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Distortion effects of Export Quota Policy: An analysis of the *China - Raw Materials* dispute

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Abstract

The *China - Raw Materials* dispute recently arbitrated by the WTO opposed China as defendant to the US and the EU as claimants, on the somewhat unusual issue of export restrictions. For the claimants, Chinese export restrictions on various raw materials of which the country is a major producer create shortages in foreign markets. This scarcity does not prevail in the Chinese market and the price in the foreign markets increases, providing a cost advantage to the Chinese industries using these raw materials. China defends export limitations using Article XX of the GATT 1994 on possible exceptions to the prohibition of quantitative restrictions to conserve natural resources. This paper offers a theoretical analysis of the dispute with the help of a model of a monopoly extracting a non-renewable resource and selling it on both the domestic and foreign markets using Fischer and Laxminarayan (2004)'s framework. The theoretical results focus on the effects of imposing an export quota on quantities, prices and efficacy, and are used to comment on the claims of the parties and on the findings of the Panel and Appellate Body. Given the crucial importance of demand elasticities in this theoretical understanding of the conflict, the empirical part of the paper provides estimates of import demand elasticity of the claimants as well as of China – for each product concerned in the case, defined at the HS6 level. The empirical results show that among the products concerned in the dispute, two groups can be differentiated depending on China's export position. When China is a major or first exporter, there is no evident sign of the distortionary effect of an export quota. When China is a weak exporter, but a strong producer and consumer, there is evidence coherent with the model according to which China is imposing a quota export restriction that is inefficient.

Key Words: Export restrictions, WTO, exhaustible natural resources, price discrimination, Article XX of the GATT 1994.
JEL codes: F130, F180, F510, K330, Q370.

1 Introduction

The *China - Measures Related to the Exportation of Various Raw Materials* (*China - Raw Materials*) dispute recently arbitrated by the WTO, opposed China as defendant to the US, the EU and Mexico – hereafter the claimants – on a somewhat unusual issue: export restrictions. This dispute, involving major trade countries, was over four types of export restrictions – export duties, export quota, export licensing and minimum export prices – on various raw materials.[1] In essence, the dispute raises an important issue: the possibility to use environmental concerns in order to justify restrictions of the export of exhaustible natural resources.

The claimants considered that China's export restrictions on raw materials of which the country is a major producer, create shortages in foreign markets, which pushes up prices, while this scarcity does not affect the Chinese market. A higher foreign markets price gives a cost advantage to the Chinese industries using these raw materials. The claimants challenged the export restrictions under Article XI of the GATT 1994 prohibiting quantitative restrictions.[2] China defended the export limitations using Article XX of the GATT 1994 highlighting out possible exceptions to the prohibition of quantitative restrictions, for environmental reasons such as the conservation of exhaustible natural resources (Article XX(g)) and the protection of human health (Article XX(b)). These types of exceptions are not without limits, however. For example, if discrimination is proved, resorting to exceptions of Article XX is not sustainable.

The Panel ruled that China's export restrictions were inconsistent with Article XI of the GATT 1994. It then found that the general exceptions in Article XX of the GATT 1994 could not be used to justify the constraining measures because the Chinese export restrictions were deemed discriminatory. Restrictions on exports that are allowed by the Article XX should be doubled by imposition of corresponding restrictions on domestic consumption. If this condition is not met, there is discrimination. The Panel stated that this condition was not met by China.

Trade in natural resources has been the focus of attention in connection with its importance for economic activity, its effect on the environment and its specific international and domestic regulation (WTO, 2010; Collier and Venables, 2010; Ruta and Venables, 2012; Massari and Ruberti, 2013). This international commercial dispute exemplifies current tensions in raw materials markets. In a recent OECD publication, Kim (2010) shows that the number of countries applying export restrictions has increased since 2000. Most restrictions apply to raw materials and basic agricultural products. The motives of this

[1] 24 raw materials under the category of Bauxite, Coke, Fluorspar, Magnesium, Manganese, Silicone Carbide, Silicone Metal, Yellow Phosphorus, and Zinc were considered.

[2] The Chinese export restrictions were also challenged pursuant to Articles VIII and X of the GATT 1994.

trade policy are various and include the protection of the environment (pollution from the mining industry and energy consumption), the conservation of natural resources for future use, the protection of downstream processing industries, the objectives of fiscal receipts and the control of inflationary pressures. As a result, export restrictions are a fairly common trade policy in natural resources sectors, while tariff protection is less developed than in other sectors as shown by Latina et al. (2011). Korinek and Kim (2011), studying the presence and impacts of export restrictions on raw materials, question the idea that export restrictions are the most effective tool to achieve environmental goals showing that, in many cases, these restrictions do not lead to a consistent reduction in production. Raw materials as well as rare earths are increasingly the subjects of trade disputes and, given the characteristic of exhaustibility of these resources and their key position in high technology production, will continue to figure in such disputes.[3]

This paper offers a theoretical analysis of the *China - Raw Materials* dispute along with an estimation of the import demand elasticity of the claimants as well as China.[4] We model a monopoly extracting a non-renewable resource and selling it on both the domestic and foreign markets using Fischer and Laxminarayan (2004)'s framework. This theoretical analysis allows discussion of the economic rationales of the arguments of the parties in the dispute. The effects of export restrictions on prices and natural resources extraction are investigated with the aim of characterizing the context in which the parties' arguments are corroborated. The theoretical analysis provides a context for discussing discrimination from a different point of view to that of the Panel, that focuses on price distortion and the consequences for societal wellbeing. In the dispute, discrimination was recognized based on the asymmetric treatment of domestic and foreign raw materials markets by China's trade policy. Hudec (2003) points out that isolating differential treatment is a first step in investigating discrimination; in order to conclude about discrimination, a second step is needed to show that something is "wrong" in the differential treatment. Interestingly, one of the results of the model is to show that differential treatment of domestic and foreign markets implied by export restrictions increases price distortions only under certain circumstances. In some situations price distortion is reduced, with the result that nothing "wrong" attaches to the natural resources export restrictions.

A better understanding of the conflict from a theoretical perspective is achieved by making the discussion of the parties' arguments and the effect of export restrictions on price distortion dependent on comparison of the price elasticities of domestic and foreign demand. Because of the crucial importance of demand elasticities, the empirical part of the paper provides estimates of the import demand elasticity of the claimants, – the US,

[3]Raw materials are involved in numerous high-technology components of production. For instance, silicon, used for the production of solar panels, is a main raw material in the photovoltaic industry.

[4]The dispute is analysed from a legal point of view in Karapinar (2012).

the EU27 and Mexico–, as well as of China, for each product concerned in the case defined at the 6 digit International Trade Classification level. The estimates are based on the methodology in Hauk (2008) using Arellano and Bond (1991) and Arellano and Bover (1995) panel data techniques to account for endogeneity problems. Among other results, the empirical part of the paper shows that two cases should be considered. In the first, China is a major exporter and does not discriminate according to demand elasticity and there is no evidence of a quota effect on prices. In the second, China is a weak exporter although a major producer and in this case, the estimates support the existence of a quota distortion in a monopoly pricing behaviour.

The paper is organized as following. The theoretical model is developed in Section 2. Section 3 develops the empirical investigation and Section 4 provides a concluding discussion of the case.

2 Monopoly, resources extraction, and export quota

Fischer and Laxminarayan (2004) examine the case where a monopolist exploits an exhaustible resource and sells it on two different markets. The model retains the features of Stiglitz (1976) model with iso-elastic demand and zero extraction costs. Under these assumptions and in presence of two markets where arbitrage is not possible, the authors compare the results found in the cases of the monopolist maximizing its profit, and the social planner maximizing total welfare. They find that the monopolist exploits the difference in demand characteristics and sells at two different prices whereas the social planner fixes the same price on both markets in order to signal equivalent scarcity cost. In terms of quantities, they show that the monopolist extracts more rapidly than the social planner.

2.1 A model of natural resources extraction and export

In order to develop a theoretical analysis of *China – Raw Materials* dispute we introduce in Fischer and Laxminarayan (2004)'s model a trade policy aimed at restricting the exports of an exhaustible natural resource. We then consider that the resource extracted by the monopolist is sold on two markets: the domestic and the foreign. The aim of the model is to emphasize the consequences of an export restriction consisting of a quota on: the quantity sold overseas; the price; the resource extraction path; and welfare. Three different scenarios are considered: (i) $[P]$, a social planner maximizes total welfare $j = P$; (ii) $[M]$, a monopolist maximizes its profit $j = M$; and (iii) $[E]$ a monopolist maximizes its profit while it is constrained by an export quota $j = E$.

2.1.1 Assumptions for the three scenarios

The three scenarios have the following features in common. The domestic and foreign markets are denoted respectively d and f. In these markets, the two demands have different price elasticities η_d and η_f. For simplicity, we suppose – following Stiglitz (1976) – that both elasticities are constant and greater than 1 and that there are no extraction costs. The constant discount rate is denoted r. Demand is given by:

$$q_i^j(t) = \frac{\mu_i}{p_i^j(t)^{\eta_i}} \quad \forall j = P,\, M,\, E \quad \forall i = d,\, f \tag{1}$$

where μ_i is the relative size of the market i. The inverse demand functions are then:

$$p_i^j(t) = \left(\frac{q_i^j(t)}{\mu_i}\right)^{\frac{-1}{\eta_i}} \qquad \forall i = d, f \quad \forall j = P,\, M,\, E \tag{2}$$

The extraction rate at time t is $q^j(t)$ and is split into: $q_d^j(t)$ the amount of the resource offered on the domestic market and $q_f^j(t)$ the amount of the resource offered on the foreign market:

$$q^j(t) = q_d^j(t) + q_f^j(t) \quad \forall t,\, \forall j = P,\, M,\, E \tag{3}$$

The resource reserve S is known with certainty at time 0. The constraint on total extraction is such that:

$$\int_{t=0}^{\infty} \left[q_d^j(t) + q_f^j(t)\right] dt \leq S \quad \forall j = P,\, M,\, E \tag{4}$$

