

# The Home Market Effect in International Arms Trade\*

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## Abstract

I show that military spending contributes to international arms proliferation through a *push* effect: large demand encourages production growth in the domestic market if transport costs are non-negligible. Under increasing returns to scale, the country can then supply weapons on the global market at low prices. This is a manifestation of the home market effect, which states that countries with higher demand for a differentiated good will be net exporters of that good. I construct a monopolistic competition model of international trade which accounts for differences in demand across countries, and test its predictions using post-Cold War data.

**Keywords:** home market effect; arms trade; military expenditure; economic geography; government procurement

**JEL classification:** F1, H5, R1

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# 1 Introduction

## 1.1 International trade perspective

Traditional models predict that international trade is driven by differences in factor endowments or production technologies, with each country exporting goods in which it has a comparative advantage. If we allow for variation in demand in this setting, we find that countries with higher demand for a good are net importers of that good.<sup>1</sup> In the monopolistic competition model, on the other hand, Krugman (1980) introduces scale economies and draws predictions about the direction of trade from variations in demand: differentiated, increasing returns to scale goods will be produced in, and exported from, the market that has higher demand for them.<sup>2</sup> This is the home market effect - a prediction that runs counter to the intuition drawn from comparative advantage models, and which can therefore be used to tease out the importance of economies of scale and transportation costs in determining international trade patterns.

In practice, testing this effect poses significant endogeneity challenges. For most goods we have no measure of demand aside from revealed spending patterns, and these often respond to the same factors that impact the supply side. Therefore the typical approach has been to assume that individual citizens of different countries have identical preferences, and simply use country *size* to measure demand: in a pair of countries, the larger one is said to have higher demand for all goods; the home market effect is then the prediction that the large

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<sup>1</sup>This is true as long as comparative advantage patterns are not positively correlated with demand.

<sup>2</sup>For this result to obtain, an additional condition is needed: that these goods have non-negligible transport costs, since otherwise production could concentrate in any country, even one with zero consumption of the good in question.

country exports more differentiated goods, while the small country exports more constant returns to scale, homogeneous goods.<sup>3</sup>

In this paper, I use government military spending to measure the demand for arms and ammunition, which allows me to account for variation in the patterns of demand across countries, while limiting potential sources of endogeneity. Results are no longer dependent on the absolute size of nations; instead, the model's empirical prediction is that countries with higher military spending as a share of GDP export more arms relative to homogeneous civilian goods. This represents a closer interpretation of the original home market effect formulation, and a more direct empirical verification of it.

To elaborate further, standard treatments of the home-market effect (as in Helpman and Krugman, 1985; Feenstra, 2004) are based on a monopolistic competition model of trade that has one homogeneous, constant returns to scale industry with zero transport costs, and one differentiated, increasing returns to scale industry with positive transport costs. Hanson and Xiang (2004) extend this model to allow for a continuum of differentiated-product industries.<sup>4</sup> They show that industries with high transport costs and low substitution elasticities (i.e., more product differentiation) tend to concentrate in the larger country, while industries with low transport costs and high substitution elasticities (i.e., less product differentiation) tend

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<sup>3</sup>Among the few exceptions, Davis and Weinstein (1999) look at how Japanese regional variation in demand influences production of goods within industries, and find that home market effects matter in several manufacturing industries. Davis and Weinstein (2003) run a similar analysis for OECD countries, and again find that a significant number of sectors display home market effects. Head and Ries (2001) test the existence of the home market effect in US-Canada trade, and find some evidence both for and against. However, since in both approaches demand is measured by actualized private consumption, estimates are unbiased only if industry demand shocks are uncorrelated with industry supply shocks.

<sup>4</sup>Holmes and Stevens (2005) also consider a continuum of industries, allowing for variation in returns to scale, in a model that departs from the monopolistic competition framework. They predict that goods with very strong economies of scale will be produced in the large country, and that goods with weak economies of scale are not traded.

to concentrate in the smaller country. As in the standard treatment, they exploit differences in goods' characteristics and GDP to demonstrate the home market effect. However, this approach has its drawbacks; gross domestic product is only a loose approximation of demand for most goods, since preferences are of course not identical across countries. This doesn't become an issue in Hanson and Xiang (2004), since a varied bundle of goods is considered on both the treatment and control sides, and in aggregation GDP *does* become a suitable proxy measure for demand.

If we want to analyze a single good or a narrow set of goods, however, variation in demand patterns becomes a potentially confounding factor. The military sector in particular is an example where different countries exhibit vastly different spending preferences: consider for instance that Mexico is over 6 times the size of Israel in terms of GDP, but its military expenditure is less than a third that of Israel's - any empirical test that relies on GDP alone will therefore have misleading results.

I present a monopolistic competition model that builds upon that of Hanson and Xiang (2004), but includes a differentiated military sector in addition to the continuum of civilian industries. I then show the home market effect as stemming from both differences in goods' characteristics and from differences in demand: in agreement with theoretical predictions, countries with higher military spending relative to GDP are found to export significantly more arms relative to control goods.<sup>5</sup> The empirical approach relies on a double differentiation: first, I compare exports of arms from two countries to a common importer, thus eliminating importer-specific determinants of trade, such as remoteness (identified as a source

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<sup>5</sup>The set of control goods is composed of undifferentiated, cheap to transport civilian goods.

of bias in Anderson and van Wincoop, 2003), importer GDP, importer tariffs, etc. Second, I take the difference with respect to control civilian trade flows between the same 3 countries - this controls for the tendency of large countries to export more of everything, as well as any trade policies specific to exporter-importer pairs.

Within the military sector, my findings translate into a less recognized mechanism for international arms proliferation: through excessive defense spending on the exporter (rather than the importer) side. At its worst, this suggests that first world militarism, even when manifested only through domestic investments, may help fuel conflicts in at-risk countries by inundating the global market with cheap weapons.

## 1.2 Addressing Political Science concerns

Stepping back, I would like to address a number of concerns that come up when discussing the arms industry.

In the post-Cold War world most arms producers are private firms rather than government institutions.<sup>6</sup> However, there is still room for governments to influence the direction of arms flows by banning sales to certain countries and by encouraging exports to others.<sup>7</sup>

Strategic interests certainly played an influential role in determining international arms flows during the Cold War, when both the United States and the Soviet Union sought to strengthen their allies and extend their influence through arms exports. For this reason, I exclude the pre-1990 period from the empirical analysis.

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<sup>6</sup>This is true even in former communist countries - see for instance Kiss (2014) for an analysis of the industry in East Central Europe.

<sup>7</sup>This latter type of intervention usually works through military aid, as I will discuss shortly.

