FIW – Working Paper

FIW Working Paper N° 181
December 2017

Crucial Materials? How Export Restrictions Upstream Boost Manufacturing Exports Downstream

Eva Wichmann[1]

Abstract

This paper shows both theoretically and empirically how raw material rich countries use export restrictions upstream to give manufacturing sectors downstream a competitive advantage. For young and relatively small industries this can be seen as a type of infant industry protection that takes advantage of the global value chain. Estimating a fixed effect model, I provide evidence that export restrictions on industrial raw materials upstream help promote manufacturing exports downstream.

Keywords: Export Restrictions, International Trade, Competitive Advantage, Resource Rich, Manufacturing, Metals, Minerals.

JEL: F12, F14, L25, L61, L71, Q3.

The author

1 PhD candidate in Economics at GSEM, University of Geneva, Switzerland. Email: Eva.Wichmann@unige.ch.

I wish to thank Marcelo Olarreaga, Michele Pelizzari and other seminar participants of the GSEM Brown bag seminar on 24th May 2017 and Frédéric Robert-Nicoud for helpful suggestions.

Crucial Materials?
How Export Restrictions Upstream Boost Manufacturing Exports Downstream

Eva Wichmann*†

December 4, 2017

Abstract

This paper shows both theoretically and empirically how raw material rich countries use export restrictions upstream to give manufacturing sectors downstream a competitive advantage. For young and relatively small industries this can be seen as a type of infant industry protection that takes advantage of the global value chain. Estimating a fixed effect model, I provide evidence that export restrictions on industrial raw materials upstream help promote manufacturing exports downstream.

JEL Code: F12, F14, L25, L61, L71, Q3.

Keywords: Export Restrictions, International Trade, Competitive Advantage, Resource Rich, Manufacturing, Metals, Minerals.

*PhD candidate in Economics at GSEM, University of Geneva, Switzerland. Email: Eva.Wichmann@unige.ch.

†I wish to thank Marcelo Olarreaga, Michele Pelizzari and other seminar participants of the GSEM Brown bag seminar on 24th May 2017 and Frédéric Robert-Nicoud for helpful suggestions.

1 Introduction

This paper shows both theoretically and empirically how export restrictions upstream can be used to give a competitive advantage to domestic manufacturing sectors downstream. Especially useful for a raw material rich country having a young and relatively small manufacturing industry downstream, this might be used as a type of infant industry protection. The mechanism of this presumed new (infant) industry protection[1] can be briefly described as the following: the raw material rich country restricts exports of industrial raw materials upstream in order to raise marginal costs for foreign firms. Hence, domestic manufacturing firms downstream with access to cheaper raw material get a competitive advantage in markets where they compete with foreign firms.

Estimating a fixed effect model, I find empirical evidence in line with the existence of such a type of industry protection in the case of industrial raw materials: I find a highly significant positive effect of the introduction of an export restriction upstream on the export value in the manufacturing sectors downstream. This effect is even higher and lasts longer when taking into account the market power of the country in the raw material market upstream - a fact that is in line with the theoretical model presented in this paper. Besides, we also find a positive effect of the introduction (or extension) of an export restriction upstream on export quantities downstream. Thus it seems fair to conclude that raw material rich countries dispose of a new type of infant industry protection for their manufacturing sectors - if and only if they are big enough to influence the world market price for the raw material.

The idea of such a new type of industry protection that exploits the global value chain albeit appealing is certainly not only of academic interest. Recently, concerns have been made by parts of the European producing industry that countries rich in certain raw materials such as rare earths or antimony could restrict the exports of those in order to give their own firms a competitive advantage. Those raw materials have thus been called "strategic raw materials" and gained attention and concern of policy makers [2]. The stylized facts of export restrictions for industrial raw materials are certainly in favour of this hypothesis: we do find a trend in protectionist behaviour as over the recent years there has been quite a number of introductions of export restrictions (especially in 2010), but only very few eliminations[3] of existing export restrictions for industrial raw materials. Albeit the bulk of export restric-

[1]Please note that while this type of protection would certainly help young industries, there is no need for the industry to be an infant one for this type of industry protection to be imposed. However, we do find some evidence for young industries in the dataset among those that introduce export restrictions upstream, i.e. very high percentage increases in export value that are sharply decreasing in the recent years. Nevertheless, there is no clear definition of infant industry and the term has been mainly used as an argument for imposing direct tariff measures on the industry downstream.

[2]See for instance the raw materials initiative of the European Commission that has been implemented in 2008.

[3]See Appendix for tables

tions left unchanged.[4] Thus - even though simple absolute frequencies do not tell anything about the severity of the restriction - the first picture is already in line with the idea of export restrictions upstream as (infant) industry protection for the manufacturing sector downstream.

Without doubt the biggest obstacle in the way of a systematic empirical assessment has been a lack of data: in order to address this presumed modern (infant) industry protection, one needs a lot of different data and part of it as disaggregated as possible. First of all, data on export restrictions for industrial raw materials have long been scarce and even today the data available is far from being satisfactory. There has not been any ready available data source until the OECD started in 2009 to gather data on export restrictions for industrial raw materials.

For my empirical assessment I created two novel datasets for testing by combining manufacturing firm data, end-use data and data on export restrictions. For the first dataset, I have combined UN Comtrade export value data with data on export restrictions of industrial raw materials provided by the OECD Inventory on export restrictions on Industrial Raw Materials. In order to match industrial raw materials upstream with their corresponding manufacturing products relying on them downstream, I used detailed end-use data for each raw material provided by the US Geological Service (USGS). The result is a novel and comprehensive dataset that allows to empirically test the effect of export restrictions of a wide range of industrial raw materials and metals that are considered crucial to the manufacturing sector[5]. The second dataset had been created in a similar way using export quantity data provided by UN Comtrade instead of the export value data.

Furthermore it might be worthwhile to clearly define what is meant by industrial raw materials in the present paper. When talking of industrial raw materials, I like to consider a list of metals and its ores as well as selected industrial minerals such as Zirconium or Rare Earth that are important for the manufacturing industry.[6] Clearly excluded are all energy raw materials since this would cover a different topic. As the idea of this paper is to detect a possible industry protection in the manufacturing sector, the focus is on metals and selected industrial raw materials.[7] A list of the industrial raw materials considered in the present paper can

[4]The main measures are export taxes and licensing requirements, but one can find some export prohibitions as well.