When an export quota is introduced in the monopolist's decision problem ($j = E$), the total resource extraction dedicated to the foreign market is limited to S_w:[5]

$$\int_{t=0}^{\infty} q_f^E(t)dt \leq S_f \tag{5}$$

2.1.2 Three decision problems

The social planner is supposed to maximize the total surplus which is equal to the total consumer surplus since there is no extraction cost. The social planner's maximization problem is thus:

$$\begin{array}{ll} \underset{q_d^P(t), q_f^P(t)}{max} & \int_0^{\infty} e^{-rt} \left[\int p_d^P(t) + \int p_f^P(t)\right] dt \\ s.t. & \int_0^{\infty} \left[q_d^P(t) + q_f^P(t)\right] dt \leq S \end{array} \qquad [P]$$

The monopolist aims at maximizing its profits under the resource stock constraint:

[5]Therefore, the monopolist has to choose how to allocate S_w over time.

$$\max_{q_d^M(t), q_f^M(t)} \int_0^\infty e^{-rt} \left[p_d^M(t)\, q_d^M(t) + p_f^M(t)\, q_f^M(t) \right] dt \qquad [M]$$
$$s.t. \int_0^\infty \left[q_d^M(t) + q_f^M(t) \right] dt \leq S$$

The decision problem of the monopolist facing the export quota is:

$$\max_{q_d^E(t), q_f^E(t)} \int_0^\infty e^{-rt} \left[p_d^E(t)\, q_d^E(t) + p_f^E(t)\, q_f^E(t) \right] dt$$
$$s.t. \int_0^\infty \left[q_d^E(t) + q_f^E(t) \right] dt \leq S \qquad [E]$$
$$and \int_0^\infty q_f^E(t)\, dt \leq S_f$$

2.2 The consequences of an export quota

While Fischer and Laxminarayan (2004) focused on decision problems $[P]$ and $[M]$ to study the behaviour of a monopolist extracting an exhaustible natural resource and selling it on two different markets, here we focus on problem $[E]$ to study the impact of an export quota on the monopolist's behaviour.

Replacing the price functions by their expressions given in (2) allows the first order conditions of the maximization of the monopolist's profit under the total extraction and the quota conditions to be written as:

$$e^{-rt} \cdot \frac{\eta_d - 1}{\eta_d} \cdot \left(\frac{q_d^E(t)}{\mu_d} \right)^{\frac{-1}{\eta_d}} - \lambda_1 = 0 \tag{6}$$

$$e^{-rt} \cdot \frac{\eta_f - 1}{\eta_f} \cdot \left(\frac{q_f^E(t)}{\mu_f} \right)^{\frac{-1}{\eta_f}} - \lambda_1 - \lambda_2 = 0 \tag{7}$$

$$\int_{t=0}^{\infty} \left[q_d^E(t) + q_f^E(t) \right] dt \leq S \qquad (\lambda_1 > 0) \tag{8}$$

$$\int_{t=0}^{\infty} q_f^E(t) dt \leq S_f \qquad (\lambda_2 > 0) \tag{9}$$

Both extractions conditions must hold along the resource extraction paths for both markets.[6] In the rest of the paper we consider the two constraints to be binding in order to concentrate on the Chinese claim that natural resource scarcity matters, and on the claimants' concern over export restrictions.

2.2.1 The rate of growth of prices and the extraction paths

A first characteristic common to the solutions of the maximization problems $[P]$, $[M]$, and $[E]$ is that prices are rising at the interest rate, as stated in Lemma (1).

[6] To satisfy the first order conditions the two quantities extracted must be strictly positive in every period (even if infinitesimally small).

Lemma (1). Under the three decision problems $[P]$, $[M]$, and $[E]$, the prices in both markets are rising over time at the discount interest rate:

$$p_i^j(t) = \mathrm{e}^{rt} p_i^j(0) \quad \forall i = d,\, f \quad \forall j = P,\, M,\, E \tag{10}$$

Fischer and Laxminarayan (2004) showed this result under decision problems $[P]$ and $[M]$. The proof under problem $[E]$ is given in the annex. The extraction paths (from Hotelling rules) for the domestic and foreign markets can be calculated as the dual result of the price paths as follows:

$$q_i^j(t) = \mathrm{e}^{-\eta_i rt} q_i^j(0) \quad i = d,\, f \quad \forall j = P,\, M,\, E \tag{11}$$

Extraction paths have the same form under the three decision problems $[P]$, $[M]$, and $[E]$. Note, however, that as relative prices differ under the three problems, the extraction paths will diverge.

2.2.2 The impact of constraining exports on prices

Fischer and Laxminarayan (2004) show that the social planner equates the two prices in order to reflect equivalent scarcity costs on both markets. But, since demand functions differ in their elasticities and market size parameters, the optimal quantity chosen by the social planner for each market will differ. Using (2) and price equality on both markets under $[P]$, we find a relationship between $q_f^P(t)$ and $q_d^P(t)$:

$$q_f^P(t) = \mu_f \left(\frac{q_d^P(t)}{\mu_d} \right)^{\frac{\eta_f}{\eta_d}} \tag{12}$$

Unlike the social planner, the monopolist has an incentive to discriminate conditional on demand elasticities: i.e. to fix a higher price in the lowest demand elasticity market. The profit-maximizing monopolist equates each market's marginal revenue. It follows the relation between the two prices under $[M]$:

$$p_f^M(t) = \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot p_d^M(t) \tag{13}$$

If the domestic demand price elasticity η_d is higher than the foreign demand price elasticity η_f, then $p_f^M(t)$ is higher than $p_d^M(t)$. And symmetrically, when $\eta_d < \eta_f$, then $p_f^M(t) < p_d^M(t)$.

The introduction of an export quota in the monopolist's decision problem modifies these results: an export quota can push the foreign price above the domestic price, even if the domestic demand elasticity is smaller than the foreign demand elasticity, provided the export quota is sufficiently restrictive.

Lemma (2). When the profit maximization is subject to an export quota constraint, the monopolist chooses extractions $q_d^E(t)$ and $q_f^E(t)$ such that:

$$p_f^E(t) = \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot p_d^E(t) + \lambda_2 e^{rt} \frac{\eta_f}{\eta_f - 1} \tag{14}$$

The proof is provided in the annex. If the export quota constraint is not binding ($\lambda_2 = 0$), (14) and (13) are identical and, as a consequence, the results found by Fischer and Laxminarayan (2004) apply: the monopolist charges a higher price in the market with the lowest demand elasticity. When the export quota is binding ($\lambda_2 > 0$), two cases are possible depending on the relative size of both demand elasticities.

First, if domestic demand elasticity is larger than foreign demand elasticity ($\eta_d > \eta_f$), then $p_f^M(t) > p_d^M(t)$, because $\lambda_2 e^{rt} \frac{\eta_f}{\eta_f - 1} > 0$. Then, when $\eta_d > \eta_f$, $p_f^M(t) > p_d^M(t)$ holds irrespective of the presence of an export quota.

Second, if domestic demand elasticity is smaller than foreign demand elasticity ($\eta_d < \eta_f$), the monopolist facing an export quota may charge a higher price in foreign market.

This outcome is addressed in two steps. First Proposition (1) shows that the effect of an export quota is to raise the price on the foreign market and to lower the price on the domestic market. Then, Proposition (2) establishes a condition under which the foreign price is higher than the domestic price even if the foreign demand elasticity is greater than domestic demand elasticity.

Proposition (1). Constraining the monopolist's export through a quota raises the price on the foreign market and lowers the price on the domestic market: $p_f^E(t) > p_f^M(t)$ and $p_d^E(t) < p_d^M(t)$.

The proof is given in annex. The price effect of an export quota is independent of the level of the relative demand elasticities and has implications for consumers' welfare as stated in Corollary (1).

Corollary (1). Consumers in the foreign market (resp. the domestic market) suffer (resp. benefit) from the export quota.

This result, whose proof is given in annex, follows Proposition (1).

The possibility of a higher foreign than domestic price one as a consequence of export restrictions ($p_f^E(t) > p_d^E(t)$) when $\eta_d < \eta_f$, can now be stated.

Proposition (2). Under an export quota, if the export quota constraint is sufficiently constraining, the monopolist can fix a foreign price higher than the domestic price for the exhaustible resource even if foreign demand price elasticity is greater than the domestic demand elasticity. This requires that the initial extraction for export is small enough:

$$q_f^E(0) < \mu_f \left(\frac{q_d^E(0)}{\mu_d} \right)^{\frac{\eta_f}{\eta_d}} \tag{15}$$

The proof is given in the annex. In a situation where the foreign demand elasticity is higher than the domestic demand elasticity, the monopolist without export restriction would choose a foreign price lower than the domestic price. Imposing an export quota can push the foreign price above the domestic price if the quota is sufficiently restrictive. This situation appears if condition (15) is satisfied, implying that $q_f^E(0)$ the initial resource extraction for export is sufficiently small.

Proposition (2) shows that, as asserted by the claimants, an export quota could lead to an implicit cost advantage for the Chinese producers because it might induce an increase in the foreign price relative to the domestic price that is not related to an elasticity difference. In the context of *China - Raw Materials*, condition (15) shows that this charge against China is reasonable only if the export quota is sufficiently restrictive.

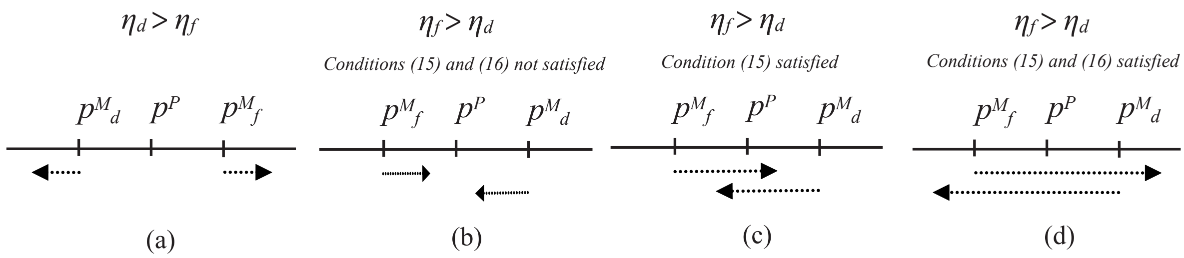
2.2.3 The impact of constraining exports on the monopolist equilibrium distortion

We can compare the prices fixed by the social planer and the monopolist with and without export quota. Fischer and Laxminarayan (2004) show that the monopolist's equilibrium must be at a higher price than is optimal in the market with the lowest demand elasticity, and at a lower price than the optimal in the market with the highest demand elasticity. Two situations can therefore be considered. The first is $p_f^M(t) > p^P(t) > p_d^M(t))$, which arises when $\eta_f < \eta_d$; the second one is $p_d^M(t) > p^P(t) > p_f^M(t)$, which arises when $\eta_f > \eta_d$. Propositions (1) and (2) taken together show that the effect of the export quota is to raise the price on the foreign market and to lower the price on the domestic market, and that the price on the foreign market might be higher than the price on the domestic market even if $\eta_f > \eta_d$ (when condition (15) is satisfied). These results have implications for price distortion in the monopolist's equilibrium as shown in Proposition (3) and Corollary (2).