The Political Science literature suggests that since the fall of the Iron Curtain international arms flows have been driven increasingly by economic forces, to the detriment of strategic considerations (see for example Lumpe, 1999; Anderton, 1995). Nonetheless, countries continue to export preferentially to allies - therefore in the empirical estimations I control not just for the standard measures of geographic and cultural distance between trading partners, but also for political distance as measured by United Nations General Assembly voting records, by Polity score similarity, and membership in NATO and the EU.

There is also evidence that powerful players like the US can sometimes use trading relationships to influence foreign country policy by threatening to disrupt arms flows (see Caverley and Kapstein, 2012). If these occurrences are sufficiently common and successful, we can expect that a large military producer may choose to export to a given country for the sole purpose of influencing its policy, even if the trading relationship in itself is not lucrative. In practice, since arms producers are private firms not willing to incur losses to further national interests, this usually takes the form of military aid: international “aid” that is given to a target nation conditional on the money being spent to purchase military goods from the donor. This scenario introduces a positive link between military expenditure and arms exports, which threatens to confound the interpretation of empirical results herein. I get around this problem by restricting the set of importers to be rich and well-connected countries,<sup>8</sup> ones that are less vulnerable to unilateral pressures,<sup>9</sup> and which do not receive military aid. Finally, I consider different samples of exporters and conduct sensitivity

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<sup>8</sup>Specifically, high income EU and NATO-member countries

<sup>9</sup>An instructive example is the American attempt in 2005 to dissuade Spain from exporting weapons to Venezuela by withholding permission to re-export the US-made parts. Instead, Spain was able to substitute European-made parts and went ahead with the deal.

analysis to excluding the top exporters.

Another frequent concern lies with the measurement of trade itself. There is a sizeable international black market for arms, which by definition will be omitted from any official datasets. This illicit trade consists primarily of small arms, since they are easily transported, and require minimal know-how to operate and maintain. But despite the disproportionately high impact these smuggled weapons have on conflicts in developing nations, their volume of trade is relatively low - estimates place the size of the illicit market at up to 10-20% of the total trade in small arms,<sup>10</sup> and an even smaller percentage once we include larger weapons and armoured vehicles in the denominator.

Finally, conflicts or anticipation of conflicts can potentially influence both military spending and trade. I address this in the empirical section, in particular sub-section 3.6.

I argue that military spending is driven mainly by idiosyncratic preferences and perceived threats, and that, due to institutional constraints, it cannot react quickly to trade shocks.<sup>11</sup> This limited responsiveness to potentially confounding factors makes it a suitable demand measure for the analysis at hand. Section B of the online Appendix<sup>12</sup> discusses the relevant literature on the determinants of military expenditure, and presents a brief empirical analysis in support of these claims. As an additional check, I instrument for military spending with its lagged values (by up to 10 years) and find no significant deviations from the OLS results.

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<sup>10</sup>See Krause (2001)

<sup>11</sup>Although the sole buyer on the domestic market for weapons, the government does not act like a typical monopsonist because of the way taxes, military budgets, and in many cases procurement contracts are determined ahead of time.

<sup>12</sup>The online appendix is posted at [http://cmc.edu/pages/faculty/OTocoian/arms\\_appendix.pdf](http://cmc.edu/pages/faculty/OTocoian/arms_appendix.pdf)

## 2 Theoretical model

I model<sup>13</sup> two types of goods: a continuum of differentiated civilian industries whose products are demanded by consumers, and a differentiated military sector whose goods are demanded exclusively by the government.

There is a large country and a small country. Each has one factor of production: labor. The large country has a mass  $L > 1$  of workers, each supplying one unit of labor inelastically and earning wage  $w$ . The small country's labor endowment and wage are normalized to 1 (so  $w^*L^* = 1$ ). Each country's military budget  $ME$  ( $ME^*$ ) is extracted from workers through an income tax  $f$  ( $f^*$ ), so that workers will have after-tax income  $Y = wL(1 - f) = wL - ME$  ( $Y^* = 1 - f^* = 1 - ME^*$ ).

Civilian goods are modeled on a continuum, in order to allow for variation in differentiation and transport costs. In particular, I consider a continuum of monopolistically competitive industries (as introduced by Dixit and Stiglitz, 1977) indexed by  $z \in [0, 1]$ . Consumers derive utility from purchasing many different varieties of a given product. Each variety is characterized by increasing returns to scale, so in equilibrium it will be produced by a single firm. There is free entry and costs are identical, so all firms earn zero profits.

Individuals have Cobb-Douglas preferences over industries, and constant elasticity of substitution (CES) demand over varieties within an industry:

$$U_{\text{consumer}} = \prod_{z \in [0,1]} \left[ \left( \sum_{i=1}^{n(z)} q_{zi}^{\frac{\sigma(z)-1}{\sigma(z)}} \right)^{\frac{\sigma(z)}{\sigma(z)-1}} \right]^{\alpha(z)}$$

Here,  $\alpha(z)$  is the consumption share of industry  $z$  products and  $\int_0^1 \alpha(z) dz = 1$ ;  $n(z)$  is the number of product varieties in industry

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<sup>13</sup>This section outlines the model setup and solution; for the detailed derivation and discussion, please refer to section A in the online appendix.



$z$ ,  $\sigma(z)$  is the elasticity of substitution between varieties (restricted to be larger than one), and  $q_{zi}$  is the quantity of variety  $i$  in industry  $z$ . Let  $\tau(z) > 1$  be the iceberg transport cost incurred in shipping one unit of output from one country to the other, and  $x(z) = \tau(z)^{\sigma(z)-1}$  the effective trade cost<sup>14</sup> for industry  $z$ . I will assume there is no international specialization at the industry level, meaning each country produces some goods in each industry. The varieties of industry  $z$  are symmetric: let  $c(z)$  be the fixed labor requirement, and I normalize the variable labor requirement for each variety to one.

In deciding how to model demand for military goods, I considered the fact that modern war is multifaceted, and a nation that wishes to defend itself against unknown future threats has to be ready to operate in a variety of battle theaters, using a synergy of weapons.<sup>15</sup> I therefore consider the love-of-variety approach to be suited for the arms sector as well, and I use the monopolistic competition model with CES aggregator to represent in reduced form the government's decision over arms purchases. Mathematically, the military goods industry will be characterized by the same variables as any individual civilian industry  $z$ . I mark variables of military goods by subscript  $m$ .  $U_{\text{government}} = \left( \sum_{i=1}^{n_m} q_{mi}^{\frac{\sigma_m-1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_m-1}}$

The following equilibrium condition obtains:

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<sup>14</sup>As in all monopolistic competition models, transport costs matter more for industries with high elasticity of substitution (see for instance Head and Mayer, 2004).

