The Global Arms Trade Network[*]

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Abstract

We use a unique data set on international arms trade 1950-2007 to characterise patterns in global arms trade. We are ultimately interested in whether arms trade can serve as a useful measure of the strength of international relations. Using tools from social network theory, we are able to identify networks in arms trade and study their evolution over time. We also find substantial differences between the structure of the Cold War period's two large military alliances: NATO and the Warsaw pact. Having identified and analysed key characteristics of arms trade networks present in the data, we relate our findings to political and economic characteristics. In particular, we address the issue of whether countries tend to prefer trade partners with the same polity, i.e. if it is the case that democracies trade with other democracies while autocracies trade arms with other autocracies. Our conclusion is that arms trade is indeed strongly correlated with political relations between countries.

Keywords: Arms Trade, Networks, Democracy, Autocracy, NATO, The Warsaw Pact

JEL-classification: F19, F51, F59, P51

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1   Introduction

This paper focuses on the interaction between international trade in arms and political regimes using a unique dataset on global arms trade. Ultimately, we are interested in how countries can affect other countries' type of government. It is challenging to find empirical measures of political connections and the strength of international relations. This paper argues that trade in arms and military equipment can be one such measure. Our objective is to provide a thorough understanding of the global arms trade network and to assess the importance of political regimes for the likelihood of bilateral trade in arms. First, we structure the global arms trade pattern using network analysis and, second, we examine how the degree of democracy influences which countries trade in arms. The issue of causality is beyond the scope of our analysis and left for a follow-up paper. The dataset we use is a unique collection of international arms trade data by the Stockholm International Peace Research Institute (SIPRI) and covers all trade in military equipment (except small arms) during the period 1950-2007. To our knowledge, our methodology has never been applied to neither this dataset nor to any other dataset on arms trade. We are also convinced that the quality of the dataset is sufficiently high for addressing these issues, despite the involved nature of the arms industry.[1]

Network analysis is an increasingly popular tool for analysing complex interaction between a large number of agents.[2] This type of analysis offers, for example, measures of how centralised networks are, how influential certain agents are for the functioning of the system and how dense these networks are. It therefore provides a very useful methodology for addressing our research question. Indeed, we find that the global arms trade network has many characteristics that are similar to those of other networks, but we are also able to identify some interesting differences. Most notably, the influence of the most central countries is very large. Moreover, we find substantial changes in key measures over time and also large differences between the two dominating military alliances during the Cold War: NATO and the Warsaw Pact. The network as a whole becomes much denser over time as more countries start trading in arms

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[1] Since trade in small arms are excluded, we face a much smaller risk of missing observations since illegal trade is very difficult for larger types of military equipment. Most of the trade in the type of equipment the dataset covers can be found in at least one of the sources that SIPRI uses to compile the dataset.

[2] See Jackson (2008) for a an overview.

and form more links per country. The NATO network is also found to be more decentralised than the Warsaw Pact and the largest trader in the NATO network (the United States) is less important compared to the largest trader in the Warsaw Pact (where the Soviet Union holds a very domination position throughout the Cold War).

Democracy is found to be strongly correlated with the formation of arms trade ties. First, the largest exporters have a strong bias towards countries with a similar type of government as themselves. The largest democracies export to both democracies and autocracies but (with some notable exceptions) they tend to favour democracies over autocracies. The largest autocracies, on the other hand, have an even stronger bias towards other autocracies. To control for factors such as geographic proximity and colonial ties we apply a gravity regression to examine the correlation between differences in polity and the likelihood of arms trade. We find that there is a significant and negative relationship throughout the Cold War period and that this relationship is sustained also after 1990. Somewhat surprisingly, this relationship does not hold for aggregate trade (in nonmilitary items) and, in fact, not for any other type of good that we look at. It seems to be the case that arms trade has a particular relation to political regime whereas trade in other goods does not display this characteristic. Given that democracies tend to have better relations with other democracies, our results therefore suggest that arms trade is indeed an adequate measure of political relations.

The paper is organised as follows. Section 2 provides a brief review of related literature. Section 3 provides a descriptive analysis of the evolution of the global arms trade network using social network theory. Section 4 addresses the issue of polity and arms trade by reporting the results from estimating a gravity model. Finally, section 5 concludes.

2   Related Literature

According to The Democratic Peace Theory two democratic regimes are extremely unlikely to engage in militarised conflict, see for instance Kadera et al. (2003). As argued by Mulligan et al (2004), democratic leaders have less reason to worry about foreign military threats as foreign invaders are more likely to attack nondemocratic regimes. Assuming that the decision to instigate an attack on a foreign autocracy is governed by the attacking leader's strive to

be reelected, he is more willing to attack a regime that his electorate is not supportive of. An implication of these theories is that democracies are more likely to trade arms with other democracies than with autocracies, since the former are not perceived as potential adversaries.

There is no doubt that the economic consequences of armed conflict are huge. In terms of human suffering and mortality rates, civil and interstate conflict have both immediate and lingering effects (Li and Wen, 2005). As reported by Levine et al (1997), arms trade is highly controversial precisely because of the difficult moral and political questions it raises.

The theoretical literature tends to focus on arms races i.e. how two countries perceiving each other as threats react to increases in military expenditure or advancements in weapons technology from the perceived opponent. For obvious reasons, game theoretic settings are well suited to study theses issues. Early contributions include Intriligator (1975) and Brito and Intriligator (1981). Ayanian (1986) provides some empirical tests of theoretical predictions from the earlier literature. Levine and Smith (1995) construct a dynamic model of arms trade where sellers care about profits but also about the security impact of the sale. More recently, Baliga and Sjöström (2004) derive conditions for when an arms race will occur.

Turning to the relationship between political regime and military expenditure, Mulligan et al (2004) address differences in military spending between democracies and autocracies. They find that ceteris paribus, military spending is higher in autocracies than in democracies. They argue that the military affects the position of the political leader in the following three ways. First, the leader's opponent may be dependent on the military if he wants to initiate a coup. Second, democratic leaders may have less reason to worry about foreign military threats than a dictator. Third, the military may constitute a part of the domestic policing system.

The idea that democratic countries are likely to prefer exporting arms to other democracies captures the notion that interstate cooperation and exchange is more likely between countries who share similar political views. A relevant paper is therefore Persson and Tabellini (2008) who launch the concept of democratic capital, measured by the nation's historical democratic experience and by the incidence of democracy in its neighbourhood. The model suggests that proximity to other democracies may matter for the sustainability of democracy. Persson and Tabellini show that democracy induces endogenous sorting of countries into political regimes.

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The probability of a regime change in the model is determined in a global game where citizens decide whether to participate in defending democracy (or attacking autocracy). The empirical results suggest that democratic capital explains the probability of exit from democracy. The exit rate out of autocracy (democracy) increases (decreases) in two forms of democratic capital.

Do the incentives to instigate conflict depend on polity? As noted by Cowen (1990), a democratic leader is likely to go to war if he thinks that international victories will strengthen his mandate or probability of reelection. On the other hand one may argue that also an autocratic leader might strive for popularity if his future lies in the hands of a political elite or a selectorate of the type discussed in Besley and Kudamatsu (2009).

Is a democratic world order detrimental to conflict? Kadera et al. (2003) present a study motivated by the aforementioned democratic peace theory. The authors address the issue of whether a more democratic community is likely to decrease the propensity to conflict and present a dynamic theory of the relationship between democracy and conflict at the systemic level. The model stresses how a more democratic community is likely to pressure autocracies to switch regime. The model suggests that when the global system becomes more democratic, two opposing effects are possible: (i) a more democratic community encourages democracies to be more aggressive towards non-democracies and (ii) a more democratic community may increase the fear and isolation of non-democratic states who will start to act more aggressively towards democracies. The authors argue that for a low level of democracy in the global system, increased democratisation increases conflict. However, once the global system has become sufficiently democratic, democratisation is likely to promote peace.

Another strand of literature focuses on the simultaneous relationship between trade and conflict; see Martin et al (2008a, 2008b) and others. Keshk et al (2000) find evidence of the so-called Primacy of Politics, i.e. the claim that conflict inhibits trade. Mansfield et al. (2004) study the reverse causality and in particular the impact of Preferential Trade Agreements (PTAs) on conflict. They find that the propensity to dispute is low within PTAs. Keshk et al (2000) provide a review of the academic debate.

In recent years, social network theory has become increasingly recognised as a useful part of the applied economist's toolbox. Due its global nature, network theory is ideally suited for

studying complicated interactions between a large set of players. Flandreau and Jobst (2005) use network theory to characterise core and peripheral countries in the international monetary system. De Benedictis and Tajoli (2008) use tools from social network theory to study the global trade network. Flandreau and Jobst (2009) study the existence of strategic externalities in the international currency system. Goyal et al. (2006) study the "small world property" of networks, by documenting coauthorships in economics.

3   The Global Arms Trade Network

In this section we study the evolution of the global arms trade network over time. We begin with a thorough discussion of the SIPRI dataset in Section 3.1. We then aggregate arms trade between countries over five-year intervals and graph the global arms trade in section 3.2. We then define key centrality measures in Section 3.3. The evolution of these measures over time are reported in Section 3.4.