> **Proposition (3)**. When domestic demand elasticity is greater than foreign demand elasticity, the export quota increases the inefficiency of the monopoly. When, foreign demand elasticity is greater than domestic demand elasticity, imposing an export quota increases the inefficiency of the monopoly if $p_f^E(t)$ is sufficiently larger than $p_f^M(t)$ and $p_d^E(t)$ sufficiently smaller than $p_d^M(t)$, satisfying the following conditions:

$$\begin{aligned} p_f^E(t) &> p_f^M(t) \cdot \tfrac{\eta_f - 1}{\eta_f} \cdot \tfrac{\eta_d}{\eta_d - 1} \\ p_d^E(t) &< p_d^M(t) \cdot \tfrac{\eta_f}{\eta_f - 1} \cdot \tfrac{\eta_d - 1}{\eta_d} \end{aligned} \tag{16}$$

The proof is given in the annex. Four cases are considered in relation to Proposition (3). In the first situation the monopolist without export quota fixes a higher price on the foreign market because $\eta_f < \eta_d$. In this case (depicted in figure 1.a), the quota increases the inefficiency of the monopolist's equilibrium because of the increase in $p_f^M(t)$ and the decrease in $p_d^M(t)$ it implies: $p_d^E(t) < p_d^M(t) < p^P(t) < p_f^M(t) < p_f^E(t)$.



The second situation, corresponding to $\eta_f > \eta_d$, includes three sub-cases, since, as shown in the proof of proposition (3), conditions (16) imply that condition (15) is satisfied, but the converse is not true. In the first sub-case corresponding to figure (1.b) conditions (15) and (16) are not satisfied. In that case the increase in the foreign price and the decrease in the domestic price implied by the export quota are not big enough to result in $p_d^E(t) < p_f^E(t)$. The effect of the export quota, therefore, is to move the two prices closer to the price chosen by the regulator: $p_f^M(t) < p_f^E(t) < p^P(t) < p_d^E(t) < p_d^M(t)$ and, as a result, to reduce price discrimination. In the second sub-case corresponding to figure (1.c) condition (15) is satisfied whereas conditions (16) are not. In this case the effect of the quota is to push the foreign price above the domestic price. However, $p_f^M(t) < p_d^E(t)$ and $p_f^E(t) < p_d^M(t)$ so that the monopolist's equilibrium price distortion is reduced as a consequence of the export quota. In the last sub-case corresponding to figure (1.d), condition (15) and conditions (16) are satisfied. The foreign price is higher than the domestic price and the increase in the former and the decrease in the latter are sufficiently large to amplify the monopolist's equilibrium price distortion: $p_d^E(t) < p_f^M(t) < p^P(t) < p_d^M(t) < p_f^E(t)$.

Finally, we can note with Corollary (2) that when the monopolist's equilibrium price distortion is reduced, the monopolist does not set prices equal to those of the social planner.

> **Corollary (2)**. When imposing a quota reduces the monopolist's equilibrium price distortion, optimality is not restored.

The proof is given in the annex. Proposition (3) is especially important in the context of the *China - Raw Materials* dispute since it deals with discrimination. Discrimination was recognized in this dispute through the simple asymmetric treatment by China's trade policy of the domestic and the foreign markets. When the consequences of this differential treatment are fully appreciated based on examination of the price distortion (and, therefore, welfare), Proposition (3) shows that the differential treatment of domestic and foreign demand using an export quota should not be seen automatically as augmenting price distortion in the context of a monopoly and, on the contrary, might reduce it.

2.2.4 The impact of export quota on the resource total initial extraction

Should the export quota, in any cases, be considered a resource conserving policy? To answer this question, we first characterize the initial extractions $q_d^E(0)$ and $q_f^E(0)$. Then, we compare the total extraction in the initial period under $[M]$ and under $[E]$ in order to appreciate the consequences of the export quota on the conservation of the natural resource.

Integrating over time $q_i^j(t)$ given in the extractions paths (11) for $i = d,\, f$ and $j = P,\, M,\, E$ gives:

$$\int_{t=0}^{\infty} q_i^j(t)\, dt = \frac{q_i^j(0)}{r\eta_i} \qquad \forall i = d,\, f \quad \forall j = P,\, M,\, E \tag{17}$$

The constraint on total extraction (4) under each decision problem can thus be written as:

$$\frac{q_d^j(0)}{r\eta_d} + \frac{q_f^j(0)}{r\eta_f} \leq S \qquad \forall j = P,\, M,\, E$$

The initial extraction in d in terms of that in f, when the constraint is binding, can thus be expressed as:

$$q_d^j(0) = r\eta_d S - \frac{\eta_d}{\eta_f} q_f^j(0) \qquad \forall j = P,\, M,\, E \tag{18}$$

The total initial extraction $Q_0^j = q_d^j(0) + q_f^j(0)$ is therefore:

$$Q_0^j = r\eta_d S + \left(1 - \frac{\eta_d}{\eta_f}\right) q_f^j(0) \qquad \forall j = P,\, M,\, E \tag{19}$$

The introduction of $\int_{t=0}^{\infty} q_d^E(t)\, dt$ and $\int_{t=0}^{\infty} q_f^E(t)\, dt$ calculated in (16) under $[E]$ in the first order conditions (8) and (9) (with λ_1 and $\lambda_2 > 0$) solve the optimal initial extractions:

$$\frac{q_f^E(0)}{r\eta_f} = S_f \Leftrightarrow q_f^E(0) = r\eta_f \cdot S_f \tag{20}$$

$$q_d^E(0) = r\eta_d(S - S_f) \tag{21}$$

The total initial extractions under $[E]$ and $[M]$ can be compared in order to capture the implications of the export quota on both the initial total extraction and the rate of depletion of the resource. The results depend on the relative size of the two demand elasticities as presented in proposition (4) and Corollary (3).

Proposition (4): Imposing an export quota increases (decreases) the initial total extraction if the domestic demand elasticity is larger (smaller) than the foreign demand elasticity.

When $\eta_d > \eta_f$ the net effect on the total initial supply, of imposing a quota, is positive. This result is similar to the result in Fischer and Laxminarayan (2004) who compare the total initial extractions under $[P]$ and $[M]$: the increase in the supply on the market with more elastic demand overcomes the decrease in the supply on the market with less elastic demand. This effect is reinforced when the monopolist is constrained by an export quota.

The difference in the total initial extraction $Q_0^E - Q_0^M$ is negative when $\eta_f > \eta_d$. The net effect of imposing an export quota on the total initial supply is negative. The fact that the contraction of supply (and the rise in the price) appears on the market with more elastic demand and that the rise in supply appears on the market with less elastic demand, implies that the net effect is reduction in the total initial supply. These results have consequences for the rates of resource extraction as shown with Corollary (3).

Corollary (3). Imposing an export quota implies that the monopolist extracts more (less) rapidly if domestic demand elasticity is bigger (smaller) than foreign demand elasticity.

The proof of Corollary (3) uses the result of proposition (4), showing that imposing an export quota increases the initial extraction when $\eta_d > \eta_f$ and decreases it otherwise, and the result of Lemma (1), showing that resource extractions under $[M]$ and $[E]$ grow over time at the interest rate. Note that since the first order conditions (6)-(9) must hold along the extraction path, if domestic demand elasticity is bigger than foreign demand elasticity, the monopolist under an export quota constraint initially extracts more than it would were there no export quota, but cannot do this indefinitely. The total stock constraint implies that at some point the extraction path under $[E]$ crosses the extraction path under $[M]$.

Proposition (4) and Corollary (3) propose important results to interpret the *China - Raw Materials* dispute. First, China's defence of imposing export restrictions as a resource conservation policy is acceptable only when domestic demand elasticity is smaller than foreign demand elasticity. Second, in this case, asking for a restriction on the domestic consumption of the resource, as the Panel did, is useless. However, it should be required when domestic demand elasticity is bigger than foreign demand elasticity.

We turn now to an attempt to bring this model to the data in order to cast new light on the empirical evidence.

3 Empirical analysis

Any empirical attempt to grasp the effect of the Chinese export restrictions on prices by identifying two periods, before and after implementation of the export quota, is extremely challenging. Indeed, the dispute addresses four types of policy implying 40 measures. Also, for the most part, the measures are decided annually and renewed over time, while the trade policy duration is unclear. The fact that some of the restrictions were allowed to a certain extent in China's accession to the WTO protocol, shows that the raw materials export restrictions may have always been in place. However, given the theoretical understanding of the *China - Raw Materials* dispute developed in Section 2, we have some directions for assessing China's trade policy with regard to China's motives and the claimants' charges. The model states that foreign and domestic demand elasticities, η_d and η_f, are of the utmost importance as are the differences in foreign and domestic prices. The claimants feared an increase in the price of strategic imported raw materials above the Chinese domestic price, which would create unfair competitive advantage.[7] However, the model shows that differences in price have to be judged considering differences in demand elasticities. The WTO Panel found evidence of discrimination since the export restrictions were not accompanied by restrictions on domestic demand, but the model specifies that parallel restrictions are required only if domestic demand elasticity is larger than foreign demand elasticity. The model shows also that the Chinese argument of resource conservation is admissible in a certain configuration of demand elasticities (i.e. when domestic demand is less elastic than foreign demand). Estimating demand elasticities, therefore, should shed light on the dispute from an empirical point of view. To carry out this empirical work, in a first step, we describe the quantity and prices of the trade flows concerned in the dispute, and in a second step, estimate claimants' and China's import demand elasticities.