<sup>15</sup>For example, the US Armed Forces comprise five separate service branches: Army, Navy, Marine Corps, Air Force, and Coast Guard, each with its own designated area of operations and specialized arsenal. And while there are some common staples, like the M16 rifle, there is also remarkable diversity in the range of weapons employed within and across branches, from submachine guns, to light and heavy machine guns, grenades, rockets, missiles and their launching systems, unmanned vehicles, armored trucks, tanks, helicopters, fighter jets, etc.

$$0 = \int_0^1 \alpha(z)g(z)dz + g_m \quad (1)$$

$$\text{where } g(z) = \left[ \frac{Y}{x(z)w^{\sigma(z)} - 1} - \frac{Y^*}{x(z)w^{-\sigma(z)} - 1} \right] \quad (2)$$

$$g_m = \left[ \frac{ME}{x_m w^{\sigma_m} - 1} - \frac{ME^*}{x_m w^{-\sigma_m} - 1} \right] \quad (3)$$

Note that the function  $g(z)$  (or  $g_m$ ) is positive if and only if Home is a net exporter of good  $z$  (or  $m$ ). In equilibrium trade is balanced, so Home will be a net exporter of some goods, but not others. The question at hand is whether the model's prediction about which sectors fall into each category is in accordance with the empirical evidence.

Both  $g(z)$  and  $g_m$  are strictly decreasing in  $w$ , so equation (1) has a unique solution  $w > 1$ , as long as  $\left[ (Y - Y^*) \int_0^1 \frac{\alpha(z)dz}{x(z)-1} + (ME - ME^*) \frac{1}{x_m-1} \right] > 0$ , which is met if both the civilian and military sectors of the big country are larger than those of the small country.

A typical formulation for is that industry  $z$  displays the home market effect (HME) if the large country's share of varieties of  $z$  produced globally exceeds its share of world factor supplies; however, this is after assuming an identical demand structure across countries, which does not apply here. In the present paper, as in Krugman's seminal 1980 AER paper, preferences are not identical: demand *within* the civilian and military sectors follows the same pattern across countries, but governments idiosyncratically dictate how income is allocated *across* these two sectors. Therefore I develop a more general definition on the home market effect, which subsumes the Hanson and Xiang (2004) definition in the special case where demand is identical across countries.

**Definition - home market effect**

Industry  $z$  is said to display the home market effect if the country with higher demand for  $z$  produces a larger share of world  $z$  output than its share of world demand for  $z$ .

In my two-country world, that translates to:

a) For civilian industries indexed by  $z$ :  $\frac{n(z)p(z)q(z)}{n^*(z)p^*(z)q(z)} = \frac{n(z)w}{n^*(z)} > \frac{\alpha(z)Y}{\alpha(z)Y^*} = \frac{Y}{Y^*}$ .

Define  $\tilde{n}(z) = n(z)w$ . Then the condition is  $\tilde{n}(z)/\tilde{n}^*(z) > \frac{Y}{Y^*}$  or  $n(z)/n^*(z) > \frac{Y/w}{Y^*}$ .<sup>16</sup>

b) Under the assumption that the larger country (Home) also has higher military expenditure ( $ME > ME^*$ ).<sup>17</sup> the military sector displays the home market effect if

and only if  $\tilde{n}_m/\tilde{n}_m^* > \frac{ME}{ME^*} \Leftrightarrow n_m/n_m^* > \frac{ME/w}{ME^*}$ .

Industry  $z$  displays the home market effect if and only if  $g(z) > 0$ . Similarly, the military sector displays the home market effect if and only if  $\tilde{n}_m/\tilde{n}_m^* > \frac{ME}{ME^*} \Leftrightarrow g_m > 0$ . Intuitively,  $g$  reflects the trade-off between production costs (represented by  $w^\sigma$ ) and trade costs (represented by  $x = \tau^{\sigma-1}$ ). High- $x$  and low- $\sigma$  industries have relatively high  $g$  and so are more likely to display the home market effect. Assuming military expenditure is small relative to GDP for all countries, there will be some civilian industries for which  $g(z) > 0$  and some for which  $g(z) < 0$ . Furthermore, if a civilian industry shows home market effects, so will all industries that have at least as high effective trade costs and are at least as differentiated.

As I extend this result to the military sector and compare  $g_m$  to  $g(z_0)$ , an extra parameter becomes relevant: the relative ratio of military spending out of GDP. Whether  $g_m > 0$  or

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<sup>16</sup>Note that if demand is forced to be the same across countries, we have:  $\frac{Y/w}{Y^*} = \frac{wL/w}{w^*L^*} = L$ , so the home market effect condition simplifies to the typical formulation that the large country's share of varieties of  $z$  exceeds its share of the world factor supplies:  $n(z)/n^*(z) > L$

<sup>17</sup>I will limit the empirical analysis to a sample of country pairs in which the larger country also has higher military expenditure, since otherwise the prediction of how production varies with  $ME/ME^*$  flips.

$g_m < 0$  depends on how transport costs and the elasticity of substitution compare across sectors, but also on military and civilian budgets in the two countries: e.g. if  $ME/ME^* \gg Y/Y^*$  the military sector is much more likely to display the home market effect.

### Proposition 1

Let  $z_0$  be a civilian industry so that  $g(z_0) > 0$ . Then  $g_m > 0$  if  $x_m \geq x(z_0)$ ,  $\sigma_m \leq \sigma(z_0)$ , and  $ME/ME^* \geq Y/Y^*$ .

Proposition 1 states that if a civilian industry  $z_0$  displays the home market effect, so will the military industry, as long as military goods have at least as high effective trade costs and are at least as differentiated as  $z_0$ , and Home's military spending relative to Foreign is higher than the ratio of Home to Foreign civilian spending. This last condition that  $ME/ME^* \geq Y/Y^*$  is equivalent to  $f \geq f^*$  (i.e. Home has a higher military income tax).

### Estimating equation

Let  $\tau_{ijk}$  be iceberg transport costs for industry  $i$  between countries  $j$  and  $k$ , and assume the following form:  $\tau_{ijk} = d_{jk}^{\gamma_i}$ , where  $\gamma_i > 0$  and  $d_{jk}$  is the distance between  $j$  and  $k$ .

