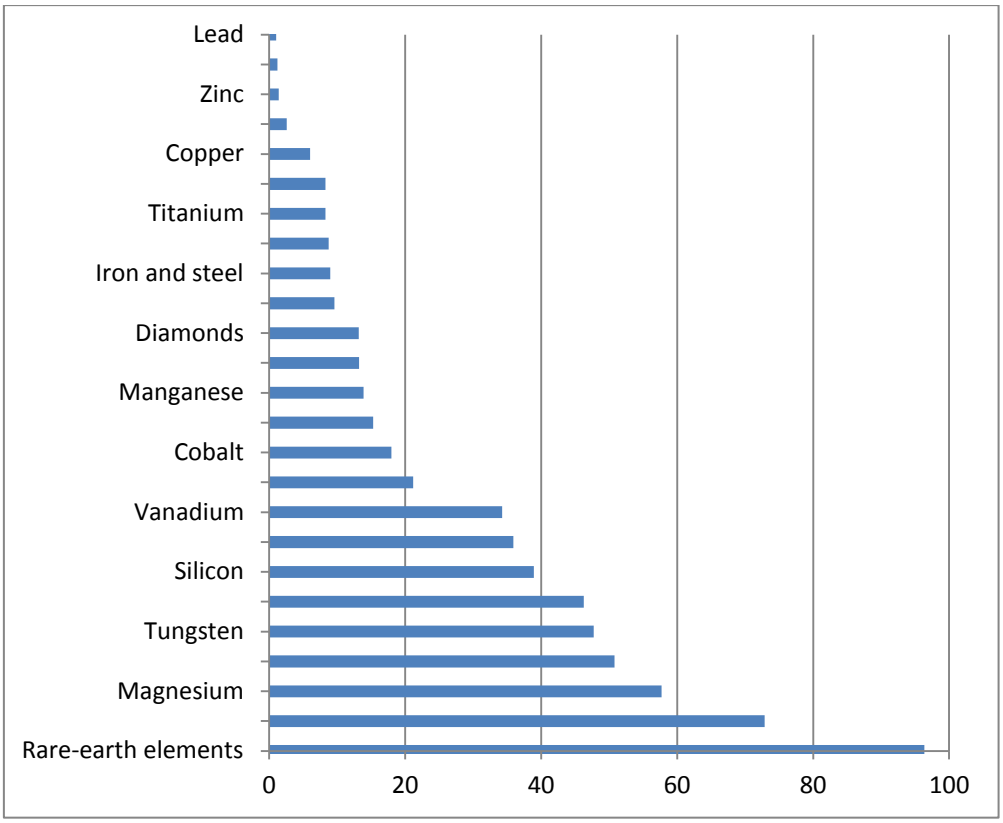
Source: *OECD Inventory of restrictions on exports of raw materials* (2012).

The impact of export taxes and quotas on mineral and metals markets is generally determined by three main factors: the concentration of production and export in the sector; the frequency of use of export restrictions; and the level of tax or quota instituted. The case of rare earth elements is an extreme example: 96% of trade is affected by an export tax (Figure 2). This coincides with a high concentration of exports (96% globally) in one country. The second most affected export market is that for germanium and zirconium ore: an estimated 73% of exports in that market are subject to an export tax. Other markets that are highly distorted by the use of export taxes are: magnesium (an estimated 58% of exports), borates (an estimated 51%), tungsten (48%), phosphates (46%), silicon (39%), nickel (36%), vanadium (34%), refined germanium (21%), and cobalt (18% - see Figure 2). This can be contrasted with the situation in some other markets where export taxes are less prevalent as shown in Figure 2, as well as approximately 20 other metals and minerals that are not included in the graph because less than one percent of their trade is affected by export taxes.[6]

6 It should be kept in mind that these estimates are extrapolated from information included in the OECD inventory of restrictions on exports of raw materials for major producers and should be regarded as indicative.

Figure 2. Share of exports affected by an export tax

2010



Note: * Includes germanium, vanadium, gallium, hafnium, indium, niobium, and rhenium.

Includes minerals and metals in ore and semi-processed form: HS26, 28, 71-71, 74-81. Refers to HS2007. Does not include metal waste and scrap, except: Manganese & articles thereof including waste & scrap (HS 811100) and germanium, vanadium, gallium, hafnium, indium, niobium (columbium), rhenium, & articles of these metals, including waste & scrap, Data for Algeria, Kazakhstan and Uruguay are 2009, Ukraine data from 2011, Guinea HS2002 classification data from 2008.

These data are estimates of the share of exports affected by a tax in total exports using the share of exports affected by a tax included in the database, i.e.:

Share of exports affected by tax (survey level) = (Exports affected by tax/export covered by survey)*100

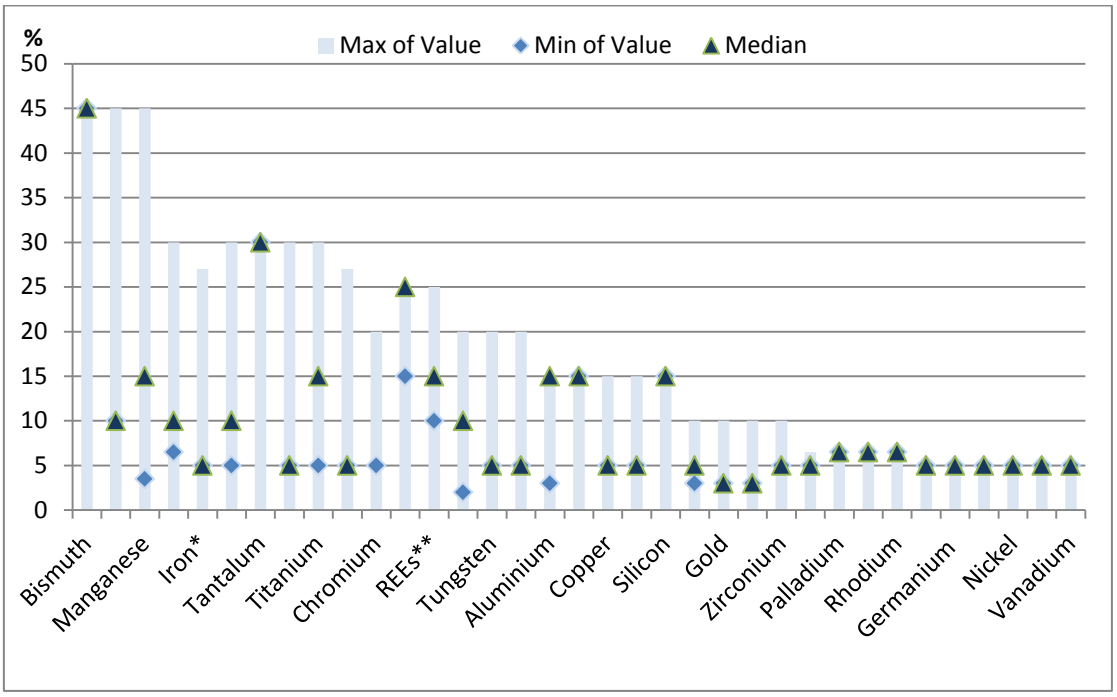
Source: *OECD Inventory of restrictions on exports of raw materials* (2012), UN Comtrade.

The level of export tax differs significantly among the minerals and metals examined. Maximum values of export taxes levied range from three to 45% (Figure 3).[7] These taxes are high, particularly compared with import tariffs on industrial raw materials which average 3% and their processed products which face an average import tariff of 3.8%. For some products, the maximum values are very high: manganese, magnesium and bismuth

7 Only *ad valorem* taxes were used in this analysis, which accounts for the vast majority of export taxes in the sample. Specific export taxes (i.e. where the tax levied is expressed as an amount per weight such as USD/ton) represent a small minority of the taxes recorded in the dataset and since they cannot be compared with ad valorem rates, are excluded from this analysis. Mixed or variable tariff rates (e.g. 25% or EUR 330/tonne, whichever is greater) do not appear in the sample here.

(45%); iron ore, lead, tantalum, titanium and zinc (30%); cobalt (27%); pig iron and rare earth elements (25%); antimony, chromium, tin and tungsten (20%); aluminium, cerium, copper, molybdenum and silicon (15%); and diamonds, gold, silver and zirconium (10%). These magnitudes of taxation are all restrictive, especially when compared with average levels of import tariffs. It should be noted that none of the export taxes on the products in Figure 3 are at the level of "nuisance tariffs", a term that has been used to refer to (generally import) tariffs of 3% or less that are considered more difficult to implement and collect than actually distorting.

Figure 3. Level of export tax: maximum, minimum and median



Note: Only *ad valorem* taxes have been taken into account. Taxes used were those by all suppliers for which information has been collected in the database.

*Iron and steel semi-processed.

**Rare earth elements.

***Iridium, osmium, ruthenium.

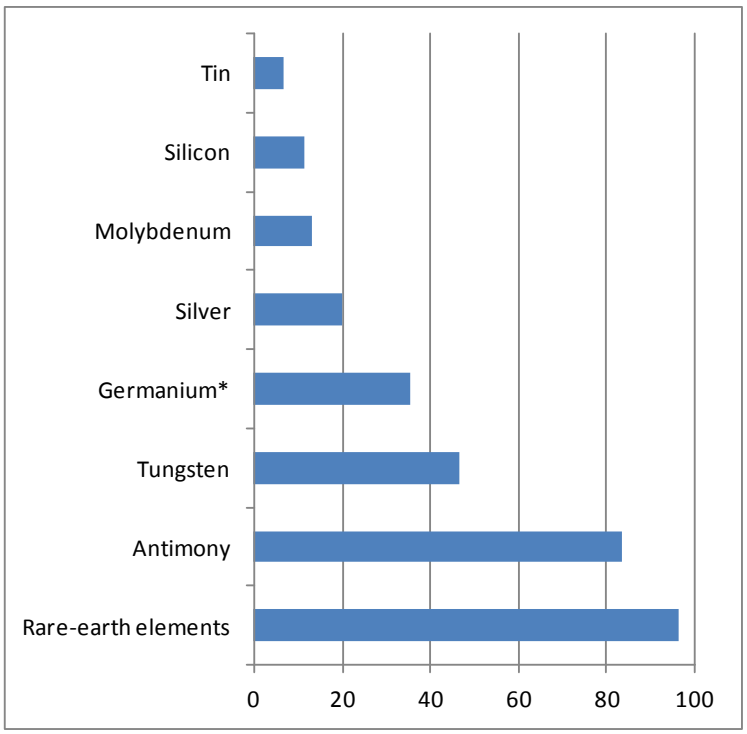
Source: *OECD Inventory of restrictions on exports of raw materials* (2012).

Markets are most distorted when a large share of world trade is affected by an export tax and that tax level is high. This is indeed the case for some products: rare earths elements, magnesium, silicon, tungsten, cobalt and manganese are all in this category and, to a lesser extent molybdenum and industrial diamonds. In these cases, export taxes are generally high and affect a substantial share of trade of the product (Figures 2 and 3).

Quantitative restrictions are less widely used than taxes to restrict exports. It will be seen in the next section however that the presence of export quotas is generally more welfare distorting than the presence of export taxes. In addition, in some cases, products are subjected to an export quota and an export tax. Sixteen of the 47 products examined are subject to an export quota or ban. In some cases, the amount of trade affected is small. In others, however, it is very significant: 96% of trade in rare earths elements is affected

by an export quota;[8] 83% of trade in antimony; 47% of tungsten; 36% of processed germanium, vanadium, gallium, hafnium, indium, niobium and rhenium; 20% of silver; 13% of molybdenum and 12% of silicon (Figure 4). For these products, therefore, it is probable that trade is substantially distorted by the presence of export quotas.