3.1 Quantity and price: An appraisal

3.1.1 Quantities at stake

The *China - Raw materials* dispute covers a small (24) number of products that we refer to as "products under conflict" (hereafter *PUC*). The 24 raw materials products are defined at the finest level of aggregation (8 digits) of the Harmonized System (HS) classification. The most detailed level of aggregation available in the trade database that we use – BACI-CEPII from UN trade database – is 6 digits. This a lower level than is used by the WTO, but, for most products, provides a sufficient level of aggregation because the products are

[7]Recall that the claimants are countries that are opposed to China (EU27, US and Mexico).

mostly homogeneous and aggregation levels 6 and 8 generally overlap.[8] Our final group of raw material numbers 21 products because three HS6 products (Coke, 270400; Zinc, 790112; Manganese, 811100) are split across several HS8 under-classes.[9]

To isolate some specific characteristics of the *PUC* products with regard to trade policy, we consider a larger group of products including *PUC*. Specifically, we retain all products at the 6-digit level (HS6) included in the six HS2-classes of products that includes the *PUC* products. We refer to this group of products as *HS2_PUC*.[10] The *HS2_PUC* group includes 388 products defined at the HS6 level, including the 21 *PUC* products.

Table 1: Country Share in percentage of HS2_PUC World Import – Average over 1995-2009

HS2	Name	Claimants	China	USA	France	Germany	Japan
25	SALT and SULPHUR	49	4	10	4	6	6
26	ORES, SLAG AND ASH	37	17	5	3	7	19
27	MINERAL FUELS and OILS	49	3	17	4	5	10
28	INORGANIC CHEMICALS	50	4	14	6	6	7
79	ZINC	58	6	17	5	9	2
81	OTHER BASE METALS	58	3	16	5	9	12

Source: BACI-CEPII, 1995-2009.

Table 1 presents the total share of world imports of the claimants, of China and of the individual main claimants for the different $HS2\_PUC$ groups. It shows that world imports are dominated by the group of claimant countries of which the US is the larger contributor, while China is a large importer of "Ores, Slag and Ash". Although China is considered the main producer of PUC products, it also imports all of them.[11]

The short names of the *PUC* products and their percentages in total world imports are provided in Table 2.[12] It unveils that the claimants are the main world importers of *PUC* products. It is also remarkable that China is still a major world importer at this finer product level. This import activity allows us to estimate an import elasticity for China that can be used to proxy for Chinese domestic demand elasticity.

Of course, these raw materials products represent a very small share of the total imports of both the claimants and China.[13] However, as highlighted in the introduction,

[8] This is the highest disaggregated level of import elasticity estimates computed so far, see e.g. Kee et al. (2008).

[9] Coke, 270400 = 27040019 + 27040019 + 27040030 + 27040090; Zinc, 790112 = 79011210 + 79011230 + 79011290; Manganese, 811100 = 81110011 + 81110090.

[10] The full name of each of *HS2_PUC* product is provided in Appendix Table B.1.

[11] In the growing South-South trade, China is a large importer of raw materials because of its specialization pattern and fast growth. See Hanson (2012) and Roberts and Rush (2012).

[12] Full names are provided in the Appendix.

[13] See Appendix Table B.2 and B.3.

Table 2: Country Share in percentage of HS6-PUC World Import – Average over 1995-2009

		Claimants	China	USA	France	Germany	Japan
250830	Fireclay	62.9	1.2	5.4	1.5	1.9	1.7
252921	Fluorspar< 97%[a]	41.1	0.7	9.9	1.0	4.4	16.0
252922	Fluorspar> 97%[a]	64.6	0.1	28.7	0.5	14.4	13.2
260200	Manganese ore	28.0	24.1	4.6	8.0	0.5	13.8
260600	Aluminium	62.5	4.5	23.7	4.8	6.5	3.8
260800	Zinc ores	53.4	6.6	1.9	5.5	4.5	10.4
262019	Slag with zinc	72.9	0.9	7.1	8.4	4.5	5.2
262040	Slag with aluminium	75.3	6.7	10.5	2.5	24.5	3.1
270400	Coke	56.7	0.1	10.1	4.8	15.9	6.0
280469	Silicon	55.8	1.3	15.0	2.3	14.0	19.8
280470	Phosphorus	41.8	0.1	4.6	1.8	13.0	12.0
281700	Zinc oxide & peroxide	63.5	3.7	15.5	5.1	6.0	3.8
284920	Carbides of Silicon	61.3	0.6	18.7	5.0	11.8	13.2
790111	Unwrought zinc> 99%[a]	59.4	4.0	22.6	2.1	7.3	2.3
790112	Unwrought zinc< 99%[a]	62.6	1.9	20.6	6.9	6.5	1.3
790120	Unwrought Zinc alloys	46.0	13.2	1.7	6.0	11.0	1.0
790200	Zinc waste	45.3	21.8	5.7	3.1	6.1	0.6
810411	Magnesium> 99%[a]	54.0	0.0	14.6	4.0	8.4	12.7
810419	Magnesium< 99%[a]	74.0	0.3	27.6	2.3	12.6	6.3
810420	Magnesium Waste	58.5	1.3	25.1	1.0	7.1	0.5
811100	Manganese dust & powder	51.5	0.3	9.7	4.9	12.5	20.6

Source: BACI-CEPII, 1995-2009.

[a] Means % of purity.

their contribution in production is very important.

China can be considered a monopolist if it has the highest share of world export. This applies to some of the *PUC* products. Most often, there is a large number of exporters of each *PUC* product, but restricting this to the leading 20 exporters accounts for more than 90% of world export. Appendix Table B.4 presents the share of the five biggest exporters of *PUC* products in 1995-2009. China is among the top 5 for 12 of the 21 *PUC* products, and is the main world exporter for 8 *PUC* products (see Table 3).

Table 3: *PUC* Products for which China is the First World Exporter and Corresponding Share of World Export in percentages – 1995-2009

HS6	Name	Share
252921	Fluorspar$<$ 97%	26
252922	Fluorspar$>$ 97%	52
270400	Coke	36
280469	Silicon	29
280470	Phosphorus	29
284920	Carbides of Silicon	45
810411	Magnesium$>$ 99%	24
811100	Manganese dust & powder	51

3.1.2 Unit Value as Price

Before embarking on the econometric part, we analyse prices proxied by unit values. The analysis is centred on imports from the claimants. Table 4 gives an average unit value for all import flows of each product, as well as the annual average growth rate of unit value. Table 4 Column (1) displays the arithmetic average export unit value of the five first exporters (4 if China is among the first 5); Column (2) gives the same statistic for Chinese export only.[14] This unable comparison of Chinese prices with the average prices of other large exporters of the same product over the period. Chinese export prices are below the mean of the four (or 5) first exporters for 14 HS6 products and above the mean for the remaining 7. This means that, for two thirds of *PUC*, Chinese exporters have a competitive advantage relative to the main exporters.

Table 4 Columns (3) to (6) display weighted indexes. In order to proxy what the Chinese really obtain from their export, we compute a weighted unit value index where export weights are the share of each destination (import country) in Chinese total HS6 export. To assess what the Chinese pay for their import, we compute a weighted unit

[14] The 5 largest exporters of PUC products account for nearly 70% of PUC trade in 1995-2009. Appendix Table B.4 presents the names and shares of the first five exporters per HS6 product.

value where import weights are the shares of each country of origin in China's total HS6 imports. The weighted Chinese export unit value per product is used as a proxy for foreign price $\hat{p_f}$. Foreigners are the claimants and $\hat{p_f}$ gives an index of what the claimants as a whole paid for imports from China. The weighted Chinese import unit value per product is used to proxy for the Chinese domestic price, $\hat{p_d}$. We suppose that China imports similar products from abroad to those it produces at home. This is reasonable if we accept the hypothesis of homogenous products at the 6-digit level of aggregation. It is also coherent with our estimate of Chinese demand elasticity based on import demand elasticity, as described below.

Comparisons of $\hat{p_f}$ and $\hat{p_d}$ show that most of the time foreign/export price is lower than domestic/import price – 13 products over 21. Nearly two thirds of products are such that China experiences unfavourable terms of trade. It imports at a higher price than it exports for 13 products. There are 8 products for which the contrary is happening.

The annual average growth rates displayed in Table 4 are nearly always positive. There are a few products where prices decreased. Among the 21 products, 10 show a higher increases for import prices than export prices. This suggests support for Proposition (1) for half (11) PUC products: Chinese domestic prices decrease whereas the prices paid by foreigners increase.[15]

The first row in Table 4 gives the results for the PUC aggregate: (i) China's PUC export price is lower than the average price for the other main exporters, thus China has a competitive advantage (this is also true if we drop product *280470* which behaves as an outlier); (ii) China imports at a higher price than it exports, and we can deduce that China's PUC domestic price is higher than the export price; (iii) the annual average growth rates of Chinese domestic and export price are positive and equivalent. To interpret these observations on prices with respect to trade policy, we need to estimate demand elasticities.

3.2 Import demand elasticities

3.2.1 Estimation Methodology

We extend Hauk (2008)'s methodology for estimating import demand elasticities. This method accounts for endogeneity problems by using Arellano and Bond's difference General Method of Moments (GMM) panel data techniques. Here, we use an augmented GMM system based on Arellano and Bover (1995) and Blundell and Bond (1998) where the addition of lagged variables instruments allows more efficient estimates.

For the import demand of claimants (as an aggregate) and China, estimation of demand price elasticity is based on the following equation:

[15] However, it is likely that other demand and supply shocks caused the changes in prices during the period. It is not possible here to isolate trade policy shocks.