Total sales in industry  $i \in \{z, m\}$  by country  $j$  to country  $k$  are:

$$\begin{aligned} \text{for civilian industries: } S_{zjk} &= \alpha_z Y_k n_{zj} \left( \frac{P_{zjk}}{P_{zk}} \right)^{1-\sigma_z} \\ \text{for military: } S_{mjk} &= ME_k n_{mj} \left( \frac{P_{mjk}}{P_{mk}} \right)^{1-\sigma_m} \end{aligned}$$

where  $P_{ijk}$  is the delivered c.i.f. (including cost, insurance, freight) price in country  $k$  of a good from industry  $i$  produced in country  $j$ , and  $P_{ik}$  is the CES price index for industry  $i$  in

country  $k$ . I compare country  $j$ 's exports of good  $i$  to country  $k$  with some other country  $h$ 's exports (also of good  $i$  to country  $k$ ). Let  $i$  be the treatment (military) industry and  $o$  the control industry (higher substitution elasticity and lower transport costs). Then applying a double difference, I obtain:

$$\frac{S_{ijk}/S_{ihk}}{S_{ojk}/S_{ohk}} = \frac{\tilde{n}_{ij}/\tilde{n}_{ih} (w_{ij}/w_{ih})^{-\sigma_i}}{\tilde{n}_{oj}/\tilde{n}_{oh} (w_{oj}/w_{oh})^{-\sigma_o}} (d_{jk}/d_{hk})^{(1-\sigma_i)\gamma_i - (1-\sigma_o)\gamma_o} \quad (4)$$

If industry  $i$  is military and  $o$  is a civilian industry of equal or lower transport costs and equal or higher  $\sigma$ , proposition 1 suggests that  $\frac{\tilde{n}_{ij}/\tilde{n}_{ih}}{\tilde{n}_{oj}/\tilde{n}_{oh}}$  will be increasing in  $\frac{ME_j/ME_h}{Y_j/Y_h}$ . That result was obtained under the condition that  $Y_j > Y_h$  and  $ME_j > ME_h$ , therefore in the empirical estimation I order exporter pairs so that the first exporter ( $j$ ) is larger, and I restrict the sample so that exporter  $j$ 's military expenditure is also larger than that of exporter  $h$ . I then estimate the regression:

$$\ln \left( \frac{S_{ijk}/S_{ihk}}{S_{ojk}/S_{ohk}} \right) = \alpha + \beta \ln \left( \frac{ME_j/ME_h}{GDP_j/GDP_h} \right) + \phi(X_j - X_h) + \theta \ln(d_{jk}/d_{hk}) + \epsilon_{iojkh} \quad (5)$$

where  $\frac{ME_j/ME_h}{GDP_j/GDP_h}$  is the relative military spending out of GDP<sup>18</sup> of the two exporters.  $X_j$  and  $X_h$  control for the production costs of industries  $i$  and  $o$  in the two exporter countries, and  $d_{jk}$  and  $d_{hk}$  are distances from each of the exporters to the common importer. A positive  $\beta$  coefficient will then be evidence that the military goods sector displays home market effects.

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<sup>18</sup>Since in my sample the median military expenditure level is just under 2% of GDP, I approximate civilian expenditure  $Y$  by  $GDP$ :  $Y = GDP - ME \approx GDP$ . This will make results easier to interpret, especially given that military spending is often reported and discussed as a percentage of GDP.  $\frac{ME_j/ME_h}{GDP_j/GDP_h}$  is then introduced in equation (5) as an approximation to  $\frac{ME_j/ME_h}{Y_j/Y_h}$

## 3 Empirical analysis

### 3.1 Data sources

I use bilateral trade data from UN Comtrade, classified by the Standard International Trade Classification (SITC) revision 3, from 1990 through 2012. To account for the distance variable  $d$  from equation (5), I use physical, cultural, religious, and political closeness: inter-capital distance data and indicators of common language, contiguity, and past colonial relationship are from *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII). Thomas Baranga kindly provided his index measure of religious similarity (Baranga, 2009). The Polity score is from the 2013 update of the Polity IV Project data (Marshall et al., 2002), and UN General Assembly voting record affinity is defined in Gartzke and Jo (2006).<sup>19</sup>

The  $X$  vector of variables is intended to control for production costs across industries, and it includes capital per worker data from the Penn World Tables 8.0 (see Feenstra et al., 2013), average total years of education from the 2010 update of the Barro and Lee (2001) dataset, and land per worker from the World Bank's World Development Indicators (WDI). GDP and military expenditure as a share of GDP were also extracted from the World Bank's WDI.<sup>20</sup> In addition to overall military spending, a disaggregated measure of equipment spending is also used, but this is only available for NATO members. Data on international conflicts is from the UCDP/PRIO Armed Conflict Dataset, as described in Gleditsch et al. (2002), specifically version 4-2014 updated by Themnér and Wallensteen (2014).

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<sup>19</sup>Update downloaded from Strezhnev and Voeten (2012).

<sup>20</sup>The military expenditure data is originally sourced from the Stockholm International Peace Research Institute (SIPRI).

## Military and control goods

In order to accurately use military expenditure as a measure of demand for arms, I exclude weapons which have mainly civilian or law enforcement uses: sporting firearms, signal pistols; compressed air and spring-operated guns; cartridges used for riveting/captive bolt guns, handguns and their parts, as well as shotguns and parts, shotguns cartridges and airgun pellets. The resulting set of goods includes military small arms and light weapons, as well as various types of munitions, tanks and other armored vehicles. However, military aircraft and ships are not distinguishable from civilian vehicles in the data, and therefore cannot be included in the analysis. Note that by excluding these goods of extreme R&D and other initial fixed costs, I am left with a set of goods of more moderate returns to scale.

The model's predictions are formulated against control civilian goods with lower transport costs and of lower levels of differentiation. To determine which goods fall into this category, I use the substitution elasticity parameter estimates from Broda and Weinstein (2006)<sup>21</sup> and the freight rates estimated by Hanson and Xiang (2004). Under these parameters, the arms and ammunition category is characterized by high differentiation, but relatively low transport costs: it falls within decile 2 of both elasticity of differentiation  $\sigma$  and the freight rate. Of the 16 industries that have lower freight rate and higher substitution elasticity than arms and ammunition, I eliminated aircraft and engines, since these categories include military goods.<sup>22</sup>

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<sup>21</sup>Another frequently used set of estimates is from Hummels (1999). However, these are only available at the 2-digit level, which would force me to group the arms and ammunition category (891) with printed matter, toys etc. in category 89 - "miscellaneous manufactures".

<sup>22</sup>The final sets of military and control goods are listed in section C of the online Appendix.