Figure 4. Share of exports affected by quota or prohibition
2010



Note: * Includes germanium, vanadium, gallium, hafnium, indium, niobium, and rhenium.

Includes minerals and metals in ore and semi-processed form: HS26, 28, 71-71, 74-81. Refers to HS2007. Does not include metal waste and scrap, except: Manganese & articles thereof including waste & scrap (HS 811100) and germanium, vanadium, gallium, hafnium, indium, niobium (columbium), rhenium, & articles of these metals, including waste & scrap, Data for Algeria, Kazakhstan and Uruguay are 2009, Ukraine data from 2011, Guinea HS2002 classification data from 2008.

These data are estimates of the share of exports affected by quotas in total exports using the share of exports subject to a quota included in the database, i.e.:

Share of exports affected by quota (survey level) = (Exports affected by quota/export covered by survey)*100

Source: *OECD Inventory of restrictions on exports of raw materials* (2012), UN Comtrade.

Export taxes and quotas are more prevalent on raw materials than on processed and semi-processed products. Industrial raw materials are therefore characterized by an export tariff reduction (or de-escalation) at higher levels of processing. Export taxes and quotas are particularly prevalent on products in the form of oxides, which have undergone some processing but less so than semi-processed and processed products. Eight percent of exports of ores and concentrates are affected by export taxes, and 17% of oxides. This can

8 In addition to an export tax

be contrasted with materials that have undergone further processing: 9% of exports of semi-processed and processed products are affected by export taxes (Table 1). Almost all export quotas are placed on the lesser-processed oxides, affecting 11% of their trade, whereas only 1% of semi-processed and processed goods are subject to an export quota or ban.

Table 1. Share of exports affected by taxes or quotas by level of processing

Product group	World exports	Exports covered by survey	Exports affected by tax (survey level)	Exports affected by quota and prohibition (survey level)	Share of world exports covered by survey	Share of exports affected by tax (survey)	Share of exports affected by quota or prohibition (survey)
	Million USD				%	%	%
Ores and concentrates (HS26)	176 367	140 450	10 941	503	80	8	0
Oxides (HS28)	52 760	23 292	3 956	2 453	44	17	11
Semi-processed and processed products (HS71-81)	882 743	264 426	23 732	1 411	30	9	1

Source: *OECD Inventory of restrictions on exports of raw materials* (2012), UN Comtrade.

Insights from recent literature

A small body of existing literature explicitly models the economic effects of export restrictions. Some recent work (WTO, 2010; Latina et al., 2011) has resulted in simple models of the impacts of export taxes and quantitative restrictions in the case where the restrictions are placed by a country with a significant share of world trade, particularly pertinent in the area of mineral resources. This work examines effects of export restrictions on domestic and world markets and on downstream industries. An earlier paper by Piermartini (2004) describes the impact of a ban or tax by a large country on importing and exporting producers and consumers from the point of view of economic efficiency, terms of trade, changes in world prices and income effects. She describes such effects in the case of a small country that cannot impact world prices and a large country where world prices will be affected. Complementary and substitute sectors are examined as are downstream and upstream industries.

The recent interest in better examining impacts of export restrictions has drawn on general international economic theory. Gandolfo (1998) models the export tax in the case of a small country. He suggests that in the small country case, i.e. where there is no monopolistic power in the broad sense, a symmetrical relationship exists between the social cost of an import duty and an export duty (Lerner symmetry). The limitation of the Lerner symmetry is that it assumes an economy-wide symmetry of import duties on all products with export duties on all products. It states that a uniform tariff on all imports is equivalent to an equal uniform tax on all exports (Ethier, 1983). This is therefore a purely theoretical case, as seen in the previous section which outlines the presence of export restrictions and tariffs in industrial raw materials sectors.

Some recent work examining the economics of export restrictions has been written in the context of the 2008-09 rise in the prices of agricultural products and subsequent

restrictive policies. Mitra and Josling (2009) examine the domestic and global impacts of export bans, quotas and taxes on agricultural products. Abbott (2011) models the impact of an export tax that is implemented following a surge in demand in world markets. Liefert, Westcott and Wainio (2011) build on existing work to model the impact of export licenses and domestic quotas. Martin and Anderson (2011) highlight the collective action problem associated with the use of export restrictions as price stabilisation policies: the use of restrictive measures by all exporters would be ineffective in stabilizing domestic prices, while magnifying international price instability. They estimate the extent to which changes in insulating policies such as export restrictions have contributed to price surges for staple foods such as rice and wheat. They find substantial impacts for both the price surges in 1973-4 and 2006-8. According to their calculations, for example, insulating policies affecting the market for rice explain 45% of the increase in the international price for rice in 2006-8 (Martin and Anderson, 2011). Giordani, Rocha and Ruta (2012) find a multiplier effect associated with export restrictions. They find evidence to support their hypothesis that a sudden rise in food prices brings governments to respond by imposing export restrictions, which exacerbates the price shock and in turn solicits other exporting countries to apply export restrictions. Finally, they estimate that a 1% increase in global export restrictions served to further increase international food prices by 1.1% on average during 2008-10, following the surge in international food prices (Giordani, Rocha and Ruta, 2012).

Bouët and Laborde (2010) examine export taxes as beggar-thy-neighbour policies that deteriorate terms of trade and real incomes of trading partners and elicit retaliation from importing countries. They examine the trade policies in a general equilibrium game theoretic context and find large and significant impacts due to the imposition of export restrictions by one country and lowering of import tariffs or subsidizing of exports by a trading partner. They also estimate the effect of these policies on a third country, which is small and obliged to import the good. A scenario modelling the 2006-08 increase in food prices, suggests that export restrictions and corresponding import tariff reductions contribute to double the initial increase in world wheat prices. The beggar-thy-neighbour policies therefore have as much effect on world wheat prices as the initial price surge, according to their estimates. The authors draw the policy conclusion from this non-cooperative equilibrium that international cooperation in the area of disciplining export restrictions is necessary, particularly to offset the large welfare losses of small countries who cannot use such trade instruments to improve their welfare.

For a number of reasons, the case of agricultural export restrictions and the impacts of insulating policies used in reaction to surges in food prices is not directly applicable to other sectors such as industrial raw materials. In many of the models (e.g. Mitra and Josling, 2009; Liefert, Westcott and Wainio, 2011), supply is assumed to be inelastic since the situation modelled is one where export restrictions are put into place after planting decisions have been taken. Additionally, in much of the agricultural literature (e.g. Abbott, 2011; Bouët and Laborde, 2010; Liefert, Westcott and Wainio, 2011; Mitra and Josling, 2009; and Giordani, Rocha and Ruta, 2012), the assumption is that export restrictions are placed after a surge in world demand or a surge in world prices. Neither of these assumptions necessarily holds in the case of industrial raw materials.[9] For these

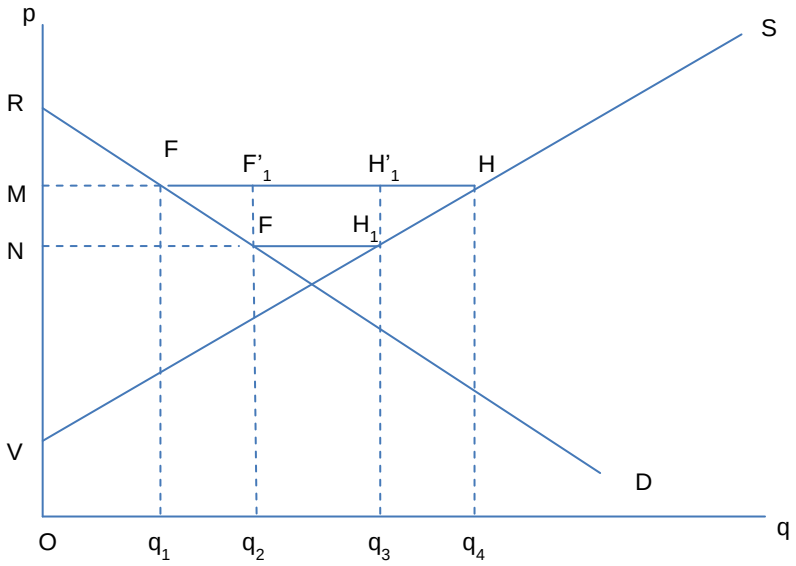
[9] This is not to suggest that industrial raw materials supply is particularly elastic. In the short to medium term however many mining facilities can increase their levels of production somewhat. It would therefore be inappropriate to illustrate these sectors using a perfectly vertical supply curve as is done in some of the analysis of the agriculture sector.

reasons, this paper will concentrate on models that are not specifically designed to explain impacts of agricultural export restrictions although some of the considerations in that rich body of literature will be drawn upon.

Export tax imposed by a small country

A number of papers illustrate the effects of an export tax on domestic producers and consumers graphically (Latina et al., 2011; WTO, 2010; Mitra and Josling, 2009; Appleyard et al., 2010; Gandolfo, 1998; Abbott, 2011). The partial equilibrium case of an export tax imposed on a good by the government in a small country, defined here as a country whose exports in the restricted good are not large enough to impact the world price, is the most basic. This is well illustrated by Gandolfo (Figure 5).

Figure 5. Effects of an export tax imposed by a small country



Source: Gandolfo (1998).

In Figure 5, domestic demand and supply are shown and the good is exported, therefore the original ("free trade") price is OM and the quantity exported is FH (or q_4 minus q_1). When an export tax of magnitude MN is imposed, domestic producers base their output calculations on ON as they will have to pay out MN as tax on all exported goods. The domestic price thereby falls to ON. Exports contract to F_1H_1 (or q_3 minus q_2). Since the domestic price is lower, domestic consumers will benefit whereas domestic producers will suffer. Consumers benefit by an amount equal to area MNF_1F in Figure 5. Producers lose by an amount equal to area MNH_1H. Government revenue collected by the export tax is measured by the area $F'_1F_1H_1H'_1$. The social cost of the tax is illustrated by triangles $FF_1F'_1$ and H'_1H_1H (Gandolfo, 1998).

A number of observations can be taken from this analysis: i) in the case of a small country with no impact on world prices in the market of the good on which the export tax is levied, domestic welfare in the aggregate is necessarily lower than before the imposition of the export tax; ii) there is a transfer of income from domestic producers to domestic consumers due to lower prices and greater availability in the domestic market; iii) the more inelastic domestic supply and demand are, the smaller the impact of the tax;

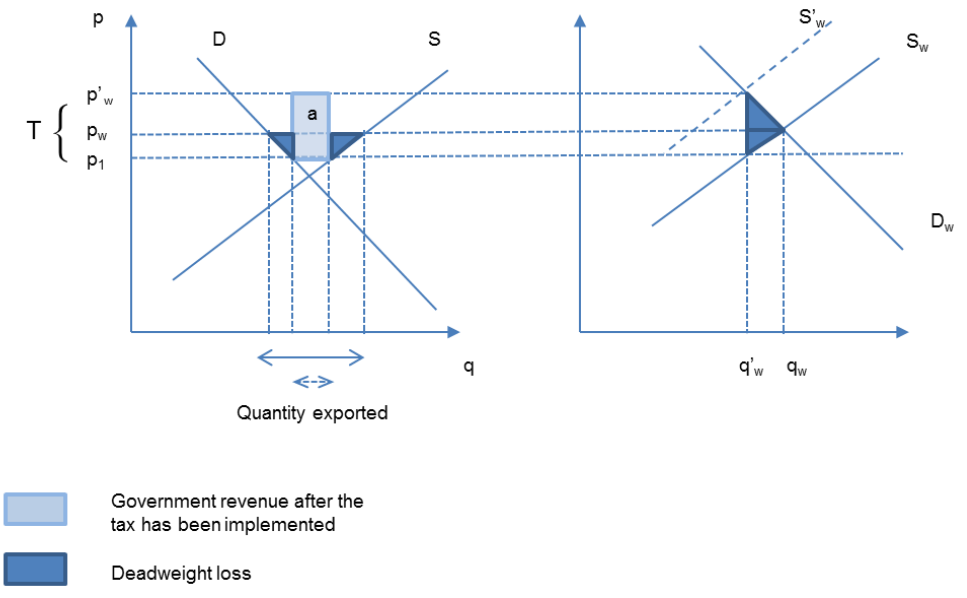
and iv) in practice, governments will probably overestimate the revenue generated by the tax if they do not account for lower levels of production that it will bring about.