Table 4: Mean and Annual Average Growth of unit value per product – 1995-2009

PUC-HS6[f]	EXPORT UV		CHINESE WEIGHTED UV[b]			
	First FIVE[a]	CHINA	EXPORT		IMPORT	
			$\hat{p_f}$	AGR 95-09	$\hat{p_d}$	AGR 95-09
	(1)	(2)	(3)	(4)	(5)	(6)
PUC	4.50	3.31	1.61	0.07	8.03	0.07
250830	0.77	0.81	0.33	0.22	0.50	0.04
252921	0.77	0.33	0.16	0.08	0.46	0.02[c]
252922	0.16	11.37	0.79	0.07	2.82	0.15[c]
260200	0.43	1.84	0.51	0.12	0.23	0.34
260600	0.93	0.18	0.15	0.12	0.52	0.07
260800[e]	4.34	3.38	4.62	0.23	4.11	-0.32
262019[e]	3.92	2.90	2.89	0.06[c]	6.52	0.20
262040	2.58	1.76	0.48	-0.09	0.69	0.18
270400	0.30	0.47	0.31	0.12	0.58	-0.02
280469	5.68	2.10	1.24	0.05	22.20	0.20
280470	34.22	11.92	2.93	0.08	96.64	0.13
281700	2.25	1.63	1.42	0.08	1.23	0.04
284920	8.95	2.72	0.82	0.01	3.58	0.05
790111[e]	2.40	2.19	1.54	0.04	1.30	0.03
790112[e]	1.64	3.39	1.91	0.10	1.25	0.05
790120[e]	3.73	7.56	3.15	0.03	1.27	0.06
790200[e]	1.34	2.95	1.89	0.12[d]	1.24	0.06
810411	5.32	3.54	2.56	-0.01	5.49	0.00
810419	8.23	3.66	2.52	0.01	7.75	0.01[c]
810420	3.91	2.27	1.93	0.02	1.41	0.01[c]
811100	2.69	2.52	1.73	0.04	8.93	0.09

Source: BACI-CEPII, 1995-2009. Unit value in thousand dollars per ton.

[a] Average of the first five exporters or first four if China is one of them.

[b] Import Weights are shares of each country of origin in Chinese total HS6 import. Export weights are share of each importers in Chinese total HS6 export.

[c] Average annual growth rate over 1997-2009 [d] 1997-2006, no export from 2007 up to 2009. [e] Very few flows from China over the total period.

[f] Bold HS6 numbers are products for which China is first exporter.

$$\log q_{i,j,t} = a_{i,0} + a_{i,1} \log q_{i,j,t-1} + a_{i,2} \log p_{i,j,t} + A_i' X_{i,j,t} + \epsilon_{i,j,t} \quad (22)$$

where $q_{i,j,t}$ is the quantity of good i imported from country j at time t, $p_{i,j,t}$ is the price of the imported good i, $a_{i,1}$ is the import price elasticity for the good i, and $\epsilon_{i,j,t}$ is an error term. A vector of the covariates is also included which takes account of the average price of imported goods from other countries in the same sector-HS6 product and the real GDP of the importing country. To account for possible rigidities in response to market changes, a lagged value of the quantity of the good imported is added.

Estimation of elasticity is affected by an endogenous bias because quantity and price are both causing one another. Also, by introducing the lagged value of the imported quantity, we introduce a dynamic effect – here a persistence effect – but we also introduce an element of correlation with the error term. All this renders the OLS estimator biased and inconsistent. We use system GMM estimators proposed by Blundell and Bond (1998) to deal with the panel structure as well as the endogeneity bias.

First, we estimate Equation (22) on the 388 HS2-PUC products and then on the 21 *PUC* products only. This provides an aggregate estimate of elasticity to be compared with the first row of Table 4. Then we replicate Equation (22) for each of the 21 *PUC* and discuss the results for the 21 demand elasticity estimates with respect to the prices proxies in Table 4. These regressions are processed using the panel structure of the data in which the cross-section dimension is the origin of the import, i.e. the different exporting countries.

3.2.2 Results

We start by considering PUC products as an aggregate item that we want to compare with a larger aggregate of raw materials based on HS2_PUC. We turn next to the estimate per PUC product.

Aggregate Estimates: Table 5 gives the results of the estimation of Equation (22) on all HS2-PUC and on only PUC products. Elasticities are given by the coefficient of unit value. Columns (1) and (3) provide the estimates of the elasticity when import is an aggregated flow of the 388 HS2-PUC products per country of origin and per year; columns (2) and (4) give the estimates of the elasticity when import is an aggregated flow of the 21 *PUC* products.

All price elasticity estimates are negative and significant. On average a 10% rise in price leads to a 7 to 11% decrease in import quantity depending on the country and the group of products.

Comparison of HS2 and HS6 estimates for Claimants tells us whether "to be a product under conflict" has an impact on price elasticity. The results show a clear larger sensitivity for PUC products compared to the whole group of HS2 products. This result is not observed for China. Chinese import price elasticity is not significantly different between PUC products and HS2-PUC products.

Comparison of Claimants and China brings another interesting result: while Chinese elasticity is larger than Claimants elasticity for HS2 group, the reverse is observed for PUC products. Chinese imports of PUC products are less sensitive to a change in price than are Claimants' imports. Considering Proposition (4) China's defence of export restrictions as a resource conservation policy is acceptable only if domestic demand elasticity is smaller than foreign demand elasticity, which turns out to be the case based on the empirical evidence when PUC are considered in aggregate.

Table 5: HS2 and HS6 PUC Import Elasticity for Claimants and China

Dep. Variable	Claimants		China	
Imp.Quantity (log)[a]	HS2	HS6	HS2	HS6
	(1)	(2)	(3)	(4)
L.Imp.Quantity (log)	0.210***	0.200***	0.096	0.208***
	(0.07)	(0.06)	(0.06)	(0.08)
Unit value (log)	-0.749***	-1.131***	-0.946***	-0.943***
	(0.13)	(0.09)	(0.12)	(0.13)
Price Index (log)	0.828***	-47.880***	0.133	-0.402
	(0.22)	(16.86)	(0.09)	(0.93)
GDP (log)	1.043***	0.924***	1.146***	1.450***
	(0.17)	(0.13)	(0.19)	(0.29)
Observations	2038	1137	855	377
Groups	194	117	129	69
Instruments	77	80	77	65
Arell-Bond AR(2) p-value	0.99	0.23	0.28	0.65
Hansen Test p-value	0.26	0.84	0.99	0.64

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Robust standard errors in parentheses.

[a] GMM system Estimators, Estimates include year dummies.

So, does this negative difference in elasticities taken in absolute value which happens to be significant, $\widehat{\eta_d - \eta_w}$ $(0.943 - 1.131)$, support the presence of a quota distortion given the conclusions from the model?

From the first line of Table 4, we know $\widehat{p_d - p_w}$ positive. This is what we would expect to support standard discrimination monopolist behaviour. Hence, when all *PUC* products are taken together, the estimation of elasticity, given our hypothesis about the difference in prices, illustrates the theoretical case (b) from Proposition (3) and Figure (1) of the model. It provides no evidence of a distortionary effect of the Chinese export quota. To obtain more precise results, we consider a more disaggregated level of PUC products to account for their very different weight in China's exports and imports.

Per PUC product Estimates: We estimate import elasticity for each of the 21 PUC products following Equation (22). Table 6 gives the coefficient $a_{i,2}$ estimated from Equation (22) for each product using the Arellano and Bover (1998) estimator (GMM system) in columns (1) and (3) and Baltagi and Wu (1999) estimator in columns (2) and (4). The Baltagi and Wu (1999) estimator is used also in order to have a second estimation in case the number of observations is insufficient to provide estimates from the system GMM that pass the Hansen test. The Baltagi and Wu (1999) estimator is a feasible generalized least squares handling unequally spaced panel data with autoregressive disturbances. The full regression tables with test results for Claimants and for China are given in Appendix (Tables B.5 and B.6). All significant coefficients are, as expected, negative.

Chinese import elasticities are most often larger in absolute value than import elasticities of Claimants: two thirds of products exhibit a higher Chinese elasticity – column 5 indicates "+" for positive difference between Chinese elasticity and foreign elasticity both taken in absolute value. Results per HS6 show that Chinese demand is more sensitive than non-Chinese demand in 13 cases out of the 19 we were able to estimate. The last column is deduced from Table 4. On average over 1995-2007, Chinese prices are higher than foreign prices – then $\widehat{p_d - p_w} > 0$ – for 13 products.

Results in Table 4 can be interpreted with regard to the theoretical results of Proposition (3) and Figure (1) of the model on the impact of export restrictions on prices.

Let us start with the indisputable case of (a) where $\widehat{\eta_d - \eta_w} > 0$. In this case the model shows foreign prices are expected to be higher than domestic prices. The case (a) – when columns 5 and 6 are filled (+/−) – applies only to four products of which two can be considered equal elasticities (790111 and 790112).[16] This result corresponds to a situation where the export quota effect on prices enhances the monopolist's price discrimination. The case (b) supposes $\eta_d - \eta_w < 0$ and $p_d - p_w > 0$ which is found for two products (280469 and 810411). It corresponds to a situation where the quota effect on prices contradicts the monopolist's price discrimination without being strong enough to reverse the price ranking given by discrimination. Hence there are six products that illustrate the standard result of a discriminatory monopoly – 260200, *Manganese ore*; 810420, *Magnesium Waste*; ; 810411, *Magnesium* > 99 of which three – 280469, *Silicon*; 790111, *Unwrought zinc* > 99; 790112, *Unwrought zinc* < 99 – could as well be considered to display equal elasticities. The monopoly price discrimination result has finally a minority occurrence in our estimations. For those products, the export quota's effect on price can only be suspected. There is no

[16] Sign for difference in elasticity for product 281700 is not clearcut given the contradictory results for the two estimations results.

evidence of a distortionary effect of the Chinese export quota.

Cases (c) and (d) suppose $\eta_d - \eta_w < 0$, but also a negative difference between domestic price and foreign price because of the export quota effect on prices. This is observed for three products: 260800, *Zinc ores*; 790200, *Zinc waste*; and 790120, *Unwrought Zinc alloys*. China exports minimum amounts of these products, but it is a major producer and a huge consumer of them.[17] Here, comparison of price and elasticity differences is a clear evidence that the export quota policy is not compatible with the resources conservation argument.

