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The Effects of the International Arms Trade on National Military Expenditures: An Empirical Assessment

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1. Introduction

According to US Defense Secretary Robert Gates, NATO is in a precarious state of affairs: While the United States of America (USA) provide the predominant share of the alliance´s military capability, most European North Atlantic Treaty Organization (NATO) members, he claims, do not meet their obligations, starving their defense budgets instead (Thom Shanker, The New York Times, 2011). Less reputable, but nonetheless a loud voice in contemporary US-American politics, populist presidential candidate Donald Trump holds the even stronger view that the USA, to its disadvantage, shoulders “the lion´s share” of the defense burden, on which its NATO allies deliberately rely on (Glenn Kessler, The Washington Post, 2016). As such, Mr Trump makes explicit mention of Germany. Allegations of this kind have been raised for a fairly long time and are not completely unfounded, too. In 2002, when the NATO summit in Prague took place, the USA spend 3.2 percent of GDP on defense, while German defense spending was less than half with 1.5 percent of GDP (The Economist, 2002). In 2014, with the NATO summit in Wales taking place, only four European NATO members met NATO´s defense spending target of 2 percent of GDP, Germany again not one of them (The Economist, 2014c). In contrast to its military spending, however, Germany entertains some of the biggest arms exporting companies in the world and, with continuously flourishing arms sales worth €1 billion a year Germany is the third largest exporting country of defense goods worldwide (The Economist, 2014a). Strikingly, 10 percent of exported German arms are sold to the USA (The Economist, 2014b). This thesis intends to answer the question, if and how a country´s arms trade, in particular its arms export, and its national military expenditure are intertwined. How can it be that Germany holds such significance as an arms supplier to its allies, but plays a relatively small role, when it comes to its own defense spending?

Most research literature conceives the imbalance of defense provision, which NATO supposedly faces, as a variation of the public goods dilemma. Generally, the public goods dilemma describes a game-theoretical equilibrium, in which none of the parties has an incentive to provide the optimal share of a public good (Hardin, 1968). As a public good is characterized by non-rivalry in and non-excludability from its consumption, public good provision exerts a positive externality, that is, it does not only benefit the providing party, but any other party as well. Because the providing party accounts only for its own benefit of consumption in its public good provision decision, it will only provide an inefficiently low amount. In order to fit the defense context, the public goods dilemma needs refining because it predicts underprovision of the public good, namely joint defense, by all parties involved. In the real world this seems unlikely, since it implies that all countries equally take advantage of, in other words free ride on, each other´s defense provision. Countries might face different threat levels, have different levels of income at their disposal or possess different preferences towards power projection abroad (Olson & Zeckhauser, 1966). Accounting for these factors in the public goods dilemma would allow for a wide ranging degree of free riding between countries, as it permits some countries to rely more on joint defense, while others prefer to take defense matters in their own hands. Referring back to the previous example of the USA and Germany, one would expect the USA to be intrinsically motivated to provide joint defense, while Germany, as many other NATO countries, takes advantage of this fact and free rides on the US-American defense provision (Sandler et al., 1980). Arms trade comes into play, if one allows for the fact that arms exporting countries might anticipate that the recipient country will subsequently increase its defense provision level (Levine, Sen, & Smith, 1994). Under this assumption and assuming that arms exporting countries are able to free ride on the defense provided by their respective trading partners, that is, foreign defense exerts a positive security externality, they will export more arms relative to the case without any of the two assumptions. Previous literature left the adjustment of the defense provision by the arms exporting country in response to higher foreign defense provision unmentioned. For this reason, this thesis will combine the fact that arms export causes an anticipated increase in foreign defense provision with the fact that countries potentially free ride on foreign defense, therefore reducing their own defense provision and lowering their national military spending. Based on both facts, one would expect that a country anticipates a positive security externality, when it exports arms to another country, which then provides a higher defense level, and consequently decreases its national military expenditure, as its need for own defense provision decreases. With respect to the introductory example, Germany foresees that its arms export increases the US-American military capability. As it will benefit from the higher US-American defense provision, Germany is able to curb its own military expenditure, resulting in national defense spending below the commitment level. In short, when a country exports a higher quantity of arms, it expectedly decreases its military expenditure in turn. Following the same logic it should reversely hold true that an increase in arms import is expected to be accompanied by increasing military expenditure. This presumed relationship between arms trade and military expenditure is captured in the hypothesis below.

Hypothesis: As foreign defense provision exerts a positive security externality, arms exporting (importing) countries reduce (increase) their national military expenditure.

In this thesis the hypothesis is firstly adapted theoretically and afterwards verified empirically. The results of this thesis are ambiguous. While the empirical tests based on an unrestricted dataset, containing 165 countries, confirm the hypothesis, restricting the dataset to 19 NATO countries yields results, which negate the hypothesis.

The remainder of this thesis is structured as follows. In the second section the hypothesis is developed theoretically. For this purpose, the model of Levine et al. (1994) serves as a basis. As their model focuses on the influence of security externalities on the global arms stock, it has to be expanded upon in multiple ways in order to showcase the negative relation between arms export and domestic defense provision, i.e. national military expenditure. As this theoretical implication is to be tested in the forthcoming regression analysis, in the third section the variables included in the regressions are specified and the sources and composition of the dataset described. Here again, this thesis relies largely on existing literature, namely Nordhaus et al. (2012). They provide the dataset, on which basis the hypothesis is tested. In section 4 the methodological approach of the regression analysis is briefly clarified. Section 5 is divided in four subsections. Subsection 5.1 contains the baseline regression, in which the military expenditure is regressed on the whole set of control variables and the results of Nordhaus et al. (2012) are reproduced. Subsection 5.2 introduces the arms trade variables, i.e. arms export and arms import, to the model, while for the set of regressions in subsection 5.3 interaction terms between the arms trade variables and the arms trade balance are added. In the last subsection the dataset is restricted to NATO member countries and only arms trade within NATO is considered. In section 6 regression results are compiled and jointly interpreted. As a huge discrepancy is found between the regressions in subsection 5.2, 5.3 and 5.4 potential explanatory approaches are provided, too. In the seventh and final section of this thesis, the results of all previous sections are brought to a conclusion, suggestions for improvement are brought forward and an outlook on further research on the topic is proposed.

2. Theoretical Background

In this section the theoretical mechanism underlying the hypothesis is developed in a modified version of the model of Levine et al. (1994). They present a theoretical model, in which identical countries decide on the quantity of their arms export. Exporting arms does not only yield revenue gains, but also influences the security of the exporting country because the military power, i.e. the arms stock, of the recipient country exerts a security externality. Given positive security externality, the arms exporting countries have an additional incentive, apart from the export revenue, to export arms (Levine et al., 1994). Levine et al. (1994) come to the conclusion that, if a positive security externality exists, the global arms stock is higher relative to the benchmark case without security externality. However, two aspects crucial to the hypothesis of this thesis are omitted in their model. Firstly, they assume that countries produce arms for the purpose of exporting only, but cannot employ arms production for their own use. As the arms exporting countries cannot spend on their own defense, the national military expenditure does not enter the model and its interaction with arms trade stays untouched upon. Based on the model of Levine et al. (1994) it cannot be verified, if the arms exporting countries in fact free ride on foreign defense provision. In order to fill this gap, the model of this thesis includes utility from own defense consumption and constrains export arms production and defense good production to a fixed limit to establish a trade-off between both types of goods. Apart from free riding, the model in Levine et al. (1994) does not take the recipient countries into account and limits itself to the supply side of the international arms market. This leaves the question untouched, why the recipient countries behave differently from the arms exporting countries and import arms to provide defense instead of free riding themselves. The forthcoming model includes a representative arms exporting, free riding country, S, as well as a recipient country, D, which is equipped with an intrinsic motive to provide joint defense and build up military power, in accordance with the reasoning of Sandler et al. (1980). Based on the arms trade model in Levine et al. (1994) together with these two newly introduced notions, the relation between arms export and the military expenditure of the arms exporting country can be theoretically described.

First, the demand of country D for arms is derived. Country D is endowed with a fixed defense budget $B > 0$, which it can either spend on arms import q at price p or on numeraire defense good x^D at a price normalized to 1. The numeraire good denotes a good, on which the defense budget is spent residually after deducting arms import expenses, e.g. on machine maintenance or on current administrative costs. It increases country D´s utility by $u_D(x_t^D)$ in time period t. It is presumed that x_t^D yields positive, but diminishing marginal returns, such that $u'_D > 0$ and $u''_D < 0$. As country D exists for an infinite number of time periods, arms import accumulate to the arms stock S of country D. The arms stock S_{t+1} in $t+1$ is composed of the arms stock S_t in t, less a share of depreciated arms δS_t, and the arms import quantity q_t in t, such that $S_{t+1} = (1-\delta)S_t + q_t$. The arms stock in t increases the utility of country D according to a linear attack function $\alpha + \beta S_t - \bar{Q}$ (Levine & Smith, 1995). α indicates a predetermined military advantage. In addition, the arms stock multiplied with military technology βS_t yields military power, which has to surpass a threshold $\bar{Q}$, equivalent to the external threat level. By choosing the optimal levels of x_t^D and q_t country D optimizes its objective function W^D, depicted in Equation I, i.e. the utility from the defense good $u_D(x_t^D)$ and military power from the arms import aggregate βS_t over all time periods t. In order to account for time preferences, defense good utility and military power in period t are discounted by $\left(\frac{1}{1+r}\right)^t$. However, country D´s optimization is constrained by the defense budget and the arms stock dynamics. As a third constraint the transversality condition $\lim_{T\to\infty} \lambda_{2,T}\, S_T = 0$ ensure that country D abides to an even arms trade balance in the limit and cannot build up long-term debt. It is import to note that it is impossible for country D to free ride on the military power of country S, as it is not accounted for in the W^D.

$$\max_{\{x_t\},\{q_t\},\{S_t\}} W^D = \sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t [u_D(x_t^D) + \alpha + \beta S_t - \bar{Q}] \text{ s.t. } \begin{cases} x_t^D + pq_t \leq B \\ S_{t+1} = (1-\delta)S_t + q_t \\ \lim_{T\to\infty} \lambda_{2,T} S_T = 0 \end{cases}$$