## Variables used in estimation

As indicated by equation (5), I run a double-difference specification: first, across exporters and second, across goods. The dependent variable is the log of the double ratio: value of arms trade from the first exporter ( $j$ ) to the importer ( $k$ ) vs. from the second exporter ( $h$ ) to the importer ( $k$ ), divided by the same ratio for control goods.<sup>23</sup>

Control variables are simple or log differences between the two exporters, or between the two exporter-importer dyads. The main independent variable is the log difference between exporter 1's military expenditure as a share of GDP and exporter 2's military expenditure as a share of GDP.<sup>24</sup> *Geographical distance* is the log difference of inter-capital distances between each of the two exporters and the importer - so a positive value indicates that the importer is closer to the second exporter than to the first. *Colonial relationship*, *common border* and *common language* are simple differences of dyadic dummy variables relating the two exporters to the importer. For these and following distance measures, a positive value indicates that the importer is more similar to exporter 1 than to exporter 2. *Religious similarity* is a simple difference between the index of religious closeness between exporter 1 and the importer vs. exporter 2 and the importer. Two measures of political distance are included: a simple difference between the UN General Assembly voting similarity index between each of the exporters and the importer (see Gartzke and Jo, 2006), and a measure of Polity score *distance*.<sup>25</sup> <sup>26</sup>

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<sup>23</sup>For convenience, I will refer to exporter  $j$  as exporter 1, and exporter  $h$  as exporter 2.

<sup>24</sup>Throughout the empirical analysis, military expenditure will be considered as a share of GDP, even if this isn't spelled out at every instance.

<sup>25</sup>The Polity score distance measure is constructed as follows, where  $P$  stands for Polity score:  
Polity similarity =  $[-(P_{exporter1} - P_{importer})^2 + (P_{exporter2} - P_{importer})^2] / 100$

<sup>26</sup>Another candidate control variable is the number of inter-state alliances from the Correlates of War



*Capital per worker*, *land per worker*, and *years of schooling* are log differences between endowment levels of exporters 1 and 2. Anderson and Marcouiller (2002) argue that omitting controls of institutional quality biases coefficients in gravity models. To avoid losing observations, I use Polity score as a measure of institutional quality: specifically, a simple difference in the two exporters' Polity score, so that a positive value indicates that exporter 1 is more democratic than exporter 2. In the same spirit, I control for the simple difference between exporter 1's NATO/EU membership status and exporter 2's status.

### 3.2 Summary statistics

I explore three groups of exporters: the top 60 economies, a smaller set of just the top 30 countries,<sup>27</sup> and finally a sample of high income OECD countries.<sup>28</sup> The different samples are intended to capture any systematic differences between large vs. smaller countries on one hand, and between high vs. middle and low income countries on the other hand.

Table (1) shows summary statistics for the three samples of exporters. The averages of the top 30 sample appear placed between the top 60 and OECD samples for all variables shown. The direction of change is for the most part as expected: OECD countries export somewhat less weaponry, relative to civilian goods. They spend less of their GDP on the

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(COW) project. However, these data are only available through 2000.

<sup>27</sup>The top 60 and top 30 exporter samples are selected by GDP ranking in 2005. The top 30 include Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Mexico, Netherlands, Norway, Poland, Russia, Saudi Arabia, South Africa, South Korea, Spain, Sweden, Switzerland, Turkey, USA, and UK. To these, the top 60 sample adds: Argentina, Bangladesh, Chile, Colombia, Croatia, Czech Republic, Egypt, Hungary, Iran, Israel, Kazakhstan, Kuwait, Malaysia, Morocco, New Zealand, Pakistan, Peru, Philippines, Portugal, Romania, Singapore, Slovak Rep., Thailand, Ukraine, Venezuela, and Vietnam.

<sup>28</sup>I use the World Bank classification based on 2005 GNI per capita. This sample comprises: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, South Korea, Spain, Sweden, Switzerland, USA, and UK.

military, are more democratic, have higher capital endowment, even slightly higher land endowment, and a more educated workforce. All variables except for land/worker have the highest variance in the top 60 sample, and the lowest variance in the OECD sample. Combined with a diminishing sample size, this suggests we will obtain less precise estimates for the OECD sample. Also note that exporters are rather frequently involved in conflicts in the top 60 sample (19% of the country-year observations), and hardly at all in the OECD sample (only 4%).<sup>29</sup>

Table 1: Summary statistics for the exporters in the samples

	Top 60		Top 30		OECD	
	Mean	SD	Mean	SD	Mean	SD
Ratio total arms/control exports	0.014	0.066	0.009	0.012	0.008	0.010
Ratio ME/GDP (%)	2.55	3.41	2.21	1.79	1.85	0.84
Polity score	6.09	5.88	7.74	5.02	9.80	0.66
Capital/worker	1.32	0.83	1.65	0.80	2.04	0.47
Land/worker	0.08	0.14	0.09	0.17	0.10	0.19
Years schooling	8.98	2.55	9.62	2.29	10.71	1.45
Conflict indicator	0.19	0.39	0.14	0.35	0.04	0.19
N exporter-year obs	1,239		675		496	
N exporters	56		30		22	

*Notes:* The unit of observation is an exporter during a given year, for country-year pairs that have non-missing values for all these variables. The top 60 and top 30 samples contain the largest economies by GDP in 2005. The high income OECD sample is chosen according to the World Bank classification based on 2005 GNI. Four of the top 60 countries (Algeria, Iraq, Nigeria, and UAE) are never in the sample due to missing data.

The unit of observation in the estimation sample is composed of two exporters and one importer. Consistent with the theoretical derivation, exporters are ordered so that exporter 1 is larger, and the sample is trimmed so exporter 1 also has higher military expenditure

<sup>29</sup>The conflict indicator is not used directly in the baseline regressions, however I do conduct robustness checks to both including the indicator and restricting the sample - see section 3.6.

ME.<sup>30</sup> In practical terms, ordering the exporters by size is a convenient way to avoid double counting observations. Trimming the sample so that the larger exporter also has higher military expenditure is done because my test of the home market effect only applies under these conditions.<sup>31</sup> The restriction reduces the top 60 sample by 12%, the top 30 sample by 9% and the OECD sample by only 6%, and empirical results are similar if the trimming and ordering are not performed.<sup>32</sup>

The set of importers is held the same across all 3 samples of exporters. In order to address the exports-as-policy-tool concern (see section 1.2), I opted to only consider as importers the high income OECD countries which are both EU and NATO members.<sup>33</sup> The intuition is that, by considering only wealthy and well-connected importers, I eliminate trading relationships in which the exporter is furnishing the recipient with weapons at a loss (usually through military aid), in order to project political influence.

Table (2) shows summary statistics for the difference-in-difference estimation sample. The unit of observation here consists of two exporters and one importer, and variables are as described in section 3.1. As expected, the OECD sample has lower variation for a number of variables, in particular Polity similarity (between exporters and importer), Polity score (difference between exporters), and years of schooling.