Throughout the section we study (i) all countries trading arms, (ii) countries trading arms with at least one full member of NATO (we call this set of countries the "NATO network") and (iii) countries trading arms with at least one full member of the Warsaw Pact ("the Warsaw Pact network").[3]

3.1   Data

SIPRI hosts 6 different databases related to international relations, military expenditure, production and arms trade. The data used in this study is obtained from the SIPRI Arms Transfers Database, holding information on all international transfers of seven categories of *Major Conventional Weapons* from 1950 onwards. The concept of Major Conventional Weapons comprises aircraft, armoured vehicles, artillery, sensors, air defence systems, missiles, ships, engines (for military aircraft, combat ships and most armoured vehicles) and other major conventional

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[3] During the decade following World War II, the majority of the industrialised world was roughly divided into two defense alliances. The North Atlantic Treaty Organization (NATO) was founded on April 4 1949. The Treaty of Friendship, Cooperation and Mutual Assistance, commonly referred to as the Warsaw Pact, was founded on May 17 in 1955 and disestablished on July 1 in 1991. The member countries of NATO and the Warsaw pact are listed in Table A1 in the Appendix.
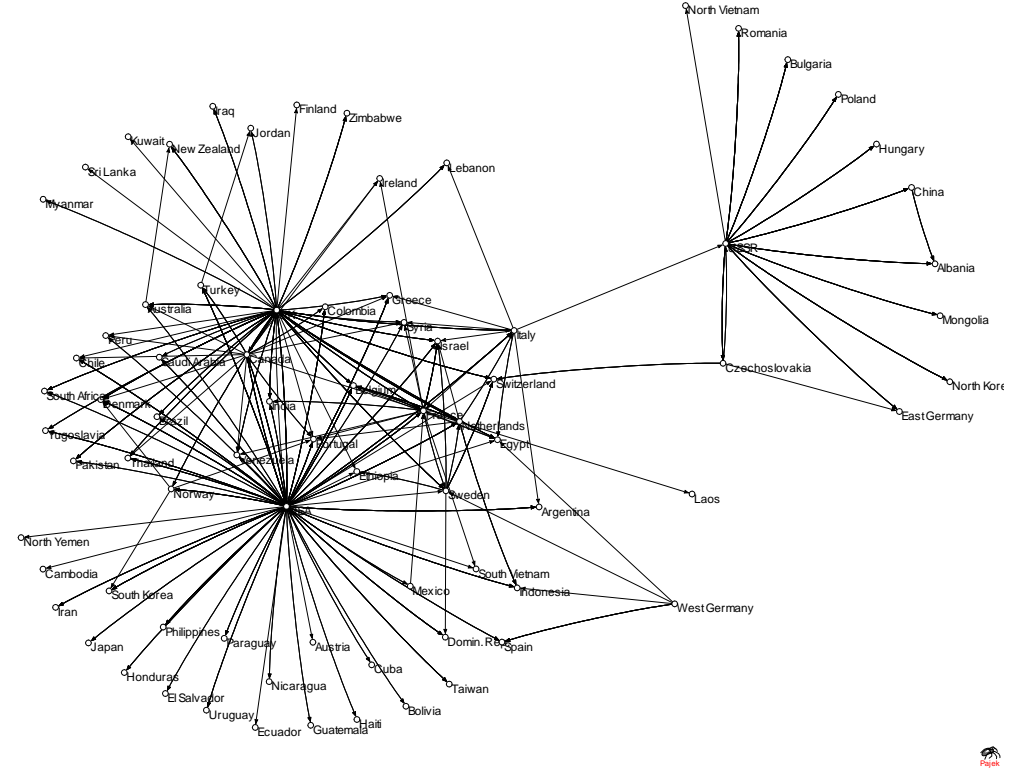
Figure 1: The global arms trade network, 1950-1954.

weapons (mainly turrets for armoured vehicles and ships).

Our measure of arms trade is total bilateral exports (imports) of Major Conventional Weapons over the period 1950-2007. In order to minimise the noise in the data, we have chosen to eliminate rebel groups from the sample. Discussions with representatives of SIPRI have ensured us of the high quality of the dataset. We have learned that since the rules and surveillance pertaining to arms are so strict and the fact that equipment of this nature and size is difficult to move without being observed, trade not captured by the dataset is very rare.

3.2 Graphs of The Arms Trade Network

In order to be able to graph the evolution of the arms trade network over time, we first

Figure 2: The global arms trade network, 1955-1959.

compute five-year averages of bilateral arms trade and plot them. Figure 1 displays the arms trade network over the period 1950-1954 and Figure 2, the network over the period 1955-1959.[4] For ease of exposition, plots of the network over the period 1960-2007 are displayed in Figures A1-A10 in the Appendix. In these graphs, each node represents a country and each link indicates that there is trade between the two countries in question. The length of each link is thus not proportional to the magnitude of the trade, they simply indicate whether trade has occurred during the period. The arrows run from exporter to importer.

Figure 1, covering the period 1950-1954, shows that during this period, global arms trade is roughly divided into two networks. The first network is centered around the US and the

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[4] All network graphs are processed using the Pajek software. We use the Kamada-Kawai method of energising the data for the layouts as this seems to produce more stable results than for instance the Fruchterman Reingold energy command; see de Nooy et al (2007).

other around the USSR. The same holds for the 1955-1959 network in Figure 2. As can be seen from Figures A1-A10 in the Appendix, this pattern is preserved throughout the cold war, but the divide between the two groups is particularly clear in the 1950:s.

3.3   Network theory: Definitions and Key Concepts

We next describe some key statistics for characterising the evolution of the arms trade network over time. Let $N = \{1, ..., n\}$ denote the set of nodes in the network. Each node represents a country. Let g represent an $n \times n$ matrix where g_{ij} represents the link between countries i and j. For our purposes, it is the existence of arms trade rather than the magnitude of the trade that matters, and we therefore think of each link as having equal strength. In other words, we think of the network as being unweighted and define

$$g_{ij} = \begin{cases} 1 \text{ if } i \text{ and } j \text{ are trading arms} \\ 0 \text{ otherwise} \end{cases}.$$

The neighbourhood of a node i in the network g is the set of nodes linked to i:

$$N_i\left(g\right) = \{j : g_{ij} = 1\}.$$

The degree of a node, $d_i(g)$, is the number of links that involve that node, i.e.

$$d_i\left(g\right) = \#\{j : g_{ji} = 1\} = \#N_i(g).$$

A path between nodes i and j is a sequence of links $i_1 i_2, i_2 i_3, ..., i_{K-1} i_K$ such that $i_k i_{k+1} \in g$ $\forall k \in \{1, ..., K-1\}$ with $i_1 = i$ and $i_K = j$, and such that each node in the in the sequence $i_1, ... i_K$ is distinct. A path never hits the same node twice. The distance between two nodes is the number of links in the shortest path (geodesic) between them. For future reference, denote the distance between i and j by $l(i, j)$.

We next define key micro statistics pertaining to individual nodes. These concepts are important in identifying and characterising important players in the network. It is useful to start with a description of these individual characteristics as some of the definitions are needed when describing the properties of the network at large.

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Degree Centrality   The degree centrality of country i is computed as

$$Ce_i^D(g) = \frac{d_i(g)}{n-1}. \tag{1}$$

A country with degree $n-1$ would be trading arms with every other country in the network. By contrast, a country with a low degree would be considered less central. Since the maximum degree is $n-1$, the measure of degree centrality is confined within the unit interval.

The degree centrality-measure has some shortcomings. While it does provide some indication of connectedness, it says nothing about how close each node is to other nodes or about the location in the network.

Closeness Centrality   Closeness centrality tracks how close a node i is to any other node j in the network. Recall that $l(i,j)$ denotes the number of links in the shortest path between i and j. Closeness centrality is defined as

$$Ce_i^C = \frac{n-1}{\sum_{j \neq i} l(i,j)}. \tag{2}$$

Closeness centrality thus measures the inverse average distance between i and j.

Betweenness Centrality   Let $P_i(jk)$ denote the number of shortest paths between nodes j and k that i lies on and let $P(jk)$ be the total number of shortest paths between j and k. The ratio $P_i(jk)/P(jk)$ captures the importance of i in connecting j and k. If $P_i(jk)/P(jk)$ is close to one, country i lies on most of the geodesics between j and k. If the ratio is close to zero, country i is less important in connecting j and k. Betweenness centrality is defined as

$$Ce_i^B = \sum_{j \neq k : i \notin \{j,k\}} \frac{P_i(jk)/P(jk)}{(n-1)(n-2)/2}. \tag{3}$$

Betweenness centrality is thus a measure of the ratio of $P_i(jk)/P(jk)$, averaged across all pairwise nodes j and k that meet the above criteria.

We next define some key statistics that are useful when attempting to characterise the network as a whole.

Diameter   The diameter of the network is the largest distance between any two nodes in the network. It thus provides an upper-bound measure of the size of the network.

Length Length here simply means sample size, i.e. the number of countries trading arms any given five-year period.

Density The density of the network is computed as the average degree divided by $n-1$, i.e.

$$D(g) = \frac{\sum_i d_i(g)}{n(n-1)}. \tag{4}$$

Degree Distribution The degree distribution, $P(d)$, of the network captures the relative frequencies, i.e. fractions of nodes that have different degrees, d. A power distribution (scale-free distribution) satisfies:

$$P(d) = cd^{-\gamma} \tag{5}$$

where $c > 0$ normalises the support of P to sum to 1. Taking logs we obtain:

$$\log\left(P(d)\right) = \log c - \gamma \log d. \tag{6}$$

Using actual data on the observed distribution of degrees, γ can be estimated from this formulation.

Overall Clustering Clustering coefficients describe how connected nodes in the network are. Overall clustering of the network is defined as

$$Cl(g) = \frac{\sum_i \#\left\{jk \in g | k \neq j, j \in N_i(g), k \in N_i(g)\right\}}{\sum_i \#\left\{jk | k \neq j, j \in N_i(g), k \in N_i(g)\right\}} = \frac{\sum_{i;j \neq i;k \neq j;k \neq i} g_{ij}g_{ik}g_{jk}}{\sum_{i;j \neq i;k \neq j;k \neq i} g_{ij}g_{ik}}. \tag{7}$$

To understand this concept, consider two nodes, ij and ik, sharing the common node i. The measure of average clustering measures how common it is that also the nodes j and k are linked to each other.