Equation I - Objective function of country D

After setting up the Lagrangian five first-order optimality conditions are derived, which are presented in Equation II. For the purpose of finding the long-term, intertemporal equilibrium, the steady state is computed by setting $S_t = S_{t+1} = \bar{S}$, $x_t^D = \bar{x}_D$, $\lambda_{2,t} = \lambda_{2,t-1} = \bar{\lambda}_2$, $\lambda_{1,t} = \bar{\lambda}_1$ and $q_t = \bar{q}$.

$$\mathcal{L}_D = \sum_{t=0}^{\infty} \left(\frac{1}{1+r}\right)^t [u_D(x_t^D) + \alpha + \beta S_t - \bar{Q}] + \sum_{t=0}^{\infty} \lambda_{1,t}(B - x_t^D - pq_t) + \sum_{t=0}^{\infty} \lambda_{2,t}((1-\delta)S_t + q_t - S_{t+1})$$

(1) $\frac{\partial \mathcal{L}_D}{\partial x_t^D} = \left(\frac{1}{1+r}\right)^t u_D'(x_t^D) - \lambda_{1,t} = 0$

(2) $\frac{\partial \mathcal{L}_D}{\partial q_t} = \lambda_{1,t} p - \lambda_{2,t} = 0$

(3) $\frac{\partial \mathcal{L}_D}{\partial S_t} = \left(\frac{1}{1+r}\right)^t \beta + \lambda_{2,t}(1-\delta) - \lambda_{2,t-1} = 0$

(4) $\frac{\partial \mathcal{L}_D}{\partial \lambda_{1,t}} = x_t^D + pq_t - B = 0$

(5) $\frac{\partial \mathcal{L}_D}{\partial \lambda_{2,t}} = (1-\delta)S_t + q_t - S_{t+1} = 0$

Equation II – Optimization of country D´s objective function

Reformulating (2), (3) and (4) and inserting them into (1) yields $F(\bar{q}, p) = 0$ (see Appendix, A). This expression implicitly defines the inverse demand function $p(q_t)$ of country D for arms. Implicit differentiation reveals that arms import price p and arms import $\bar{q}$ stand in a negative relation, if $\left|\frac{\delta p^2 \bar{q}}{\beta}\right| < \left|\frac{1}{u_D''}\right|$ holds (Appendix, B). Practically, this implies that country D exhibits a conventional inverse demand function $p(q)$ with $p'(q) < 0$ under one reasonable condition: If price p rises to p', then spending the price difference $p' - p$ on numeraire good $\bar{x}_D$ yields more utility than paying the higher price p' for arms import $\bar{q}$.

In a next step, the optimization problem of the arms exporting country S is considered. Once again, two types of goods are distinguished, a numeraire defense good x_t^S and export arms. In each period t country S optimizes utility from $u_S(x_t^S)$, which features identical properties as $u_D(x_t^D)$, and revenue $p(q_t)q_t$ from exporting arms q_t to country D, which exhibits a positive demand for imported arms, as has been shown above. As seen in W^S in Equation III, the optimization objective is again collapsed into a single sum over all time periods t, under consideration of time preferences. Apart from the export revenue, country S is subject to the security externality $dS_t + eS_t^2$ of country D´s arms stock S_t. In accordance with the hypothesis, country S benefits from the security externality, such that $d > 0$ and $e > 0$

(Levine et al., 1994). When determining the optimal arms export quantity, country S takes into account that its arms export increases country D´s arms stock, following the dynamic law $S_{t+1} = (1-\delta)S_t + q_t$, which in turn increases the value of its objective function W^S due to the security externality. Other than the dynamic law of the arms stock and the transversality condition, the optimization problem of country S underlies a production capacity restriction as well: It is presumed that only a limited quantity of the defense good x_t^S and export arms q_t can be produced at cost $c(x_t^S)$ and $c(q_t)$ respectively without exceeding the production capacity P.

$$\max_{\{x_t\},\{q_t\},\{S_t\}} W^S = \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t [u_S(x_t^S) + p(q_t)q_t + dS_t + eS_t^2] \text{ s.t. } \begin{cases} c(x_t^S)x_t^S + c(q_t)q_t \le P \\ S_{t+1} = (1-\delta)S_t + q_t \\ \lim_{T\to\infty} \mu_{2,T} S_T = 0 \end{cases}$$

Equation III: Objective function of country S

In order to find the optimal levels of x_t^S, S_t and q_t, the Lagrangian is once more computed and five first-order optimality conditions derived, which are displayed in Equation IV. Again, the steady state values of all endogenous variables is focused on by setting $S_t = S_{t+1} = \bar{S}$, $x_t^S = \bar{x}_S$, $\mu_{2,t} = \mu_{2,t-1} = \overline{\mu}_2$, $\mu_{1,t} = \overline{\mu}_1$ and $q_t = \bar{q}$.

$$\mathcal{L}_S = \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t [u_S(x_t^S) + p(q_t)q_t + dS_t + eS_t^2] + \sum_{t=0}^{\infty}\mu_{1,t}(P - c(x_t^S)x_t^S - c(q_t)q_t) + \sum_{t=0}^{\infty}\mu_{2,t}((1-\delta)S_t + q_t - S_{t+1})$$

(1) $\frac{\partial\mathcal{L}_S}{\partial x_t^S} = \left(\frac{1}{1+r}\right)^t u_S'(x_t^S) - \mu_{1,t}(c'(x_t^S)x_t^S + c(x_t^S)) = 0$

(2) $\frac{\partial\mathcal{L}_S}{\partial q_t} = \left(\frac{1}{1+r}\right)^t \left(p'(q_t)q_t + p(q_t)\right) - \mu_{1,t}(c'(q_t)q_t + c(q_t)) + \mu_{2,t} = 0$

(3) $\frac{\partial\mathcal{L}_S}{\partial S_t} = \left(\frac{1}{1+r}\right)^t (d + eS_t) + \mu_{2,t}(1-\delta) - \mu_{2,t-1} = 0$

(4) $\frac{\partial\mathcal{L}_S}{\partial \mu_1^t} = c(x_t^S)x_t^S + c(q_t)q_t - P = 0$

(5) $\frac{\partial\mathcal{L}_S}{\partial \mu_2^t} = (1-\delta)S_t + q_t - S_{t+1} = 0$

Equation IV: Optimization of country D´s objective function

Rearranging (1), (3) and (5) and inserting the expressions into (2) yields function $F(\bar{q},\bar{x}) = 0$, which implicitly defines the relationship between arms export $\bar{q}$ and domestic military good $\bar{x}_S$ (Appendix, C). Implicit differentiation yields the derivative $\frac{\partial \bar{x}_S}{\partial \bar{q}}$ (see Appendix, D). For reasons of simplicity, two further assumptions are imposed. Firstly, the export price change $p'(\bar{q})$ is not affected by the export arms quantity, implying that the unit price stays constant and $p''(\bar{q}) = 0$. Secondly, the marginal production costs of an arms unit $\bar{q}$ or of the military good $\bar{x}_S$ respectively do not vary dependent on the overall production volume, such that $c''(\bar{q}) =$

$c''(\bar{x}_S) = 0$. Subject to these conditions, it can be shown that $\frac{\partial \bar{x}_S}{\partial \bar{q}} < 0$, if $\left|\frac{u_S' 2c'}{c'\bar{x}_S + c(\bar{x}_S)} - 2p'(\bar{q})\right| < \left|\frac{e}{\delta^2}\right|$. The sign of the derivative, together with the condition, indicates that in the steady state an additional unit of arms export $\bar{q}$ reduces country S´s consumption of the military good $\bar{x}_S$, if the long-run security externality of the foreign arms stock outweighs the price decline of export arms and the utility loss by foregone consumption of $\bar{x}_S$ relative to its production costs. This effect becomes the stronger, the greater the long-run positive security externality, i.e. the greater the value of e.

What does this model result imply? Under the assumption that country S cannot saturate the arms market and at the same time limitlessly consume the defense good itself due to the production capacity limit, it faces the choice whether to produce arms intended for exporting or to produce a numeraire defense good for its own consumption. The latter is produced at cost $c(x_t^S)$ and characterizes country S´s national military expenditure $c(x_t^S)x_t^S$. Given the fact that country S is able to free ride on the military capability of country D, country S, being fully aware of the security externality enhancement caused by its arms export, assesses the net benefits of arms export relative to domestic defense consumption. Ultimately, the model implicitly shows that, if the net benefits of arms export are relatively higher, country S will increase its arms export, while simultaneously decreasing the production of the numeraire defense good. In turn, a declining defense good quantity induces lower national military expenditure. Within the setting of the model, an increase in arms export therefore precipitates decreasing military expenditure of the arms exporting country. Thus, the model presents the mechanism underlying the hypothesis that arms export decreases the national military expenditure in light of a positive security externality. How can the model be related to the introductory example of Germany and the USA? The USA is represented in country D, as they do not free ride on the military capabilities of their allies, i.e. the NATO member states, but have an inherent motive to counter an external military threat by possessing sufficient military power. Germany, on the other hand, might take the positive security externality of US-American military power into account, when making its arms export decision, much like country S in the model. For this reason, Germany might dampen its own military expenditure, when the military presence of the United States is reinforced by German arms.

Beyond, the model supports several other real-world implications. Although only the export decision of country S is considered, the model implicitly predicts the effect of arms imports on the national military expenditure. It might be reasonably suspected that an additional unit of arms import affects the military budget in the same way as a lesser unit of arms export: In both cases country D´s arms stock decreases and the positive security externality deteriorates as a consequence. Assuming this was true, the effect of arms import would be precisely contrary to the effect of arms export, as indicated by $\frac{\partial \bar{x}_S}{\partial(-\bar{q})} > 0$. The attenuation of the security externality makes the free riding country reinforce its own defense consumption and raise the national military expenditure. However, this relation hinges on a crucial assumption. If country S exports arms, it can be fairly sure that country D purchases arms in order to employ them, thereby exerting a security externality. On the other hand, if country S imports arms, it needs to believe that the respective other country would have employed the arms for its own use, had it not exported them. Otherwise, country S´s expectation cannot be justified that the security externality deteriorates. This assumption yields the real world implication that the government of the arms exporting country expectedly steps in and purchases any excess export arms, which seems unlikely.