The final empirical case is observed for the remaining products: $\widehat{\eta_d - \eta_w} > 0$ and $p_d - p_w > 0$. This unexpected case is found for ten products. For eight of them, China is first world exporter. This situation of dominance is based on large disposal of resource and a competitive export price. China is part of a small oligopoly scheme and does not discriminate with respect to elasticity. There are three products for which we cannot draw any conclusions.

All in all, results by *HS6* allow us to conclude that the result for the whole PUC aggregate is partly due to a composition effect. Although small the set of PUC products displays heterogeneity regarding the impact of trade policy. The empirical results suggest that when China is a major exporter, it does not discriminate according to demand elasticity and we found no evidence of any quota distortion. On the other hand, when China is a weak exporter and a major producer (as in the case of Zinc), our estimates support the existence of a quota distortion in a monopoly pricing behaviour.

4 Conclusion

Trade partner discrimination was identified by the WTO Panel dealing with the *China – Raw Material* dispute since the export restrictions were not "applied jointly with" a restriction on the domestic production or consumption of the natural resources at stake. Discrimination was acknowledged in this dispute on the basis that China's trade policy gives asymmetric treatment of the domestic and foreign markets. The theoretical and empirical economic analysis developed in this paper deals with price discrimination, considering a monopoly extracting an exhaustible natural resource and selling it at two different prices – on the domestic and foreign markets. The model throws light on the consequences of an export quota on prices, resources extraction and welfare in this context. Propositions 1 and 2 of the model confirm the expected result according to which the export quota increases foreign prices relative to domestic prices and may lead to a

[17] China is the major producer and world's biggest consumer in the world of Zinc. China consumes more Zinc than the US, Japan, India, Germany, Italy and Belgium together. Note also that the difference in prices is negative for *Unwrought zinc* > 99; 790112, *Unwrought zinc*< 99 for which the elasticity could be considered equal.

Table 6: Import Elasticities Estimates per HS6

HS6	CHINESE Elasticity $\hat{\eta_d}$ (1)	$\hat{\eta_d}$ (2)	CLAIMANTS Elasticity $\hat{\eta_f}$ (3)	$\hat{\eta_f}$ [a] (4)	$\widehat{\eta_d - \eta_f}$ (5)	$\widehat{p_d - p_f}$ (6)
250830	-0.936***	-1.072***	-0.650***	-0.869***	$+$	$+$
252921	-1.440	-1.097***	-1.030***	-1.068***	$+/=$	$+$
252922	.	2.694	-1.058***	-1.356***	.	$+$
260200	-2.325***	0.299	-1.121***	-1.142***	$+$	$-$
260600	-1.829***	-1.264	-0.970***	-1.094***	$+$	$+$
260800	-0.906***	-0.551	-1.186***	-1.273**	$-$	$-$
262019	-1.494***	17.766	-0.381***	-0.288**	$+$	$+$
262040	-1.281	-0.599	-0.600***	-0.810***	$+$	$+$
270400	-1.694***	-1.107	-1.479***	-1.431***	$+$	$+$
280469	-0.649***	-0.738***	-0.699***	-0.713***	$-/=$	$+$
280470	-1.539	-0.885***	-0.825***	-0.662**	$+$	$+$
281700	-0.824***	-1.297***	-0.850***	-0.995***	$=/+$	$-$
284920	-0.824***	-0.582	-0.647***	-0.499**	$+$	$+$
790111	-1.255***	-1.203***	-1.200***	-1.233***	$+/=$	$-$
790112	-1.271***	0.429	-1.203***	-1.318***	$+/=$	$-$
790120	-0.658***	-0.964***	-0.935***	-0.955***	$-$	$-$
790200	-0.189	-0.178	-0.750***	-0.872***	$-$	$-$
810411	.	-1.135***	-1.046***	-1.370***	$-$	$+$
810419	-2.460	17.372*	-0.561***	-0.641*	$+$	$+$
810420	-1.099	0.244	-0.079	-0.399***	$+$	$-$
811100	-1.222***	-1.905**	-1.038***	-0.951***	$+$	$+$

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

(1) and (3) are fixed-effects estimations with autoregressive error; (2) and (4) are System GMM estimations. Diagnostics of each regressions are provided in appendix.

permanent superiority of the foreign price. In light of these results China's trade policy can be considered strategic, as claimed by the US and the EU. Propositions 3 and 4 indicate less intuitive results. Interesting for the discussion on discrimination, when the foreign demand elasticity is higher than the domestic demand elasticity, Proposition 3 shows that an export quota can, under certain conditions, reduce the monopolist's equilibrium price distortion pushing the two prices closer together around the optimal price. This perspective, centred on economic efficacy, can be used as an argument to defend the Chinese trade policy. Regarding resource extraction, the model challenges the idea that an export quota always favours conservation of natural resource. Here, again, the relative sizes of the demand elasticities are decisive. An export quota favours resource preservation in the monopolist's equilibrium only if domestic demand elasticity is smaller than foreign demand elasticity. If not, Proposition (3) and Corollary (4) show that the monopolist initially extracts more – and more rapidly, when constrained by an export quota. The situation where the export quota is a conservation measure because domestic demand elasticity is smaller than foreign demand elasticity, can be proposed to defend the Chinese trade policy. This is revealed empirically by the aggregate estimation on PUC products. This clearly advocates for the export quota to be considered conservation measure based on the theoretical results of the model. But this result must be nuanced by the heterogeneity in relative elasticities when products are considered one at a time, and only one third of them falls within the scheme of the aggregate elasticity. Concerning the distorting effect of the export quota, we find differences by product, but it is possible to identify two opposite cases. In the first, China is a major exporter and does not discriminate demand according to elasticity. In this case no evidence of any export quota distortion on prices can be found. In the second situation, China is a weak exporter but a major producer. In this case the empirical results show the existence of price distortion, showing a price discrimination and export quota distortion.

A Proofs of Lemmas, propositions and corrolaries

A.1 Proof of Lemma (1)

Fischer and Laxminarayan (2004) show that under decision problems $[P]$ and $[M]$ prices in both markets are rising over time at the interest rate. From conditions (6) and (7) we can show that this result holds under decision problem $[E]$. Using the inverse demand functions (2), the first order condition (6) in $t = 0$ can be written as $p_d^E(0) = \lambda_1 \frac{\eta_d}{\eta_d - 1}$, so that:

$$\lambda_1 = \frac{\eta_d - 1}{\eta_d} p_d^E(0)$$

With this value of λ_1, condition (6) can be written as (10): $p_d^E(t) = \mathrm{e}^{rt} p_d^E(0)$. The domestic price is thus rising at the interest rate.

The introduction of λ_1 in condition (7) calculated using the inverse demand function (2) in $t = 0$ shows that λ_2 takes the following value:

$$\lambda_2 = \frac{\eta_f - 1}{\eta_f} \cdot p_f^E(0) - \frac{\eta_d - 1}{\eta_d} p_d^E(0)$$

With these values for λ_1 and λ_2, condition (7) can be written as (10): $p_f^E(t) = \mathrm{e}^{rt} p_f^E(0)$. The foreign price is thus rising at the rate of interest.

A.2 Proof of Lemma (2)

The condition (7) can be written as:

$$e^{-rt} \cdot \frac{\eta_f - 1}{\eta_f} \cdot p_f^E(t) = \lambda_1 + \lambda_2$$

Condition (6) is satisfied at any time (and especially at the initial period $t = 0$) implying (see demonstration of lemma 1) that $\lambda_1 = p_d^E(0) \cdot \frac{\eta_d - 1}{\eta_d}$. From Lemma (1) we know that the prices $p_d^E(t)$ rise at the interest rate over time. We can therefore write the equation above as:

$$p_f^E(t) = \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot p_d^E(t) + \lambda_2 \mathrm{e}^{rt} \frac{\eta_f}{\eta_f - 1}$$

A.3 Proof of the proposition (1)

Suppose that $p_f^E(t) \leq p_f^M(t)$, implying that $q_f^E(t) \geq q_f^M(t)$. From Lemma (2) and (13) the inequality in price can be written as:

$$p_d^E(t) \cdot \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} + \lambda_2 \mathrm{e}^{rt} \cdot \frac{\eta_f}{\eta_f - 1} \leq \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot p_d^M(t)$$

So that:

$$\lambda_2 e^{rt} \cdot \frac{\eta_f}{\eta_f - 1} \leq \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot \left[p_d^M(t) - p_d^E(t)\right]$$

Since $\lambda_2 e^{rt} \cdot \frac{\eta_f}{\eta_f - 1} > 0$, we should have $p_d^M(t) - p_d^E(t) > 0$, so that $q_d^M(t) < q_d^E(t)$. Since $q_f^M(t)$ and $q_d^M(t)$ satisfy the stock constraint, $q_f^E(t)$ and $q_d^E(t)$ would violate it if $q_f^E(t) \geq q_f^M(t)$ and $q_d^M(t) < q_d^E(t)$ were satisfied.

Suppose now that $p_d^E(t) \geq p_d^M(t)$, implying that $q_d^E(t) \leq q_d^M(t)$. From Lemma (2) and (13) this inequality can be written as:

$$p_f^E(t) \cdot \frac{\eta_f - 1}{\eta_f} \cdot \frac{\eta_d}{\eta_d - 1} - \lambda_2 e^{rt} \cdot \frac{\eta_d}{\eta_d - 1} \geq \frac{\eta_f - 1}{\eta_f} \cdot \frac{\eta_d}{\eta_d - 1} \cdot p_f^M(t)$$

So that:

$$\lambda_2 e^{rt} \cdot \frac{\eta_d}{\eta_d - 1} \leq \frac{\eta_f - 1}{\eta_f} \cdot \frac{\eta_d}{\eta_d - 1} \cdot \left[p_f^E(t) - p_f^M(t)\right]$$

Since $\lambda_2 e^{rt} \cdot \frac{\eta_d}{\eta_d - 1} > 0$, we should have $p_f^E(t) - p_f^M(t) > 0$, so that $q_f^E(t) < q_f^M(t)$. Since $q_d^M(t)$ and $q_f^M(t)$ satisfy the stock constraint, $q_f^E(t)$ and $q_d^E(t)$ would not bind it if $q_d^E(t) \leq q_d^M(t)$ and $q_f^E(t) < q_f^M(t)$ were satisfied.