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<sup>30</sup>Of course, the ratio  $ME/GDP$  is not ordered, so that the main control variable  $\ln\left(\frac{ME_j/ME_h}{GDP_j/GDP_h}\right)$  can take both positive and negative values.

<sup>31</sup>See the definition of the home market effect and footnote 17.

<sup>32</sup>Although the extra observations should not be included from a theoretical standpoint, they do not affect results since for these pairs of exporters the relative  $ME/GDP$  ratio is close to 1.

<sup>33</sup>Section D.1 in the online Appendix reports baseline estimations for trade from the top 60 sample of exporters to progressively restricted samples of importers: all top 60 countries, NATO members, high income OECD countries, countries that are both in NATO and in the high income OECD category, EU members, and finally countries that are part of all 3 categories. I select this last sample as the baseline set of importers, as it is the most conservative.

Table 2: Summary statistics for the difference-in-difference baseline estimation samples

	Top 60		Top 30		OECD	
	Mean	SD	Mean	SD	Mean	SD
dependent variable $\ln\left(\frac{S_{mjk}/S_{mhk}}{S_{ojk}/S_{ohk}}\right)$	-0.17	3.58	0.09	3.29	0.14	3.24
$\ln(\text{ME}/\text{GDP})$	0.10	0.70	0.29	0.61	0.26	0.53
<i>exporter-importer distance measures</i>						
geographical distance	0.13	1.56	0.36	1.55	0.35	1.54
colonial relationship	-0.01	0.36	0.02	0.35	0.03	0.33
common language	-0.02	0.38	-0.03	0.39	-0.03	0.41
common border	0.03	0.42	0.00	0.46	0.00	0.49
religious similarity	-0.02	0.30	-0.03	0.31	-0.04	0.31
Polity similarity	0.02	1.04	-0.13	0.95	0.00	0.02
UNGA affinity	-0.04	0.39	-0.12	0.36	-0.14	0.30
<i>exporter endowment and institutions</i>						
capital/worker	0.24	1.13	0.02	1.11	0.07	0.32
land/worker	-0.04	1.97	-0.36	1.99	-0.38	2.11
years schooling	0.04	0.42	0.02	0.38	0.04	0.19
Polity score	0.42	6.35	-0.80	5.67	-0.09	0.84
NATO member	0.20	0.68	0.19	0.69	0.24	0.64
EU member	0.03	0.69	-0.10	0.71	-0.12	0.68
N obs	62,914		35,016		21,780	
N exporter pairs	1,423		424		221	

*Notes:* The unit of observation is a pair of exporters  $j$  and  $h$ , a common importer  $k$ , and a year. Dep. variable =  $\ln\left(\frac{S_{mjk}/S_{mhk}}{S_{ojk}/S_{ohk}}\right)$ : flow of military goods ( $m$ ) from exporters  $j$  and  $h$  to importer  $k$ , vs. flows of control goods ( $o$ ). Exporter pairs are ordered so that  $GDP_j > GDP_h$ , and the sample is restricted so that  $ME_j > ME_h$  - see the discussion on page 18.  $\ln(\text{ME}/\text{GDP}) = \ln\left(\frac{ME_j/ME_h}{GDP_j/GDP_h}\right)$ . Geographical distance is the log difference between the  $(j, k)$  and  $(h, k)$  distances. Other distance variables are simple differences between the two exporter-importer pairs  $(j, k)$  and  $(h, k)$ . Capital per worker, land per worker and years of schooling are log differences between the respective values for the two exporters  $j$  and  $h$ . Polity score and NATO and EU membership are simple differences between the two exporters (importers are both NATO and EU members).

### 3.3 Baseline regression results

Moving on to regression analysis, table 3 reports results from the OLS estimation of equation (5). A positive and significant coefficient on the log-differenced ratio of military expenditure to GDP is interpreted as evidence of the home market effect. Across the three samples, I find that a 10% increase in military expenditure is associated with a 4.3 to 10.4% increase in arms exports. The coefficient is highest for the OECD sample, and lowest for the top 30 sample, suggesting stronger home market effects in more advanced economies, and weaker effects in large but poorer countries. This is consistent with the fact that richer countries have better technical capabilities to produce weaponry with broad international appeal.

The secondary coefficients reported in Table (3) are also of interest. The coefficient on *geographical distance* is significantly negative. This is consistent with the fact that control goods have lower freight rates than military goods: all other things equal, goods with lower transport costs will be shipped farther. Having been in a colonial relationship with the importer predicts lower arms exports in the top 30 and OECD samples. Common language is insignificant, and the effect of common border is in line with the result obtained for geographic distance: countries export the higher transport good more to neighbors. Religious similarity is a strikingly strong determinant of the arms trade: the variable varies between -0.86 and 0.86 in the sample; the magnitude of the coefficients therefore indicates that, even when accounting for other forms of cultural and political alignment, pairs of countries which share the same religion trade two to three times the volume of weapons as compared to countries which have no religion in common.

Table 3: Baseline OLS estimation results

	Top 60	Top 30	OECD
	(1)	(2)	(3)
ln(ME/GDP)	.85 (.09)***	.43 (.11)***	1.04 (.21)***
<i>exporter-importer distance measures</i>			
geographical distance	-.36 (.05)***	-.16 (.06)***	-.28 (.08)***
colonial relationship	-.09 (.11)	-.53 (.13)***	-.46 (.23)**
common language	.02 (.11)	-.02 (.12)	.03 (.16)
common border	.28 (.09)***	.30 (.11)***	.15 (.13)
religious similarity	1.11 (.14)***	.96 (.15)***	.69 (.18)***
Polity similarity	-.40 (.23)*	-.75 (.29)***	-5.98 (3.60)*
UNGA affinity	-1.65 (.20)***	-2.16 (.22)***	-.62 (.34)*
<i>exporter endowment and institutions</i>			
capital/worker	.02 (.08)	.73 (.14)***	1.81 (.25)***
land/worker	.48 (.03)***	.56 (.04)***	.59 (.06)***
years schooling	-.33 (.26)	-1.75 (.36)***	.72 (.57)
Polity score	.10 (.04)**	.18 (.05)***	.21 (.15)
NATO member	-.39 (.10)***	-.25 (.12)**	-.25 (.14)*
EU member	.04 (.11)	.41 (.13)***	.38 (.18)**
Obs.	62,914	35,016	21,780
e(N-clust)	1,423	424	221
$R^2$	.15	.18	.21

*Notes:* The unit of observation is a pair of exporters  $j$  and  $h$ , a common importer  $k$ , and a year. Dep. variable =  $\ln\left(\frac{S_{mj k}/S_{m h k}}{S_{oj k}/S_{oh k}}\right)$ : flow of military goods ( $m$ ) from exporters  $j$  and  $h$  to importer  $k$ , vs. flows of control goods ( $o$ ). Variables and sample composition are as described in table 2. Year and importer country dummies are also included in all regressions, and standard errors are clustered at the exporter-pair level. Significance indicated is at 10%(\*), 5%(\*\*), and 1%(\*\*\*).