[5]The choice of material is in line with several so called criticality studies such as “Kritische Rohstoffe für Deutschland” (Critical Raw Materials for Germany) or the “Risklist 2015” of the British Geological Service, see bibliography for details.

[6]This is for instance in line with the criticality study “Kritische Rohstoffe für Deutschland” (Critical Raw Materials for Germany, see bibliography.

[7]So for instance potash used as fertilizer in non-manufacturing sectors of food production is not in the focus of this paper. Also materials used for construction such as gypsum and materials used for energy production such as coal are excluded.

be found in the appendix.[8]

The present paper is related to several different strands of the literature: it is linked both to the literature in international trade and to the one in industrial organization. First, as this paper presents a type of industry protection that can be used as an infant industry protection, the idea of this paper is without doubt linked to Krugman (1984) import protection as export promotion. In contrast to Krugman (1984) I do not deal with import protection directly but with export restrictions in a previous stage of the value chain that both acts as import protection and export promotion for the domestic market. While the main driver in Krugman (1984) are economies of scale, the mechanism in the present paper in this modern type of (infant) industry protection lies in the global value chain where access to cheap key materials might become a competitive advantage.

Secondly, this paper contributes to the industrial organization literature on raising rivals' costs. It basically takes the idea of raising rivals' cost to get a competitive advantage and put it in an international trade context showing that export restrictions upstream can be used as an instrument to raise rival's costs in downstream markets. The idea to raise rivals' costs in order to obtain a competitive advantage is not new to the industrial organization literature. It somehow dates back to Salop and Scheffman (1983) who argue that inducing supplier group boycotts or lobbying for more government regulations can be used as instruments to raise production costs for competitors. This basically led to models of vertical integration and foreclosure: Salinger (1988) and Ordover, Saloner and Salop (1988) show that a downstream firm could have an interest in strategically acquiring an input supplier to reduce upstream competition and hence raise the input price for its downstream competitors. [9]. While the industrial organization literature focussed on vertical integration aspects (an upstream monopolist vertically integrating downstream such as in Weisman and Kang (2001) or a downstream firm acquiring an upstream supplier as previously mentioned), the present paper shows that raising rivals' costs can be also achieved without vertical integration.

We furthermore certainly agree with the effective rate of protection literature that when it comes to protection one should not only focus on output tariffs but also on input tariffs.[10] Nevertheless, instead of having an overall tariff structure that has both a tax and a subsidy element - with the tariffs on the final goods operating as a subsidy and the ones on imported inputs as a tax - we show how raw

[8]The list of industrial raw materials of this study is very similar to the so called "Risklist 2015" of the British Geological Service.

[9]See for instance Normann (2011) for an overview of the literature on vertical integration and foreclosure following Salinger (1988) and OSS (1988).

[10]See for instance Greenaway and Milner (2003) for a critical review on the effective rate of protection concept and literature as well as Diakantoni and Escaith (2014) for an overview of the empirical use and the evolution of effective protection rates.

material rich countries can avoid implementing tariffs on the final good by placing an export tax on the relevant raw material and still achieve a subsidy-like effect.

The remainder of this paper is organized as follows: In Section 2, I model the presumed modern type of industry protection that give rise to the empirical model presented in Section 3. Section 4 provides a detailed description of the data used and how the different data sources have been combined in order to construct my datasets. Section 5 gives an overview over the estimation results and Section 6 concludes.

2 Theoretical Framework

A Simple Model

Let us consider the following simple model: The good produced by firms in A and B is homogeneous. There are N firms in market A with $N \in [1;\infty[$ that are serving both markets A and C with product x.[11] They produce at mc_A. There are M firms in market B with $M \in [1;\infty[$ that are only serving market B with product x, but could potentially also export to market C. They produce at $mc_B > mc_A$. Further assume that country B is rich in raw material R and does not limit its exports. R is traded at the world market price r. Both firms need the raw material R as input z_1 to produce product x.

Firms produce with different technologies. A firms produce with the Cobb-Douglas production function $f(z_1,z_2) = z_1^{\alpha} z_2^{\beta}$ with $\alpha \geq 0, \beta = (1-\alpha)$ and where z_1 denotes input of raw material R and z_2 all other inputs for product x. All firms maximize a profit function of the type $\pi = (p - mc - t)D$ with D being the demand in the market and t the transportation costs per unit to ship to it. Assume for the time being that $t = 0$ and that there are no fixed costs (neither of production nor to export).[12] All other inputs necessary to produce product x are included in z_2.

Assume furthermore that consumers in C have no preference for a certain firm or brand and simply by from the cheapest one. Thus, a single A firm is facing the following demand function in market C

$$D_A(p_c^n, p_c^m) = \begin{cases} \frac{1}{N}\, D(p_c^n) & \text{if } p_c = p_c^n < p_c^m \\ \frac{1}{N+M}\, D(p_c^n) & \text{if } p_c^n = p_c^m \\ 0 & \text{if } p_c^n > p_c^m \end{cases} \tag{i}$$

The reverse is true for D_B. All firms serving market C are engaged in perfect competition. Hence $p_c = mc_A$, as $mc_B > mc_A$, $p_c = p_c^n < p_c^m$. Thus each (of the N) A firms is maximizing

$$\pi_n = (p_c - mc_A) D_A(p_c^n, p_c^m) = 0 \tag{ii}$$

and each (of the M) B firms is maximizing

$$\pi_m = (p_c - mc_B) D_B(p_c^n, p_c^m) < 0 \tag{iii}$$

As that means that B firms would incur real losses, they are not serving market C.

B firms find this situation unsatisfying. Assume they have successfully convinced their government to impose an export tax on the relevant raw material. Thus,

[11] For the moment being I am not specifying whether those firms are mono-product firms or multi-product firms.