A case in point of these effects is that of Argentina where export taxes are imposed on virtually all agricultural products, industrial raw materials, hides and skins, oil and natural gas and their derivatives. Nogués (2008) estimates that an elimination of export barriers would increase Argentina's GDP by 2-4%. He indicates that an elimination of export barriers would provoke a rise in consumer prices, thereby necessitating temporary adjustment mechanisms to reduce the social cost of an adjustment. Eliminating Argentina's export barriers would lead to an expansion of production and therefore employment – by 300 000 jobs in the case of Argentina according to the author (Nogués, 2008). An important source of government revenue would however also be eliminated, which may largely explain the plethora of export taxes in Argentina, unparalleled elsewhere in the global economy.

Export tax imposed by a country large enough to impact world market prices

Due to the geographical concentration of mineral deposits, a common case of export taxes imposed on industrial raw materials is that of a country whose changes in production impact world prices, often called a "large country" case. Most of the analysis in the previous section on the presence of export restrictions concerns the top five exporters of each raw material so any of the export taxes described there would most likely fall into this category. In the case that an export tax is imposed by a large country, world commodity prices change and effects must therefore be regarded both domestically and globally. This is well illustrated by Latina et al. (2011) in Figure 6.

Figure 6. Effects of an export tax imposed by a large country



Source: Latina et al. (2011).

As in the small country case, domestic producers reduce their supply of the good on which the export tax is applied. In the case of a large country, however, world supply contracts (from S_w to S'_w) leading to higher world prices (increasing from p_w to p'_w). At the same time, supply to the domestic market increases as producers attempt to expand

within country sales to avoid the export tax; domestic prices therefore fall (from p_w to p_1). The price differential between the world and domestic prices (p'_w minus p_1) equals the tax.

Income effects, or changes in welfare, imply that domestic consumers gain from the policy due to lower prices (and correspondingly greater consumption) while foreign consumers lose as they are obliged to pay higher prices (and therefore consume less). Note that in some cases, domestic consumers are themselves producers of downstream products. In this way, the export tax effectively subsidizes downstream industries (Latina et al., 2011). Domestic producers lose from the policy since they face lower prices for their goods and they have to pay the export tax. Government revenue increases by the amount illustrated by the striped area in Figure 6.

The net welfare effect on the domestic economy in the large country is therefore ambiguous. The area marked *a* in Figure 6 represents the terms of trade gain from an increase in the world price. The deadweight loss, or social cost, generated by the export tax is equal to the two shaded triangles in Figure 6 and represents distortions in production. The change in welfare in the large export-tax imposing country depends therefore which of the two effects – the increase in terms of trade or the decrease in efficiency – is greater. Overall, if the terms of trade gain more than offsets the efficiency loss, a large country may be tempted to improve its welfare through the introduction of an export tax (Latina et al., 2011). At the level of the world market, however, there is a clear overall welfare loss as the terms of trade gain to producers is more than offset by a loss in income for world market consumers.

Export taxes therefore have a re-distributional effect within the country imposing the tax (WTO, 2010). Raw materials producers experience negative consequences whereas downstream consumers of raw materials are indirectly subsidized. The policy actually transfers welfare from the sector producing the raw commodity to the processing industry that uses it. Raw material production is discouraged and employment and wages may fall in the sector. However, the processing industry will benefit from lower prices of its resource inputs, gain competitiveness in the international market and expand (Piermartini, 2004). In the case that they produce intermediate or finished goods, the tax may encourage production of a good in which the country does not have a comparative advantage (WTO, 2010).

An export tax imposed on a raw material in a large country also has a re-distributional effect in the importing country. Consumers in the importing country lose since they must pay higher prices for the good, whereas producers in the importing country, if they exist, will gain from higher prices for their goods due to lower levels of supply by their competitor (Piermartini, 2004).

The precise impact of an export tax on domestic and foreign consumers and producers depends on how much consumers react to price changes (the price elasticity of demand). In the case of elastic demand, or high responsiveness of demand to price, welfare losses are greater than in the case of more inelastic demand for products. This is due to the greater distortion in the quantity of goods consumed when prices are distorted by the policy instrument (Mitra and Josling, 2009).

It should be noted that the above analysis is static, assuming changes to production, consumption and prices that result from the export tax alone.[10] In practice, in the longer term, sustained high world prices create an incentive for importing countries to invest in new resource-saving technologies that reduce their natural resource inputs per unit of output (WTO, 2010). They may also invest in research in order to substitute other raw materials in the production process. In addition, new producers may start mining activities which were not profitable when world prices were low but which become viable given higher world prices. These producers have no guarantee however that the distorting export policy will be maintained thereby forcing world prices up artificially. This creates greater uncertainty in world markets both for raw materials producers and for downstream consumers and may create negative long-run effects (Korinek and Kim, 2010).

An export tax also impacts the price and availability of the factors of production that are used in the production process. If production of a raw material decreases due to higher prices, industries that service the raw material production process will suffer, inasmuch as they are not mobile. Input industries and services that are not mobile across sectors will necessarily be negatively impacted by an export tax. Similarly, employment in the mining industry will fall. These issues will be further discussed later in this paper.

Export quotas

There exist fewer papers on export quotas as compared with export taxes for a number of reasons. The impacts of an export quota depend on a number of factors such as the level of restrictiveness of the quota and the way the quota is administered, and are somewhat more difficult to ascertain than impacts of export taxes. One way of assessing the impact of an export quota is to assume that it has the same effect as a corresponding export tax. As in the case of import quotas, at every level of quota there is a theoretical tax that will introduce the same distortions. The analysis of the effect of an export quota is therefore similar to that outlined above in the case of the export tax. Export bans are generally modelled as an extreme case of an export quota of zero. The outstanding difference between an export tax and an export quota is that government revenue is not generated in the case of the quota.

The recipient or beneficiary of the quota rent is unclear and largely depends on the way in which the quota is administered. In the case that the quota is auctioned by the government in the exporting country, exporters in principle bid on the privilege to trade up to an amount equal to a theoretical export tax (Appleyard et al, 2010). In this case, the government would be the beneficiary of the quota rent much in the same way as they would at a corresponding level of export tax. If the exporting firms organize as single sellers, however, and sell their goods on the importing countries' markets at the higher market-clearing price, the quota rent is captured by the exporting firms (Appleyard et al., 2010).

10 In particular, there appears to be no study that looks at the optimal path of export taxes on exhaustible resources (WTO, 2010, p. 148).

Box 1. Molybdenum export quotas led to an increase in production

The Chinese government put into place restrictive measures on exports of molybdenum in 2007.[11] The rationale given by the Chinese government, after a case was subsequently brought to WTO, for the imposition of the restrictive measures was for environmental reasons (pollution from the mining industry and excessive use of energy to process molybdenum products) and in order to preserve its natural resources. China holds 43% of known worldwide reserves of molybdenum and currently accounts for 38% of world production, by far the world's largest producer.

In 2007, an export quota was also placed on molybdenum and its level was further reduced in 2008. Other measures were also implemented at this time. China placed an export tax of 10% on molybdenum concentrates and oxides and ferromolybdenum and a 15% tax on molybdenum powder, unwrought molybdenum and scrap on 1 January 2007. This tax was raised to 20% on exports of ferromolybdenum in 2008. In mid-2007, an export licensing system was implemented raising the level of criteria for potential exporters of molybdenum and its products. At the same time, the VAT rebate was rescinded on molybdenum hydroxides and reduced to 5% on more processed molybdenum products.

Exports of molybdenum and its products on which export taxes and quotas were put into place in 2007 and 2008 dropped.. Exports of molybdenum articles that have undergone further processing however increased sharply (by 120%) in 2007 from very low levels prior to that year, despite the restrictions placed on them that year.

More importantly still, the export restrictions have had the opposite effect on production than that for which they were implemented. In order to fulfil the stated policy objectives of environmental stability and preservation of natural resources, the export restrictions would have had to have resulted in a decrease in the production of molybdenum in China. This has not been the case, as the production of molybdenum has risen continually since 2004 and even more dramatically since 2007 when the export quota was implemented (Table 2). It is clear, therefore, that the measures that were introduced did not achieve their stated objectives.

Table 2. Molybdenum production in China (000 MT of molybdenum content)

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
28.9	28.2	29.3	30.6	29	40	41.9	59.8	81	93.5	93.6	94

Source: Korinek, J. and J. Kim "Export Restrictions on Strategic Raw Materials and their Impact on Trade and Global Supply", in The Economic Impact of Export Restrictions on Raw Materials, OECD Trade Policy Studies, 2010.

Export quotas produce bigger welfare losses in the case of products characterized by inelastic demand.[12] Export taxes, on the other hand, produce bigger welfare losses when applied to products with more elastic demand, i.e. a higher responsiveness to price changes (Mitra and Josling, 2009).

In general, the exhaustibility of natural resources implies a trade-off between present extraction rates and extraction in the future. For a country that exports everything it produces, establishing an export quota will generally result in higher future rates of extraction (WTO, 2010). In this case, and in principle, export quotas could be used to achieve optimal rates of extraction in the case that private sector producers would have an

11 Molybdenum is generally alloyed with steel to produce ultra-high strength steels used in applications such as missile and airplane parts. It is also used as a catalyst in petroleum refining.

12 This is often the case of industrial raw materials which are one of many components used in a sophisticated manufacturing supply chain.

incentive to extract minerals faster than is optimal.[13] Even if the country imposing the quota exports all of its production in the short run, however, it may start to export downstream products if they become competitive due to their access to supply of raw materials. This was the case of molybdenum in China after a series of export restrictive measures were implemented (Box 1).

In the case of natural resource extraction, uncertainty plays a large role. There is uncertainty about the exact size and availability of deposits; there is uncertainty of demand since substitutes for resources can be developed; and there may be different perceptions of risk by governments and private sector participants (WTO, 2010).