Polity similarity appears to be negatively correlated with arms exports, although the coefficient is only precisely estimated in the top 30 sample. This indicates that countries are more likely to trade with either more or less democratic countries than with similar partners. The coefficient on the similarity index of UN General Assembly voting pattern is also surprising. Robustness checks reported in section D.2 of the online Appendix suggest that this result is driven to a significant extent by observations including the US. In addition, we have to remember that the regression includes other controls for cultural similarity.

Capital per worker has a positive impact on arms exports in the top 30 and OECD samples, with the effect being much larger for the latter sample. This is likely due to the fact that poorer countries export less technologically advanced weaponry, which require lower capital investments. Land per worker is predictive of higher arms exports, and the result is highly statistically significant. One possible explanation is that having long borders to defend has forced geographically large countries to gain proficiency in manufacturing weapons. Or perhaps countries which have historically been good at producing arms were better able to maintain the integrity of their physical borders. The human capital endowment indicator - average years of schooling - is significant only in the top 30 sample and suggests a negative association between education and the level of arms exports. Finally, the coefficients on the last three variables indicate that, holding other things constant, more democratic countries, non-NATO members, and EU members tend to export more weapons.

A potential source of bias is the impact, or *pull*, of neighboring markets - the so-called *agglomeration shadow*. I follow Hanson and Xiang (2004) in constructing a market potential

variable: for any given country  $i$ , the market potential is the sum of GDP in other countries, weighted by the inverse of the distance to country  $i$ . I run robustness checks to including this variable (more specifically, the log difference between the two exporters), as well as own market size (log difference of exporters' GDP).<sup>34</sup> Both market potential and GDP are only significant in the large (top 60) sample, and for all three samples there is no measurable change in other coefficients. Results are reported in section D.3 of the online Appendix.

### 3.4 Instrumental variables estimation

I have argued that military expenditure as a share of GDP is driven by political and strategic preferences,<sup>35</sup> and not immediately linked to the type of economic factors that might influence exports - for instance the price of weapons on the global market. To test whether there is nonetheless some endogeneity-driven bias, I employ own lags of the ratio of military spending as instruments for the current value. The intuition is that, even if there are shocks which influence both exports and military spending, *past* values of military expenditure will be unaffected. This argument carries despite the fact that many military goods are durable: even if governments take into consideration that current production will also fill future needs for weapons aside from immediate ones, they cannot adjust to factors they cannot predict.

First stage estimations (reported in section D.8 of the online Appendix, along with complete IV results) confirm that 5 and 10-year lags are strong instruments for current values of the leading explanatory variable across all three samples of exporters.

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<sup>34</sup>The rationale for testing the inclusion of GDP is to ensure that results aren't an artifact of country size.

<sup>35</sup>See the discussion in section B of the online Appendix



Table 4 summarizes IV estimation results, adding OLS results for comparison. For brevity, only the main coefficient (on relative military spending) is reported. Row 1 repeats the baseline result from table 3. Row 2 reports IV regression results, where the 5-year lagged value is used to instrument for current spending. Since we reach 5 years into the past, the regression sample is reduced, starting in 1995 instead of 1990. Row 3 shows OLS regression results estimated over this sub-sample for a more pertinent comparison. Similarly, rows 4 and 5 show IV and OLS estimation results over the sub-sample starting in 2000.

Table 4: Summarized IV and OLS results (showing only coefficient on  $\ln(\text{ME}/\text{GDP})$ )

	Top 60	Top 30	OECD
	(1)	(2)	(3)
OLS, baseline	.85 (.09)***	.43 (.11)***	1.04 (.21)***
IV, using lag 5	.94 (.12)***	.60 (.14)***	.86 (.22)***
OLS, restricted <sup>(a)</sup>	.88 (.11)***	.53 (.13)***	.73 (.20)***
IV, using lag 10	.64 (.14)***	.34 (.15)**	.51 (.23)**
OLS, restricted <sup>(b)</sup>	.71 (.12)***	.42 (.13)***	.50 (.19)***

*Notes:* dep. variable =  $\ln\left(\frac{S_{mjk}/S_{mhk}}{S_{ojk}/S_{ohk}}\right)$ : flow of military goods ( $m$ ) from exporters  $j$  and  $h$  to importer  $k$ , vs. flows of control goods ( $o$ ). All other controls from table 3 were included, but are omitted here for brevity.

<sup>(a)</sup> OLS results where the sample is restricted to be the same as in the IV (lag 5) sample.

<sup>(b)</sup> OLS results where the sample is restricted to be the same as in the IV (lag 10) sample.

Standard errors are clustered by exporter pair, and the level of significance indicated is at 10%(\*), 5%(\*\*), and 1%(\*\*\*).

IV estimates are comparable to their OLS counterparts, and are all positive and significant. For the top 60 and top 30 samples, using 5-year lags yields coefficient estimates on

military spending that are slightly higher than when employing OLS. Using 10 year lags, we obtain slightly lower estimates. For the OECD sample, both 10 and 5-year lag IV estimates are below the OLS values, however as rows 3 and 5 show, this is due to sample selection.<sup>36</sup> I conclude that the OLS results are unbiased, and go on to use these as baseline estimates.

The fact that we do not find OLS results to be biased when instrumenting with up to 10-year lags serves to ease concerns of endogeneity over the short and medium term. Still not addressed is the possibility of bias due to long-term reverse causality: could it be that the arms-producing industry established decades ago has been able to lobby the government into very high military spending in the countries where it has taken a strong hold? We often hear that US policy makers are under pressure to either acquire or allow exports of products by domestic arms manufacturers.<sup>37</sup> However, results carry across all three samples of exporters and are robust to dropping the US or any of the other top exporters (see appendix section D.2) Furthermore, it is hard to imagine how a powerful military industrial complex could have arisen in the first place, other than spurred by domestic investment.

### **3.5 Product sub-samples and spending sub-categories**

A further way to test the model is to separate the arms and ammunition category along relevant dimensions, chief among them being the level of differentiation. I isolate two categories: a high differentiation one which includes armoured vehicles, military rifles, bombs, grenades, torpedoes, mines, missiles, and similar munitions of war; and a less differentiated

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<sup>36</sup>See also appendix section D.7 for an idea of how OLS estimates vary over the sample period.