Average Clustering In order to compute the average clustering coefficient, we first need to define individual clustering. The individual clustering coefficient is given by:

$$Cl_i(g) = \frac{\#\left\{jk \in g | k \neq j, j \in N_i(g), k \in N_i(g)\right\}}{\#\left\{jk | k \neq j, j \in N_i(g), k \in N_i(g)\right\}} = \frac{\sum_{j \neq i;k \neq j;k \neq i} g_{ij}g_{ik}g_{jk}}{\sum_{j \neq i;k \neq j;k \neq i} g_{ij}g_{ik}}. \tag{8}$$

The individual clustering coefficient of node i therefore considers all pairs of nodes that it is linked to, and then registers how many of them are linked to each other. The average clustering coefficient is then the average of all individual clustering coefficients, i.e.

$$Cl^{Avg}(g) = \sum_i \frac{Cl_i(g)}{n}. \tag{9}$$

Average clustering gives more weight to low-degree nodes than the overall clustering coefficient.

Max Degree   The Max Degree of the network, Ce_i^{D*}, is the degree of the node with the highest number of links.

Max Closeness   The Max Closeness of the network, Ce_i^{C*}, is the value of Closeness Centrality of the node with the highest measure of this statistic.

Max Betweenness   The Max Betweenness of the network, Ce_i^{B*}, is the value of Betweenness Centrality of the node with the highest measure of this statistic.

Degree Centrality   The Degree Centrality of the network is given by:

$$Ce^D(g) = \frac{\sum_i \left| Ce_i^D - Ce_i^{D*} \right|}{(n-2)(n-1)}. \tag{10}$$

Closeness Centrality   The Closeness Centrality of the network is given by:

$$Ce_i^C = \frac{\sum_i \left| Ce_i^C - Ce_i^{C*} \right|}{(n-2)(n-1)/(2n-3)}. \tag{11}$$

Betweenness Centrality   The Betweenness Centrality of the network is given by:

$$Ce_i^B = \sum_i \left| Ce_i^B - Ce_i^{B*} \right|. \tag{12}$$

Assortativity   Turning to the correlation patterns among high-degree nodes, we turn to the concept of assortativity. If high-degree nodes tend to be connected to other high-degree nodes, there is said to be positive assortativity. The degree of assortativity of the network g is computed as

$$A(g) = \frac{\sum_{ij \in g} (d_i - m)(d_j - m)}{\sum_{i \in N} (d_i - m)^2}. \tag{13}$$

3.4 Characteristics of the Arms Trade Network

Figure 3 plots the evolution of the statistics defined in Section 3.3 for the network including all countries. Starting with the aggregate properties of the network, Figure 3 suggests that the average length has increased along with the diameter and the density. This suggests that an increasing number of countries have started to trade in arms. This may be due to either an increase in the number of exporters (producers of arms) or an overall increase in import demand for arms. The graphs in Figures 1 and 2, but in particular in Figures A1-A10 in the appendix support the claim that the global arms trade network has become much more dense and complicated over time. While there is a clear divide between NATO and the Warsaw pact at least in the early days of the cold war, the division is much less distinct in the past two decades.

The number of countries that trade in arms increases rapidly during the sample period. The diameter increases as well but remains very low throughout the sample, a feature of many networks often called the "small world property".[5]

We see that the country with the highest number of links, as measured by max degree, was increasing in the beginning of the sample but is starting to decrease at the end of the cold war. While overall clustering has increased, average clustering has been falling over time. The fall in average clustering is the result of new small countries entering the networks which only trade with a few countries which typically do not trade among each other. The fact that overall clustering increases, however, is the result of the network as a whole growing denser and more connected. All three centrality measures are also decreasing over time, meaning that the most important countries become less influential over time, their positions are less central than before. This means, for example, that if arms trade in fact measures political connections, countries in this network had more and more alternatives to contact or influence other countries as time progressed. The centrality measures, however, remain relatively high during the sample period, demonstrating the importance of a few countries.

Finally, assortativity is negative throughout but less so during later years. Negative assortativity is typical for many other trade networks or technological networks where countries with

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[5] See Goyal et al. (2006) for a discussion.

many connections are more likely to trade with countries with fewer connections. Countries with few connections, on the other hand, are more likely to trade with countries with many trading partners. This is opposed to many social networks where, for example, the friends of individuals with many friends also tend to have many friends.[6]

Figure 4 displays the results from performing the same exercise for NATO and the Warsaw Pact. We see that length and diameter are displaying positive trends for both networks. The fact that the diameter is almost the same for the two networks despite the larger size of NATO shows that NATO is better connected than the Warsaw Pact. While the NATO network is becoming more dense, density for the Warsaw Pact is sharply falling until its disestablishment in 1991. We also see that the max degree is much higher in NATO than in the Warsaw Pact, indicating that the US has more links than the USSR throughout the cold war. This is hardly surprising given that NATO is larger.

Regarding the centrality measures, these are all relatively stable over time but show that the Warsaw Pact was a much more centralised network than NATO. This can also be seen in the network graphs Figures 1, 2 and A1-A5 where the Warsaw Pact network most clearly resembles a "star" network with one central node (the USSR) surrounded by peripheral trading partners that are unlikely to trade with each other (this can also be seen by the fact that the overall clustering variable is substantially lower in the Warsaw Pact throughout). The fact that the USSR was more important for the Warsaw Pact than the United States was for NATO is shown by the measures of maximum centrality; these are higher for the Warsaw Pact than NATO throughout.

Figure 6 displays the degree distribution of the global arms trade network in 1950, 1965, 1980 and 2000. The results suggest that a scale-free distribution of the Pareto type would characterise the network quite well. The estimated value of γ in (6) is around 0.9.

Figure 7 plots the degree distribution against average clustering for these years and a clearly negative relationship can be observed. This means that most of the trading partners of the most active arms traders do not trade with each other which is a typical feature of "star" networks.
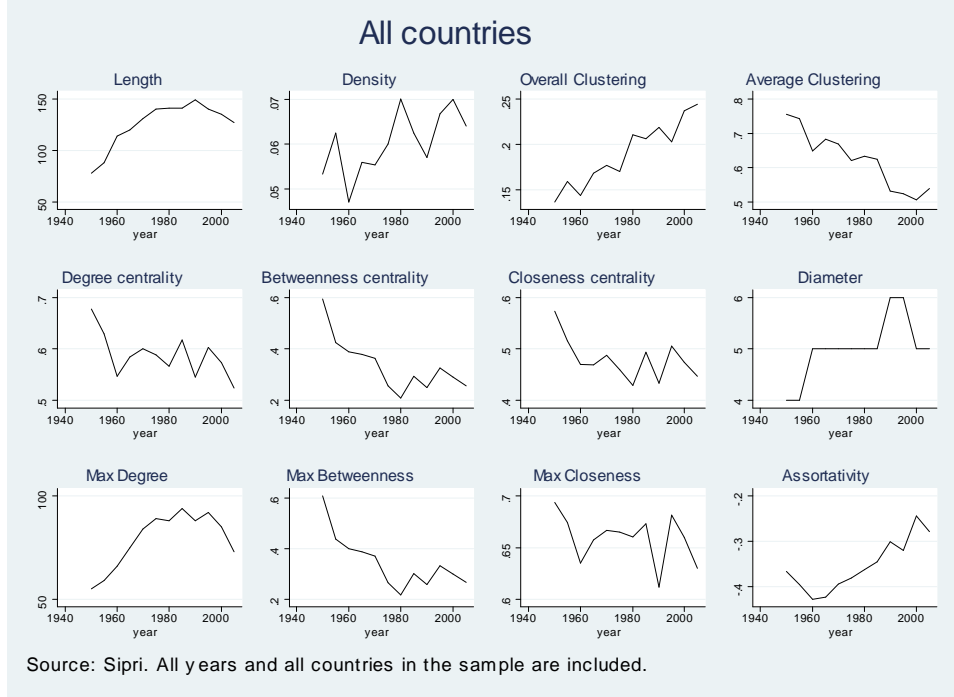
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[6]See Newman (2002).

Figure 3: Network statistics for the global arms trade network.

4   Polity and Arms Trade

Having characterised the global arms trade network over the sample period, we turn to the relationship between arms trade and political regimes. We therefore add data on economic characteristics and estimate a gravity equation where one of the independent variables is a measure of whether the two trading countries have the same polity. In order to address the question of how arms trade differs from trade in other goods, we report estimates of the same gravity equation for trade in other groups of goods.

4.1   Data

In order to compare our findings on arms trade to trade in other goods, we add data on trade from the United Nations Comtrade database over the period 1962-2000. In addition to studying aggregate trade between the countries in the sample, we study the subgroups textiles, oil, coffee, chemicals, leather, cars, wheat and rice. Data om GDP per capita is from
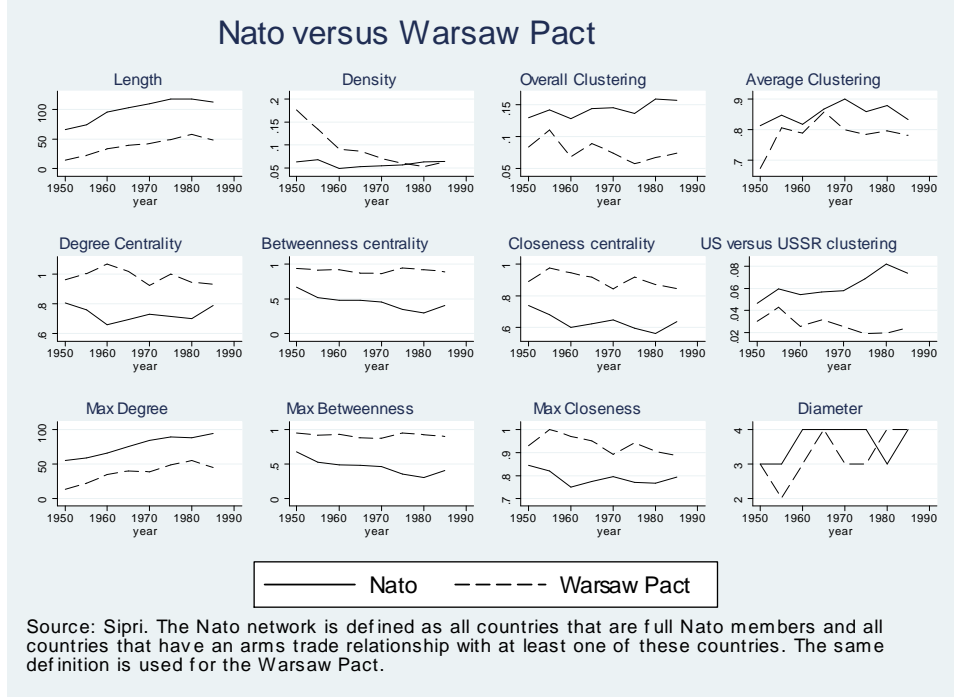
Figure 4: Network statistics for NATO and the Warsaw Pact.