[12] One could for instance see them as sunk costs and thus irrelevant for the current time period.

in the next stage country B imposes an export tax τ per unit of raw material R. As A firms rely on a different technology and both cost and production function of A firms are unknown in country B, the government of B does not know how much of mc_A is due to the cost for input z_1, i.e. the cost for raw material R. The task of fixing an optimal τ is hence difficult: it has to be high enough to raise mc_A at least to the level of mc_B in order to get half of the demand D. The government would also not mind to raise mc_A above mc_B to get all the demand D.

Nevertheless, at the same time there might also be an upper bound for the export tax given by the firms selling the raw material R. Suppliers of the raw material R certainly have an interest to sell all of their supply (given a certain price) and B firms might not have a sufficient demand for the moment. So in order to avoid that suppliers of R cannot sell enough of their stock which would certainly drive them to black or secondary markets to bypass the export tax, the government will not fix a too excessive export tax.[13]

What is the impact of τ? Assume that country B is an important supplier of raw material R in the world market and that hence its introduction of the export tax can raise the world market price r. Let us further assume an upward sloping supply curve and a downward sloping demand curve. Thus, after implementation of the export tax, there are now two different prices for raw material R: firms worldwide can purchase it at r^W and firms in B can get it at $r^B < r^W$[14]. This leads to an increase in marginal costs for A firms with mc_A^{new} denoting the new marginal costs they are facing; and decreasing marginal costs for firms in B, i.e. mc_B^{new} denoting their new marginal costs.

We can hence distinguish three cases: (i) The export tax was chosen too small, i.e. $p_c = mc_A$, as $mc_B > mc_A$ still holds (even though the difference between the two had been shrinking); (ii) the export tax was chosen high enough in order to equalize the marginal costs; and (iii) the export tax has been chosen such that $mc_B < mc_A$. In case (i), B firm(s) still do not enter market C as they would still incur real losses in case of entering. Nevertheless, as demand is downward sloping and $mc_A^{new} > mc_A$ results in a higher price, a single A firm is now facing the following demand in market C:

$$D_A^{new}(p_c^n, p_c^m) = \frac{1}{N} D^{new}(p_c^n) < D_A(p_c^n, p_c^m) = \frac{1}{N} D(p_c^n). \tag{iv}$$

As each of the A firms now face less demand in C, this leads to the following proposition.

[13]This is in line with the export tax levels one can find in practice. China, a large supplier of a large list of industrial raw materials, has for instance export taxes of between 5% and 30% of the value.

[14]Please note that $r^B < r$.

Proposition 1 *Both mean and total exports of A firms decrease with the introduction of export tax τ as $q_A = \frac{1}{N} D^{new}(p_c^n = mc_A^{new}) = \frac{1}{N} D^{new}(mc_A + r^W(\tau) - r)$*

PROOF. Imagine this would not be the case and demand would stay at the same level as it has been before at the lower price. That would mean that there are some in-elasticities and firms could charge a mark-up and make real profits in C. Positive profits would act as an incentive for more A firms to enter. As there is free entry and firms are homogeneous, A firms would enter until profits in C are zero again. Thus, the proposition must hold.

In case (ii) firms of B are entering market C and take over part of the demand from A firms. Thus each single firm serving market C is now facing the following demand:

$$D_A^{new}(p_c^n, p_c^m) = D_B^{new}(p_c^n, p_c^m) = \frac{1}{N+M} D^{new}(p_c^n) \tag{v}$$

As we are assuming a downward sloping demand curve and $mc_A < mc_A^{new} = mc_B^{new}$ results in a higher price, $D^{new}(p_c^n) < D(p_c^n)$ still holds as it has been in case (i). This yields the following proposition.

Proposition 2 *If the export tax is high enough to equalize marginal costs, both mean and total exports of A firms decrease with τ as $\frac{1}{N+M} D^{new}(p_c^n) < \frac{1}{N} D(p_c^n)$ and mean and total exports of B firms increase with it.*

PROOF. As shown before, demand in market C decreases with τ as the demand curve is downward sloping. With B firms selling at the exact same price as A firms and no firm is leaving market C[15], demand is met by more firms as before. Thus the first part of the proposition must hold. So does the second part because B firms now are productive enough to start serving market C.

Being that said, what is the impact on the number of firms serving market C? Due to perfect competition, all firms make zero profits in equilibrium. If a firm would be incurring real losses instead, it would stop serving market C. As each (of the N) A firms is facing $\pi_n = (p_c - mc_A)D_A(p_c^n, p_c^m) = 0$, it serves market C as long as $p_c = mc_A^{new}$. Thus, with $mc_A < mc_A^{new} = mc_B^{new}$ all of the N A firms keep serving market C, but face the additional competition of the M B firms that now could enter. The following propositions is hence true:

Proposition 3 *If the export tax is high enough to equalize marginal costs, both number of B exporters (in C) and total number of exporters (in C) increase with τ.*

PROOF. Imagine this would not be true. In order for the total number of exporters serving C not to increase with the export tax, there must be either no B

[15]Firms still meet their (marginal) costs and hence in the absence of fixed costs stay in the market making zero profits but no real losses.

firms entering or A firms exiting. As there is free entry, B firms enter once they can meet their marginal costs. So the only possibility left for the number of exporters not to increase would be A firms exiting. So could that be? As A firms can still meet their marginal costs and make zero profits, they stay in the market and have no incentive to leave. Thus the proposition must hold.

Case (iii) however is an extreme case where B firm(s) drive A firms completely out of market C. As we are assuming a downward sloping demand curve and $mc_A < mc_B^{new}$ results in a higher price, $D^{new}(p_c^n) < D(p_c^n)$ still holds. All of the demand in C is now served by B firms.

While the previous proposition is certainly true with homogeneous firms, it would also mean that as B firms are homogeneous, either all or none of them are entering. Thus, in order to smooth this mechanism let us now depart from the assumption of homogeneous firms in the raw material rich country.[16] Let us instead assume that B firms differ in their productivity. Similarly to Melitz (2003) productivity of B firms now follows a distribution.[17] Firms with a higher productivity can produce at a lower marginal cost. So, marginal cost of B firms follow a distribution that is inversely related to their productivity with mc_B^{mean} being the mean marginal cost of B firms and mc_B^{med} the median one.