Furthermore, the model implicitly permits to predict a country´s reaction towards a negative security externality. Assigning a negative value to the long-run externality e likely changes the sign of $\frac{\partial \bar{x}_S}{\partial \bar{q}}$, as now the monetary gains of arms export have to offset not only the foregone domestic military good consumption, but also the negative security externality of the higher military capability of a foe country in order to maintain the positive relation. An in fact change of $\frac{\partial \bar{x}_S}{\partial \bar{q}}$ into the positive implies that the exporting country takes the subsequently higher military threat by its trading partner into account and increases its own defense consumption accordingly. However, it is arguable, whether international arms trade of this kind is effectively taking place: Why would the USA, for example, admit to export arms to Cuba, North Korea or Iran, if it could also sell arms to politically more neutral countries or even close NATO allies? Lastly, the model implicitly predicts that arms import under negative security externality decreases national military expenditure. However, this prediction suffers from a very similar deficiency as arms import under a positive externality, as it is questionable, if importing arms from an antagonist country reduces its military capabilities and the negative security externality.

	security externality	
	Positive	Negative
arms export	$\boldsymbol{\frac{\partial \bar{x}_S}{\partial \bar{q}} < 0}$	$\frac{\partial \bar{x}_S}{\partial \bar{q}} > 0$
arms import	$\frac{\partial \bar{x}_S}{\partial (-\bar{q})} > 0$	$\frac{\partial \bar{x}_S}{\partial (-\bar{q})} < 0$

Figure I – Relation between $\bar{x}_S$ and $\bar{q}$ depending on arms trade and security externality[1]

In conclusion, the theoretical background firmly suggests a negative connection between the arms export and the military expenditure of an arms exporting country, as it depends on the

[1] Expression in bold is theoretically strongest suggested.

least assumptions. It also constitutes the most plausible correlation to be found in the data with respect to its real world implications.

3. Variable Definition and Data Description

The regression analysis conducted in section 5 is based on a dataset compiled from three different sources. For the most part, the data used in Nordhaus et al. (2012), which is available on the website of the International Organization Journal, has been adopted (International Organization Data Archive, 2012). In their paper, the effect of the threat of armed conflict, in contrast to its actual materialization, on national military expenditure is explored (Nordhaus et al., 2012). Essentially, the authors conduct a linear regression, for which the natural logarithm of military expenditure $\ln(milex_{it})$ of any country i in purchasing power parity (PPP) Dollar for time period t constitutes the dependent variable. It is regressed on the conflict threat level, captured by the probability of militarized interstate conflict p_{it}^{war} for time period t, as the main explanatory variable. The authors go to great length to compute p_{it}^{war} in a first-stage linear regression, for which they consider more than 12,000 pairs of countries in the period between 1885 and 2000. For each country pair i, j the onset of militarized interstate dispute is estimated by regressing a dummy variable, which reflects the onset of military conflict for each time period t, on the democracy level of both countries i and j, the geographical proximity and membership in military alliances, among other things. The regression yields the dyadic probability of military conflict $\hat{p}_{i,j,t}^{war}$ as a result. In addition, the bilateral trade relative to GDP is included, representing the economic interdependence and the proportion of one country´s GDP relative to the other´s is introduced to the model in order to control for relative military power. Similarly, the absolute military power of each country is taken into account, by including the logarithm of GDP relative to global gross production. Eventually, the conflict probability p_{it}^{war} for each country i and time period t is computed by multiplying the estimated non-conflict probabilities $(1 - \hat{p}_{i,j,t}^{war})$ between the respective country and any other country j in the panel and then deducting the resulting product from 1. Notably, by doing so, the authors assume that dyadic conflict probabilities are stochastically independent from one another.

$$p_{it}^{war} = 1 - [\prod_{j=1}^{n} \left(1 - \hat{p}_{i,j,t}^{war}\right)]$$

Equation V – Compiling the expected probability of military conflict p_{it}^{war} for country i[2]

For their second-stage regression, specifically Table III (p. 503, Nordhaus et al., 2012), Nordhaus et al. (2012) specify five independent variables apart from p_{it}^{war}, all of which will be adopted in the regressions in section 5.

[2] p. 495, Nordhaus et al. (2012)

In addition, the threat of armed intrastate conflict p_{it}^{cwar} as computed in Sambanis (2004) is incorporated, due to the fact that p_{it}^{war} allows for interstate armed conflict only. In this paper the probability of civil war onset is estimated in a probit model, which allows for ethnic fractionalization, economic factors, geographic and demographic country characteristics and political instability, among other things (Sambanis, 2004).

The score in a democracy ranking $democ_{it}$ constitutes another control variable. The ranking ranges on an ordinal scale between -10 to +10, where the former score corresponds to the most autocratic type of regime and the latter to the most democratic one. Moreover, the logarithm of military expenditure lagged by one time period $\ln(milex_{it-1})$ is included in the empirical model to account for bureaucratic inertia. The adjustment of the domestic military budget to changes in the exogenous variables might be delayed due to an inefficient bureaucratic process, such that the military expenditure of the previous period still has some explanatory power over the one in the current period (Nordhaus et al., 2012).

In addition the natural logarithm of real GDP ($\ln(GDP_{it})$ is inserted into the empirical model, since wealthier countries are naturally more capable of affording higher military expenditure. The remaining control variables are twofold: Firstly, the logarithmic military expenditure of antagonistic countries in PPP Dollar $\ln(foes_{it})$ is controlled for. It either influences military expenditure positively, because allied countries commit to overcome the public good dilemma and jointly provide defense (Olson & Zeckhauser, 1966; Sandler & Hartley, 1995). Or, in accordance with the hypothesis, countries display free riding behavior and reduce their military expenditure, if allied countries increase theirs. Secondly, the model comprises logarithmic military expenditure of allies in PPP Dollar, $\ln(friends_{it})$. According to the literature on arms race, it is expected to interact negatively with the national military budget, as countries increase their military expenditure, if antagonist countries increase theirs (Brito & Intriligator, 1995; Dunne & Smith, 2007).

For the purpose of testing the hypothesis the panel data set from Nordhaus et al. (2012) is expanded by two additional independent variables: The arms export $export_{it}$ as well as the arms import $import_{it}$ in trend-indicator value (TIV) units for any country i and time period t are added to the independent variables. Both variables were retrieved from the Arms Transfer Database of the Stockholm International Peace Research Institute (SIPRI) (SIPRI Arms Transfer Database, 2015). Instead of recording the sales prices of arms transfers, the research institute assigns each arms transfer a trend-indicator value, which does not only allow for depreciation, but is also based on the reconstructed production costs of the transferred arms or a comparable arms product. SIPRI argues that arms prices are often distorted or unidentifiable because alongside newly produced complete weapons systems, already used arms, arms production licenses and arms components are purchased and sold as well. By measuring arms trade in a common cost unit SIRPI intends to ensure that arms transfers of any kind are comparable (SIPRI, 2016). On the other hand, measuring the arms export or arms import variable in TIV units does not permit any direct comparison with military expenditure or any other variable expressed in monetary terms for that matter.

Merging the dataset from Nordhaus et al. (2012) with the SIPRI data yields 6699 observations from 165 countries. The dataset covers the time period between 1951 and 2001 for 75 countries. For the remaining countries observations for fewer points in time are available, mostly because those countries were founded only after 1951. For Eritrea, Slovakia and Macedonia the least observations are available, as they were only observed between 1993 and 2001. For the regressions conducted in subsections 5.2, 5.3 and 5.4 the panel data is appended by another independent variable, $trade_{it}$, stemming from a third data source. The variable contains the sum of exports and imports of goods and services measured as a share of real gross domestic product for any country i and time period t. The data on $trade_{it}$ is provided under the indicator name „Trade (% of GDP)" in the World DataBank for 214 countries from 1960 onwards (The World Bank, 2015). Data on the German Democratic Republic, South Yemen, South Vietnam and Taiwan is only available single-sidedly, which is why these countries are eliminated from the merged dataset. As a result, the final dataset contains 12 variables, including country indicators, and is constructed of 6565 observations from 161 countries, ranging from 1951 to 2001.

4. Methodology

Although this thesis adopts the panel dataset of Nordhaus et al. (2012) almost completely, the empirical methodology differs significantly. Nordhaus et al. (2012) conduct simple pooled OLS regressions. Curiously, Nordhaus et al. decided against including country-fixed effects allowing for time invariant country characteristics. They argue that country-specific coefficient estimates might be biased, if included, as country characteristics and national military expenditure might be jointly determined by business cycle features, which would cause omitted variable bias (Nordhaus et al., 2012). However, omitting country fixed effects arguably provokes bias in the estimated coefficients as well, because any unobserved effect, which does not vary over time, is thus not controlled for and potentially constitutes an omitted variable. Unlike in Nordhaus et al. (2012), here the panel nature of the dataset is exploited by using fixed effects regressions and eliminating country-specific heterogeneity altogether. This is achieved by taking the average for each variable, independent as well as dependent, over all time periods T observed for any country i. Next, the variable average is deducted from each variable in the regression such that it holds for any variable x that $\ddot{x}_{it} = x_{it} - \bar{x}_i$ with $\bar{x}_i = \frac{1}{T}\sum_{t=1}^{T} x_{it}$. With respect to the transformed dependent variable $\ln(\ddot{milex}_{it}) = \ln(milex_{it}) - \overline{\ln(milex_{it})}$, its values can now only be explained by changes in time-variant independent variables, as the variable has been adjusted by its time-invariant component.