Maddison and covers the full sample period 1950-2006. Data on distance between countries, common language, common borders and common origin of colonisation is retrieved from *Centre D'Etudes Prospectives et D'Informations Internationales* (CEPII). Data on the degree of democracy (from now on sometimes called "polity" in the text) is from POLITY IV. Its polity variable is an index ranging from −10 to +10, where a negative value represents autocracy and a positive value represents democracy. The higher the value, the stronger the democratic regime in terms of a number of criteria specified within POLITY IV.

4.2 Trends in Democratisation

Figure 8 depicts the evolution of the sample size and the average polity over the sample period. The left graph shows that over the period 1950-2007, sample size displays a positive trend, implying that an increasing number of countries are trading arms. The trend is particularly strong until the beginning of the 1980s. During the 1980s, the trend is in fact decreasing
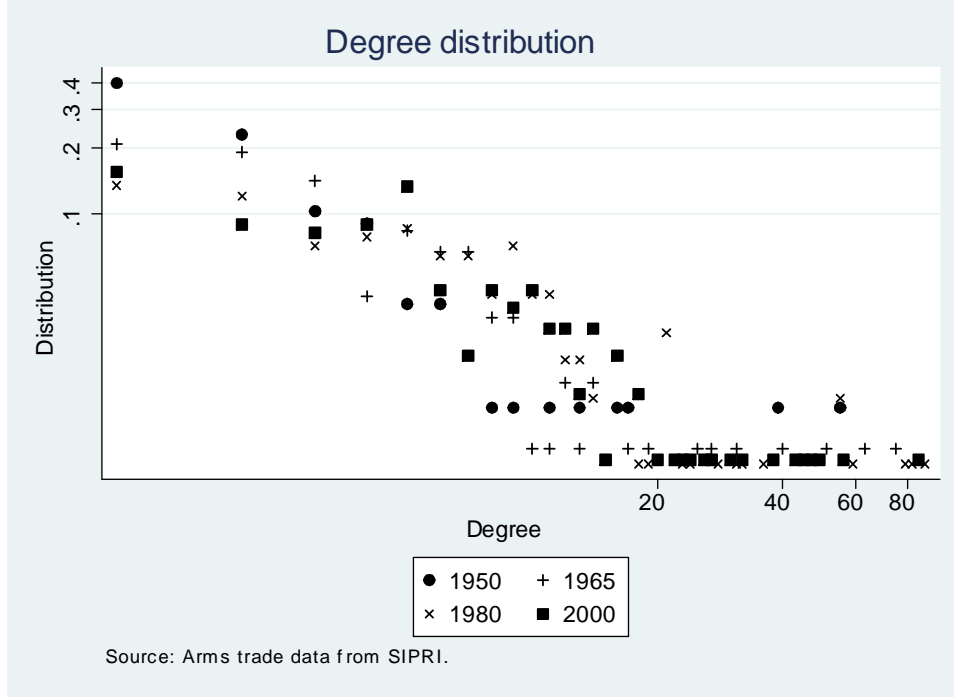
Figure 5: Degree distribution 1950, 1965, 1980 and 2000.

but starts to increase again in the middle of the 1990s. This pattern holds for the NATO network as well as for the overall network. The trend for the Warsaw Pact is increasing until its disestablishment in 1991.

The right graph in Figure 8 captures the average Polity in the entire sample and in the two subgroups. A positive Polity index indicates that the sample is democratic on average, while a negative value indicates that the sample is non-democratic according to the POLITY IV criteria. The results suggest the NATO network was, on average, democratic in the beginning of the 1950s, but became less democratic in the 1960s and 1970s. In the early 1980s, democratisation again started to increase and average polity of the NATO network again displays a positive trend. The trend for the Warsaw Pact is increasing, but average Polity remains negative throughout the existence of this network. These results suggest that a country trading arms with members of the Warsaw Pact, was non-democratic on average. The trend for the overall sample closely follows that of the NATO network since NATO comprised more countries.
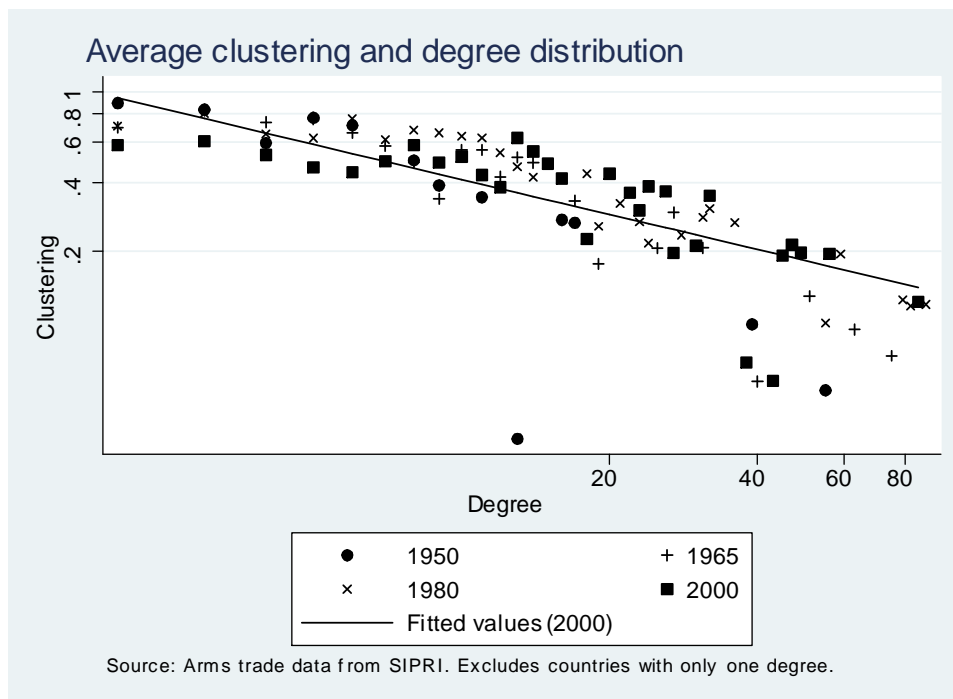
Figure 6: Average clustering and degree distribution, 1950, 1965, 1980 and 2000.

We next address the question of whether countries are more likely to export arms to countries with the same Polity. Figure 9 displays the polity of the export destinations of the US, the UK, France, Sweden the USSR and China over the period 1950-2007. Each dot represents the Polity index of each export destination in a given year and the black line indicates the per-year average. The top left graph of the US shows that the world's oldest democracy has consistently had a tendency to export arms to other democracies. However, as the graph shows, the US has also exported arms to autocratic countries throughout the sample period. There is a positive trend in the plot for the US, indicating that the US has chosen to export arms to countries that have become increasingly democratic. However, this could just be symptomatic of the overall tendency to world democratisation rather than of the US becoming increasingly choosy when deciding which countries to export to. The patterns for the UK, France and Sweden are more volatile. The UK and France tend to export arms to other democracies except for in the 1970s and, in the case of France up to the mid-1980s. Sweden has mainly stayed on
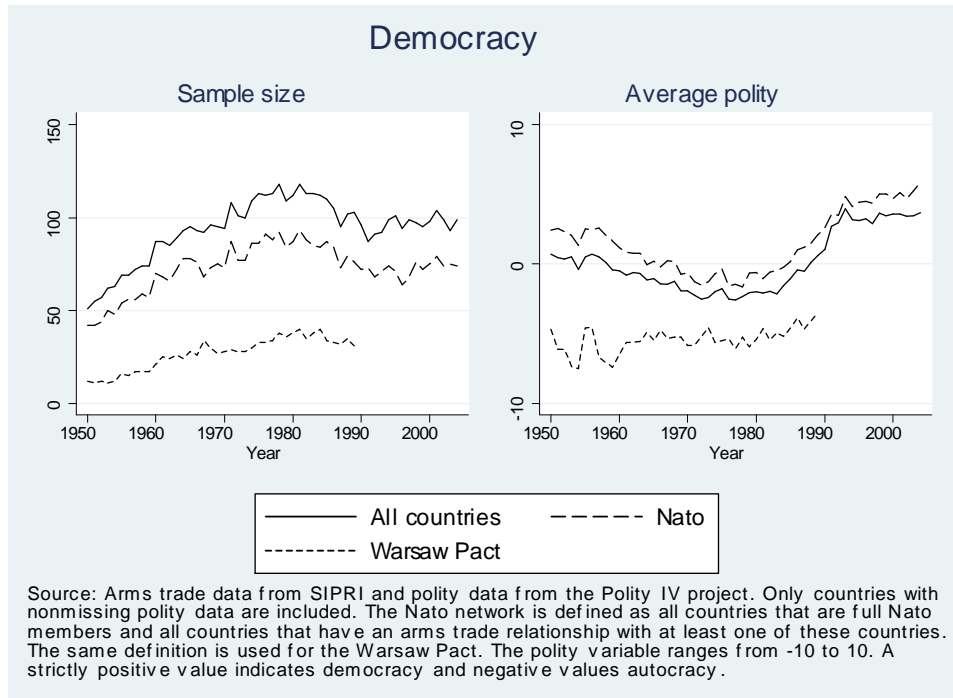
Figure 7: Arms trade participation and average polity, 1950-2007.

the democratic-side of the x-axis except for in a few years in the late 1970s when there was a tendency to export arms to non-democracies, albeit with average polity scores close to zero.