Overall, B firms are still less productive than A firms such that $mc_B^{mean} > mc_A$ and $mc_B^{med} > mc_A$. Let us also assume that - as in the basic set-up - before the introduction of the export tax no B firm is productive enough to serve market C. So they successfully convince their government to impose an export tax on the relevant raw material. As in the basic setting, the implementation of τ if chosen high enough increases production costs for A firms and hence the market price of product x in C. With a higher p_c^n, the most productive B firms can enter market C.[18] Thus, one now has to distinguish between B firms entering market C and B firms only serving their domestic market: the most productive B firms produce at mc_B* and sell their product at p_c^{m*}. Thus, demand for product x in market C for a single A firm is now given by

$$D_A(p_c^n, p_c^{m*}) = \begin{cases} \frac{1}{N} D(p_c^n) & \text{if } p_c^n < p_c^{m*} \\ \frac{1}{N+m*(\tau)} D(p_c^n) & \text{if } p_c^n = p_c^{m*} \\ 0 & \text{if } p_c^n > p_c^{m*} \end{cases} \quad \text{(vi)}$$

with $m*$ being the number of B firms productive enough to enter market C and

[16] Please note that A firms serving market C cannot be heterogeneous as free entry and perfect competition would otherwise force the least productive firms to exit. Thus we keep assuming that A firms serving market C are homogeneous.

[17] Please note that as there is no need to further specify the underlying distribution, I will not do so.

[18] This is in line with Melitz (2003) that it is only the most productive firms that are entering the export market.

$m* \in [0;M]$. The reverse is true for D_B. As $m*$ depends on the size of the export tax, we can also write it directly as $m*(\tau)$. The number of firms in market C is now endogenous: not necessarily all of the M B firms can enter market C after the implementation of τ.

We can hence distinguish the following cases: (i) The export tax was chosen too small, i.e. $p_c = mc_A$, as $mc_B* > mc_A$; (ii) the export tax was chosen high enough so that the most productive B firms can enter. They have all the same productivity and hence the same mc_B* that is equal to the marginal cost of A firms; (iii) is almost as (ii) the only difference being that now the entering B firms differ in their productivity. The least productive to enter have the same marginal costs as A firms. While in case (i), B firm(s) still cannot enter market C, in case (ii) they are entering market C and and take over part of the demand from A firms. Case (iii) is an extreme case where B firm(s) drive A firms completely out of the market if and only if the most productive firms can meet all the demand of market C. This reasoning leads to the same propositions as before.

This simple model shows how an export tax on raw materials upstream can be successfully used as an (infant) industry protection for the manufacturing sector downstream. In the following, I will now empirically test for the above made propositions and show whether there is empirical evidence that is in line with the (successful) existence of such an industry protection downstream via export restrictions upstream.

3 The Empirical Model

The simple theoretical model left us with several propositions that can be empirically tested. In proposition 1 and 2, we see how firms' exports depend on the export tax imposed by B. In order for proposition 2 to hold empirically, we should find a positive impact of the export tax on B firms' exports. Thus the following equation would be a natural starting point for our estimations:[19]

$$y_{cgt} = \alpha_{cg} + \alpha_{ct} + \alpha_{gt} + \sum_{i=1}^{I} \beta_i \left(U_{ig} * ExportRest_{ict}\right) + \varepsilon_{cgt} \tag{1}$$

where y_{cgt} denotes the variable of interest, i.e. mean/total export quantity or export value. U_{ig} is the dummy for whether material i is used in good g and $ExportRest_{ict}$ denotes whether there is the introduction or extension of an export restriction for material i in country c and time period t. We can rewrite this equation using $D_{i,cgt} = U_{ig} * ExportRest_{ict}$ which yields the following equation:

$$y_{cgt} = \alpha_{cg} + \alpha_{ct} + \alpha_{gt} + \sum_{i=1}^{I} \beta_i \, D_{i,cgt} + \varepsilon_{cgt} \tag{2}$$

As I am estimating a three-dimensional panel, α_{cg} denotes the country-good fixed effect, α_{ct} the country-year fixed effect, α_{gt} the good-time fixed effect, $\beta_{i,cgt}$ the coefficient of interest (i.e. the influence of the introduction/extension of the export restriction for material i per country-year-good on the variable of interest) and $D_{i,cgt}$ the binary variable of whether there is the introduction or extension of an export restriction for this country, year and good for material i. Capital I is the number of materials considered.

As there is a quite a list of materials covered and we do not need to know the exact coefficient of each different material separately, we can further simplify:

$$y_{cgt} = \alpha_{cg} + \alpha_{ct} + \alpha_{gt} + \beta \, D_{cgt}^{any} + \varepsilon_{cgt} \tag{3}$$

where D_{cgt}^{any} denotes the binary variable whether there is any (i.e. at least one) introduction (or extension) of an export restriction for good g imposed by country c in year t. Adding lags leaves me with the following equation for estimation:

$$y_{cgt} = \alpha_{cg} + \alpha_{ct} + \alpha_{gt} + \beta \, D_{cgt}^{any} + \gamma \, D_{cgt}^{any,L1} + \varphi \, D_{cgt}^{any,L2} + \varepsilon_{cgt} \tag{4}$$

where D_{cgt}^{L1} denotes the lagged binary variable whether there was any (i.e. at least one) introduction or extension of an export restriction for good g imposed by country c in the previous year $(t-1)$. As it is unclear how long it takes for the export tax upstream to show impact downstream, I am adding lags. [20]

[19] Assuming a linear relationship can be seen as a Taylor approximation of an unknown function.

[20] This could be for instance due to storage of the raw material or the produced product.