Thus, the monopolist's equilibrium under the export quota must be such that $p_f^E(t) > p_f^M(t)$ and $p_d^E(t) < p_d^M(t)$

A.4 Proof of the Corollary (1)

Proposition (1) states that the effect of an export quota is to raise the price with fewer resource supplied on the foreign market and to decrease the price with more resource supplied on the domestic market. The consumers on the foreign market (on the domestic market) suffer (benefit) from this trade policy as a consequence.

A.5 Proof of the proposition (2)

The first order conditions of $[E]$ indicate with (14) that: $p_f^E(t) = \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot p_d^E(t) + \lambda_2 e^{rt} \frac{\eta_f}{\eta_f - 1}$. Two cases must be distinguished, depending on the relative size of the price demand elasticities.

In the first case we have $\eta_d > \eta_f > 1$, so that $\frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} > 1$. In this case (14) indicates, since $\lambda_2 e^{rt} \frac{\eta_f}{\eta_f - 1} > 0$, that $p_f^E(t) > p_d^E(t)$.

In the second case we have $\eta_f > \eta_d > 1$, so that $\frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} < 1$. In this case (14) does not necessarily indicate that $p_f^E(t) > p_d^E(t)$, since $p_d^E(t) > \frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} \cdot p_d^E(t)$. In order to get $p_f^E(t) > p_d^E(t)$, we must have $p_d^E(t) \left[\frac{\eta_f}{\eta_f - 1} \cdot \frac{\eta_d - 1}{\eta_d} - 1\right] + \lambda_2 e^{rt} \frac{\eta_f}{\eta_f - 1} > 0$. With $\lambda_2 = \frac{\eta_f - 1}{\eta_f} \cdot p_f^E(0) - \frac{\eta_d - 1}{\eta_d} p_d^E(0)$ and the demands (1) expressed in $t = 0$, this condition can be written as (15): $q_f^E(0) < \mu_f \left(\frac{q_d^E(0)}{\mu_d}\right)^{\frac{\eta_f}{\eta_d}}$

A.6 Proof of Proposition (3)

We show first that the export quota deteriorates the inefficiency of the monopolist when the domestic demand elasticity is greater than the foreign demand elasticity. We then show that this result holds when foreign demand elasticity is greater than the domestic demand elasticity only if conditions (16) are verified.

When $\eta_d > \eta_f$, (13) shows that the monopolist fixes discriminating prices such that $p_f^M(t) > p_d^M(t)$. In that case (represented in figure $1.a$), we know that $p_f^M(t)$ is larger than and that $p_d^M(t)$ is smaller than the optimal prices $p^P(t)$ that a social planner would choose in the same situation. From Proposition (1), we know that the effect of a quota on the monopolist's equilibrium is to raise the price on the foreign market and to lower the price on the domestic market. As a consequence, the export quota exacerbates the inefficiency of the monopolist's equilibrium when $\eta_d > \eta_f$.

When $\eta_f > \eta_d$, (13) shows that the monopolist fixes discriminating prices such that $p_d^M(t) > p_f^M(t)$. In that case, we know furthermore that $p_d^M(t)$ is larger than and $p_f^M(t)$ is smaller than the optimal prices $p^P(t)$ that a social planner would choose in the same situation. From Proposition (1), we know that the effect of a quota on the monopolist's equilibrium is to raise the price on the foreign market and to lower the price on the domestic market. As a consequence, the export quota exacerbates the inefficiency of the monopolist's equilibrium only if the increase in the foreign price and the decrease in the domestic price it generates are sufficiently important to reach the following configuration: $p_d^E(t) < p_f^M(t) < p^P(t) < p_d^M(t) < p_f^E(t)$. In order to have $p_f^E(t) > p_d^M(t)$ and $p_d^E(t) < p_f^M(t)$, (13) indicates that the two conditions (16) must be satisfied:

$$\begin{aligned} p_f^E(t) &> p_f^M(t) \cdot \tfrac{\eta_f - 1}{\eta_f} \cdot \tfrac{\eta_d}{\eta_d - 1} \\ p_d^E(t) &< p_d^M(t) \cdot \tfrac{\eta_f}{\eta_f - 1} \cdot \tfrac{\eta_d - 1}{\eta_d} \end{aligned}$$

We can further show that when conditions (16) are satisfied, condition (15) of Proposition (2) is satisfied too, but that the converse is not true. For that, note that introducing (13) in conditions (16) permits to write: $p_f^E(t) > p_d^M(t)$ and $p_d^E(t) < p_f^M(t)$. when $\eta_f > \eta_d$, we have $p_f^M(t) < p_d^M(t)$ and therefore $p_f^E(t) > p_d^E(t)$ so that (15) is verified. However (15) can be satisfied with $p_f^E(t)$ and $p_d^E(t)$ such that conditions (16) are not met.

A.7 Proof of corollary (2)

Imposing an export quota reduces the monopolist's equilibrium price distortion when $\eta_f > \eta_d$ and conditions (16) not satisfied. When $p_f^M(t) < p_d^E(t) < p_f^E(t) < p_d^M$, suppose that $p_d^E(t) = p^P(t)$ and $p_f^E(t) > p^P(t)$. This would imply that $q_d^E(t) = q_d^p(t)$ and $q_f^E(t) < q_f^P(t)$. Since $q_d^P(t)$ and $q_d^P(t)$ satisfy the stock constraint, $q_d^E(t)$ and $q_f^E(t)$ would not bind it. By the same reasoning, if $p_f^E(t) = p^P(t)$ and $p_d^E(t) < p^P(t)$, $q_d^E(t)$ and $q_f^E(t)$

would violate the stock constraint. Thus, the monopolist's equilibrium under an export quota constraint must have higher prices than optimal on the foreign market and lower prices than optimal on the domestic market. The same reasoning can be developed when $p_f^M(t) < p_f^E(t) < p_d^E(t) < p_d^M$ to show that we must have $p_f^E(t) < p^P(t)$ and $p^P(t) < p_d^E(t)$.

A.8 Proof of Proposition (4)

The difference in the total initial extractions under $[E]$ and $[M]$ can be expressed as following:

$$\begin{aligned} Q_0^E - Q_0^M &= r\eta_d S + \left(1 - \frac{\eta_d}{\eta_f}\right) q_f^E(0) - r\eta_d S - \left(1 - \frac{\eta_d}{\eta_f}\right) q_f^M(0) \\ &= \left(1 - \frac{\eta_d}{\eta_f}\right) \left[q_f^E(0) - q_f^M(0)\right] \end{aligned}$$

From proposition (1) we know that imposing a quota constraint reduces extraction for export and raises supply in the domestic market, compared to the situation under $[M]$. The initial extractions for the foreign market, therefore, are such that: $q_f^E(0) < q_f^M(0)$. As a consequence, $Q_0^E - Q_0^M$ is positive when $\eta_d > \eta_f$ and negative when $\eta_f > \eta_d$.

A.9 Proof of Corollary (3)

From proposition (4) we know that imposing an export quota increases (decreases) the initial total extraction if the domestic demand elasticity is bigger (smaller) than the foreign demand elasticity. From (11) we know that the rate of growth of the extraction paths under $[M]$ and $[E]$ is the interest rate. As the constraint on total extraction is always verified, imposing an export quota implies the monopolist extracts more (less) rapidly if the domestic demand elasticity is bigger (smaller) than the foreign demand elasticity.

B Additional Tables

B.1 Data

B.2 Average Share of Country Import 1995-2007 by products

B.3 Share of World Export of 15 first exporters 1995-2007

Table B.1: Full HS2 Name

HS2	Name
25	SALT; SULPHUR; EARTHS AND STONE; PLASTERING MATERIALS, LIME AND CEMENT
26	ORES, SLAG AND ASH
27	MINERAL FUELS, MINERAL OILS AND PRODUCTS OF THEIR DISTILLATION; BITUMINOUS SUBSTANCES; MINERAL WAXES
28	INORGANIC CHEMICALS; ORGANIC OR INORGANIC COMPOUNDS OF PRECIOUS METALS OF RARE-EARTH METALS
79	ZINC AND ARTICLES THEREOF
81	OTHER BASE METALS; CERMETS; ARTICLES THEREOF

Table B.2: Product at HS2 level – Share of Country Import 1995-2007

HS2	Name	EU15	US	Japan	China	Germany	France
25	SALT and SULPHUR	0.38	0.21	0.37	0.24	0.25	0.25
26	ORES, SLAG AND ASH	0.55	0.18	2.27	2.45	0.31	0.31
27	MINERAL FUELS and OILS	9.67	12.19	19.96	8.18	8.96	8.96
28	INORGANIC CHEMICALS	0.85	0.70	1.02	0.70	0.91	0.91
79	ZINC	0.13	0.12	0.04	0.15	0.11	0.11
81	OTHER BASE METALS	0.15	0.12	0.30	0.09	0.12	0.12

Source: BACI-CEPII, 1995-2007.

Table B.3: Product at HS6 level – Share of Country Import 1995-2007

HS6	Name	EU15	US	Japan	China	Germany	France
250830	Fireclay	0.0030	0.0009	0.0008	0.0009	0.0006	0.0008
252921	Fluorspar< 97%	0.0015	0.0015	0.0068	0.0002	0.0013	0.0004
252922	Fluorspar> 97%	0.0025	0.0054	0.0076	0.0001	0.0053	0.0004
260200	Manganese	0.0062	0.0037	0.0333	0.0743	0.0009	0.0213
260600	Aluminium	0.0188	0.0321	0.0146	0.0115	0.0159	0.0194
260800	Zinc ores	0.0625	0.0060	0.0946	0.0733	0.0280	0.0516
262019	Slag with zinc	0.0046	0.0012	0.0030	0.0006	0.0015	0.0043
262040	Slag with aluminium	0.0032	0.0011	0.0013	0.0026	0.0057	0.0008
270400	Coke	0.0552	0.0364	0.0740	0.0006	0.1026	0.0478
280469	Silicon	0.0178	0.0170	0.0694	0.0046	0.0313	0.0086
280470	Phosphorus	0.0056	0.0015	0.0118	0.0002	0.0180	0.0017
281700	Zinc oxide & peroxide	0.0098	0.0084	0.0062	0.0078	0.0063	0.0077
284920	Carbides of Silicon	0.0081	0.0091	0.0174	0.0011	0.0140	0.0078
790111	Unwrought zinc> 99	0.0475	0.0749	0.0278	0.0338	0.0480	0.0224
790112	Unwrought zinc< 99	0.0236	0.0285	0.0074	0.0091	0.0200	0.0307
790120	Unwrought Zinc alloys	0.0166	0.0017	0.0032	0.0586	0.0218	0.0188
790200	Zinc waste	0.0042	0.0016	0.0005	0.0208	0.0034	0.0029
810411	Magnesium> 99	0.0076	0.0052	0.0199	0.0001	0.0085	0.0055
810419	Magnesium< 99	0.0055	0.0092	0.0060	0.0004	0.0074	0.0023
810420	Magnesium Waste	0.0008	0.0017	0.0001	0.0004	0.0010	0.0002
811100	Manganese	0.0054	0.0031	0.0206	0.0003	0.0082	0.0050

Source: BACI-CEPII, 1995-2007.