Cournot-Nash model applied to export restrictions

Export tax model

This section describes and discusses a basic theoretical model of export restrictions. In the first instance, the focus is on export taxes. The model is a static, one-shot game in a partial equilibrium framework. Given the characteristics of extractive industries, natural resources markets will be modelled as an international oligopoly rather than a perfectly competitive market. This is an appropriate model since a given mineral or metal is often exported by a relatively small number of countries or producers. Producers tend to have substantial market power. This simplified model assumes two international firms, one domestic and one foreign, that produce a homogenous product. The domestic firm produces quantity x, with x^h consumed in the home market and x^e exported to the foreign country. Total mineral output produced by the home firm is:

$$x = x^h + x^e$$

The foreign firm produces quantity y for its own market. Thus we have a situation where only the home country exports. Total output in the global mineral industry is:

$$Y = x + y$$

Oligopolistic firms can be modelled either as Bertrand-Nash (price-setting) firms or Cournot-Nash (quantity-setting) firms. Because the extractive industries involve a limited number of firms that are facing differing cost and pricing structures, and because the Bertrand equilibrium will lead to price equalling marginal cost, it is more natural to describe these firms as Cournot-Nash firms. In the Cournot-Nash setting, firms produce identical products; even the higher cost firms can survive and produce positive outputs. However, it is well known in this theoretical literature that results can change if we change the various features of the game. The usual features considered in existing research include: price-setting versus quantity-setting, the number of producers, whether there is free entry, identical versus differentiated products, etc. Insights from other general theoretical cases can be obtained by consulting, e.g. Brander and Spencer (1984), Helpman and Krugman (1985), Helpman and Krugman (1989), Bhagwati, Panagariya and Srinivasan (1998), Bagwell and Staiger (2009a), Bagwell and Staiger (2009b), Fung (1989), Grossman and Rogoff (1995), Krishna (1989), etc. The model and framework outlined here are drawn from a reading of this existing literature and adapting these models to apply to the case of export restrictions in the industrial raw materials sector.

13 It is unclear in the theoretical literature whether this is a significant issue. Stiglitz (1976) suggests that the rate of exploitation of exhaustible natural resources by a profit-maximizing monopolist is not higher than that in a competitive market.

Returning to the model, assume the exporting government imposes an export tax t. With an integrated international market, the domestic price P plus the export tax t will equal the foreign price P*, i.e.

$$P + t = P^*$$

Assume that the domestic direct demand is D(P) and the foreign direct demand is D*(P*). Substituting the domestic price into the foreign demand gives D*(P + t). Summing up these demands horizontally yields total output Y. From this relationship we can see that domestic price P is a function of total industry output Y and the export tax t, i.e. P (Y, t). Furthermore since the foreign price is simply the domestic price plus the export tax, we also have P* (Y, t). From this market integration feature, therefore, other things being equal, a rise in the export tax will lower the domestic price but raise the price in the foreign market. A large export tax will directly raise the foreign price thereby constricting world demand. To restore equilibrium, the local price must fall to stimulate domestic demand.

How do these changes in the raw materials markets affect the two Cournot-Nash firms? The home firm's profit function consists of revenues from the domestic market Px^h and from exports P^*x^e , with the costs being cx^h, cx^e and tx^e, where c denotes the constant marginal cost of production for the domestic output. Using the expression $P^* = P + t$, the home profit function can be reduced to:

$$H = Px - cx.$$

The foreign firm's profit function H* is:

$$H^* = P^*y - c^*y$$

where c* is the constant marginal cost for the foreign output y.

For a given export tax t, profit maximization by the domestic firm yields $H_x = 0$, where the subscript now denotes partial differentiation with respect to the strategic output variable x. $H_x = 0$ is the domestic firm's reaction function, where there is an optimal response x chosen for any foreign quantity y. As is standard, this Cournot-Nash reaction function in y-x space will be downward-sloping.

Similarly maximizing the foreign profit function for a given t will yield $H_y^* = 0$. This first order condition represents the reaction function of the foreign firm, with a best-reply y for any x. For both firms' maximizations, we assume that the second order conditions hold. In a graph with y on the vertical axis and x on the horizontal axis, again the Cournot reaction curve for the foreign firm $H^* = 0$ will be downward-sloping. The domestic reaction function will also be steeper than the foreign reaction function, yielding a stable equilibrium.

The quantities produced by the two firms according to the Cournot-Nash equilibrium are those at the point where the domestic reaction function intersects the foreign reaction function, which can be expressed as (x^{CN}, y^{CN}). This equilibrium is defined for a given export tax t. How would an increase in the export tax affect firms' equilibrium outputs? An increase in the export tax will shift the domestic reaction curve in, i.e., the domestic firm will produce less in every situation, while it will shift the foreign reaction curve out since the foreign firm will produce greater quantities of the raw material. Note that in the profit functions, the export tax affects the domestic price P and the foreign price P* through the market integration condition. We make standard assumptions typical of these types of models. For example, we assume that the two outputs x and y are strategic

substitutes. We assume that the usual stability condition holds. With these standard conditions, the resulting equilibrium is one where the domestic output x is lowered and the foreign output y is increased. These outcomes hold for straight-line demand functions as well as other well-behaved demands. With the export tax increase, exports by the domestic firm to the foreign country fall. What happens to the price of this mineral in the world market? This is simply the price prevailing in the foreign market since it is assumed that there are no trade barriers imposed by the foreign country and transport costs and other forms of friction are inexistent. The world price $P^{\wedge}$ can be defined as $P^{\wedge} = P + t = P^*$. In other words, the world price rises with an increase in the export tax.

So far, we have analysed the quantity and price responses in our international oligopoly model due to an increase in the export tax on a mineral imposed by the (home) government. To summarize, an increase in the export tax will lower the domestic price of the mineral, raise the foreign and thus the world price of the mineral, increase foreign production of the mineral, lower production of the mineral by the domestic firm and also lower its exports of the mineral.

There are several welfare implications of an export tax in our international Cournot-Nash oligopoly model. First, there is the domestic consumer surplus, where consumers in some cases can be downstream firms that use these resources as inputs in their production processes. Because the price in the domestic market declines with an increase in the export tax, domestic consumer surplus, and therefore the welfare of downstream producers, rises. Another way to look at this improvement in domestic welfare is to examine the distortions introduced by the firms with market power in our model. Given that it is oligopolistic, the domestic firm will typically charge a price higher than marginal cost ($P > c$). This oligopolistic distortion creates a deadweight loss in the domestic economy. An increase in the export tax lowers P and ameliorates the inefficiency associated with this type of distortion. In addition, the world price of the exported product rises, so there is an improvement in the terms of trade of the mineral for the exporting country, but a deterioration of the terms of trade for the importing country. Profits of the domestic firm decline with an increase in or imposition of an export tax. Intuitively, since for Cournot-Nash firms, profits are positively related to outputs and market shares (for linear demands, profits are directly proportional), and since output produced by the domestic firm declines, the domestic firm's economic profits shrink. The opposite happens to the foreign firm. Foreign profits increase as foreign output increases. So profits are shifted *away* from the domestic firm to the foreign firm. This profit-shifting or rent-shifting effect is standard in international oligopoly, but it is new to the literature on export restrictions of minerals or metals since the existing literature uses models assuming perfect competition. One novel conclusion (even for the strategic trade policy literature) is that the government imposing the trade policy actually shifts rents away from its own firm and reduces its profits. Lastly, let us consider the welfare implications associated with the export tax revenue. An increase in export tax revenue implies an equivalent increase in welfare for the public sector in the country imposing the tax.

To sum up, with an increase in or imposition of an export tax, in the importing country, the producer gains and consumers or downstream industries lose. Assuming that the producer continues to sell only to its domestic market, there is also a terms of trade loss. For the exporting country, the producer loses, the consumer or downstream industry gains, tax revenue increases and there is a terms of trade gain. There may be, therefore, an

export tax that optimizes domestic welfare albeit diminishing global welfare.[14] To obtain the optimal export tax to maximize domestic welfare, the national welfare function can be expressed as follows:

$$NW = H + S + R,$$

where S is domestic consumer surplus and is a function of P, R is tax revenue, which is equal to tx^e and H is as before the economic profits of the domestic producer. The optimal export tax is implicitly defined by $NW_t = 0$, where the subscript refers to differentiation with respect to the export tax t. Again, we assume that the second order condition holds.

The basic model outlined above informs as to the welfare impacts of an export tax in the case that there are producers and consumers in both the exporting and importing countries. In a situation where production occurs only in the exporting country and consumption takes place only in the importing country, an imposition of an export tax will improve the welfare of the producing country. The world price of the raw material will rise and the consuming country will be hurt. In general, the welfare of the global economy will decline.

A richer welfare analysis of the export tax can be provided by adding some additional characteristics of the international mineral industry and selected features of some exporting countries. First, suppose there is a downstream firm that uses these raw materials as inputs in its production process. In the domestic economy, profits of the downstream firm can be represented as V (z, P), where z is the output of the downstream firm and P is the price of the mineral used by the downstream firm. For a given P, the downstream firm maximizes its profits by choosing z so that $V_z = 0$. It has been shown already that an increase in export tax will lower the domestic price of this resource input. A lower P will increase the profits of the downstream firm, i.e. $V_P < 0$. With a lower marginal cost of production, the downstream firm will expand its output and thus employment. These results continue to hold if we also have a downstream firm in the foreign country. We can write its profit function as V* (z*, P*). Profit maximization by the foreign downstream firm yields $V^*_{z^*}=0$. If the two downstream firms also engage in strategic rivalry, then we have a two-stage static (one-shot) game. In the first stage, the mineral sector engages in oligopolistic rivalry, yielding Cournot-Nash equilibrium prices P and P*. Given these input prices, the two Cournot-Nash downstream firms compete, leading to equilibrium z and z*. An increase in the export tax will shift these games to a new equilibrium. For the second stage game, this means that the domestic downstream firm will have lower marginal cost of production. This increases its output, employment and profits. For the foreign downstream firm in the importing country, the marginal cost of production rises and therefore its output, employment and profits decline.

In some cases, a firm located in the exporting country may be a multinational affiliate. Its profits are at least partially repatriated overseas. The government may not want to include the profits of the multinational firm in its welfare calculation. This may partially explain why some governments may be willing to impose export taxes even though these taxes can shift profits away from the firm located in their country.

14 The issue of an optimal export tax in the raw materials sector was brought to the Working Party's attention in the October 2009 OECD Workshop on Raw Materials in a paper presented by David Tarr. See D. Tarr, *The Economic Impact of Export Restraints on Russian Natural Gas and Raw Timber*, in OECD (2010), *The Economic Impact of Export Restrictions on Raw Materials*, p. 139.

In many countries jobs and employment are a major issue; governments may include a labour component into their objective welfare functions, e.g.

$$NW = wL + H + S + R,$$

where w is the wage rate and L is employment. If we assume that w is fairly fixed in the short run, then the focus from including wL into the government objective function will be on employment alone. Notice that in our model, we can have a *job-shifting* or *employment-shifting* effect. This can be seen by noting that in downstream firms, an increase in or imposition of an export tax will increase its employment even though there is a drop in the employment in the upstream mineral sector. If the downstream firm is more labour-intensive, then the net impact will tend toward increasing employment in the exporting country and decreasing employment in the importing country. The actual net effect will depend on the size of each sector.

Export quotas

What is the impact on producers and consumers and welfare effects in the case of an export quota on the industrial raw material in the home country? The model used here maintains the same features as discussed in the export tax case. In particular, the focus is again on a Cournot-Nash duopoly with identical products. Therefore, the results found for the impact of an export quota can be compared with those in the case of an export tax.