By contrast, the USSR and China have typically exported arms to other autocratic countries. The results suggest that they have indeed exported arms to democracies as well, but the average trading partner has been non-democratic. There is some evidence that China started exporting more arms to democratic countries in the beginning of the 21th century, but the trend has been reversed in recent years.

It can also be noted that the degree to which the USSR and China tended to export arms to countries with a similar polity score as themselves was stronger than that of the NATO members.
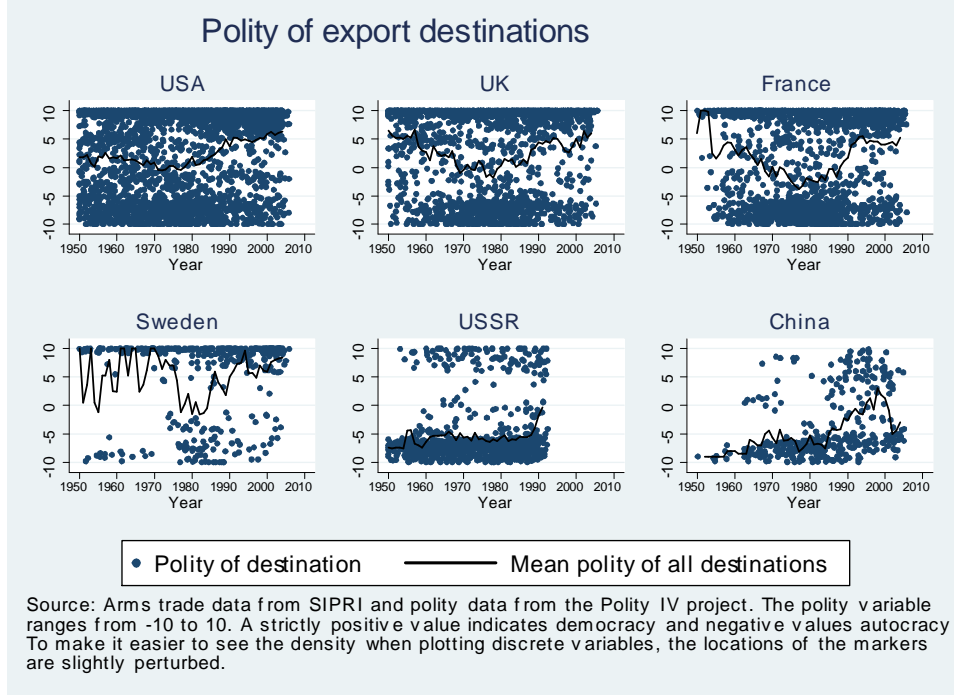
Figure 8: Polity of export destinations for six key players, 1950-2007.

4.3 The Gravity Equation

As reported in the previous section, data clearly suggests that there is a correlation between polity divergence and arms trade. In order to test this hypothesis controlling for several other variables that may influence export decisions, we specify and estimate a gravity equation containing these variables. Let Y_t^{ij} be a dichotomous variable capturing trade between countries i and j, such that

$$Y_t^{ij} = \begin{cases} 1 \text{ if countries } i \text{ and } j \text{ trade in } Y \text{ at time } t \\ \quad\quad\quad 0 \text{ otherwise} \end{cases}. \tag{14}$$

In the same way we define the variable B_t^{ij}, assuming the value 1 if i and j share the same border (contiguity), L_t^{ij}, assuming the value 1 if i and j share the same official language, CR_t^{ij}, assuming the value 1 if i and j were ever in a colonial relationship, $CC_t^{45,ij}$, assuming the value 1 if the countries were colonised by the same country post-1945, $CR_t^{45,ij}$, assuming the value 1 if the countries were in a colonial relationship post-1945 and finally, SC_t^{ij}, assuming the value

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1 if the countries were the same country historically. Let D_t^{ij} denote distance between i and j, let GDP_t^i denote GDP of country i, let $GDP_t^{C,i}$ denote GDP per capita and let $RGDP_t^{C,ij}$ be relative GDP per capita between i and j, i.e. $RGDP_t^{C,ij} = GDP_t^{C,i} - GDP_t^{C,j}$. Finally, let Pol_t^i be the Polity index of country i at time t. For notational convenience, let X_t^{ij} denote the vector of control variables:

$$X_t^{ij} = \left(B_t^{ij}, L_t^{ij}, CR_t^{ij}, CC_t^{45,ij}, CR_t^{45,ij}, SC_t^{ij}, \ln GDP_t^i, \ln GDP_t^{C,i}, \ln \left(RGDP_t^{C,ij} \right)^2, \ln D_t^{ij} \right).$$

(15)

We then estimate the following linear probability model:

$$Y_t^{ij} = \alpha \left(Pol_t^i - Pol_t^j \right)^2 + \overline{\beta} X_t^{ij} + \epsilon_t^{ij}$$

(16)

where $\overline{\beta}$ is a vector of parameters. Letting Y_t^{ij} denote arms trade, a significant negative estimate of α thus suggests that the more different i and j are in terms of polity, the less likely they are to trade in arms.

4.4 Results

Columns (1)-(3) in Table 1 display the results from estimating (16) on arms trade using pooled OLS. For the sake of comparison, columns (4), (5) and (6) report the results from estimating the same equation using data on aggregate trade, trade in cars and trade in coffee, respectively.

The results in columns (1)-(3) suggest that differences in polity has a negative effect on the likelihood of arms trade. If the difference in polity between countries i and j increases, they are less likely to engage in arms trade. As shown in columns (4)-(6), this is not true for trade in other goods. Column (4) indicates that differences in polity may in fact increase the probability of trade. This may seem odd at first, but could simply reflect that these countries trade for reasons of comparative advantage etc. Since trade in other goods is not as constrained by policy as trade in arms appears to be, these results could simply capture that non-democracies may demand goods produced in democracies and choose to import these goods as there are no political barriers keeping them from doing so. Exporting chemicals or rice to a non-democracy is clearly less controversial than exporting arms to such a country. The results for cars in column (5) are similar: differences in polity indicate a higher likelihood

Table 1: Results from estimating the gravity equation. Pooled OLS.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Arms	Arms	Arms	All	Cars	Coffee
$(Pol_t^i - Pol_t^j)^2$	-1.31e-05**	-1.52e-05**	-1.27e-05**	.000566**	9.06e-05**	-3.97e-07
	(1.59e-06)	(1.58e-06)	(1.63e-06)	(6.84e-06)	(4.15e-06)	(3.81e-06)
$\ln(GDP_t^i)$	1.79e.08**	1.23e-08**	1.27e-08**	1.06e-07**	3.63e-08**	5.17e-08**
	(2.54e-10)	(2.65e-10)	(2.69e-10)	(1.14e-09)	(6.90e-10)	(6.32e-10)
$\ln(GDP_t^{C,i})$		.000273**	.000267**	.00275**	.00188**	.000720**
		(4.00e-06)	(4.08e-06)	(1.73e-05)	(1.05e-05)	(9.60e-06)
$\ln(RGDP_t^{C,ij})^2$			-.000499**	.0206**	.00734**	.00475**
			(7.11e-05)	(.000300)	(.000182)	(.000167)
$\ln D_t^{ij}$	-.00899**	-.00630**	.00623**	-.0544**	-.0568**	.00167*
	(.000278)	(.000279)	(.000279)	(.00118)	(.000717)	(.000656)
B_t^{ij}	.0170**	.0189**	.0184**	-.00138	.0453**	.0530**
	(.00139)	(.00138)	(.00139)	(.00586)	(.00356)	(.00326)
L_t^{ij}	-.00492**	-.00331**	-.00315**	.0623**	.0119**	.0171**
	(.000595)	(.000592)	(.000592)	(.00250)	(.00152)	(.00139)
CR_t^{ij}	.0556**	.0470**	.0466**	.260**	.164**	.273**
	(.00242)	(.00240)	(.00241)	(.0102)	(.00617)	(.00565)
$CC_t^{45,ij}$	-.00639**	-.00375**	-.00388**	-.0923**	-.0459**	.0200**
	(.000784)	(.000779)	(.000779)	(.00329)	(.00200)	(.00183)
$CR_t^{45,ij}$	-.0123**	-.00440	-.00284	-.0248	.255**	.00915
	(.00323)	(.00321)	(.00322)	(.0136)	(.00825)	(.00756)
SC_t^{ij}	-.0254**	-.0217**	-.0220**	.0359	.0119*	.0158**
	(.00199)	(.00197)	(.00197)	(.00834)	(.00506)	(.00464)
Observations	313925	313925	313925	313925	313925	313925
R^2	.025	.039	.040	.194	.187	.084

of trade in cars. In 2007, the five largest producers of cars were Japan, China, Germany, the US and South Korea.[7] By necessity, a large share of the total number of cars exported from these countries will end up in countries with differing political views. Finally, the results for coffee in column (6) suggests that differences in polity have no effect on the propensity to trade as the estimated α is insignificant.