The country-specific effect c_i, which is by definition time-invariant, has no longer any explanatory power with regard to $\ln(\ddot{milex}_{it})$ and is eliminated from the regression equation. Hence, the fixed effect estimation reduces the risk of omitted variable bias.

$$\ln(\ddot{milex}_{it}) = \ln(milex_{it}) - \overline{\ln(milex_{it})} = \underbrace{(c_i - \bar{c}_i)}_{0} + (\boldsymbol{\gamma X'} - \boldsymbol{\gamma \bar{X}'}) = \boldsymbol{\gamma \ddot{X}'}$$

Equation VI – Fixed effects regression[3]

Furthermore, the natural logarithm of the arms export variable $\ln(export_{it})$ and the arms import variable $\ln(import_{it})$ are computed. There exist two valid reasons for doing so: First and foremost, the dependent variable $\ln(milex_{it})$ in the dataset from Nordhaus et al. (2012) is expressed in the natural logarithm as well. Having both sides of the regression equation expressed as logarithms permits to interpret the estimated coefficient as an elasticity, because the natural logarithm of a variable approximates its growth rate. As a result, the estimated coefficient indicates the increase or decrease of the national military expenditure in percent, if $export_{it}$, or $import_{it}$ respectively, increases by one percent. Secondly, creating a scatter chart of $\ln(milex_{it})$ and arms export, and arms import respectively, as done in the upper row of Figure II, reveals a non-linear relation. The function of fitted values in red depicts estimates produced by a simple regression of $\ln(milex_{it})$ on $export_{it}$, and $import_{it}$ respectively, which fit the scatter plot very well, suggesting a positive, but diminishing relationship. Taking the logarithm of arms export and import linearizes the relationship between military expenditure and the respective independent variable. This is shown in the bottom row of Figure II, where the regression estimates exhibit a linear fit to the scatter plot of $\ln(milex_{it})$ on $\ln(export_{it})$, and $\ln(import_{it})$ respectively. As a consequence, in the upcoming regressions a linear relationship may be assumed and no modifications or further terms are needed in order to account for a potentially concave relationship. It is important to note that the scatter charts do not suffice to verify a positive relation between military expenditure and arms export as well as arms import as long as no further factors are controlled for, which might jointly determine military expenditure as well as arms trade. Before being transformed into logarithmic values, $export_{it}$ and $import_{it}$ were multiplied by 100. Thus, it is ensured that no values smaller than 1 exists, which turn into the negative, if taken the logarithm of, and the range of values is strictly positive. As the natural logarithm of 0 is not defined, taking the logarithm creates excessively many missing values: 5121 arms export values equal zero, while 1824 arms import values do. Missing values are therefore again replaced by a value of zero.

[3] Vector $\boldsymbol{X}$ contains all independent variables x_{it}. As c_i does not vary over time, its value equals its time average, such that $c_i = \frac{1}{T}\sum_{t=1}^{T} c_i$.

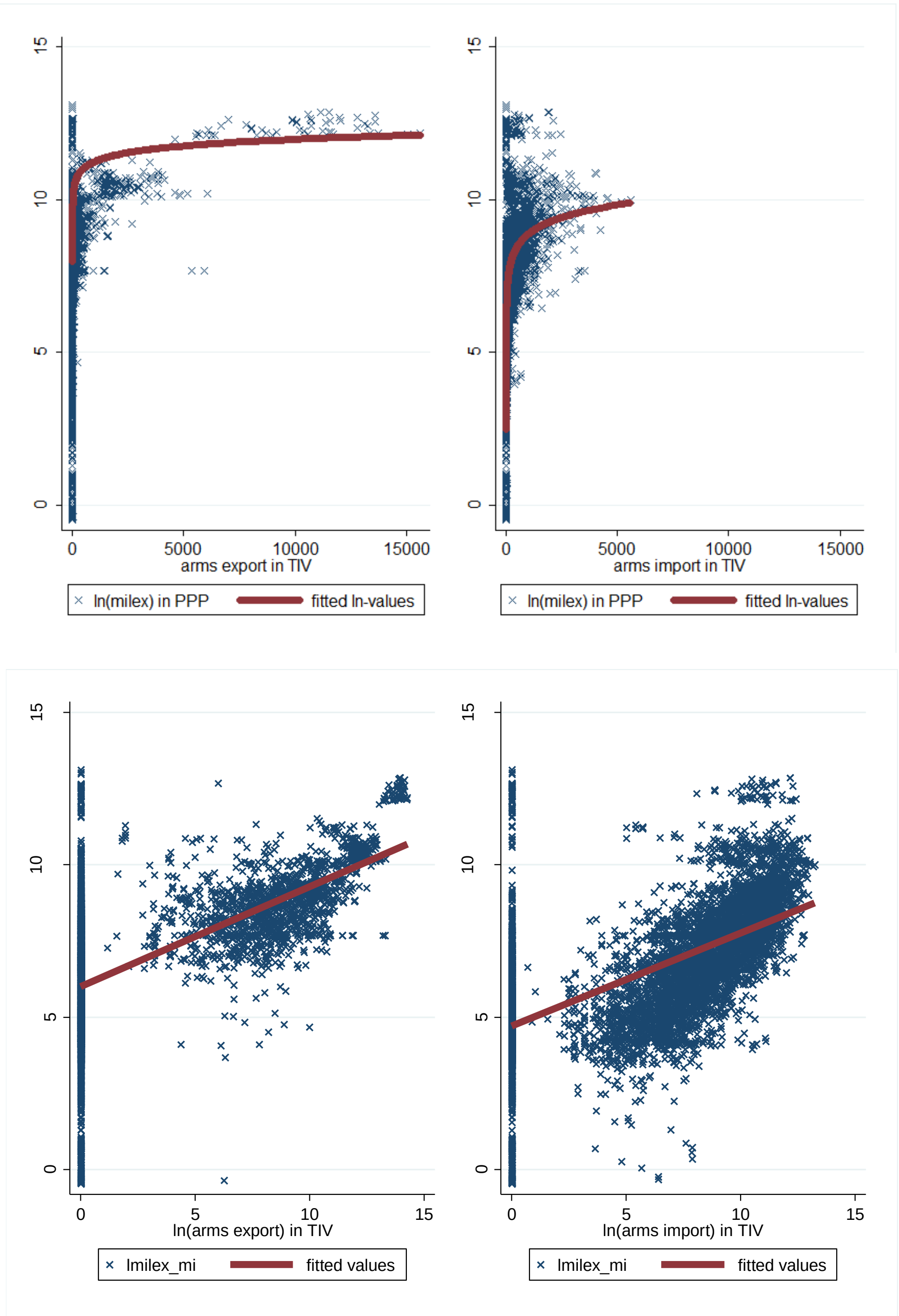

Figure II - Log-linearization of $export_{it}$ and $import_{it}$

Curiously, the dataset from Nordhaus et al. (2012) features missing values in almost every variable. A missing value causes the exclusion of the whole observation from the regression estimation, which is why missing values constitute a severe constraint on regression analysis. To this end, the panel dataset is balanced by data imputation: Using incomplete and complete variables alike as independent variables, the missing values are estimated by means of linear projection. As a result, additional 1272 complete observations were retrieved. In other terms, the number of exploitable observations in the dataset increased by roughly 24 percent.

5. The Empirical Model

In this section, four major regressions are conducted. In subsection 5.1 the main regression of Nordhaus et al. (2012) is replicated in order to validate their findings. Building on this, in subsection 5.2 the empirical model is expanded by the arms trade variables $\ln(export_{it})$ and $\ln(import_{it})$, offering a first glimpse at the relation between national military expenditure and international arms trade. Subsequently, the empirical analysis is refined in two ways: In subsection 5.3 interaction terms between the arms trade variables and the arms trade balance of the arms trading country are constructed based on the presumption that countries, which exhibit higher arms export relative to their arms import, respond to positive security externality to a greater degree. Lastly, in subsection 5.4 the dataset is restricted to NATO member countries only in order to isolate positive security externality by excluding arms trade with non-allied countries altogether. The regressions from subsection 5.1, 5.2 and 5.3 are conducted again based on the restricted dataset, expectedly bringing the hypothesized relationship between military expenditure and arms trade to light.

5.1. A reproduction of the findings of Nordhaus et al. (2012)

In order to reproduce the findings of Nordhaus et al. (2012), specifically Table 3 (p. 503, Nordhaus et al., 2012), the logarithm of national military expenditure is regressed on seven control variables in the fixed effects regression presented below in Regression Equation I.

$$\ln(\ddot{milex}_{it}) = \boldsymbol{\beta} \begin{pmatrix} \ddot{p}_{it}^{war} \\ \ddot{p}_{it}^{cwar} \\ \ln(\ddot{milex}_{it-1}) \\ \ln(\ddot{GDP}_{it}) \\ \ln(\ddot{friends}_{it}) \\ \ln(\ddot{foes}_{it}) \\ \ddot{democ}_{it} \end{pmatrix} + \ddot{\varepsilon}_{it}$$

Regression Equation I - Baseline regression (Nordhaus et al., 2012)[4]

Regression results are presented in Table I. For the most part, results coincide with those in Nordhaus et al. (2012). Here as well as in their paper, the threat of interstate conflict, p_{it}^{war}, is positive and significant on the 1% significance level in most regressions. Table I also records the estimated coefficient for the probability of civil war p_{it}^{cwar}, which are positive and highly significant. This is surprising, as Nordhaus et al. (2012) omit the variable due to its insignificant effect. Nonetheless, it is plausible that the risk of military conflict, regardless if between countries or within a country, causes the affected country to take precautions and raise its defense budget. Just like in Nordhaus et al. (2012), strong empirical evidence for

[4] for any variable x it holds $\ddot{x}_{it} = x_{it} - \frac{1}{T}\sum_{t=1}^{T} x_{it}$

bureaucratic inertia was found. The lagged variable $\ln(milex_{it-1})$ is positive and significant on the 1% level, implying that policymakers align their decision to the previous time period.

VARIABLES	(1) $\ln(\ddot{milex}_{it})$
$\ddot{p}_{it}^{war}$	0.494*** (0.161)
$\ddot{p}_{it}^{cwar}$	0.540*** (0.0441)
$\ln(milex_{it-1})$	0.489*** (0.00980)
$\ln(\ddot{GDP}_{it})$	0.482*** (0.0205)
$\ln(\ddot{foes}_{it})$	0.155*** (0.0297)
$\ln(\ddot{friends}_{it})$	0.00111 (0.00790)
$\ddot{democ}_{it}$	-0.00831*** (0.00201)
Observations	6,565
Number of actor	161
R-squared	0.575

Table I - Baseline regression results[5]

Findings for $\ln(GDP_{it})$ and $democ_{it}$ coincide with Nordhaus et al. (2012) as well and can be easily interpreted. The significantly positive coefficient for $\ln(GDP_{it})$ indicates that an economically powerful country is able to afford a higher military budget. The significantly negative coefficient for $democ_{it}$ suggests that the need for military expenditure decreases, the more democratic a country´s governance. This is congruent with the consensus that democratic countries are less likely to enter into military conflict with each other (Russett, 1994). Notably, this does not apply to every country constellation. Empirically, democratically governed countries are most prone to fight wars with autocracies.