<sup>37</sup>The most quoted reason is that a higher volume of production will allow firms to recoup initial costs and lower per-unit prices - precisely in line with the increasing economies of scale model I am proposing.

set of goods, composed of cartridges. Results (reported in section D.4 of the online Appendix) indicate that, as expected from the theoretical model, the home market effect is more pronounced for the higher differentiation sample.

So far I have used overall military spending to indicate demand for weapons. However, this measure also incorporates spending on personnel wages, pensions, training, infrastructure construction and maintenance, etc. If expenditure on weapons and ammunition has greater than 1 elasticity with respect to overall military spending, previous estimates of the home market effect may be biased upwards (although still retain the correct sign). To get around this problem, I run estimations using specifically *equipment* military spending to measure demand, rather than overall military spending. This variable is only available for NATO countries, thus reducing the regression samples considerably. Once again, results from pooled OLS estimations indicate that higher differentiation goods have a significantly higher coefficient on relative equipment military spending than lower differentiation goods.<sup>38</sup> Restricting focus to only the highly differentiated sub-sample of military goods, I find that the home market effect is more pronounced when we measure demand with overall military spending rather than just equipment spending, consistent with a greater than 1 elasticity of equipment vs overall military spending.

It is worth pointing out, however, that at the finer spending level the argument that military expenditure is exogenous becomes weaker: even if trade shocks cannot influence the total military budget, they may affect how much of that budget is allocated to armament purchases. For example, large manufacturers who encounter poor demand abroad may pressure

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<sup>38</sup>Results are reported and discussed in section D.5 of the online Appendix.

the domestic government to purchase their products, in order to keep them in business and maintain strategic independence. The bias introduced through this mechanism is negative, so it may help explain the gap in estimates mentioned in the previous paragraph. Fortunately, instrumenting with lagged military spending (either overall or capital/equipment-specific) promises to address this negative bias. Contemporaneous overall spending may be a suitable instrument as well, since lobbying efforts are unlikely to have an immediate effect on the total military budget. As expected, IV estimates are uniformly higher than OLS ones (although the difference is not significant in all cases). I prefer these IV estimates as less biased, with the caveat that they refer to a subset of military goods (what I deemed the more highly differentiated group), and they are obtained in a sample of exporters that are all NATO members, therefore external validity is not guaranteed. In terms of magnitude of the effect, the IV estimates suggest that a 10% increase in spending on military equipment will lead to between a 5.7% and 10.6% increase in exports of military weapons.

### **3.6 Discussion of alternate mechanisms**

I show that arms exports vary positively with military expenditure, and claim that this is due to economies of scale in the military sector. Could the result be driven instead by another mechanism? One possibility is that large military powers intentionally over-produce and export arms during peacetime in order to maintain excess capacity they can appeal to during conflicts - this would lead to the pattern observed even in the absence of scale economies. Gold (1999) weighs this hypothetical scenario, but questions whether

maintaining production lines for long periods of time is cheaper than restarting, and mentions that during the Gulf War there was no need for excess capacity. By incorporating data on international conflicts, I directly test this suggested mechanism. To begin with, I find that results are robust to controlling for conflict or to excluding conflicts.<sup>39</sup> In a directly pertinent test, I run the estimation over a sub-sample of observations in which exporter 1 is at war, but exporter 2 is not. If exporter 1 had been keeping production lines active merely to be able to appeal to them during conflicts, we should observe that there is no positive correlation between military spending and arms exports over this subsample. But we *do* continue to find a positive coefficient - less precisely estimated because of the reduced sample, but still significant at the 1% level for the top 60 sample and at the 10% level for the top 30 sample.

A potentially confounding issue (previously brought up in section 1.2) is military aid: military expenditure data includes aid, which is typically given in the form of credits to purchase arms from the donor country. This can lead to a mechanical link between high military spending and large arms exports. However, the restricted set of importers I consider (rich EU and NATO member countries) are not typical candidates for military aid. Furthermore, even for big donor countries, military aid represents a small minority of military spending.<sup>40</sup> Nonetheless, in order to test whether military aid or some other large exporter idiosyncrasy is generating the result, I ran robustness checks (see Appendix section D.2), excluding the top six arms exporters from all three samples, and find results to be unchanged.<sup>41</sup>

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<sup>39</sup>See online appendix section D.6 for the full estimation results referenced in this paragraph.

<sup>40</sup>As of 2006-2008, the United States disbursed approximately \$4.5 billion per year through its Foreign Military Financing program, making it by far the largest military aid donor. This amount represents less than 1% of American military expenditure.

<sup>41</sup>The top arms exporters are also the top military aid donors, with remaining countries not involved in sizeable aid programmes.

Finally, because the development of military technologies often has spillovers into civilian ones, we have to ask whether the presence of externalities affects the conclusions we can draw from this analysis. Production externalities in this case are overwhelmingly positive, which means that high military spending could improve civilian production as well. If any of the control civilian goods used in the empirical analysis capture some of these positive spillovers, this would introduce an attenuation bias in the HME estimates.

## 4 Conclusion

I develop a theoretical trade model that includes a differentiated military sector and a continuum of civilian industries, and derive an empirical test for the home market effect as it applies to arms and ammunition. This approach is novel in that I use military expenditure to introduce variation in demand within countries, rather than assume identical preferences and use differences in country size to infer trade patterns. Using post-Cold War data, I verify the model predictions that countries with large military expenditure relative to GDP export more arms relative to homogeneous civilian goods. The magnitude of the effect is economically significant: a 10% increase in military spending leads to an increase in exports of arms and ammunition between 5 and 10%.<sup>42</sup>

I instrument for military expenditure with its lagged values from up to 10 years before, and find that results are unaffected. Consistent with the model, the effect is stronger (8 to 13%) for more highly differentiated weapons than for cartridges. I use a measure of

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<sup>42</sup>Recall that *any* increase would be indicative of the home market effect.

equipment-specific military spending where available and obtain, again as predicted, similar but slightly lower (6 to 11%) estimates for differentiated weapons.

These findings can be interpreted through different policy lenses. From a domestic perspective, I conclude that high military spending helps countries become successful arms exporters and so can have a stimulating effect on the economy. However, I have not accounted for the opportunity costs of diverting money from other public investments, which could easily overwhelm the benefits. My results also suggest an alternate channel through which the global community can reduce the supply of weapons on the international market: by pressuring major arms exporters to jointly reduce defense budgets.

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