Figure 10 displays the estimated α-coefficient from equation (16) and the associated 95-percent confidence interval in each year. The results suggest that the estimate is negative and significantly different from zero. The estimated parameter is remarkably stable throughout the

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[7] Data from the International Organization of Motor Vehicle Manufacturers (OICA).
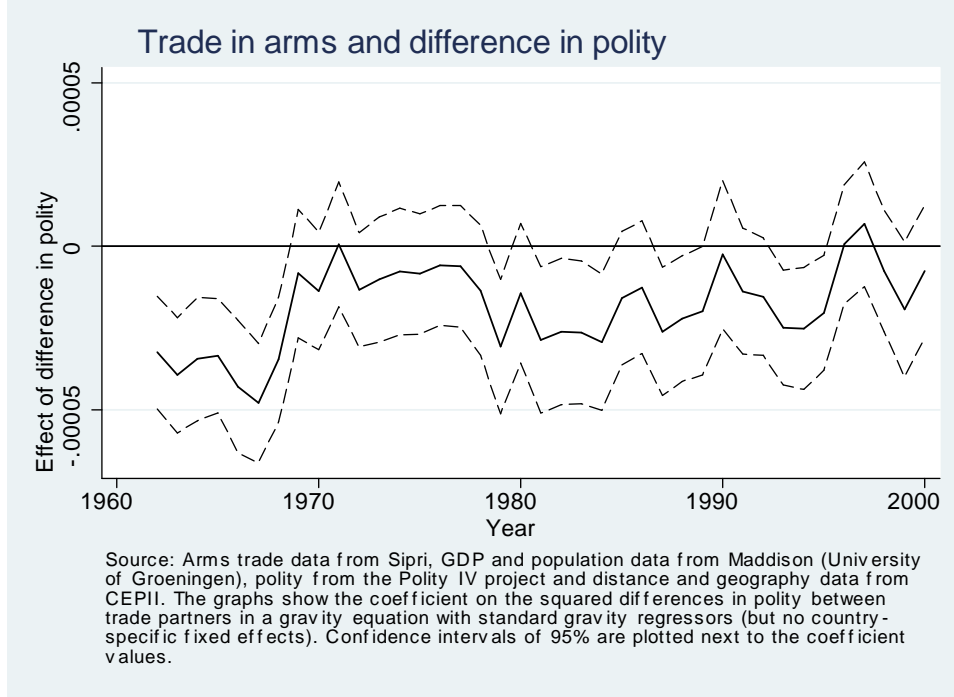
Figure 9: Polity divergence and arms trade.

sample period. this is consistent with the results from the pooled OLS-estimations in Table 1. Again, we compare this result to trade in other goods and estimate equation (16) on data on a number of other goods. Figure 11 reports the impact of polity-divergence on arms trade, total trade and trade in cars. As in Table 1, the results lend support to the hypothesis that polity divergence is no barrier to trade in other goods than arms. Similar graphs for other groups of goods (coffee, chemicals, leather, rice, textiles and wheat) are given in Figures A11-A13 in the Appendix.

5   Concluding Remarks

In this paper we argue that arms trade is a relevant measure of political links between countries. We find that political regimes matter for the patterns of global arms trade. Unlike all other goods to which we have applied our methodology, countries with similar political regimes were persistently more likely to trade in arms than countries with different political regimes. The
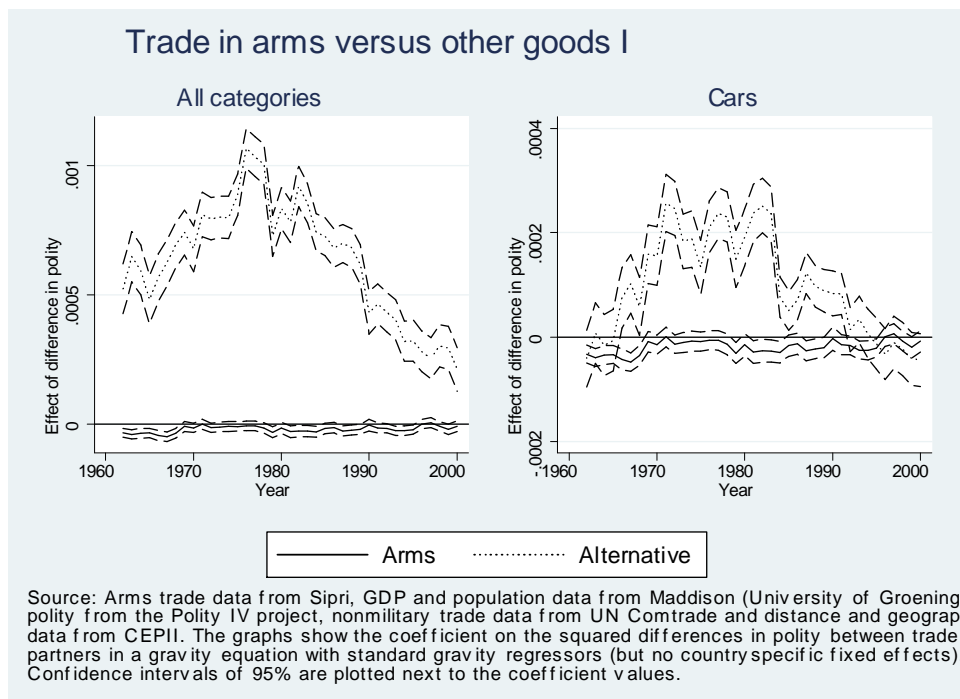
Figure 10: Polity divergence, arms trade, aggregate trade and trade in cars.

evidence suggests that this relationship was stable during the Cold War as well as after the collapse of the Soviet Union. By contrast, many other goods that are important in international trade do not exhibit this property.

We also provide an analysis of the structure of the global arms trade by applying a network-based methodology. Our results suggest that the global arms trade network exhibits several features often observed in networks of other kinds: a small world property, negative correlation between degree and clustering coefficients and a scale-free distribution of degree distribution. Moreover, the network exhibits negative assortativity which is common in other trade networks as well. A comparison between the trading patterns of the Cold War's two large military alliances, NATO and the Warsaw Pact, uncovered substantial differences between them. The Warsaw Pact was more centralised throughout the Cold War and had more the resemblance of a "star" network than NATO. The USSR played a key role in the Warsaw Pact while NATO comprised several countries that were important for its functioning.

We conclude that arms trade is an adequate measure of political links between countries. Compared to other types of trade and other measures that we have found, arms trade is most strongly linked to political regime. Moreover, applying network analysis to the arms trade network yields results that we believe are strongly in line with how most historians would describe the political reality of the Cold War.

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Tables

Table A1: Member Countries of NATO and the Warsaw Pact.

| NATO	Entry	The Warsaw Pact	Entry	Exit
Belgium	1949	People's Republic of Albania	1955	1961
Denmark	1949	People's Republic of Bulgaria	1955	1991
France	1949	Czechoslovak Socialist Republic	1955	1991
Iceland	1949	People's Republic of Hungary	1955	1991
Italy	1949	People's Republic of Poland	1955	1991
Canada	1949	People's Republic of Romania	1955	1991
Luxembourg	1949	The Soviet Union	1955	1991
Netherlands	1949	East Germany	1956	1990
Norway	1949			
Portugal	1949			
Great Britain	1949			
USA	1949			
Greece	1952			
Turkey	1952			
(West) Germany	1955			
Spain	1982			
Poland	1999			
Czech Republic	1999			
Estonia	2004			
Latvia	2004			
Lithuania	2004			
Romania	2004			
Slovakia	2004			
Slovenia	2004			
Croatia	2009			
Albania	2009			

Figures
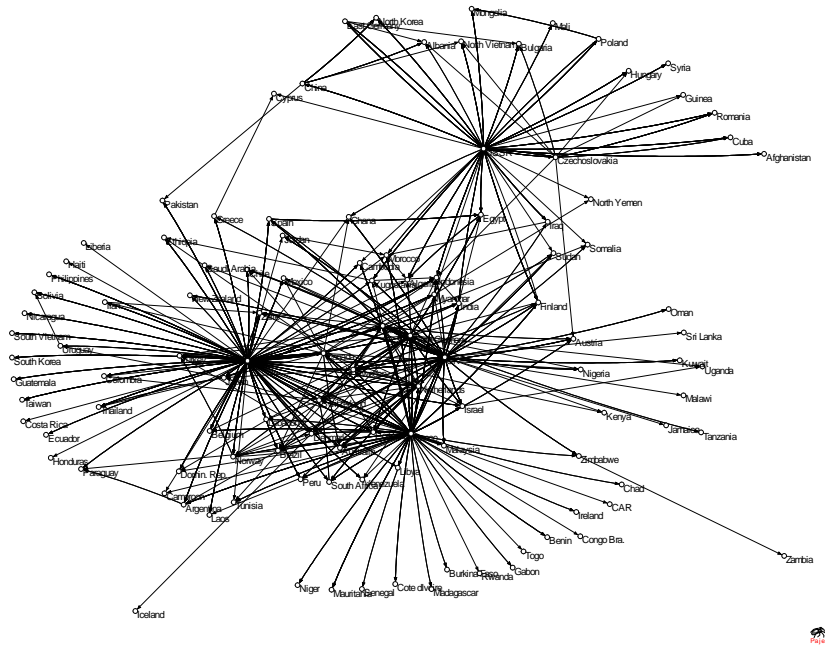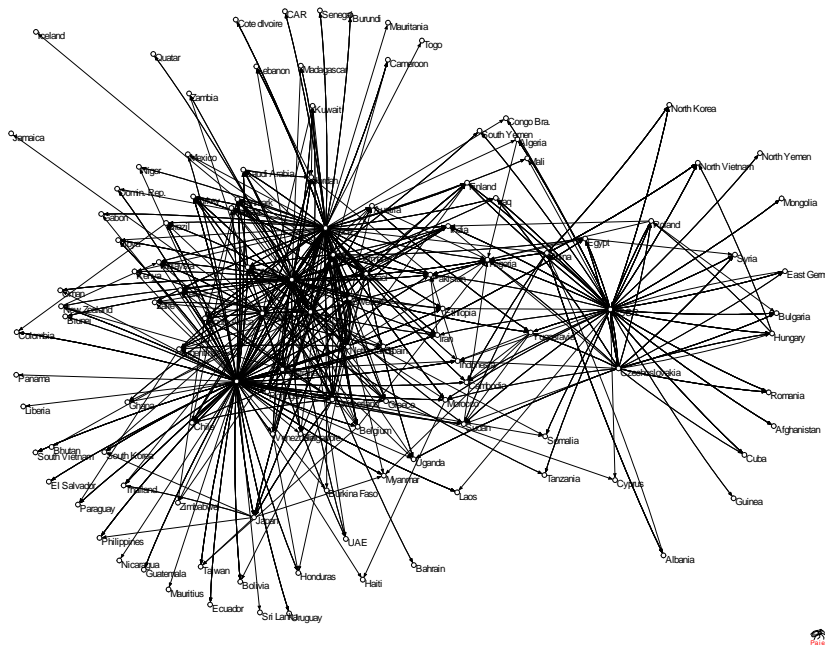

Figure A1: The global arms trade network, 1960-1964.