This analysis examines the profit function of the home firm, i.e., the payoffs to the home firm, under an export quota. For simplicity, we assume that the firm bids and pays the home government to obtain a license enabling it to export. It pays a maximum of $(P^*-P)x^e$ to the domestic government for the right to export within the confines of the quota. This may also be the case if the domestic resource firm is state-owned, in which case the quota rents are technically also owned by the government. In that case, the profit function becomes:

$$H=Px^h-cx^h+P^*x^e-cx^e-(P^*-P)x^e=(P-c)x,$$

which corresponds exactly to the payoffs under the export tax case. For the foreign firm, the profit function (or the payoff to the foreign firm) is also the same as in the export tax case, given as:

$$H^* = P^*y-c^*y.$$

The question at hand is the following: if x^e is fixed, at a given level of an export quota which corresponds to the same lower level of output as that found in an export tax case, and assume that y is at y^{CN}, then what is the best response by the domestic firm? The best response will be for the home firm to choose x^h so that $x=x^h+x^e$ will be at x^{CN}. Similarly, if the home firm chooses x^{CN}, then the best response by the firm in the importing country will be y^{CN}. Since these quantities are mutually optimal, we obtain a Cournot-Nash equilibrium. Thus, with an export quota that limits exports to the same extent as a given level of export tax, the resulting Cournot-Nash equilibrium will yield the same output levels. With the exception of the administration and distribution of the quota rents, the welfare implications will also be the same. For the importing country, price will increase and output will be higher. Economic profits of the foreign firm will rise and foreign consumers will lose, as in the case of the export tax. If there is a downstream firm, it will lose competitiveness since the price of the mineral input in the importing country will increase. In other words, economic profits and employment of the downstream firm in the importing country will be lowered by the export quota.

The economic impacts of the export tax and export quota on producers and consumers of the raw material in the Cournot-Nash oligopolistic theoretical model are therefore broadly similar. The distribution of the surplus created by the quota rent, however, may be different than the revenue collected through the tax. In the case of the export tax, the tax revenue goes to the central government that has introduced it. The recipient of the quota rent is less clear and depends how the quota is attributed or administered. The quota, or license to export, may be auctioned in an open bidding process or may be attributed according to firms' previous export shares or some other criteria. In the case that firms compete to buy a share of the quota, they could in theory bid the price of the license up to mirror the situation and welfare implications found in the case of the export tax. In this case, the quota rent would go entirely to the central authority administering the policy. If, however, the quota is attributed in another way – by shares to firms that have exported in the past, for example, or according to some another criteria – the quota rent may be distributed among all exporting firms, by a subset of them, or potentially shared between firms and the central authority.

While the assumption in this paper is that the quantity-setting Cournot-Nash model is more typical of trade in mineral resources, there may be some specific product markets where other models apply. In these situations, an export quota can create more distortions than an export tax. There are two known situations where this may occur. First, in the event that there is an unexpected increase in the demand for the raw material in the importing country, an export tax will allow an increase in exports as a response. In the case of a binding export quota, however, there will be no change in exports. In this second-stage case, an export quota will be more distortionary than an export tax. The higher unmet demand will push the price of the raw material up further and create a greater distortion in the world market.

In the second example, under certain market conditions, an export quota creates a potential for collusive behaviour between oligopolistic market participants. This may occur if firms compete on the basis of price (i.e., Bertrand-Nash duopoly) rather than quantity as in the Cournot-Nash case outlined here. It is well established in the abundant literature that for Bertrand-Nash international duopoly that a quantitative restriction can serve as a "facilitating practice" or a "collusive device" (see Krishna 1989, Grossman and Rogoff 1995, p. 1435). In the Bertrand-Nash case, as firms compete on the basis of price, the assumption is that their product is sold at a price equal to their marginal cost. Their profits are therefore theoretically close to zero. The effect of a trade restraint is to draw the oligopolistic firms into a collusive partnership as a reaction to an unsustainable drop in profits. A quantitative restriction will therefore generate more distortions than a tax in the case of a price-competing oligopoly.

The literature on price-setting Bertrand-Nash equilibria (albeit applied in existing studies to the import side) may highlight some further considerations. The "collusive" properties associated with quotas are well documented in the literature. If the firms were Bertrand players, Krishna (1989) has shown that an import quota can yield a mixed equilibrium. As elaborated in Helpman and Krugman (1989), with the quota imposed by the importing country, the home firm can opt to charge a higher price, taking advantage of the protection. But if the exporting firm chooses to raise its price sufficiently, the home firm will switch to adopt an aggressive strategy and charge a much lower price to undercut the rival. At equilibrium, both firms' profits are higher so the quota acts like a "collusive" or "facilitating" device.

In some cases, if the export taxes are set high enough, exports will cease and the export taxes act like export bans. Empirically, the threshold levels at which export taxes become export bans will vary in different raw material industries. One relevant factor is the elasticity of demand for any individual industrial material: if consumers react strongly to price changes (i.e. the elasticity of demand is high), then taxes imposed will more readily result in lower demand and very high taxes will tend to generate a situation similar to that of an export ban.

An established result in the trade policy literature indicates that an import tax is equivalent to an import quota in models of perfect competition. Once we deviate from perfect competition, the "equivalence" result does not necessarily hold. In the case of a domestic monopoly, for example, an import quota will lead to a higher domestic price and lower domestic output compared with an equivalent import tariff (see e.g. Helpman and Krugman, 1989, p. 33). In the case where the domestic firm faces a foreign monopoly, import quotas are also worse than import tariffs for the home country (see Helpman and Krugman 1989, p.56). These established results concerning import taxes and import quotas can also be translated to provide some general insights as to why export quotas may be welfare-inferior to export taxes.

For the case where a monopoly in the importing country is faced with a perfectly competitive world market, both collectively effective export taxes and export quotas can shield the monopoly from competition and increase the monopolistic power of the firm. For export quotas, they allow the competitive threats to be eliminated and allow the firm in the importing country the freedom to choose its monopolistic price. With effective export taxes, on the other hand, the implicit "threats" of imports that will swamp the importing market still exist and under some conditions the firm restrains its behaviour. Export quotas will create more distortions than export taxes. In particular, quotas will lead to a higher price and lower quantity consumed in the importing country.

In the case where an exporting country has an exporting monopoly, the exporting monopoly when faced with an export quota can charge a higher export price and capture all the quota rents. In contrast, an export tax that yields the same level of exports will provide the government in the exporting country with tax revenues equivalent to the quota rents. In this case, an export quota is an inferior trade instrument compared to an export tax due to the distribution of the quota rent.

To sum up, there are numerous instances and cases where quantitative restrictions are more distortive instruments than trade taxes. At a minimum, the quota rents are not easily captured by the government, whereas tax revenue collections are more direct and straightforward. As illustrated above, there are other cases where quotas can lead to greater consumer welfare losses.

Some policy implications in light of the theory extended to export taxes and quotas

It has been shown that an export tax or quota in a large producing country implies a shift in welfare and in profits from domestic raw materials producers and foreign downstream producers to domestic downstream producers and foreign raw materials producers. Domestic raw materials producers will therefore move to lower production levels. Lower profit levels will also imply that domestic raw materials firms will decrease their levels of investment. Downstream producers will increase production and use of other inputs. In some cases, the downstream producer is a subsidiary or partner of the raw materials producing firm. In this case, a within-firm reallocation of resources will occur.

In others, the technology input in the downstream sector is significant. In mining, the downstream sector is generally more labour intensive. Therefore a net shift within the country imposing the restriction will occur toward greater investment in the downstream technology and toward job creation in the labour intensive industry. It should be noted however that an export tax or quota will bring about a decrease in employment in the mining of the raw material in the country imposing the policy. This may bring particular challenges since many mines are located in geographically remote areas with few alternatives for employment.

Abroad, raw materials producers gain from higher world prices and lower exports of the firm(s) in the country that is subject to a tax or quota. Raw materials producers in countries that are not subject to the export restrictions will therefore increase production. They may start exporting if they do not export already. Higher world prices for their goods will increase their profits. They may use this increase in revenue to increase their investment; however, the extent to which they do so will depend on the length of time they think the policy will be in place. Due to the uncertainty of the policy, they will engage in less investment than they normally would if they were responding to changing market conditions rather than a policy that may be altered. Foreign downstream producers will lose out because of higher prices for their inputs. They will invest and produce less due to their lower profit margins. In the case that their original margins are low, some firms may exit the market. There will be a tendency toward a decrease in jobs in countries not subject to the export restriction since the downstream industries tend to be more labour intensive.

Some downstream producing firms in the mining sector use proprietary technological processes. In these cases, the downstream industry in the country imposing the export restriction is not necessarily able to avail itself of the more favourable market conditions due to the lower prices of its inputs. It will therefore look to foreign investment and transfers of technology in order to expand or initiate production. Issues of process patents will be relevant here. Downstream foreign firms (i.e., firms outside the country imposing the export restriction on raw materials), hit by higher prices of inputs, may be willing to outsource some of their production to firms in the country where the export restriction is imposed. They may also be willing to sell some of their know-how or proprietary processes if they can no longer produce profitably. The government imposing the export restriction may use its position to create an incentive for greater investment in its downstream industry by competing foreign firms.

In the longer term, however, technological innovation may suffer overall in terms of downstream production processes. This is due to the fact that the returns to such innovation have fallen in all countries outside the one imposing the export restriction. One area in which technological innovation will be fostered is in finding alternative materials, or ways in which to use less of the raw material on which the restriction is placed. If such a break through happens, the export restrictive policy will have been self-defeating, and all producers of the raw material will become less profitable due to lower demand for their goods and the subsequent fall in prices. In this case, downstream producers will be relatively less affected as they will adapt to a change in input (in the case of the foreign firms) or may continue to use the original input mix (in the case of the domestic firm). In the case that the domestic downstream firm is a subsidiary or partner to the raw materials producer, that firm will lose significantly.

Box 2. Competitive export restrictions: the case of chromite in India and South Africa

India, the second largest exporter of chromite in 2006, started restricting its exports of the raw material.[15] Demand for chromite in India was high but a strong increase in demand from foreign countries, especially China, made it more attractive to export the raw materials than to supply the domestic market. The downstream industry in India producing ferrochrome had difficulty paying the high price of chromite. In March 2007, India imposed an export tax of INR 2 000/tonne on chromite, raised to INR 3 000/tonne in April 2008, in order to provide a greater supply of this mineral to its domestic market.

Reduced exports to China combined with high demand of chromite for ferrochrome production led to an increase in import prices in China. The unit value of Chinese imports of chromite increased from 171 USD/ton in 2006 to 397 USD/ton in 2008. Reduced exports to China had the effect of diverting its source of imports from India to other countries. Imports from India decreased by 59% between 2006 and 2008. To make up for this decrease in imports from India, China increased imports from other countries. The most striking example is South Africa; Chinese imports from that country increased by 200% from 2006 to 2008.

This increase in chromite exports to China created concern in South Africa about the long-term profitability of its own downstream industry; South Africa and China compete in the downstream ferrochromium industry. This concern led South Africa to consider introducing export restrictions on chromite. In 2007, the Deputy President Phumzile Mlambo-Ngcuka indicated the government was planning new legislation to prevent South African producers from exporting chromite. This reflected the concern that South Africa was losing the benefit of exporting higher value-added goods as well as foregoing employment opportunities in the downstream industry by exporting raw chromite. The South African government decided against placing an export restriction on the export of raw chromite at the time.

Export restrictions resulted, therefore, in diverting China's imports from India to other countries, in particular South Africa. This increase in imports from South Africa led to discussion of the application of similar export restrictions by the government of South Africa. This example indicates that export restrictions in one country can induce similar measures in other exporting countries. The intended effect of the Indian export tax may have been to reduce exports of chromite by raising its export price compared with other countries. However, had South Africa applied an export tax, it would have offset the impact of the Indian measure by reducing the price gap in the chromite exports of India and South Africa. Furthermore, such measures, by further reducing international supply, would have led to an even higher international price of chromite. In that case, India would have had to raise the export taxes further to achieve the policy objective as originally intended. The effectiveness of export restrictions, therefore, depends on how other exporting countries respond to such measures.