With regard to the military expenditure of antagonist countries $\ln(foes_{it})$, the regression result deviates from Nordhaus et al. (2012). Whereas Nordhaus et al. present mixed empirical evidence for the fact that countries increase their military expenditure, whenever their foes do, here a positive coefficient for $\ln(foes_{it})$, significant on the 1% level, has been estimated. The estimate implies that negative security externality in fact exist, possibly leading to an arms race, as countries aim to offset additional military capability of any of their antagonists by increasing their own defense spending. Lastly, the estimate for the military expenditure of allied countries $\ln(friends_{it})$ is neither significant in Table I, nor in any

[5] In this and all following regressions, parentheses contain standard errors and *, **, *** indicate significance on the 1%, 5% and and 10% level respectively.

regressions conducted in Nordhaus et al. (2012). As a consequence, the estimate does not offer any evidence for the suggestion of Nordhaus et al. (2012) that allies commit to defense spending in order to overcome the public good dilemma. Neither does it support the presumption of this thesis that countries take advantage of the positive security externalities exerted by their allies´ defense expenditure and reduce their own military expenditure to this effect.

5.2. The effect of the arms trade on military expenditure

In this subsection the essential variables for the purpose of testing the hypothesis are introduced to the model. It can be seen in Regression Equation II that the fixed effects regression from subsection 5.1 is preserved except for the fact that the arms trade variables $\ln(import_{it})$ and $\ln(export_{it})$ as well as the control variable $trade_{it}$ are added to the left-hand side of the equation.

$$\ln(\ddot{milex}_{it}) = \boldsymbol{\beta}\begin{pmatrix}\ln(\ddot{import}_{it})\\ \ln(\ddot{export}_{it})\\ \ddot{trade}_{it}\end{pmatrix} + \boldsymbol{\gamma}\boldsymbol{X}' + \ddot{\varepsilon}_{it}$$

Regression Equation II - Regressing country i´s arms trade on its defense budget[6]

It suggests itself that the arms trade of a country does not only depend on its economic power, as captured by real GDP, but also on its economic competitiveness, or put differently its comparative advantage. The industrial base of Germany, for instance, supposedly bears the comparative advantage, as it is capable of producing goods, in particular arms, more efficiently. As this comparative advantage cannot be observed directly, the trade turnover relative to real GDP, i.e. $trade_{it}$, serves as a proxy. Presumably, some countries, possessing a comparative advantage, export more goods in general and arms in particular, which increases trade turnover $trade_{it}$ as domestic production is highly efficient. Thus, $\ln(export_{it})$ should be strongly correlated with $trade_{it}$. Objections to $trade_{it}$ being a valid proxy for the comparative advantage are imaginable. For lack of better data, $trade_{it}$ comprises trade turnover, which increases in exports as well in imports. Therefore, a country might hypothetically exhibit a high value of $trade_{it}$ due to its high imports, exactly because its industry base is little competitive. On the other hand, imports might be exported after being processed and often constitute intermediate goods in the global supply chain, thus being an indicator for the comparative advantage of a country as well. Furthermore, countries with non-competitive industrial bases might shun global trade altogether, as their domestic production would inevitably lose out. These countries might take protectionist measure and concede global trade to countries with competitive industrial bases. There likely exists a

[6] Define $\boldsymbol{X} = \left(\ln(\ddot{milex}_{it-1})\ \ln(\ddot{GDP}_{it})\ \ln(friends_{it})\ \ln(\ddot{foes}_{it})\ \ddot{democ}_{it}\right)$

connection between the variable and national military expenditure $\ln(milex_{it})$, too. Primarily, two possibilities of a causal relationship between $trade_{it}$ and $\ln(milex_{it})$ stand out. According to the argument in Keohane & Nye (1977), a country with flourishing foreign trade is economically interdependent with other countries, which inhibits it to become involved in armed conflict. Together with the risk of conflict, the need for military expenditure declines. Chalk (2008) make the entirely different argument that countries have to protect their trading infrastructure militarily. Under this condition, military expenditure rises with the trade turnover.

As a result, $trade_{it}$ is not only potentially correlated with the dependent variable $\ln(milex_{it})$, but also with the independent arms trade variables. Therefore, excluding the trade indicator variable from Regression Equation II risks endogeneity bias. Due to the fact that data on $trade_{it}$ is only available for approximately every third observation in the data set, the variable´s missing values are imputed in the way described in section 3. Imputation produces a dilemma, however. On the one hand, no meaningful regression estimates are obtained without imputation. On the other hand, imputation to such an extent constitutes a serious interference that could lead to biased results. Hence, the remaining regressions will be conducted both with the imputed version of $trade_{it}$ and excluding the variable altogether.

In Table II the regression results of Regression Equation II are displayed. The arms trade variables feature significant estimates in both columns. In particular, the estimate for the arms import $\ln(import_{it})$ variable is significant on the 1% level and bears a positive sign. According to the regression results, if the arms import in TIV units increases by one percent, military expenditure in PPP Dollar rises by approximately 0.02 percent *ceteris paribus* (c.p.). Even though a positive relation between arms import and military expenditure corresponds to the hypothesis, it cannot be unambiguously ascribed to a positive security externality. This is because the arms import is paid for with funds from the national defense budget, since typically the government is the final consumer of military goods. Thereby, arms import and the national military expenditure stand in a direct relationship: Each monetary unit spend on arms import necessarily increases military expenditure by one monetary unit. Positive security externality is only verifiable, if spending goes beyond this direct effect. In the present case the direct effect and the indirect effect, through a positive security externality, cannot be kept apart, because $\ln(import_{it})$ is measured in TIV units, making it unclear, how much was paid for the import in monetary terms. Hence, $\ln(import_{it})$ is not only rendered uninformative with respect to the hypothesis in this regression, but also in the following regressions.

The same concern does not apply regarding arms export, because export revenues do not flow into the government´s defense budget, but into the private defense sector. For this reason, the estimate for $\ln(export_{it})$, which is negative and significant on the 5% level in both columns of Table II, can be interpreted without ambiguity: A one percent increase in arms export concurs with a roughly 0.01 percent decrease in military expenditure c.p. The sign and significance of the estimated coefficient provides empirical support for the hypothesis: Whenever the average country exports a unit of arms, it reduces its own military expenditure. The reason for this might well be free riding behavior coupled with the belief that the trading partner will provide more defense owing to the exported arms.

VARIABLES	(1) $\ln(\ddot{milex}_{it})$	(2) $\ln(\ddot{milex}_{it})$
$\ln(\ddot{export}_{it})$	-0.00995**	-0.00960**
	(0.00387)	(0.00387)
$\ln(\ddot{import}_{it})$	0.0234***	0.0240***
	(0.00288)	(0.00288)
$\ddot{p}_{it}^{war}$	0.428***	0.352**
	(0.160)	(0.161)
$\ddot{p}_{it}^{cwar}$	0.537***	0.524***
	(0.0439)	(0.0439)
$\ln(milex_{it-1})$	0.479***	0.473***
	(0.00987)	(0.00993)
$\ln(\ddot{GDP}_{it})$	0.489***	0.533***
	(0.0205)	(0.0224)
$\ln(\ddot{foes}_{it})$	0.143***	0.149***
	(0.0297)	(0.0297)
$\ln(\ddot{friends}_{it})$	0.000695	-0.000239
	(0.00787)	(0.00786)
$\ddot{democ}_{it}$	-0.00559***	-0.00536***
	(0.00203)	(0.00202)
$\ddot{trade}_{it}$		-0.00231***
		(0.000485)
Observations	6,565	6,565
R-squared	0.580	0.581
Number of actor	161	161

Table II - Regression results after introducing $\ln(export_{it})$, $\ln(import_{it})$ and $trade_{it}$

The significance levels and sign of the control variables in column (1) do not change relative to Table I in subsection 5.1. In column (2) $trade_{it}$ appears to hold strong explanatory power and features a highly significant estimated coefficient. The estimate bears a negative sign, which adds to the argument of Keohane & Nye (1977). Based on the argumentation above, one would expect that significance, sign or magnitude of the estimated coefficients, including the arms trade variables, change, if $trade_{it}$ is included. Curiously, this is not the case with the exception of the coefficient for p_{it}^{war}, which decreased in magnitude and significance. Also, the fit of the empirical model to the data stayed almost unaffected by the inclusion of

$trade_{it}$, as indicated by R-squared.[7] Both facts suggest that $trade_{it}$ does not constitute an omitted variable in column (1) after all. Nonetheless, $trade_{it}$ showcases the robustness of the estimates for $\ln(import_{it})$ and $\ln(import_{it})$, as they do not change significantly in response to the inclusion of said variable.

5.3. Arms trade, security externality and how to measure their relation

The theoretical model in section 2 suggests that the free riding country should reduce its national military expenditure more, when exporting arms, the stronger it benefits from the positive security externality of its trading partner´s military expenditure. On this ground, the empirical evidence in favor of the hypothesized positive relation between arms trade and military expenditure should be the stronger, the more effective the positive security externality. It is natural to assume that different countries experience positive security externality to different degrees, as some arms trading partners are politically associated more closely than others. The subsequent regression aims to capture these different degrees of positive security externality by introducing interaction terms. It is reasonable to assume that higher gains from positive security externality go hand in hand with higher arms exports. A country benefitting marginally more from positive security externalities has a marginally higher incentive to export arms relative to import arms. Therefore, it is to be expected that countries export more arms and import less, the stronger the effect of the security externality. This is why the arms trade balance in percent of overall arms trade, $balance_i$, might serve as a sufficient proxy for the extent of free riding behavior. As shown in Equation VII, $balance_i$ reflects the sum of arms exports over the whole observation period T for any country i less the arms imports relative to the overall arms trade volume in TIV units. Simply put, $balance_i$ takes a higher value for countries which export relatively many arms. According to the presented argument one would expect that countries, which benefit substantially from the positive security externality and free ride correspondingly, exhibit a highly positive value of $balance_i$.

$$balance_i = \frac{1}{T}\sum_{t=1}^{T}\frac{export_{it} - import_{it}}{export_{it} + import_{it}}$$

Equation VII - Arms trade balance in percent of overall arms trade

Based on the hypothesis, countries, which benefit more strongly from positive security externalities and are therefore characterized by a higher values of $balance_i$, should reduce their military expenditure relatively more, when exporting arms. In accordance with the hypothesis, these countries should in turn increase their military expenditure relatively more,

[7] R-squared measures the variation in the dependent variable explained by the regression relative to the overall variation in the dependent variable.

when importing arms. Thus, conditional on $balance_i$ the arms trade variables $\ln(export_{it})$ and $\ln(import_{it})$ are expected to have a negative and a positive sign respectively. Essentially, the examination of the arms trade variables conditional on the arms trade balance potentially leads the effect of $\ln(export_{it})$ and $\ln(import_{it})$ back to positive security externality only, thereby providing further empirical evidence in favor of the hypothesis. For this reason, the regression presented in Regression Equation III has been conducted.

$$\ln(\ddot{milex}_{it}) = \boldsymbol{\beta}\begin{pmatrix} \ln(\ddot{export}_{it}) \\ \ln(\ddot{export_{it}}) \cdot balance_i \\ \ln(\ddot{import}_{it}) \\ \ln(\ddot{import_{it}}) \cdot balance_i \\ \ddot{trade}_{it} \end{pmatrix} + \boldsymbol{\gamma X'} + \ddot{\varepsilon}_{it}$$

Regression Equation III - Interacting arms export/import and arms trade balance

The effects of arms export and of arms import conditional on the arms trade balance are controlled for by the interaction terms $\ln(export_{it}) \cdot balance_i$ and $\ln(import_{it}) \cdot balance_i$ respectively. In all other aspects, the remaining variables are identical to the ones used in Regression Equation II.