In addition to estimating equation (4), I will also estimate the same equation taking into account whether or not the raw material rich country is big enough to influence the world market price of the raw material upstream. In order to do so, a binary variable controlling for market power had been added for each material, i.e. $\sum_{i=1}^{I} \beta_i \ (U_{ig} * ExportRest_{ict})$ in equation (1) had been extended to $\sum_{i=1}^{I} \beta_i \ (U_{ig} * ExportRest_{ict} * D_{ict}^{o30})$ where D_{ict}^{o30} denotes the binary variable whether the country c produces at least 30% of the world production of material i in period t. This can be rewritten as $\sum_{i=1}^{I} \beta_i \ D_{i,cgt}^{o30}$ in equation (2) and leads to the following additional equation for estimation:

$$y_{cgt} = \alpha_{cg} + \alpha_{ct} + \alpha_{gt} + \beta \ D_{cgt}^{any\_o30} + \gamma \ D_{cgt}^{any\_o30,L1} + \varphi \ D_{cgt}^{any\_o30,L2} + \varepsilon_{cgt} \qquad (5)$$

A similar additional estimation equation is used accounting for whether the country imposing the export restriction has a world market share upstream of at least 40 %.

4 Data

4.1 Construction of the Samples

In order to assess the effect of export restrictions for industrial raw materials upstream on manufacturing firms downstream, I am combining several datasets to build two different datasets for testing. For the first dataset, I have combined *UN Comtrade export value data* with data on export restrictions of industrial raw materials provided by the *OECD Inventory on export restrictions on Industrial Raw Materials*. In order to match industrial raw materials upstream with their corresponding manufacturing products relying on them downstream, I used detailed end-use data for each raw material provided by the US Geological Service (USGS), more precisely "A Crosswalk of Mineral Commodity End Uses and North American Industry Classification System (NAICS) codes".[21] The second dataset had been created in a similar way using data on export quantities provided by UN Comtrade instead of the export value data.

While manufacturing firms' export data is available for H2 groups 01 to 97, not all of them are relevant to the question addressed in this paper: As we are only interested in the effect on the manufacturing sectors downstream, I first of all selected both export value and export quantity data for the manufacturing HS2 codes,

[21] For conversion of the NAICS used by USGS to the HS classification used in the export value data I used the conversion tables by Pierce and Schott: Justin R. Pierce,Peter K. Schott (2009): A Concordance between ten-digit U.S. Harmonized System Codes and SIC/NAICS Product Classes and Industries. NBER Working Paper 15548

i.e. 25 to 97 Table 1 shows the different manufacturing sectors as well as the three excluded sectors.

HS 2	Sector	
01 - 05	Animal Products	not included in analysis
06 - 15	Vegetable Products	not included in analysis
16 - 24	Foodstuffs	not included in analysis
25 - 27	Mineral Products	
28 - 38	Chemicals & Allied Industries	
39 - 40	Plastics/Rubber	
41 - 43	Rawhides Leather	
44 - 49	Wood Products	
50 - 63	Textiles	
64 - 67	Footwear/Headgear	
68 - 71	Stone/Glass	
72 - 83	Metals	
84 - 85	Machinery/Electrical	
86 - 89	Transportation	
90 - 97	Miscellaneous	

Table 1: Overview Sectors and HS2

Being that done, I used the USGS end-use data to create binary variables for each material indicating whether the HS2 used the raw material (see Table 2). Those additional variables permitted me - once having added the OECD export restriction data - to create the restriction variables for each material as interaction variables, i.e. end-uses times restriction, as described in equation 1.

HS2 group	UseAntimony
25	1
26	0
27	0
...	...
95	0
96	1
98	0

Table 2: Example of Binary End-use Variable created

Apart from providing sufficient variation in the regressor variables, this approach of directly incorporating end-use information in the restriction variables also has another big advantage: one does not have to completely exclude those

HS2 groups that contain the industrial raw materials themselves for which export restrictions are considered. So even though the use of the less disaggregated H2 groups (instead of using HS4 or even more disaggregated data) comes with the disadvantage that some of the relevant dependent H2 groups also contain the relevant raw material, I can easily account for that with a zero in the end-use variable. Before detailing my estimation results, I like to briefly present the previously mentioned data-sources.

4.2 UN Comtrade Export Value and Export Quantity Data

Certainly the first test is to check for the impact of export restrictions upstream on the export value of manufacturing sectors downstream. As is customary, I am using UN Comtrade data. One of its main advantages is that it is available for any country, also for big raw material supplying countries such as China or Russia. For my analysis, I am using UN Comtrade export value data at the two-digit level.[22] Furthermore, I am not only using UN Comtrade export value but also export quantity data.

4.3 The OECD Inventory on Export Restrictions

The OECD inventory on export restrictions can be basically seen as a blacklist of where there are and where there have been export restrictions in place for industrial raw materials. Starting in 2009, the OECD collected information of export restrictions for a list of 64 industrial commodities, including 57 minerals and metals as well as six types of wood. According to the OECD note to the inventory, only the main producing countries for each raw material were checked.

The inventory is unique in providing information on a wide range of different type of export restriction measures for industrial raw materials: it distinguishes between 14 different types of measures and covers the years 2009 - 2014. Unfortunately, due to the before mentioned data collection approach, export restriction information does not cover all countries for each material or putting it differently not all materials for each country. It can be seen as a blacklist of export restrictions.[23] The other main producing countries that the OECD had checked for export restrictions but neither have nor had abolished export restrictions between 2009 and 2014 are not listed in the inventory but fortunately in the Annex of the Methodological Note to the Inventory[24]. Thus, I added this information on no restrictions for the countries above mentioned and the materials listed to the restriction data file. Furthermore, I checked for other countries mentioned in the OECD annex but not

[22] See https://comtrade.un.org/ for more information.

[23] Speaking in terms of a binary variable it includes only the ones, not the zeros except for those zeros that have been a one once between 2009 and 2014.

[24] See bibliography.

appearing in the OECD inventory and added the no-restrictions for them as well. Thus, all-together I am left with 44 countries for which we have data on export restrictions for industrial raw materials.

4.4 USGS End-Use Data

In order to match industrial raw materials upstream with their corresponding manufacturing products relying on them downstream, I needed data on end-use at the HS2 level. The US Geological Service (USGS) provides detailed end-use data for each raw material on its web-page. The excel file "A Crosswalk of Mineral Commodity End Uses and North American Industry Classification System (NAICS) codes" gives end-use data for more than the here selected industrial raw materials. As this is US end-use data[25], it is specified at the NAICS three or for some materials even more disaggregated NAICS level. In order to convert those NAICS to the HS classification used in the UN Comtrade data, I used the conversion tables by Pierce and Schott[26] [27]

4.5 World Mining Data

Furthermore I also wanted to take into account the amount of market power the raw material rich country has on the world market. Hence In order to calculate world market shares upstream for each of the materials I used the World Mining Data published by the Austrian Federal Ministry of Science, Research and Economy (BMWFW) that gives worldwide production of each of the raw materials considered per country and year.[28] The World Mining Data is considered one of the best data sources for production quantities of industrial raw materials worldwide.