Source: Korinek, J. and J. Kim "Export Restrictions on Strategic Raw Materials and their Impact on Trade and Global Supply", in The *Economic Impact of Export Restrictions on Raw Materials*, OECD Trade Policy Studies, 2010.

In the long term, the outcome is dependent on specific market conditions. In some cases, foreign producers will increase production and exports and market conditions will be restored close to their original levels. This may take place where supply is not scarce or geographically located in a small area, and where the firm(s) located in countries not using export restrictions are able to produce at a similar cost to those in the country using the restriction. In other cases, imposition of an export restriction in one country may lead other countries to adopt a similar policy. In the case of an export tax, the impact of the measure will be diminished if a number of countries apply similar measures. When India implemented an export restriction on chromite in order to diminish exports of the raw

15 Over 90% of the world's chromite production is converted into ferrochrome. Most ferrochrome is used to produce stainless steel.

material to China, Chinese importers turned to South African raw materials producers to supply their downstream industry. The South African government considered imposing a similar restriction on its exports of chromite, and had that been the case, the Indian policy would have been less effective in its objective of reducing exports (Box 2).

The impact of an export tax or quota depends in part on the ownership of the raw materials firm. In the face of lower profits due to an export restriction, multinational raw materials producers may react by shifting investment from the country imposing the restriction to its mining operations elsewhere in order to benefit from higher world prices and avoid the restrictive measure. In the case that the raw materials firm is a state owned enterprise, it may be less likely to focus exclusively on profit maximization, and more mindful of economy-wide employment objectives, than a privately owned firm and may not react as strongly to the imposition of the restriction. In this case, the state owned raw materials producer may reduce production, and even exports, less than a private firm would have done in order to supply government revenue through the tax or help achieve other societal goals, such as employment goals, for which the quota may have been placed.

A government considering implementing an export restriction may also take into account the ownership of the raw materials firm in its choice of policy instrument. In the case that the raw materials firm is multinational with foreign headquarters, it may be more likely to use an export tax to reduce exports than an export quota. In this way, the government collects revenue from the foreign-owned firm. Should it choose to implement an export quota, the multinational firm may capture a substantial share of the quota rent. A government that is managing exports by colluding with a state-owned raw materials producer however may choose to allow the SOE to capture the quota rent while allowing the downstream industry to access their inputs at a reduced price.

Not only are foreign and domestic producers of the raw materials and their downstream products affected by an export restriction; producers and consumers of complementary and substitute products are also impacted. This is a particularly important issue in the metals sector since many rare and precious metals are alloyed with steel to produce materials with precise characteristics. In the country in which the restriction is imposed, markets for complementary products (i.e., those that are used together) to the raw material will gain. Substitutes, or those products that can be used in place of the raw material, will suffer. On the world market, however, the reverse is true. Complementary products will suffer from imposition of the restriction: many of the rare metals that are alloyed with steel for example will experience a fall in demand in the case of a restriction on iron and steel exports. Substitutes, however, as far as they exist, will experience higher demand.

There is a further complication in metals and minerals markets due to the fact that some mining products are in part by-products of extraction of other minerals. One example is copper and molybdenum. Molybdenum is obtained from two different types of mines: primary mines and by-product mines. At primary mines its recovery is the prime target of the mining operation. Molybdenum is also mined as a by-product of copper extraction in some countries and regions. If the price of copper falls, due to an export tax or quota, firms producing copper will reduce their production levels. In that case, their production of molybdenum will also fall, and once stockpiles of the unrefined by-product are exhausted, the domestic price of molybdenum will rise. If the copper-producing firms are significant global producers of molybdenum, the world price of molybdenum will also rise as a result of the export restriction on copper, other things remaining equal. If

however the export restriction is placed on the by-product rather than the main metal extracted (i.e. molybdenum in the copper/molybdenum case), production of the main product (copper) will continue while the by-product (molybdenum) will probably be stockpiled while its price remains low. Hence the impact of an export restriction on a product such as molybdenum may be quite complex, depending on a number of factors such as the type of production (primary or by-product), developments in related minerals markets (in this case copper) and reactions of foreign producers in both primary and secondary markets.

It was seen in earlier sections that the incentive for some countries to impose export taxes is to collect government revenue. In the case that the revenue from export taxes is a significant part of total government revenue, and/or the raw materials exports are a significant portion of GDP, governments will attach a high level of importance to this in their objective function. In this way, taxes will be a trade policy instrument of choice as opposed to quotas since they create revenue for the government. This may be even more prevalent in cases where the producing firm is foreign-owned, as is sometimes the case among minerals producers. There may be a stronger incentive to put into place an export tax which will imply a shift of welfare (and profits) from the foreign-owned firm producing domestically to downstream producers, foreign producers and the government through revenue collection.

In some cases, when the downstream industry is relatively weak or does not possess the necessary technology to produce adequately and profitably, imposition of an export tax will shift welfare directly away from the extractive industries firm toward the government (through export tax revenue). In this case, the potential increase in welfare due to the greater production and employment in the downstream industry will not occur. Political economy concerns will play in. If extractive industries firms hold strong market power within the country, they may use their influence to do away with the export restriction or limit its implementation.

The industrial raw materials that are produced from extractive industries are by nature non-renewable natural resources. Their supply however is not fixed in the medium term, nor is it always known. In many countries, new deposits are found regularly and new information concerning existing deposits is compiled. Imposing an export tax, and to an even greater extent an export quota, will negatively impact future production by reducing firms' incentives to undertake new exploration. Exploration is a costly and high-risk activity; the vast majority of exploration ventures are unsuccessful. Firms will reduce their exploration activities in the country imposing export restrictions which strongly compromises their future production possibilities. Given that exploration is a necessary component in the extractive industries, the effects of export restrictions could be negatively felt in the domestic industry for many years.

It has been seen that some of the impacts of export restrictions are potentially stronger in the case of an export quota as compared with an export tax although production levels and changes in world prices may be similar. The incentive to capture the quota rent may lead to more collusive behaviour on the part of participating firms. The potential to collude to fix prices is strong particularly in the case of a price-setting duopoly or small number of participating firms. This implies that governments implementing quantitative restrictions on exports need be mindful of such incentives to participating firms.

Box 3. Export quotas on rare earths in China restrict world supply[1]

The case of export restrictions on rare earths has received strong attention in recent years.[2] China, producing 96% of the world's rare earths and holding a substantial share of reserves, indicated its intention to restrict exports of the materials in the early 2000s. The Chinese government stated that its reserves of rare earths are finite and therefore, they will be developed for the prime benefit of China's manufacturing industry. During a recent WTO case, China explained its rare earths policy has been implemented to "conserve resources and to maximise the benefits" of its rare earths endowment.[3] To help generate manufacturing jobs and move up the value chain, China has adopted policies that encourage downstream industries that produce goods with higher value added to locate in China.

In 2007, the Chinese government introduced a tax on rare earth exports of 10%, which was increased to 15% on selected rare earths in 2008. In 2007, China withdrew the refund of VAT (16%) on exports of unimproved rare earths, while the refund on higher value-added exports such as magnets and phosphors remained in place. The effect of this decision, combined with the export tax regime described above, was that non-Chinese rare earth processors paid 31% more for rare earth raw materials (plus transport and storage costs) than their Chinese counterparts.

Rare earths consumers, however, did not react strongly to changes in price. Rare earths are used in trace amounts in final products and changes in their price do not affect prices of most final goods significantly. The reaction to the rare earths restrictions was strongest when the export quotas started to impact export levels. China started to implement export quotas on rare earths in 2000 but set the quota well above global demand for the products. Quota levels were lowered each year starting in 2005. Initially, quota levels were lowered only slightly in comparison with the previous year's quota. Starting in 2009, however, quota levels were lowered more substantially and by the following year, the quota level was below global demand. This situation left some consumers without access to supply.

One impact of the restricted Chinese exports has been a rush to develop rare earths capacity in countries that have it. There are significant barriers to enter the rare earths market as a new producer, not least of all high capital costs. Additionally, process technology is specific to each ore body and there is limited operational expertise outside China. The industry is dominated by China where input costs are low. As in many industries in the mining sector, the initial capital investment is high and returns are uncertain and in any case do not materialize for many years.

In some OECD countries, there has been a strong incentive for governments to subsidize mining firms that open or re-open their activities. These firms could produce productively under present conditions where rare earths prices are high; should they fall, however, or should China rescind its restrictive policies, these mining operations may no longer be profitable. Firms outside China are hesitant to invest without guarantees that they will be shielded from Chinese policy decisions.

1. Much of the material in this section was provided by Dudley Kingsnorth of Industrial Minerals Company of Australia Pty Ltd (IMCOA).

2. The term "rare earths" refers to a series of 17 chemically similar metals, consisting of the 15 elements known as the lanthanides, plus yttrium and scandium. Rare earths are normally expressed in terms of rare earth oxides (REO) and often classified into three groups: light, medium and heavy. The light or "ceric" elements are: lanthanum, cerium, praseodymium and neodymium; medium elements are promethium, samarium, europium and gadolinium and the heavy or "yttric" elements are: terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium and yttrium. Scandium is also part of the rare earths group.

3. The commitment to developing the rare earths resources in China primarily for the benefit of the domestic manufacturing industries has been reaffirmed recently through a Draft Development Plan (2009-14) for the Rare Earths Industry issued by the Ministry of Industry and Information Technology.

Source: Korinek, J. and J. Kim "Export Restrictions on Strategic Raw Materials and Their Impact on Trade and Global Supply", in The Economic Impact of Export Restrictions on Raw Materials, OECD Trade Policy Studies, 2010.

The impact of an export quota on economic actors is somewhat harder to ascertain due to potential differences in quota administration. In the case that export quotas are auctioned in an open-bidding process, their impact is potentially similar to that of a tax – the quota could in principle be sold at a price that would provide the government with the same amount of revenue as would be provided by a tax. However, the outcome could be quite different: competing firms or a single firm with substantial market power could obtain the quota rent and increase its profits while limiting production. Moreover, the amount of revenue generated by auctioning the export quota is generally thought to be low in practice so the welfare shift from the exporting firms to the government in the case of the quota will probably be small.

Another potential difference in impact between export taxes and quotas exists when demand for a good is almost perfectly inelastic. This is the case of some rare earths which are used in trace amounts in some high technology and environmental goods (hybrid vehicles, cell phones, computers, televisions, energy-efficient light bulbs and wind turbines). China, supplier of 96% of global rare earths, withdrew VAT refunds on exported rare earths and put into place export taxes. Markets responded strongly however to export quotas which were implemented for the first time in 2001 and lowered significantly since then (Box 3).

How successful are export restrictions in accomplishing their objectives?

Export restrictions are used to accomplish a range of policy objectives.[16] This section will examine how successfully each of these policy objectives may be met in light of the previous assertions.

1. Export restrictions are used to indirectly subsidize downstream industries

Export restrictions are sometimes used by large countries to subsidize their downstream industries. At first glance, this industrial strategy may be valid in the case of a large country, under the model of imperfect competition. Imposing export restrictions on the raw material producers raises the world price for the input into foreign downstream industries while reducing the price for domestic downstream producers, thereby creating an indirect subsidy in their production process. This may be enough in the short run to increase profitability in such industries so that they may develop to a position of global competitors and potentially capture markets abroad.