Regression results for all independent variables react fairly stable in response to the inclusion of the reaction terms. Arms export estimate, however, becomes significant on the 1% level, while rising in magnitude by roughly 0.015. Regression results for the interaction terms are divided. On the one hand, for $\ln(import_{it}) \cdot balance_i$ an insignificant coefficient is estimated. This lack of significance may be interpreted as an indication that the positive correlation between $\ln(import_{it})$ and $\ln(milex_{it})$, found in Table II as well as in Table III, does not result from positive security externality. With respect to $\ln(export_{it}) \cdot balance_i$, the estimated coefficients in both columns are significant on the 5% level and bear a negative sign, implying that arms export conditional on positive security externality, i.e. the arms trade balance, has an additional negative effect on military expenditure. Interpreting the estimate, if a country´s arms trade balance increases by one percent, its arms export lowers the national military expenditure by further 0.02 percent c.p. on average. Under the assumption that the arms trade balance adequately reflects the country´s susceptibility for positive security externality, this particular regression result offers strong empirical support for the hypothesis by reaffirming the negative relation between arms export and military expenditure under positive security externality.

However, it is noteworthy that the insignificantly estimated coefficient for $\ln(import_{it}) \cdot balance_i$ provides little insight, as it has been established in subsection 5.2 that the estimate for $\ln(import_{it})$ itself is hardly informative. It is furthermore noteworthy that the interaction term approach contains a major deficiency: According to the reasoning above, negative values for $balance_i$ might indicate negative security externality, as over the whole observation period arms import outweigh arms export. The more negative the arms trade balance, the higher the likelihood that a country is confronted with negative security externality, although this does not need to be the case necessarily. If the interaction term changes sign, the estimate of arms export conditional on $balance_i$ might thus indicate that arms exports have a positive effect on military expenditure in light of a negative security externality. While this does not contradict the theoretical implications derived in section 2, the regression analysis and the subsequent interpretation are set out to exclusively involve positive security externality.

VARIABLES	(1) $\ln(\ddot{milex_{it}})$	(2) $\ln(\ddot{milex_{it}})$
$\ln(\ddot{export_{it}})$	-0.0243***	-0.0236***
	(0.00731)	(0.00730)
$\ln(\ddot{export_{it}}) \cdot balance_i$	-0.0231**	-0.0225**
	(0.00991)	(0.00989)
$\ln(\ddot{import_{it}})$	0.0222***	0.0229***
	(0.00708)	(0.00707)
$\ln(\ddot{import_{it}}) \cdot balance_i$	-0.00222	-0.00210
	(0.0109)	(0.0109)
$\ddot{p}_{it}^{war}$	0.394**	0.319**
	(0.161)	(0.162)
$\ddot{p}_{it}^{cwar}$	0.537***	0.524***
	(0.0439)	(0.0439)
$\ln(\ddot{milex_{it-1}})$	0.479***	0.473***
	(0.00988)	(0.00994)
$\ln(\ddot{GDP_{it}})$	0.486***	0.529***
	(0.0205)	(0.0224)
$\ln(\ddot{foes_{it}})$	0.146***	0.151***
	(0.0298)	(0.0298)
$\ln(\ddot{friends_{it}})$	0.00161	0.000660
	(0.00789)	(0.00788)
$\ddot{democ_{it}}$	-0.00567***	-0.00544***
	(0.00203)	(0.00202)
$\ddot{trade_{it}}$		-0.00229***
		(0.000485)
Observations	6,565	6,565
R-squared	0.580	0.581
Number of countries	161	161

Table III - Regression results after introducing interaction terms

As $\ln(export_{it}) \cdot balance_i$ might measure the correlation between arms export and military expenditure under partly positive and partly negative security externality, such that the corresponding estimate might not correctly reflect the influence of positive security externality only. Due to the ambiguity of the results, a third regression is conducted in the following subsection in order to find lasting and robust empirical evidence with respect to the hypothesis.

5.4. Restricting the dataset to allied countries

As the regression analysis in subsection 5.3 has shown, the potential presence of negative security externality might interfere with a conclusive estimation of the coefficient for the arms trade variables. Arms transfers exerting a negative security externality might occur, though it has been previously argued that they are unlikely. So far, in neither subsection 5.2 nor 5.3 it has been possible to definitively lead the estimated effects of $\ln(export_{it})$ back to positive security externality. The regression conducted in this subsection aims at isolating arms trades between allied countries only. By doing so, the possibility of negative security externalities is eliminated.

The North Atlantic Treaty Organization denotes the largest military alliance in existence during the observation period in terms of member countries. In addition, NATO member countries can be indisputably described as military allies to one another. For this reason, the panel dataset is restricted to observations of the 19 countries being NATO members between 1951 and 2001.

Country	Obs. period
Belgium	1951-2001
Czech Republic	**1999**-2001
Canada	1951-2001
Denmark	1951-2001
France	1951-2001
Germany	**1955**-2001
Greece	**1952**-2001
Hungary	**1999**-2001
Iceland	1951-2001
Italy	1951-2001
Luxemburg	1951-2001
Netherlands	1951-2001
Norway	1951-2001
Poland	**1999**-2001
Portugal	**1999**-2001
Spain	**1982**-2001
Turkey	**1952**-2001
United Kingdom	1951-2001
United States	1951-2001

Figure III – Composition of the restricted sample: Countries and observation periods

Thereby, nine current NATO members are excluded from the dataset, since they joined NATO only after 2001. Out of these 19 countries, eight countries joint NATO after 1951. The observations of the respective countries are therefore restricted to the time period of factual NATO membership in order to ensure that the political loyalty in fact lies with the alliance.

This is important in particular regard to the former Eastern Bloc countries. This approach, however, implies no more than three observations in the cases of Poland, the Czech Republic and Hungary. Countries kept in the dataset and the corresponding observation period for each of these countries are listed in Figure III.

In the next step, the independent variables $\ln(export_{it})$ and $\ln(import_{it})$ are redefined to ensure that only arms trade between allies is considered. For this reason, the TIV export data from the SIPRI Arms Trade Database is restricted to recipient countries, which are listed in Figure II, only. Similarly, only arms imports from NATO member countries are considered. The computation of the arms trade balance is based on intra-NATO arms trade as well.

The dataset restriction yields 965 observations, which are sufficient to conduct meaningful regressions in terms of their sheer number. By contrast, the restriction of the dataset raises several other concerns. First and foremost, Figure IV shows how arms trade activity during the observation period is mainly centered on a handful of countries. Comparing bar chart on the left and the right hand side, this applies to arms export even more as it does to arms import: The median country exports roughly 0.002 percent of the US-American aggregated export, whereas it imports 1.7 percent of the German aggregated arms import, both in TIV units.

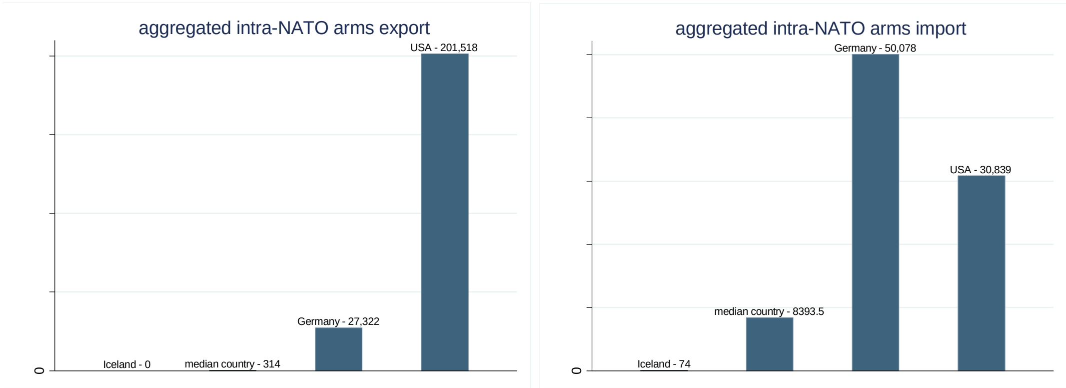

Figure IV – Aggregated, intra-NATO arms trade in TIV units, selected countries (1951-2001)

To the most part, the USA, Germany, France and the United Kingdom account for the intra-NATO arms trade, whereas the contributions of Iceland, Luxembourg, Belgium and Portugal are negligible. A possible explanation might be that small countries do not have any considerable arms producing industry. Furthermore, one might expect smaller countries to hardly be involved in interstate conflict, as they hold little political importance. Adversely, the high concentration of the arms trade might cause any regression result to mostly capture the effects between the arms trade variables and military expenditure for very few countries.