Figure A2: The global arms trade network, 1965-1969.

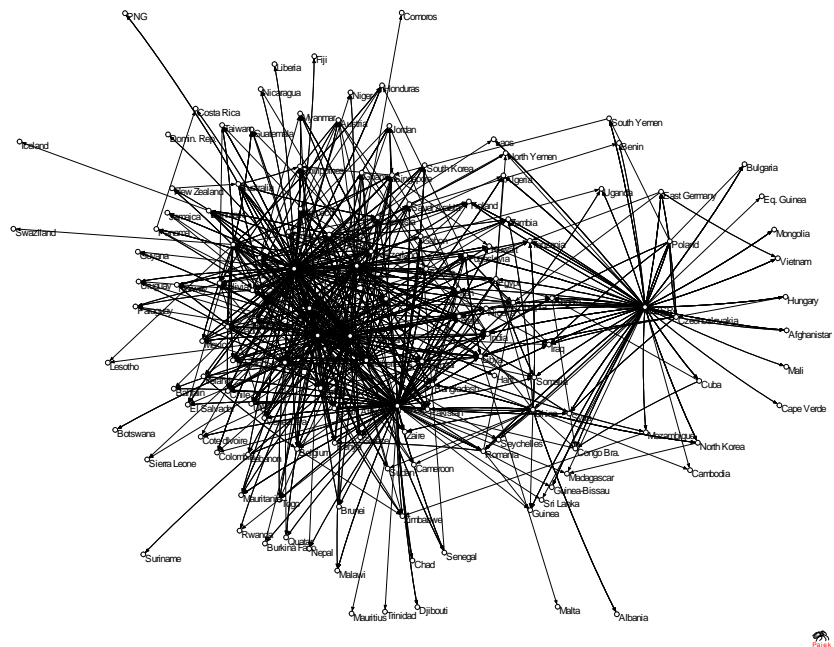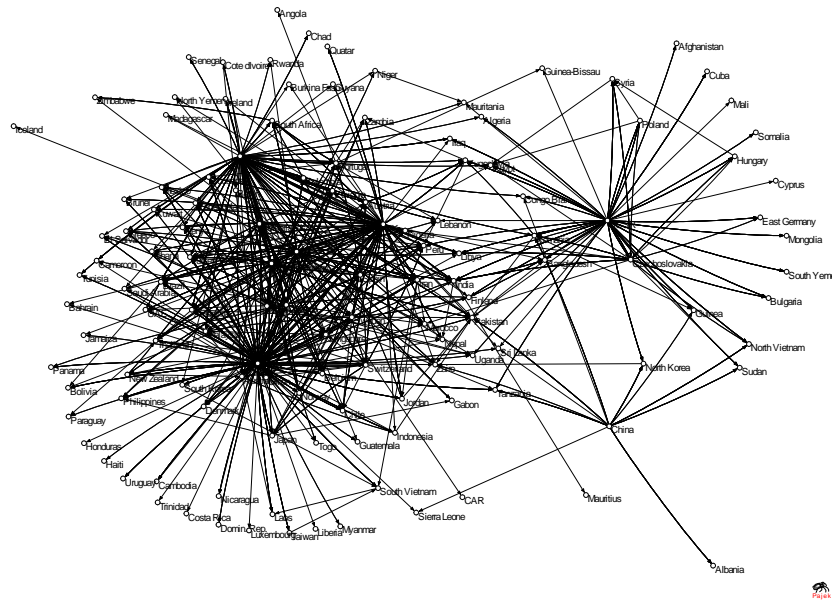Figure A3: The global arms trade network, 1970-1974.

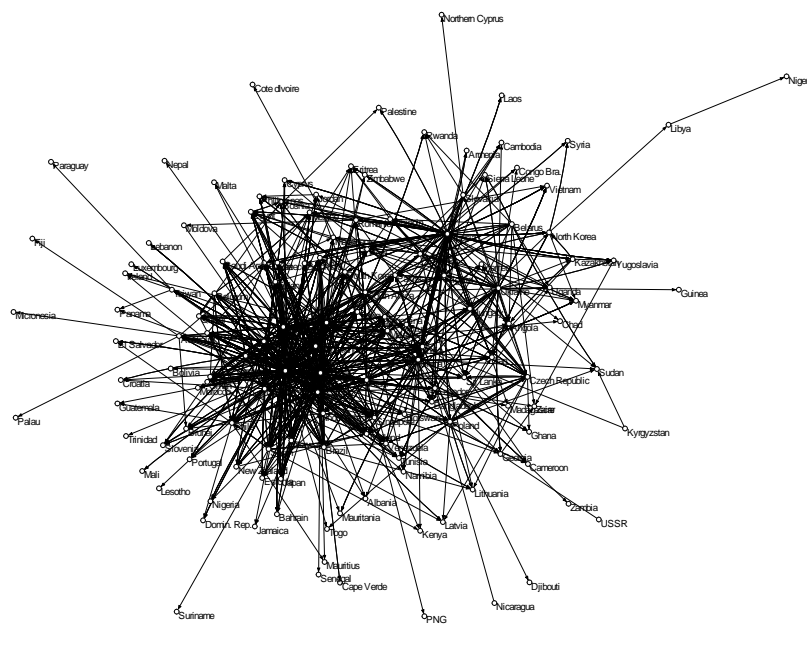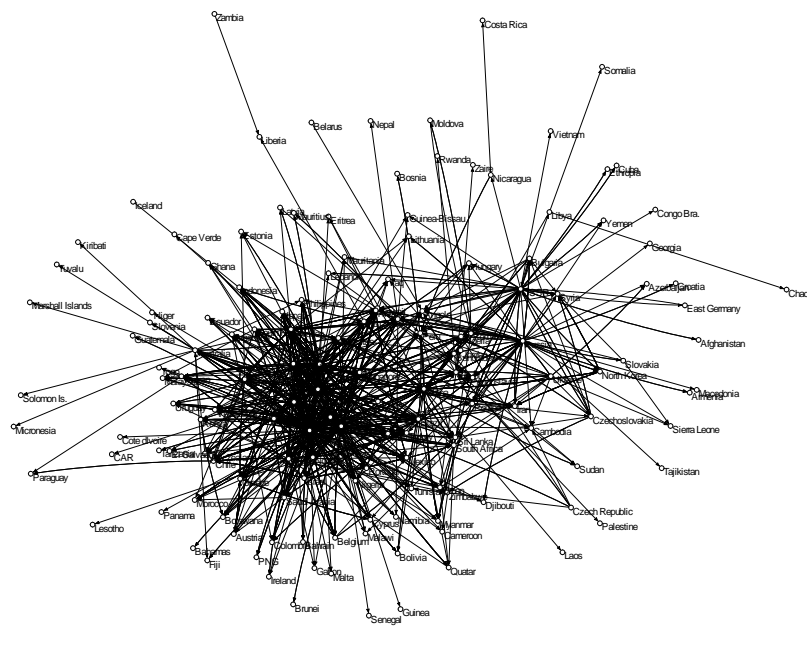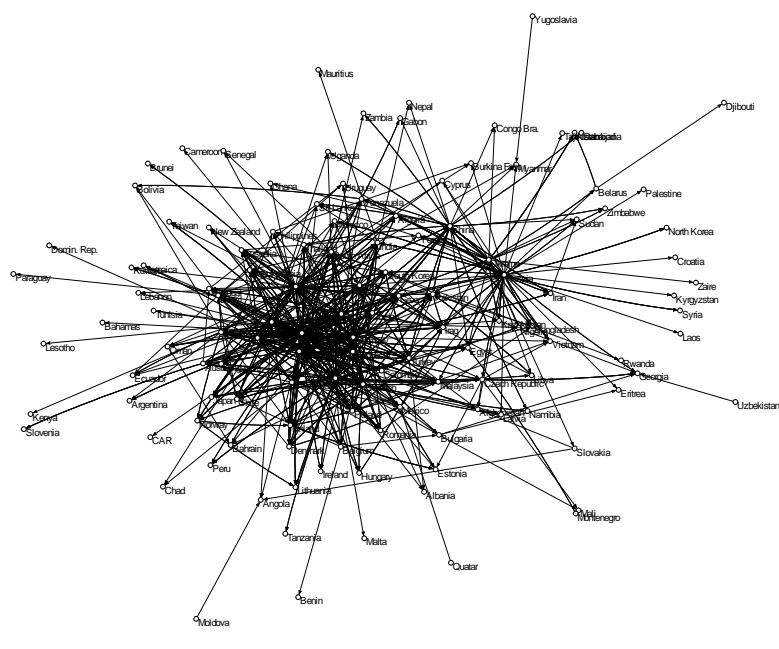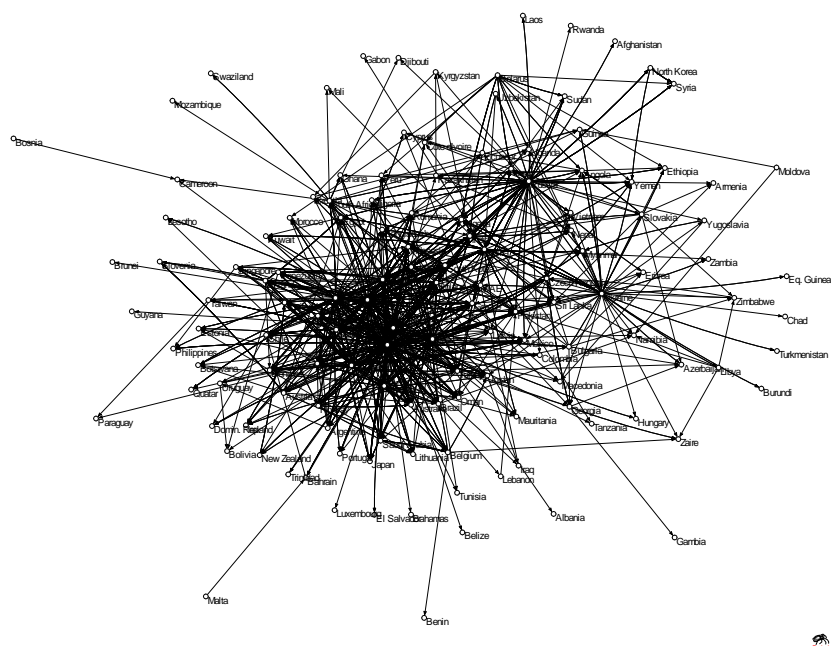Figure A4: The global arms trade network, 1975-1979.