As with all policy instruments, however, problems such as the creation of vested interest may arise. Once an export restriction is in place, it may be difficult to remove it. A downstream firm that has been indirectly subsidized will lobby to keep the subsidy in place. It will also be in the interest of foreign raw materials suppliers that the policy be kept in place as they will also benefit from higher world prices. In addition, downstream firms that use subsidized inputs will use them more intensively. Eventually, the economy as a whole will be more dependent on the raw materials.

In the longer term, using an export restriction to indirectly subsidize downstream industries may incur significant costs in terms of the competitiveness of the country using the policy. Raw materials producers will incur an overall welfare loss. This may not be of

16 See Fliess and Mard (2012), p. 18 for a full discussion of the reasons given by governments for using export restrictions. The OECD database on export restrictions includes an explanation of the policy objective for each restriction if it is available.

particular concern to policymakers, in particular if the firm is foreign-owned. In the case of an SOE, the firm may pursue other societal objectives and not be strictly profit maximizing. The welfare of the raw materials producers may be considered less important to policymakers because they are generally less labour intensive. It should be noted however that the longer term impact of the policy will depend in part on how much foreign raw materials producers can make up the difference in production levels.

In the country imposing the export restriction, the incentive for raw materials producers will be to limit exploration, technological improvements and innovation. This will have a significant effect in the long term on their productivity. If they continue to produce at similar levels, the overall impact of the export restrictions will depend on the potential of foreign raw materials producers to capture existing markets. In the case that domestic raw materials producers lose significantly in competitiveness due to lower levels of investment, they may reduce production to a point of becoming net importers of the raw material. Their impact on world markets would therefore be lost as would be the potential to subsidize input prices for downstream firms.

The potential impact of cheaper inputs on the downstream industry depends on the share of the input in the production process. The advantage of having access to a cheaper raw material may be significant when considering a downstream consumer that processes the raw material directly, for example, a smelter than transforms ore into metal or a facility that refines extracted ore. It will probably not assist significantly most manufacturing industries further down the value chain that use the raw material in their final products since the price advantage of the cheaper raw material will not bring a strong advantage.

The potential impact of export restrictions will only be felt in the case that viable substitute products are not found. In the face of export restrictions placed on an industrial raw material, alternative methods of production using less of the restricted export, or substituting it altogether, will be sought. In the short term this may be difficult but in the longer term it may be successful. There are many cases in economic history of such alternatives being developed when world prices are particularly high or producers are incapable of adequately supplying world markets.

2. Export restrictions are used to generate government revenue

A significant number of countries use export taxes to generate government revenue. Some use them extensively – by applying substantial levels of tax on a wide variety of products. In some countries export taxes are a major source of government revenue. The effects of export taxes on the raw materials sector have been outlined in previous sections: production will drop as will exports. In general, when considering applying an export tax, policymakers assume taxation at present levels of production. It should be kept in mind that levels will drop, and therefore tax revenue may be less than expected.

Tax revenue may also be less than expected in the longer term due to lower production levels if raw materials producers invest less in their operations and in exploration of new deposits. In this case, government revenue will fall from initial levels and the incentive will be to apply export taxes on other products or find alternative methods of funding government expenditure. Revenue from taxation of the minerals sector is often best collected through a profit tax or a royalty although this method of revenue collection requires more sophisticated institutions and better governance (see Otto et al., 2006, for a detailed overview of the policy alternatives in the area of taxation of the extractive industries).

Export taxes are sometimes used to generate revenue for the government by countries that have difficulty collecting taxes in another way such as property taxes, income taxes and corporate profits taxes. Reasons for this may include a lack of qualified personnel in tax administration, under-developed institutional capacity, or wider governance shortcomings. One important underlying issue is transparency. Although not put into place for the purpose of collecting taxes, implementation of the Extractive Industries Transparency Initiative (EITI) can help to make more transparent and accountable transfers of funds from the private to public sectors.

3. Export restrictions are used to conserve natural resources

A common reason given for using export taxes and quotas is to conserve the non-renewable natural resources that are the products of the extractive industries. Indeed, in some cases, private firms may have incentives to extract minerals at higher levels than optimal. There is a trade-off between extraction in the present period and potential future extraction. It should be noted however that the imposition of an export tax or quota may dampen exploration and therefore lower future minerals extraction, possibly for many years.

Export restrictions will not necessarily help to achieve optimal extraction rates; they may actually exacerbate such problems, as outlined in the molybdenum case described in Box 1. If the products of the mining industry are sold on the domestic market, production may not be significantly lower, depending on the size of the domestic market. Downstream industries that avail themselves of cheaper raw materials due to the export restrictions may use materials more intensively. It is more desirable therefore to manage total production levels, for example using a minerals tax or royalty, rather than exports. A similar concern sometimes occurs with respect to environmental protection. Export restrictions are not the best way to discipline in this area: emissions standards and environmental regulation of the sector are far superior.

4. Export restrictions are used to monitor or control export activity or control illegal export activity

Export taxes and quotas are not the best way to monitor export activity or control illegal exports. Monitoring of exports can better be done by issuing export licenses. Monitoring of export activity and controlling illegal exports of metal products are best done through trade facilitation reforms. Screening of exports and automatic procedures by which to check shipments are better ways in which to do this.

Stopping illegal trade is best done in a plurilateral context. When a mechanism is in place for peer reviewing compliance with defined norms, an incentive is created for both importers and exporters to reduce or eliminate illegal trade. Within the context of the CITES convention, for example, some processes have been put into place to mutually enforce compliance to eliminate trade in certain animal and plant species. See OECD Trade Policy Paper N°141, *Regulatory Transparency in multilateral agreements controlling exports of tropical timber, e-waste and conflict diamonds* for a discussion of this issue.

Many countries ban the export of some of the waste products of the mining industry. Bans or heavy taxes on the export of waste and scrap may be in place to guard against the export of minerals masked as waste and scrap or the export of illegally obtained metal products. This is a well-documented concern in a number of countries. Waste and scrap are subjected to almost as many documented export restrictions as all metals and minerals

combined (Fliess and Mard, 2012). The analysis in this paper does not cover the export restrictions applied to waste and scrap which is a somewhat separate issue. Given the nature of the product, it may require a different model specification.

5. Export restrictions are used to control flows of foreign exchange

For some countries, exports of minerals or metals are the primary source of foreign currency denominated revenue. Mineral exports may in part determine the value of their exchange rate. Some central governments attempt to manage their exchange flows using export restrictions. The impact of export restrictions on the exchange rate is outside the scope of this study and requires a different model specification. However, export restrictions are an inexact tool with which to manage the flow of foreign exchange, and doing so may be contrary to other development objectives. A case study on alternative policies to export restrictions such as managing revenue from taxation of the minerals sector, as well as exchange rate implications, can be found in OECD Trade Policy Paper N°145, *Mineral Resources in Chile: Contribution to Development and Policy Implications.*

Potential policy responses to trading partners that impose export restrictions

This paper has outlined the impacts of export taxes and quotas in an oligopolistic model with imperfect competition. This implies that export restrictions applied by one country in the model will affect world prices and the global supply of raw materials. Trading partners that previously imported the raw material in question will be affected. It has also been shown that export restrictions reduce global welfare, even if they can improve the welfare of one country. In the past, trading partners that have experienced diminished access to supply, or access to raw materials at a higher price, have contemplated different actions in order to counter the distortive effects of restrictive export policies. Some of the options that have been discussed in different fora are outlined below:

- Lower or remove any remaining import tariffs on the raw materials that are subject to export restrictions
- Facilitate and fund research in alternative technologies with the objective of using a more diversified set of minerals and metals as inputs in strategic industries
- Facilitate exploration of new sources of raw materials that are subject to export restrictions, for example in regions that are potential exporters
- Facilitate the development of technologies that recycle metals from discarded final-use products
- Increase cooperation between producers and consumers affected by restrictions to facilitate information flows, improve access to existing supply channels and alleviate short-term supply disruptions
- Develop measures to alleviate the most distorting effects of export restrictions in a multi-lateral context. Some suggestions as regards the agriculture sector have been put forward including "using multilaterally agreed definitions and criteria … to interpret the meaning and scope of

exceptions" to the ban on export quotas;[17] implementing disciplines on food aid such as those outlined in DDA discussions;[18] and outlining a mechanism for identifying and evaluating the appropriateness of the use of export restrictions in the context of a critical shortage of supply (op cit.).

- Integrate export restrictions provisions in plurilateral agreements among producers and consumers to ensure access to supply and to markets. This may include agreements among market participants to ensure access to supply and open markets, or negotiating disciplines on export restrictions. Some existing regional trade agreements include such clauses. See OECD Trade Policy Paper no. 139, *Multilateralising Regionalism: Disciplines on Export Restrictions in Regional Trade Agreements* for an outline of how this has been undertaken in existing agreements.

17 B. Howse and T. Josling, *Agricultural Export Restrictions and International Trade Law: A Way Forward,* forthcoming

18 December 2008 Revised Draft Modalities for Agriculture, TN/AG/W/4/Rev. 4, Annex L.

Bibliography

Abbott, P. (2011), *Export Restrictions as Stabilizing Responses to Food Crisis*, American Journal of Agricultural Economics, 94(2), pp. 428-434.

Appleyard, D., Field, A., and Cobb. S. (2010), *International Economics*, Seventh Edition, McGraw Hill.

Bagwell, K. and R. Staiger (2009a), *Profit Shifting and Trade Agreements in Imperfectly Competitive Markets*, NBER Working Paper 14803, March.

Bagwell, K. and R. Staiger (2009b), *The Economics of Trade Agreements in the Linear Cournot Delocation Model*, NBER Working Paper 15492, November.

Bhagwati, J.N., A. Panagariya and T.N. Srinivasan (1998), *Lectures on International Trade*, second edition, Cambridge, Massachusetts, MIT Press.

Bouët, A. and D. Laborde (2010), *Economics of Export Taxation in a Context of Food Crisis: A Theoretical and CGE Approach Contribution*, IFPRI Discussion Paper 00994, June.

Brander, J. (1995), "Strategic Trade Policy," in G. Grossman and K. Rogoff (eds), *Handbook of International Economics*, vol. III, pp. 1395-1455, North Holland.

Brander, J. and S. Djajic (1983), *Rent-Extracting Tariffs and the Management of Exhaustible Resources*, Canadian Journal of Economics, 16(2), pp. 288-298.

Brander, J. and B. Spencer (1984), *Tariff Protection and Imperfect Competition*, in *Monopolistic Competition and International Trade*, ed. Henryk Kierzkowski, Oxford: Oxford University Press, pp. 194-206.

Daniel, P., M. Keen and C. McPherson (2010), *The Taxation of Petroleum and Minerals: Principles, problems and practice*, Routledge and International Monetary Fund, London and New York.

Davies, G. (2010), *Trade in Mineral Resources*, WTO Staff Working Paper ERSD-2010-01, January.

Eaton, J. and G. Grossman (1986), *Optimal Trade and Industrial Policy under Oligopoly*, Quarterly Journal of Economics, 101:383-406.

Ethier, W.J., *Modern International Economics*, W.W. Norton and Co., 1983.

Finger, J. M., (1971), *Protection and domestic output*, Journal of International Economics, vol. 1(3), pages 345-351.

Flaaten, O. and C. Schulz (2009), Triple win for trade in renewable resource goods by use of export taxes, Ecological Economics, no. 69, pp. 1076-1082.