Throughout this thesis, it was suggested that net arms trade adequately indicates the degree to which a country free rides on the defense provided by its allies. By contrast, the upper right graph in Figure V shows that the median country of the restricted dataset has been a net arms importer for the whole course of the observation period. Figure V also shows, how the United States of America exported greatly more arms than were imported, whereas Germany, in fact, has been a net arms exporter only since almost 1980. This fact greatly contradicts the hypothetical scenario in which Germany exports arms to the USA, taking advantage of the subsequent provision security provided by the latter

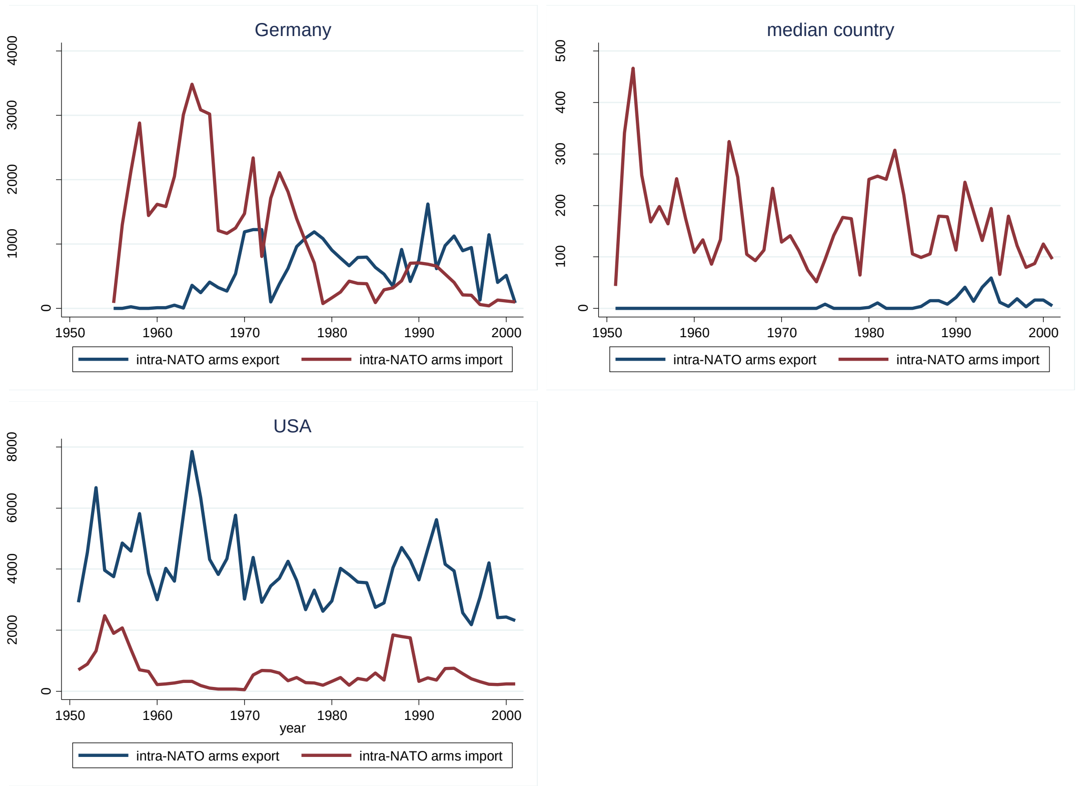

Figure V - $export_{it}/import_{it}$-time-series for Germany, USA and the median country

The high arms trade balance deficit of roughly half of the countries in the restricted dataset, including most of the observations for Germany, cast doubt on the hypothesis that, by means of arms export, free ride on the military expenditure of one or few security providers occurs. The fact that the USA is, in terms of intra-NATO arms trade, no net importer does not help the hypothesis either, since it might have been reasonably assumed to be NATO´s foremost security providing member state and, as such, should have been the main recipient of other NATO member countries´ arms export.

Despite any inconsistencies with regard to the dataset, the regressions from subsection 5.1 and from subsection 5.2, which introduced the arms trade variables, are replicated based on the restricted dataset. In addition, the regressions from subsection 5.3, which included the interaction terms between the arms trade balance and either one of the arms trade variable, are conducted once again. Regression results are depicted in Table IV.

Column (1) reports the regression results for the baseline regression. It is intended to confirm the findings in Table I in subsection 5.1, thereby supplying proof for the resemblance of both datasets with respect to the control variables. However, estimates for the effect of inter- and intra-state conflict probability, p_{it}^{war} and p_{it}^{cwar}, approximately doubled and tripled respectively. The magnitude of the estimated coefficient for $\ln(\ddot{milex}_{it-1})$ strongly increased as well. The logarithm of real GDP and the democracy ranking score are rendered insignificant, most likely due to the limited exploitable variation in both variables: NATO member countries are comparably democratic and wealthy from a global point of view, which is why these variables cannot explain much of the difference in military expenditure between NATO members. In a similar manner, the effect of military expenditure of antagonist countries loses some of its significance, as countries in the NATO alliance likely face the same foes. In contrast to Table I, the logarithmic military expenditure of allied countries $\ln(friends_{it})$ is highly significant and positive. The positive sign of the estimate dissents from the notion that countries free ride on the military expenditure of their allies.

VARIABLES	(1) $\ln(\ddot{milex}_{it})$	(2) $\ln(\ddot{milex}_{it})$	(3) $\ln(\ddot{milex}_{it})$	(4) $\ln(\ddot{milex}_{it})$	(5) $\ln(\ddot{milex}_{it})$
$\ln(\ddot{export}_{it})$		0.0275***	0.0254***	0.0358**	0.0322**
		(0.00791)	(0.00784)	(0.0143)	(0.0142)
$\ln(\ddot{export_{it}}) \cdot balance_i$				0.0151	0.0127
				(0.0212)	(0.0210)
$\ln(\ddot{import}_{it})$		0.0261***	0.0286***	0.0329**	0.0405***
		(0.00990)	(0.00981)	(0.0137)	(0.0137)
$\ln(\ddot{import_{it}}) \cdot balance_i$				0.0208	0.0346
				(0.0264)	(0.0263)
$\ddot{p}_{it}^{war}$	1.162***	1.155***	1.138***	1.146***	1.127***
	(0.358)	(0.355)	(0.351)	(0.355)	(0.351)
$\ddot{p}_{it}^{cwar}$	1.780***	1.747***	1.817***	1.777***	1.855***
	(0.229)	(0.227)	(0.225)	(0.228)	(0.226)
$\ln(\ddot{milex}_{it-1})$	0.258***	0.232***	0.244***	0.232***	0.246***
	(0.0215)	(0.0220)	(0.0219)	(0.0225)	(0.0224)
$\ln(\ddot{GDP}_{it})$	0.0792	0.00749	0.305***	0.00151	0.308***
	(0.0837)	(0.0843)	(0.105)	(0.0846)	(0.106)
$\ln(\ddot{foes}_{it})$	0.141**	0.135**	0.185***	0.137**	0.191***
	(0.0596)	(0.0592)	(0.0596)	(0.0594)	(0.0598)
$\ln(\ddot{friends}_{it})$	0.236***	0.283***	0.241***	0.287***	0.244***
	(0.0521)	(0.0528)	(0.0530)	(0.0531)	(0.0533)
$\ddot{democ}_{it}$	-0.00131	-0.00568	-0.00772*	-0.00622	-0.00858*
	(0.00444)	(0.00453)	(0.00451)	(0.00457)	(0.00454)
$\ddot{trade}_{it}$			-0.01000***		-0.0103***
			(0.00217)		(0.00219)
Observations	965	965	965	965	965
R-squared	0.402	0.416	0.429	0.417	0.431
Number of actor	19	19	19	19	19

Table IV - Regression results after restricting the dataset

Although sign, significance and magnitude of the arms import variable remains unchanged in column (2) compared to Table II, surprisingly the estimate of $\ln(export_{it})$ is positive on the 1% significance level. An increase of the arms export by one percent now brings about a 0.03 percent increase in domestic military expenditure c.p. In the unrestricted dataset, the estimated coefficient might have been taken as an indication of negative security externality: Arms export increases the military threat level by the recipient countries, which is why the arms exporting country raises its military expenditure. Since the dataset restriction to NATO member countries explicitly rules out negative security externality, this explanation is no longer applicable. The estimate for $\ln(export_{it})$ is almost unchanged, if $trade_{it}$ enters the regression equation in column (3). However, changes in the control variables are observable. Interestingly, the coefficients of $democ_{it}$ and of $\ln(foes_{it})$ gain significance as does the coefficient of $\ln(GDP_{it})$. The estimate of $trade_{it}$ itself has a highly significant and negative influence on national military expenditure, as it already did in Table II.

In column (4) and (5) the interaction terms, as presented in subsection 5.3, are introduced, which do not entail any change in the sign of the estimated effect of arm export neither. The estimated coefficient is now only significant on the 5% level, though. The estimates for the control variables remain also largely unaffected, but show the same responds to the introduction of $trade_{it}$ in column (5) as described in the previous paragraph. In contrast to Table III in subsection 5.3, the interaction term between the arms trade balance and arms export does not display any significance. This result might cast doubt either on the validity of the arms trade balance as a suitable proxy variable for positive security externality or on the hypothesis of this thesis as a whole. More likely, the informative value of the restricted dataset is limited to this effect. Figure VI shows, how little exploitable variation in the arms trade balance exists in the dataset.

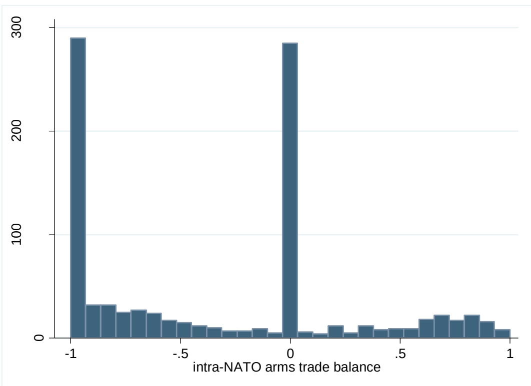

Figure VI - Distribution of intra-NATO arms trade balance

Redefining $balance_i$ as the trade balance with respect to arms traded between NATO member countries causes concern because 28.4 percent of the countries in the dataset neither export, nor import any arms. As a consequence, the corresponding country observations do not add any information to the estimation of the interaction term coefficient and are practically omitted. Another 26.11 percent of countries conduct only one arms transfer and import arms once in the course of the whole observation period. The resulting large proportion of negative value for $balance_i$ might distort the regression result, as the arms trade balance very probably does not reflect the security externality truthfully anymore. An obvious reason for the unusual distribution of the arms trade balance lies in the limited data availability. SIPRI does not raise the claim of data completeness and leaves many arms export and import values unspecified. For the purpose of the regression analysis, any unspecified values have been rendered zero in order to prevent an excessive amount of missing observations. Nonetheless, this approach risks to drastically understate the extent of arms trade.

In conclusion, Table IV largely confirms the regression estimations of the previous subsections, except for the fact that arms export is shown to relate positively to national military expenditure. By conducting a whole set of regressions, ranging from column (2) to (5), it has become apparent that the positive sign of the estimated coefficient is robust, although the NATO data suffers from some statistical issues.