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Figure A5: The global arms trade network, 1980-1984.

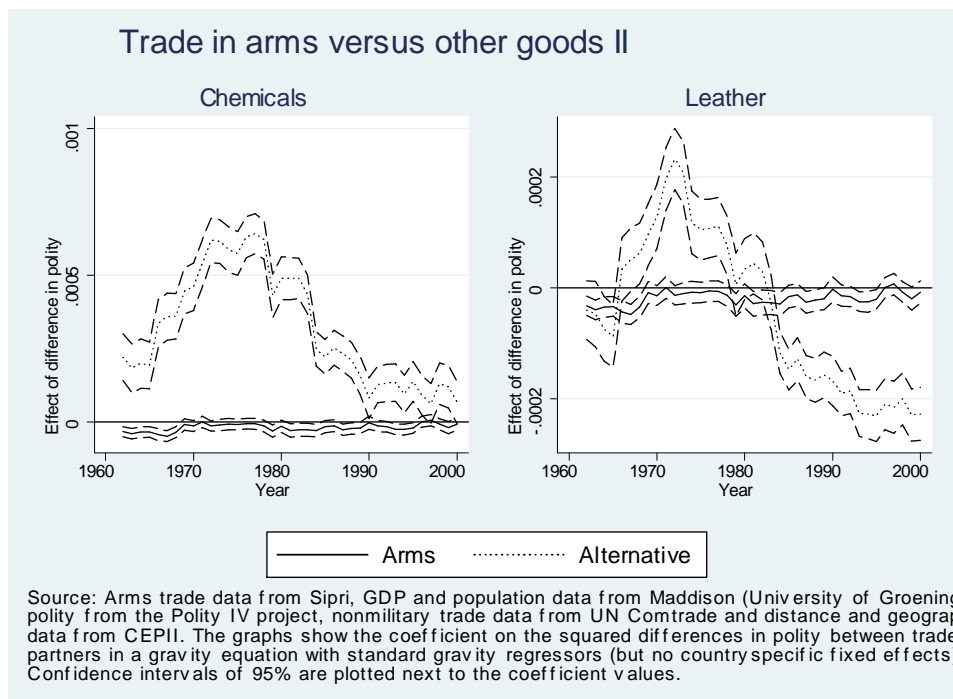Figure A6: The global arms trade network, 1985-1989.

Figure A7: The global arms trade network, 1990-1994.

Figure A8: The global arms trade network, 1995-1999.

Figure A9: The global arms trade network, 2000-2004.

Figure A10: The global arms trade network, 2005-2007.

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Source: Arms trade data from Sipri, GDP and population data from Maddison (University of Groeninge
polity from the Polity IV project, nonmilitary trade data from UN Comtrade and distance and geograph
data from CEPII. The graphs show the coefficient on the squared differences in polity between trade
partners in a gravity equation with standard gravity regressors (but no country specific fixed effects).
Confidence intervals of 95% are plotted next to the coefficient values.

Figure A11: Polity divergence and trade in arms, chemicals and leather.

Source: Arms trade data from Sipri, GDP and population data from Maddison (University of Groeninge
polity from the Polity IV project, nonmilitary trade data from UN Comtrade and distance and geograph
data from CEPII. The graphs show the coefficient on the squared differences in polity between trade
partners in a gravity equation with standard gravity regressors (but no country specific fixed effects).
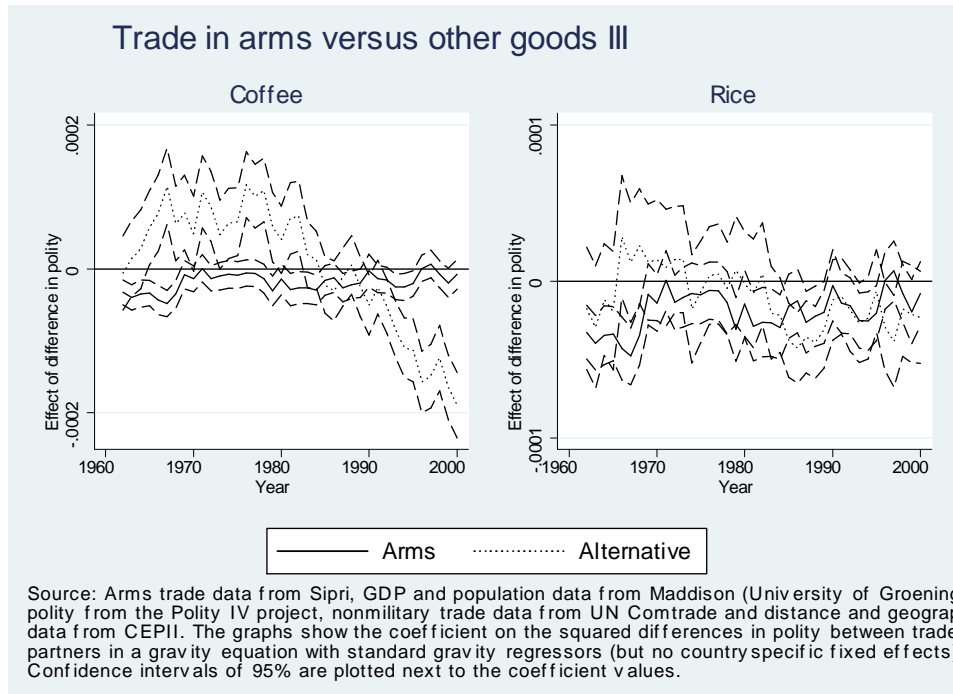Confidence intervals of 95% are plotted next to the coefficient values.

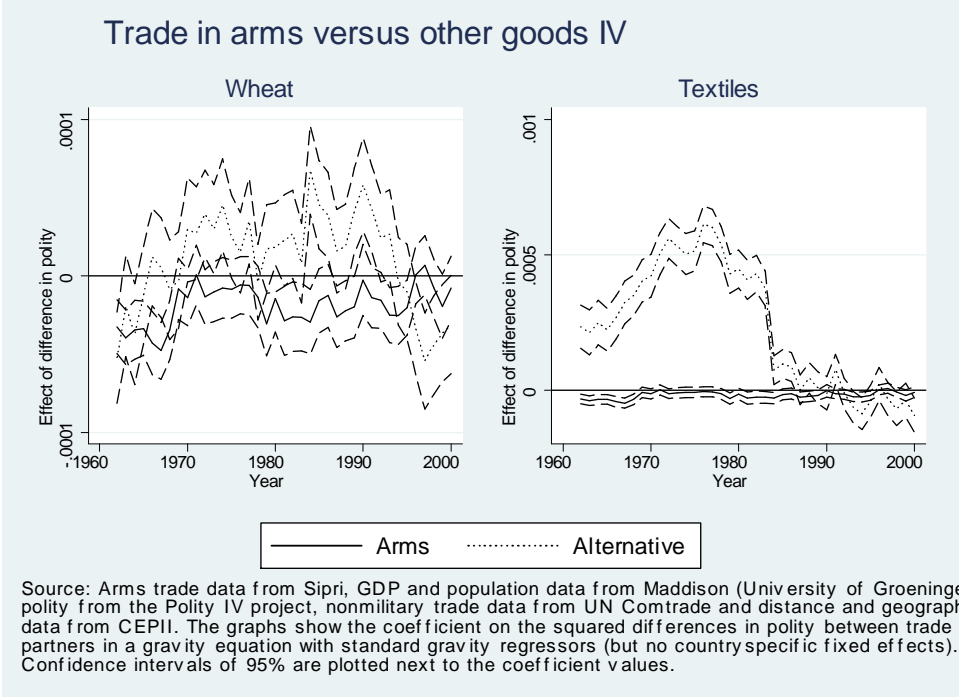Figure A12: Polity divergence and trade in arms, coffee and rice.

Figure A13: Polity divergence and trade in arms, wheat and textiles.