Fliess, B. and T. Mård (2012), "Taking Stock of Measures Restricting the Export of Raw Materials: Analysis of OECD Inventory Data", *OECD Trade Policy Papers*, No. 140, OECD Publishing. http://dx.doi.org/10.1787/5k91gdmdjbtc-en.

Fung, K.C. (1989), *Tariffs, Quotas, and International Oligopoly*, Oxford Economic Papers, No. 41, pp.749-759.

Fung, K.C. (1989), *Unemployment, Profit-Sharing and Japan's Economic Success*, European Economic Review, 33.

Fung, K.C. (1995), *Rent Shifting and Rent Sharing: A Re-examination of the Strategic Industrial Policy Problem*, Canadian Journal of Economics, May.

Gandolfo, G. (1998), *International Trade Theory and Policy*, Springer-Verlag, Berlin.

Giordani, P., N. Rocha and M. Ruta (2012), Food Prices and the Multiplier effect of Export Policy, LLEE Working Paper no. 97, LUISS Guido Carli, March/April.

Grossman, G. and K. Rogoff (1995), *Handbook of International Economics*, volume 3, North Holland, Elsevier Science B.V.

Helpman, E. and P. Krugman (1985), *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*,Cambridge, Massachusetts, MIT Press.

Helpman, E. and P. Krugman (1989), *Trade Policy and Market Structure*, Cambridge, Massachusetts, MIT Press.

B. Howse and T. Josling, *Agricultural Export Restrictions and International Trade Law: A Way Forward*, mimeo.

Korinek, J. (2013), "Mineral Resource Trade in Chile: Contribution to Development and Policy Implications", *OECD Trade Policy Papers*, No. 145, OECD Publishing. doi: 10.1787/5k4bw6twpf24-en.

Korinek, J. and J. Bartos (2012), Multilateralising Regionalism: Disciplines on Export Restrictions in Regional Trade Agreements, OECD Trade Policy Papers, no. 139, OECD Publishing.

Korinek, J. and J. Kim (2010) "Export Restrictions on Strategic Raw Materials and their Impact on Trade and Global Supply", in The Economic Impact of Export Restrictions on Raw Materials, OECD Trade Policy Studies.

Krishna, K. (1989), *Trade Restrictions as Facilitating Practices*, Journal of International Economics, 26: 251-270.

Latina, J., R. Piermartini and M. Ruta (2011), *Natural resources and non-cooperative trade policy*, International Economics and Economic Policy, 8(2), pp. 177-196, June.

Liefert, W.M., P. Westcott and J. Wainio (2012), *Alternative Policies to Agricultural Export Bans that are less Market-Distorting*, American Journal of Agricultural Economics, 94(2), pp. 435-441.

Martin, W. and K. Anderson (2011), *Export Restrictions and Price Insulation during Commodity Price Booms*, American Journal of Agricultural Economics, 94(2), pp. 422-427.

Mitra, S. and T. Josling (2009), *Agricultural Export Restrictions: Welfare Implications and Trade Disciplines*, IPC Position Paper – Agricultural and Rural Development Policy Series, January.

Noguès, J. (2008), *The Domestic Impact of Export Restrictions: The Case of Argentina*, IPC Position Paper – Agricultural and Rural Development Policy Series, July.

OECD (2010), *The Economic Impact of Export Restrictions on Raw Materials*, OECD publishing.

OECD (2012), "Regulatory Transparency in Multilateral Agreements Controlling Exports of Tropical Timber, E-Waste and Conflict Diamonds", *OECD Trade Policy Papers*, No. 141, OECD Publishing. doi: 10.1787/5k8xbn83xtmr-en

Otto, J., C. Andrews, F. Cawood, M. Doggett, P. Guj, F. Stermole, J. Stermole and J. Tilton (2006), *Mining Royalties: A Global Study of Their Impact on Investors, Government, and Civil Society*, Washington, D.C.: World Bank.

Piermartini, Roberta (2004), *The Role of Export Taxes in the Field of Primary Commodities*, World Trade Organisation, Geneva.

Stiglitz, J. E. (1976), *Monopoly and the Rate of Extraction of Exhaustible Resources*, The American Economic Review, vol. 66, no. 4, September.

Suzuki, K. (1978), *The Welfare Effects of an Export Tax Levied on an Intermediate Good*, The Quarterly Journal of Economics, vol.92, no. 1, February, pp. 55-69.

Venables, A. (1985), *Trade and Trade Policy with Imperfect Competition: The Case of Identical Products and Free Entry*, Journal of International Economics 19, 1-20.

World Trade Organisation (WTO) *World Trade Report 2010, Trade in Natural Resources*, Geneva.

Appendix

We focus on a model with a case where the home country produces and exports an industrial raw material. Since production of metals and minerals is often concentrated in a few geographical locations, we can assume that the market can be categorized as oligopolistic. To simplify further, we assume there are two firms operating in this market: one firm in the 'home' market that produces both for domestic consumption and export, and one foreign firm that produces only for its own consumption. Specifically we assume that the home firm produces for home production (x^h) and for export (x^e). The foreign producer in the foreign country produces y. Given that metals are often standardized goods, we assume that $x=x^h+x^e$ and y are identical products. The international industry output is $x^h + x^e + y = Y$ To ensure that in equilibrium, firms with different cost structures produce and stay in business, we assume that the firms compete as Cournot-Nash firms.

With P as the domestic product price and c as constant marginal cost, while P* and c* as the foreign price and foreign constant marginal cost, the profit functions of the respective home and foreign firms are:

$$H = Px^h - cx^h + P^*x^e - cx^e - tx^e$$

$$H^* = P^*y - c^*y$$

where t is the export tax imposed by the home country. Only the home firm exports, at price P*: we assume perfect price transmission to the foreign market, thereby the world price is also equal to P*. Then arbitrage implies that P*=P+t. We can simplify and rewrite H as H= Px - cx.

To maximize profits, we differentiate H with respect to x and H*with respect to y:

$$H_x = (p - c) + xP_Y = 0$$

$$H^*_y = (P^* - c^*) + yP^*_Y = 0$$

With the second order conditions assumed to hold, $H_{xx} < 0$ and $H^*_{yy} < 0$. We assume that these rivals produce goods that are strategic substitutes so $H_{xy} < 0$ and $H^*_{yx} < 0$. In addition, we assume the stability condition of the Cournot-Nash equilibrium holds so that $J = H_{xx}H^*_{yy} - H_{xy}H^*_{yx} > 0$.

The two first order conditions are the implicit reaction functions giving us the optimal x for each y and the optimal y for each x. The two reaction curves together solve the Cournot-Nash equilibrium outputs. The equilibrium naturally depends on a particular level of export tax t, with the t affecting the prices P and P* given that the international industry output equals the total demand in both countries. The home firm, faced with an export tax, turns a greater share of its production toward the home market, whereby causing the domestic price to fall and the foreign price to rise with an increase in the export tax. What happens to the equilibrium Counot-Nash outputs? To find out, we differentiate totally H (x, y, t) = 0 and H* (x, y, t) = 0:

$$H_{xx}dx + H_{xy}dy + H_{xt}dt = 0$$

$$H^*_{yx}dx + H^*_{yy}dy + H^*_{yt}dt = 0$$

Solving these two equations, we have:

$$dx/dt = (-H_{xt}H^*_{yy} + H^*_{yt}H_{xy})/J$$

$$dy/dt = (-H_{xx}H^*_{yt} + H_{xt}H^*_{yx})/J$$

For $H_{xt} = P_t + xP_{Yt}$, we need to assume that the first term dominates the second term. This is true for linear demands or if the shift of the demand is not "too" extreme due to the tax. For standard cases (see Finger, 1971 and Fung, 1989), $H_{xt} < 0$. For $H^*_{yt} = P^*_t + yP^*_{Yt}$. Again if the first term dominates, which should be the standard case (including linear demands), $H^*_{yt} > 0$. Furthermore we know that $H^*_{yy} < 0$ (second order condition), $H_{xy} < 0$ (strategic substitutes), $J > 0$ (stability), $H_{xx} < 0$, and $H^*_{yx} < 0$ (strategic substitutes), then we have:

$$dx/dt < 0$$

$$dy/dt > 0$$

Overall, the domestic price of the raw material at home declines while the foreign price of the raw material rises. Output by the domestic firm decreases and output by the foreign firm increases. Suppose there are downstream firms that use these raw materials at home and abroad. Their profit functions can be written as:

$$V(z, P) \text{ and } V^*(z^*, P^*)$$

where V and V* are the downstream profit functions, z and z* are their respective outputs and P and P* are the prices of raw materials used as inputs at home and abroad. We assume again that these downstream firms will compete as Cournot-Nash firms.

What is the impact of an increase in t on the downstream firms' profits?

From the first order conditions, $V_z = 0$ and $V_{z^*} = 0$. A small change in t induces a change in P and P* so that $V_P P_t > 0$, i.e. an increase in the export tax will lower the price of the raw material at home, thus lowering the marginal cost of production for the home downstream firm and increasing its profits. The converse is true for the foreign downstream firm: P* increases, thereby raising its marginal cost of production and lowering its profits with $V^*_{P^*}P^*_t < 0$.

Suppose the government in the home country is also concerned about the impact of the tax on aggregate employment; we have already seen that an export tax will lower the home raw material firm's output (and thus employment). What happens to the level of activity, and hence employment in the downstream firm?

We can see this by totally differentiating $V_z = 0$ and $V^*_{z^*} = 0$.

$$V_{zz}dz + V_{zz^*}d\,z^* + V_{zt}\,dt = 0$$

$$V^*_{z^*z}dz + V^*_{z^*z^*}dz^* + V_{z^*t}\,dt = 0.$$

We can solve this via Cramer's rule. Basically, the export tax will lower the raw material's price at home, which is the input used in the downstream firm. This will lower the marginal cost of production of the downstream firm, expanding its output at the expense of its foreign rival. The domestic downstream firm's reaction curve shifts out while the foreign downstream firm's reaction curve shifts in (this is in contrast to the

shifting of the upstream firms' reaction curves). This two-stage game analysis is similar to that in Fung (1989) and Fung (1995), where a drop in costs in the upstream firm implies an increase in the competitiveness of the downstream firm:

$$dz/dt > 0$$

$$dz^*/dt < 0.$$

That is: downstream firms in the home country expand output while downstream firms in the foreign country contract. If one of the goals of the home country imposing the export tax is to raise domestic employment L (although there may be other goals), then the change in employment overall depends, among other things, on the labour intensities of the upstream and downstream firms. The change in total employment can be expressed as follows:

$$dL/dt = (dL^x/dx)(dx/dt) + (dL^z/dz)\,(dz/dt).$$

If we assume that the raw materials represent a substantial share in the cost structure of the downstream firm, then the drop in marginal cost to the downstream firm will be larger and the output z increase will be larger. If we further assume that the downstream firm is generally more labour-intensive than the extractive industry (which is more capital-intensive) so $dL^z/dz > dL^x/dx$), then $dL/dt > 0$, i.e., total employment rises.

This case is reinforced if the foreign firm responds to the tax by moving from the foreign country to the home country in order to obtain the use of the domestic raw materials. The foreign affiliate and the domestic firm now both have access to cheaper metals. This will reduce the profits of the home downstream firm. But if one of the important goals for the home government is to increase domestic employment, now jobs that used to be located in the foreign country will re-locate to the home country, so total employment may increase with an imposition of an export tax. There can be an important *employment-* or *job-shifting effect* associated with an export tax.