[25] It can be safely assumed that as the United States are a sufficiently big country with quite a huge industry, that this compilation of end-uses contains all main end-uses of each raw material.

[26] Justin R. Pierce,Peter K. Schott (2009): A Concordance between ten-digit U.S. Harmonized System Codes and SIC/NAICS Product Classes and Industries. NBER Working Paper 15548.

[27] More precisely the hs_sic_naics_exports_89_106_20091016.dta. The latter contains the conversion between ten-digit HS code, four-digit SIC code and corresponding six-digit NAICS code (see Pierce and Schott (2009) for more detail.).

[28] See http://www.world-mining-data.info/.

4.6 Overview Aggregated Datasets

Before detailing the regression results, it might be worthwhile to get a brief overview over the datasets constructed. Table 3 and 4 present the two main datasets: the one on export value and export restrictions as well as the one on export quantities and export restrictions. [29]

Table 3: Overview Main Dataset a: Export Value & Export Restrictions: Selected Variables; 43 Countries

Statistic	N	Mean	St. Dev.	Min	Max
year	19,722			2009	2015
h2	19,722			25	97
logExportValue	19,722	17.041	4.047	0.000	27.121
AnyIntroduction/Extension	15,184	0.133	0.339	0	1
AnyIntro_o15	12,636	0.028	0.164	0	1
AnyIntro_o20	12,636	0.025	0.156	0	1
AnyIntro_o30	12,636	0.019	0.135	0	1
AnyIntro_o40	12,636	0.018	0.133	0	1
AnyIntro_o50	12,636	0.013	0.113	0	1
Any Introduction (Intro_Only)	15,184	0.088	0.284	0	1

AnyIntro_o15 = Any Introduction or Extension of an Export Restriction and a market share ≥ 15% in the Raw Material Market, similarly for 20, 30, 40 & 50 %

Table 4: Overview Main Dataset b: Export Quantities & Export Restrictions: Selected Variables; 40 Countries

Statistic	N	Mean	St. Dev.	Min	Max
year	17,953			2009	2015
h2	17,953			25	99
total_Quantity	17,953	3,632,630,812.000		0	24,002,760,535,959
log_Quantity	17,605	15.352	4.584	0	30.809
AnyIntro	14,499	0.141	0.348	0	1
AnyIntro_o15	12,621	0.028	0.166	0	1
AnyIntro_o20	12,621	0.026	0.158	0	1
AnyIntro_o30	12,621	0.019	0.136	0	1
AnyIntro_o40	12,621	0.018	0.135	0	1
AnyIntro_o50	12,621	0.013	0.114	0	1

AnyIntro_o15 = Any Introduction or Extension and a market share of at least 15%

[29] Tables have been build with the stargazer package in R.

5 Estimation Results

5.1 Estimations Export Value

After having shown theoretically how raw material rich countries can use export restrictions upstream to give domestic manufacturing sectors downstream a competitive advantage, it would be truly interesting whether there is empirical evidence that such a modern type of (infant) industry protection is indeed in place. Estimating a Fixed Effect model, I find a clear positive effect of the introduction of an export restriction for industrial raw materials upstream on the export value downstream in the manufacturing sectors. The effect becomes more pronounced when taking into account the market power of the country in the raw material's world market upstream.

Table 5: Estimation results log export value on Introduction or Extension of Export Restriction, robust FE

	(1)	(2)	(3)
Market Power Upstream	Any	$\geq$ 30 %	$\geq$ 40 %
AnyIntroduction/Extension	**0.086***** (0.030)		
lagAnyIntroduction/Extension	**0.072**** (0.036)		
lag 2 AnyIntro/Extension	0.013 (0.038)		
AnyIntro/Ext_o30		**0.113***** (0.037)	
lag AnyIntro/Ext_o30		**0.201***** (0.045)	
lag 2 AnyIntro/Ext_o30		**0.117***** (0.040)	
AnyIntro/Ext_o40			**0.115***** (0.039)
lag AnyIntro/Ext_o40			**0.210***** (0.046)
lag 2 AnyIntro/Ext_o40			**0.116***** (0.042)
_cons	17.587*** (0.010)	17.740*** (0.002)	17.741*** (0.002)
R^2	0.002	0.002	0.002
N	9660.000	7802.000	7802.000

*Significance levels: *p<0.10, ** p<0.05, *** p<0.01*

As can be seen in table 5 (first column), there is not only a clear positive effect of the introduction or extension of an export restriction upstream on the export value downstream, it is also highly significant at the one percent level.[30] Those results hold when regressing only on any introduction of export restriction upstream leaving all types of extensions aside.

Moreover, there is an overall positive effect of the introduction or extension of an export restriction upstream on the export value downstream one period later (see table 5, first column). The effect is slightly smaller. We find no significant effect two periods after. Thus, the effect of the export restriction upstream seems to fade out - probably due to firms' responses. Regressing on the number of introductions of export restrictions imposed by the country instead of the dummy, we found hardly any significant effect. Thus, it seems that it is only whether there is any restriction at all introduced that matters and not the quantity of export restrictions. This might not be surprising as the number of restrictions itself does say little about its severity.

As a necessary assumption in our theoretical model had been that the raw material rich country has to be big enough to influence the world market price of the raw material, it might be worth to also empirically control for it. Thus, I am estimating equation (5). As can be seen in table 5 in the second and third column, the positive effect of the introduction or extension of an export restriction upstream on the export value downstream becomes much bigger when controlling for market power upstream in the raw material market. It stays highly significant at the one per cent level.