Table B.4: Rank and Share of the first 5 exporters by product over 1995-2009

HS6	First		Second		Third		Fourth		Fifth		TOTAL 1-5
250830	Ukraine	0.34	China	0.29	USA	0.15	Germany	0.05	Kazakhstan	0.03	0.86
252921	China	0.26	Mexico	0.22	Mongolia	0.19	South. African CU	0.11	Morocco	0.06	0.84
252922	China	0.52	South. African CU	0.19	Mexico	0.08	Kenya	0.06	Morocco	0.04	0.9
260200	Australia	0.23	South. African CU	0.23	Gabon	0.21	Brazil	0.09	Ghana	0.07	0.83
260600	Guinea	0.32	Australia	0.15	Brazil	0.11	China	0.09	Jamaica	0.07	0.73
260800	Australia	0.18	Peru	0.17	USA	0.12	Canada	0.10	Bolivia	0.07	0.64
262019	Germany	0.20	Canada	0.14	Belgium	0.09	USA	0.06	Italy	0.05	0.54
262040	Germany	0.12	France	0.11	Belgium	0.11	USA	0.10	Canada	0.09	0.53
270400	China	0.36	Poland	0.15	Japan	0.08	Russian fed.	0.06	USA	0.04	0.69
280469	China	0.29	Norway	0.16	Brazil	0.15	Germany	0.07	France	0.05	0.73
280470	China	0.41	Netherlands	0.18	Germany	0.14	Kazakhstan	0.10	USA	0.06	0.9
281700	Germany	0.13	Netherlands	0.13	China	0.10	Canada	0.10	Belgium	0.05	0.51
284920	China	0.29	Norway	0.15	Germany	0.13	Japan	0.06	Netherlands	0.05	0.66
790111	Canada	0.15	China	0.11	Spain	0.08	Australia	0.06	Korea. rep.	0.06	0.46
790112	Canada	0.16	Kazakhstan	0.08	Australia	0.07	Russian fed.	0.07	Finland	0.06	0.45
790120	Belgium	0.26	Australia	0.18	Germany	0.06	Hong kong	0.05	Korea. rep.	0.05	0.6
790200	Germany	0.15	France	0.14	USA	0.09	Belgium	0.08	Netherlands	0.08	0.55
810411	China	0.45	Russian fed.	0.13	Israel	0.10	Canada	0.06	USA	0.06	0.81
810419	China	0.24	Canada	0.21	Norway	0.10	Russian fed.	0.08	Israel	0.07	0.69
810420	USA	0.21	Canada	0.19	Germany	0.15	Italy	0.06	China	0.05	0.66
811100	China	0.51	South. African CU	0.17	Germany	0.07	Ukraine	0.04	Netherlands	0.03	0.83

Source: BACI-CEPII, 1995-2009.

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Table B.5: PUC Import Elasticity per HS6 for Claimants

	XTREG[a]				XTREGAR[b]					XTABOND			[d]
HS6	Elasticity	Obs.	Elasticity	Obs.	rho_AR[c]	DW	LBI	Elasticity	Obs.	Group[c]	Inst.[c]	AR(2)p[c]	Hansenp[c]
250830	-0.742***	423	-0.650***	371	0.456	1.625	1.968	-0.869***	423	52	54	0.5	0.64
252921	-1.032***	248	-1.030***	220	0.509	1.441	1.751	-1.068***	248	28	46	0.52	1
252922	-1.059**	230	-1.058***	204	0.427	1.563	1.846	-1.356***	230	26	49	0.1	1
260200	-1.134***	366	-1.121***	324	0.531	1.45	1.883	-1.142***	366	42	53	0.51	0.94
260600	-1.142***	418	-0.970***	370	0.519	1.498	1.864	-1.094***	418	48	56	0.62	0.94
260800	-1.271***	392	-1.186***	343	0.674	1.307	1.83	-1.273**	392	49	51	0.21	0.84
262019	-0.354***	694	-0.381***	610	0.418	1.756	2.104	-0.288**	694	84	55	0.51	0.5
262040	-0.571***	544	-0.600***	480	0.466	1.533	1.949	-0.810***	544	64	55	0.41	0.39
270400	-1.548***	523	-1.479***	460	0.534	1.611	2.122	-1.431***	523	63	52	0.29	0.64
280469	-0.639***	532	-0.699***	469	0.461	1.517	1.916	-0.713***	532	63	56	0.49	0.29
280470	-0.855***	194	-0.825***	170	0.268	1.994	2.192	-0.662**	194	24	46	0.93	1
281700	-0.838***	580	-0.850***	517	0,441	1,765	1,966	-0.995***	580	63	55	0,76	0,97
284920	-0.716***	499	-0.647***	443	0.521	1.724	2.043	-0.499**	499	56	55	0.88	0.56
790111	-1.329***	578	-1.200***	509	0.395	1.675	2.103	-1.233***	578	69	54	0.92	0.84
790112	-1.346***	539	-1.203***	473	0.493	1.59	1.951	-1.318***	539	66	55	0.66	0.76
790120	-0.976***	526	-0.935***	462	0.52	1.739	1.979	-0.955***	526	64	56	0.73	0.47
790200	-0.703***	829	-0.750***	727	0.393	1.682	2.019	-0.872***	829	102	56	0.49	0.59
810411	-0.626**	378	-1.046***	333	0.558	1.807	2.041	-1.370***	378	45	56	0.95	0.89
810419	-0.580***	366	-0.561***	325	0.562	1.653	2.046	-0.641*	366	41	55	0.46	0.94
810420	-0.035	504	-0.079	440	0.548	1.715	2.023	-0.399***	504	64	54	0.33	0.46
811100	-0.861***	394	-1.038***	342	0.553	1.484	1.87	-0.951***	394	52	54	0.84	0.49

[a] XTREG gives fixed effects estimates.

[b] XTEGAR gives Estimates using the Baltagi and Wu (1999) methodology when paned data are unequally spaced and admit an AR(1) disturbance. [c] rho_AR is the estimate of the AR(1) coefficient. DW is the Durbin Watson Statistic and LBI is the locally best invariant test for zero first order serial correlation against positive or negative serial correlation.

[d] XTABOND gives estimates using the system GMM method. Inst. is the number of instruments; AR(2)p is the value of the test for autoregressive correlation of order 2; and Hansen p is the p-value of the Hansen T for endogeneity of instruments.

Table B.6: PUC Import Elasticity per HS6 for China

	XTREG		XTREGAR					XTABOND					
	Elasticity	Obs.	Elasticity	Obs.	rho_AR	DW	LBI	Elasticity	Obs.	Groups	Instr.	AR(2)p	Hansenp
250830	-1.127***	94	-0.936***	73	0.394	1.654	2.137	-1.072***	94	21	40	0.73	1.00
252921	-1.409	15	-1.440	10	0.184	1.920	2.319	-1.097***	15	5	17	0.38	1.00
252922	1.474**	13	.	.	.	.	.	2.694	13	5	13	1.00	1.00
260200	-2.202***	136	-2.325***	106	0.294	1.604	2.014	0.299	136	30	53	0.13	1.00
260600	-1.814***	62	-1.829***	43	0.117	1.819	2.272	-1.264	62	19	35	.	1.00
260800	-1.132***	167	-0.906***	123	0.355	1.549	2.113	-0.551	167	44	55	0.64	1.00
262019	-1.738***	34	-1.494***	23	0.168	1.848	2.324	17.766	34	11	23	.	1.00
262040	-1.927***	45	-1.281	34	0.403	1.399	1.748	-0.599	45	11	35	0.81	1.00
270400	-1.474***	36	-1.694***	27	0.225	1.662	2.027	-1.107	36	9	34	0.97	1.00
280469	-0.651***	113	-0.649***	89	0.024	1.986	2.275	-0.738***	113	24	49	0.38	1.00
280470	-0.990***	29	-1.539	22	-0.597	2.994	3.095	-0.885***	29	7	27	0.79	1.00
281700	-1.384***	174	-0.824***	63	0.313	1.691	2.114	-1.297***	174	30	53	0.75	1.00
284920	-0.845***	80	-0.824***	63	0.313	1.691	2.114	-0.582	80	17	55	0.70	1.00
790111	-1.089***	125	-1.255***	101	0.423	1.709	2.024	-1.203***	125	24	50	0.31	1.00
790112	-1.320***	89	-1.271***	70	0.484	1.462	2.007	0.429	89	19	36	.	1.00
790120	-0.604***	156	-0.658***	127	0.485	1.693	2.117	-0.964***	156	29	48	0.81	1.00
790200	-0.348**	314	-0.189	254	0.540	1.683	2.114	-0.178	314	60	55	0.53	0.95
810411	.	.	.	.	.	.	.	-1.135***	9	4	11	.	1.00
810419	-2.469***	24	-2.460	16	0.070	1.896	2.526	17.372*	24	8	21	0.53	1.00
810420	-1.739***	43	-1.099	27	0.225	1.767	2.252	0.244	43	16	21	.	1.00
811100	-1.023***	54	-1.222***	41	0.463	1.278	1.938	-1.905**	54	13	39	0.63	1.00

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