Interestingly, now the effect first grows before fading out later: the positive effect of the introduction or extension of an export restriction upstream on the export value downstream is higher one period later (lag 1) than in the same period. It declines two periods after (lag 2), but still is of about the same magnitude as in the period it is implemented and highly significant at the one per cent level. Thus, the effect of the introduction or extension of an export restriction upstream on the export value downstream in the manufacturing sector is not only much bigger than our first estimations (see table 5 first column) suggested, but it also lasts longer.

[30]Those results are robust to reversed causality as the reverse effect of today's export value on previous introductions is not possible. Furthermore, running a fixed effect logit regression of AnyIntroduction on logExportValue of the previous year (i.e. lag1) shows completely no significance.

5.2 Estimations Export Quantities

Can we say anything more on the effect of the introduction or extension of an export restriction upstream on the export value downstream in the manufacturing sector? Using UN Comtrade export quantity data, we also find a overall positive effect of the introduction or extension of an export restriction upstream on export quantities downstream. As can be seen in table 6, the effect is more pronounced when the country's market power in the raw material market upstream lies at at least 30 % and 40 % respectively.

Table 6: Estimation results log Export Quantity on Introduction/Increase of an Export Restriction Upstream, robust FE

	(1)	(2)	(3)
Market Power Upstream	≥ 20 %	≥ 30 %	≥ 40 %
AnyIntro/Ext_o20	**0.108***		
	(0.057)		
lag AnyIntro/Ext_o20	**0.080***		
	(0.046)		
lag 2 AnyIntro/Ext_o20	**0.168*****		
	(0.037)		
AnyIntro/Ext_o30		**0.160***	
		(0.086)	
lag AnyIntro/Ext_o30		**0.094***	
		(0.051)	
lag 2 AnyIntro/Ext_o30		**0.175*****	
		(0.043)	
AnyIntro/Ext_o40			**0.175***
			(0.090)
lag AnyIntro/Ext_o40			**0.102***
			(0.052)
lag 2 AnyIntro/Ext_o40			**0.181*****
			(0.044)
_cons	15.946***	15.947***	15.946***
	0.003	0.004	0.004
R^2	0.001	0.001	0.001
N	7801.000	7801.000	7801.000

*Significance levels: + p<0.15, *p<0.10, ** p<0.05, *** p<0.01*

6 Conclusion

This paper shows both theoretically and empirically how export restrictions on industrial raw materials upstream are used to give domestic manufacturing sectors downstream a competitive advantage. Being especially useful for a raw material rich country having a young and small manufacturing industry downstream, this might be used as a type of infant industry protection that takes advantage of the global value chain.

Estimating a fixed effect model, I find empirical evidence for the successful existence of such a "modern" type of (infant) industry protection in the case of industrial raw materials. More precisely, I find a clear and highly significant positive effect of the introduction (or extension) of an export restriction upstream on the export value in the manufacturing sectors downstream. This effect is even higher and lasts longer when taking into account the market power of the country in the raw material market upstream - a fact that is in line with the theoretical model presented in this paper. Besides, we also find a positive effect of the introduction (or extension) of an export restriction upstream on export quantities downstream. We can hence conclude that raw material rich countries that are big enough to influence the world market price for the raw material dispose of a new type of infant industry protection for their manufacturing sectors.

My estimation results have been gained using two novel datasets I created by combining several different data sources. For the main dataset, I have combined UN Comtrade export value data with data on export restrictions of industrial raw materials provided by the OECD Inventory on export restrictions on Industrial Raw Materials. In order to match industrial raw materials upstream with their corresponding manufacturing products relying on them downstream, I used detailed end-use data for each raw material provided by the US Geological Service (USGS). The second dataset had been created in a similar way using UN Comtrade export quantity data instead of the export value data.

Whether and how this modern type of (infant) industry protection could be challenged by the influence of secondary markets for industrial raw materials is less clear. Future research would be needed to shed more light on those issues. The same is true for other problems of enforcement that might hinder the successful implementation of the here described industry protection.

References

[1] Austrian Federal Ministry of Science, Research and Economy (BMWFW): World Mining Data. Available online at http://www.world-mining-data.info/. Data downloaded 16th June 2017.

[2] Barry, J.J., Matos, G.R., and Menzie, W.D. (2015): *A crosswalk of mineral commodity end uses and North American Industry Classification System (NAICS) codes* U.S. Geological Survey Open-File Report 2015–1163, 4 p., plus 77 tables in 1 Excel file, http://dx.doi.org/10.3133/ofr20151163.

[3] BGS: Risklist 2015: Current supply risk for chemical elements or element groups which are of economic value, British Geological Service.

[4] Cameron, A. Colin; Trivedi, Pravin K. (2009): *Microeconometrics: Methods and Applications*. 8th Edition., Cambridge (Cambridge University Press).

[5] Diakantoni, Antonia; Escaith, Hubert (2014): Trade in tasks, tariff policy and effective protection rates. MPRA Paper No. 60675. Available online at https://mpra.ub.uni-muenchen.de/60675/.

[6] Erbahar, Aksel; Zi, Yuan (2016): Cascading Trade Protection: Evidence from the US. Tinbergen Institute Discussion Paper No. 16-079/VI.

[7] Erdmann, Lorenz; Behrendt, Siegfried; Feil, Moira (2011): *Kritische Rohstoffe für Deutschland* (Critical Raw Materials for Germany). A study by the Institute for Futures Studies and Technology Assessment and adelphi (Institute), Berlin, Germany.

[8] Feenstra, Robert C. (2004): *Advanced International Trade: Theory and Evidence*. 1st Edition., Princeton (Princeton University Press).

[9] Greenaway, David; Milner, Chris (2003): Effective Protection, Policy Appraisal and Trade Policy Reform. World Economy, 26(4), 441-456.

[10] Hlavac, Marek (2015). stargazer: Well-Formatted Regression and Summary Statistics Tables. R package version 5.2. http://CRAN.R-project.org/package=stargazer.

[11] Krugman, Paul (1984): Import Protection as Export Promotion: International Competition in the Presence of Oligopoly and Economics of Scale. In: *Monopolistic competition and international trade*, edited by Henryk Kierzkowski, Oxford : Clarendon, 1984.

[12] Mas-Colell, A. et al (1995): *Microeconomic Theory*, New York (Oxford University Press).

[13] Melitz, M. (2003): The Impact of Trade on intra-industry Reallocations and aggregate Industry Productivity. Econometrica, 71, 1695-1725.

[14] Normann, H. (2011): Vertical Mergers, Foreclosure and Raising Rivals' Costs - Experimental Evidence. The Journal of Industrial Economics, Vol. 59, No. 3 (September 2011), 506-527.

[15] OECD (2016): Methodological Note to the Inventory of Restrictions on Exports of Raw Materials. *available on the OECD Web page*. Version updated 09/03/2016.

[16] OECD: Inventory on export restrictions on Industrial Raw Materials. Dataset downloaded 15th February 2016.

[17] Ordover, J., Saloner, G., Salop, S.C. (1990): Equilibrium Vertical Foreclosure. American Economic Review 80, 127-42.

[18] Pierce, Justin R.; Schott, Peter K. (2009): A Concordance between ten-digist U.S. Harmonized System Codes and SIC/NAICS Product Classes and Industries. *NBER Working Paper 15548*.

[19] R Core Team (2016): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

[20] Salinger, M. (1988): Vertical Mergers and Market Foreclosure. Quarterly Journal of Economics 77, 345-56.

[21] Salop, S.C.; Scheffman, D. (1983): Raising Rivals' Costs. American Economic Review 73, 267-71.

[22] Tirole, Jean (1988): *The Theory of Industrial Organization*. Cambridge/Massachusetts (The MIT Press).

[23] Weisman, D.; Kang, J. (2001): Incentives for Discrimination when Upstream Monopolists Participate in Downstream Markets. Journal of Regulatory Economics, 20:2, 125-139.

7 Appendix

Industrial Raw Materials Considered

Material	HS groups
Aluminium	7601, 7602, 7603
Antimony	8110
Barite	251110
Beryllium	811211
Bismuth	8106
Borate	2528
Carbon/Diamonds	710221, 710229
Chromium	811220
Cobalt	8105
Copper	7401-7407
Feldspar	252910
Fluorspar	252921, 252922
Gallium, Hafnium, Indium, Niobium, Rhenium	HS6 811299 (jointly)
Germanium	811230
Graphite	2504
Lead	7801
Lithium	282520, 283691
Magnesite	251910
Magnesium	8104
Manganese	8111
Molybdenum	8102
Nickel	7502, 7503, 7504
Palladium	711021, 711029
Platinum	7110
Rare Earth	280530, 284690
Selenium	280490
Silver	710610, 710692
Tantalum	8103
Tellurium	280450, joint with Boron
Titanium	8108
Tin	8001, 8002, 8003
Tungsten	8101
Vanadium	811240
Zinc	260800
Zirconium	8109

Table 7: Industrial Raw Materials considered in the present Paper

List of Countries Included

Africa and Middle-East (17 countries):
Angola, Botswana, Burundi, Congo (Republic Of) (Bra), Egypt, Ghana, Jordan , Kenya, Madagascar, Mozambique, Nigeria, Oman, Rwanda, South Africa, Tunisia, Zambia, Zimbabwe.
Americas (10 countries):
Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Jamaica, Mexico, Morocco, Peru.
Asia (8 countries):
China, India, Indonesia, Japan, Malaysia,Russian Federation, Turkey, Viet Nam.
Europe (7 countries):
Belarus, Belgium, Kazakhstan, Norway, Portugal, Spain, Ukraine.
Oceania (1 country):
Australia.

the OECD Inventory on Export Restrictions

Overview Types of Export Restrictions

Type of Restriction	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Captive Mining	1	1	1	1	1	1
Domestic Market Obligation	14	22	22	22	22	22
Export Prohibition	5	46	58	58	70	53
Export Quota	21	24	22	24	22	22
Export Surtax	24	24	24	24	24	24
Export Tax	**282**	**280**	**260**	**298**	**291**	**273**
Fiscal Tax on Exports	0	0	0	0	12	21
Licensing Requirement	269	284	284	352	263	276
Minimum Export Price	0	12	24	24	12	12
Qualified Exporters List	0	0	0	0	0	4
Restriction on Customs Clearance Point	4	1	1	7	7	7
VAT Tax Rebate Reduction / Withdrawal	0	15	0	0	0	0
Other Export Measures	58	61	61	61	61	31

Table 8: Types of Export Restrictions for Industrial Raw Materials, Source: OECD Inventory on Export Restrictions on Industrial Raw Materials, own graphics.

Export Restrictions on Industrial Raw Materials: Direction of Change

	2009		2010		2011		2012		2013		2014	
decrease	27	(4.0 %)	28	(4.0 %)	19	(2.5 %)	35	(4.1 %)	20	(2.6 %)	17	(2.3 %)
elimination	4	(0.6 %)	2	(0.3 %)	0	(0 %)	39	(4.6 %)	20	(2.6 %)	4	(0.5 %)
extension	17	(2.5 %)	3	(0.4 %)	4	(0.5 %)	34	(4.0 %)	30	(3.8 %)	0	(0 %)
increase	12	(1.8 %)	23	(3.0 %)	24	(3.2 %)	13	(1.5 %)	15	(1.9 %)	17	(2.3 %)
indeterminable	28	(4.0 %)	0	(0 %)	2	(0.3 %)	0	(0 %)	0	(0 %)	16	(2.2 %)
introduction	**60**	**(9.0 %)**	**106**	**(14.0 %)**	**12**	**(1.6 %)**	**66**	**(7.7 %)**	**19**	**(2.4 %)**	**43**	**(5.8 %)**
left unchanged	522	(78.0 %)	602	(79.0 %)	691	(92.0 %)	655	(76.6 %)	663	(85.0 %)	644	(86.9 %)
partial elimination	0		0		0		0		1		0	
revision	0		0		0		13	(1.5 %)	12	(1.5 %)	0	
Sum	670	(100 %)	764	(100 %)	752	(100 %)	855	(100 %)	780	(100 %)	741	(100 %)

Table 9: Source: OECD Inventory on Export Restrictions on Industrial Raw Materials, own graphics.