6. Model Interpretation and Implications

Strikingly, there exists a substantial discrepancy between the results of regressions in subsections 5.2 and 5.3 and in subsection 5.4: According to the regressions in 5.2 a one-percent increase in arms export decreases military expenditure by 0.01 percent c.p. In subsection 5.3 regression results suggest an even stronger negative effect on military expenditure of about 0.024 percent c.p. In addition, a constant level of arms export increases national military expenditure further by roughly 0.023 percent c.p., if the arms trade balance increases by one percentage point, which is suspected to be positively correlated with the positive security externality from arms trade. In subsection 5.4 a change of sign in the arms export coefficients was observed, despite the fact that they were expected to produce the strongest support in favor of the hypothesis among the conducted regressions: Taking only arms trade within an alliance, i.e. NATO, into account constitutes the most convincing approach in order to focus exclusively on positive security externality. Regressions restricted to allies and to arms trade among allies indicate that an increase in arms export by one percent causes military expenditure to rise by a positive amount c.p., ranging from 0.025 to 0.035 percent between regressions. This discrepancy among the different variations of the empirical model does not affect the arms import estimate, whose significance and value, as well as its positive sign hardly changes. However, it was argued before that the arms import coefficient cannot be interpreted due to the different measurement units, for which reason the direct budget effect of arms import on military expenditure cannot be controlled for.

The diverging regression results raise the question, why the average country in the restricted NATO dataset reacts differently compared to the average country in the global dataset. The simplest answer would be to dismiss NATO as a non-representative exception, an answer supported by NATO´s peculiar features outlined in subsection 5.4. Nonetheless, this approach falls short of providing the distinctive characteristic or internal mechanism, which sets NATO and comparable alliances apart from the residual countries in the global dataset. One could think of three broad approaches to explain the positive relation between the military expenditure within an alliance despite positive security externality, which can be easily transferred to a scenario allowing for arms trade among allied countries.

First and foremost, the idea of burden-sharing can be applied to intra-NATO arms trade and military expenditures of NATO member countries. Early on in this thesis, the assumption was made that the arms importing country fails to coordinate its military expenditure with the one of the arms exporting, free riding country and ignores the negative effect the positive security externality of the arms transfer casts on the military budget of the latter country. The assumption of non-coordination seems to be reasonable for alliances of convenience, where political integration is weak. However, it should not hold true for NATO, which is far from an alliance of convenience: NATO constitutes a politically highly integrated, persistent and profound coalition of countries interconnected by shared security objectives and common social values. This particular alliance has 22 members in common with the European Union (EU), arguably an ever closer political union. It stands to reason that EU integration might enable NATO members to commit to share the burden of providing joint security by coordinating on their military expenditures, thereby eradicating the possibility to free ride (Sandler et al., 1980; Sandler & Hartley, 2001). This fact is also empirically recovered in subsection 5.4, where all of the conducted regressions produced the significantly positive coefficient for $\ln(friends_{it})$. The military expenditure of any NATO member is subject to joint defense commitment and defense budget coordination, which prescribes that an increase of allied military expenditure, e.g. in response to an external military contingency, is met by an increase in the domestic military spending. If one ally were to increase its demand for arms and therefore its military expenditure, it would induce any allied country to align its military expenditure and carry the fair share of joint security, regardless of the increased arms export to the former country. Therefore, the positive security externality from arms trade is internalized by coming to a formal or informal agreement with its allies about their joint military spending. Finding agreement on fair and efficient mechanisms of burden-sharing have not only been a serious concern of recent date to NATO, but have been subject to a string in research literature as well (Hartley & Sandler, 1999).

Yet, burden-sharing only benefits a share of countries in the alliance, here the importing country, but not the arms exporting and free riding one. There exists a fundamental conflict of interest, which, from a realist perspective, can be hardly overcome by voluntary consensus. Alternatively, a politically influential and militarily powerful country, i.e. the USA, could coerce countries to keep up, in proportion, with its own military expenditure, such that free riding is ruled out (Snyder, 1984). A similar argument has been made with regard to military contingencies, for which the USA coerces its allies to take their proportional share of responsibility (Kupchan, 1988). If the coercing country chooses to raise its military expenditure and increases its demand for arms, the residual countries will export more arms, while simultaneously increasing the budget for their respective domestic military.

The second explanatory approach relates to the specialization in arms production and in defense provision within NATO. It is well established that the production of arms is subject to economics of scale: The average costs per arms unit decreases as the production quantity of the one type of arms increases in one country. The lower average cost give countries an incentive to concentrate on one type of arms and to serve the world market for this particular type of weapon, while relying on imports for all other types of arms (Anderton, 1995). Consequently, specialization in production leads to an increase in global arms trade, i.e. arms import as well as arms export. Simultaneously, NATO strives for defense provision specialization, a functional division of labor between its member states in order to increase the cost efficiency and effectiveness of its joint military potential (Locatelli & Testoni, 2009). In practice, this may well mean that Germany assumes the main naval capabilities of NATO in continental Europe, while the USA concentrate on military surveillance and reconnaissance. This second form of specialization greatly reduces the potential to free ride as individual responsibilities are well defined. Therefore, national military budgets for most medium and small military powers are expected to increase in accordance with defense provision specialization. Specialization in arms production and defense provision taken together might constitute a joint determinant of arms export and military expenditure, as countries specialize on providing the defense good, on which their arms production is also specialized on. Given this fact, specialization potentially provides an explanation for the positive relation found between arms export and military expenditure.

Thirdly, some explanatory potential might lie in the joint-product hypothesis, which claims defense product complementarity. The hypothesis was initially introduced to the public economics literature as a special type of public good, but has found its application in defense economics as well (Cornes & Sandler, 1996). In particular, is has been suggested that in the late 1970s NATO switched from its doctrine of "Mutually Assured Destruction" to the "Flexible Response" doctrine (Murdoch & Sandler, 1982). The former doctrine considers nuclear weapons, which were for the most part provided by the USA, the central pillar of military deterrence. Nuclear weapons constitute a classical public good, on which all remaining NATO member countries were able to unlimitedly free ride. The latter doctrine encompasses deterrence by nuclear weapons as well as defense by conventional weaponry, which is considered a private good. While nuclear arms are still mostly under US-American control, conventional arms are available to the USA as well as all other NATO member states. The “Flexible Response” doctrine presents an adaptation of the joint-product hypothesis, as it assumes that nuclear deterrence and conventional defense to be complementary to each other. That is, the military potential of an increased nuclear capability of the USA is only fully exploited, if it is accompanied by increased conventional capabilities of the residual NATO members. As a consequence, free riding now is possible only within limits. The changing degree in free riding on allied defense is well described in the empirical research literature: While Dudley & Montmarquette (1981) find evidence for free riding, Murdoch & Sandler (1984) produce estimates in support of the joint-product hypothesis and a reduction of free riding. It is easy to see, how a slight variation of the joint-product hypothesis supports a positive relation between arms export and military expenditure. Suppose that, instead of nuclear and conventional weapons, different types of conventional weapons were complementary to each other (Murdoch & Sandler, 1984). Then, the arms exporting country only benefits from the arms deployment of an ally, if it itself deploys arms of a second kind, thereby increasing its military expenditure. Applying the previous example again, the US-American reconnaissance capability is only militarily valuable, if supplemented with naval capabilities, as provided by Germany. Exporting reconnaissance technology to the USA is therefore only beneficial to Germany, if it matches the subsequently increased US-American reconnaissance capabilities with higher military capabilities at sea, costs thereof are drawn from the national defense budget. Ultimately, defense good complementarity could be another factor explaining the positive relation between arms export and military expenditure within NATO.

This section concludes that the discrepancy in the arms export effect on military expenditure between the global dataset and the restricted NATO dataset may stem from the fact that within NATO either a high degree of political integration or coercion, defense specialization or defense good complementarity or any combination of these factors prevails. It is important to note that these factors are neither necessarily NATO-specific, nor should they necessarily be found in any military alliance. As the negatively estimated coefficients for arms export in the regressions of subsection 5.2 and 5.3 suggest, there exist military alliances, which members are prone to free riding, while NATO and possibly other alliances alike exhibit any or multiple of the features from above, accounting for the significantly positive arms export estimates in subsection 5.4. On global level, however, the effect of free-riding outweighs any counteracting effect, thus explaining the negative relation between arms export and military expenditure in the global dataset.

7. Concluding Remarks, Criticism and Research Prospects

Following previous literature on arms trade and defense good provision, this thesis proposed the hypothesis that a country, which trades arms with an ally, should anticipate the change in the defense provision of said ally and, taking the positive security externality into account, adjust its own military spending downwards. At first, the hypothesis was developed theoretically. In the context of a bilateral arms trade model, a country chooses the level of arms export relative to its own defense consumption, while it benefits from its trading partner´s military defense provision. The theory predicts that it is optimal for the country to decrease its own defense production, if it increases its arms export. Due to the model limitations, but also due to the idea that arms trade under positive security externality is more likely than under negative security externality, only the former was explicitly allowed for in the model. In the empirical part of this thesis, the hypothesis was tested using several regression models. Utilizing the data of Nordhaus et al. (2012), the empirical results of said paper were reproduced, before expanding the dataset by arms trade data stemming from the SIPRI database. The subsequent regression showed strong support in favor of the hypothesis with regard to arms export. From this point forward, the effect of arms import has been disregarded as the measurement unit of the corresponding variable raised interpretation issues. In an attempt to exclusively identify the effect of arms trade under positive security externality, the effect of arms export conditional on the arms trade balance was introduced in a third set of regressions. Although the corresponding estimate proved to further support the hypothesis, the approach suffered from econometric flaws. In a further attempt to focus exclusively on positive security externality, the dataset was reduced from 165 countries to the 19 countries, which were part of the NATO military alliance between 1951 and 2001. Stunningly, a complete reproduction of all previously conducted regression unanimously yielded arms export estimates contradictory to the hypothesis: NATO members significantly increased their own military expenditures, if exporting arms to NATO allies. Here again, interpretation might be limited due to NATO´s peculiarities and little exploitable variance in the dataset. Nonetheless, possible reasons, why the hypothesis does not hold true for NATO arms trade, were subsequently outlined, which included political integration and coercion, defense specialization as well as defense good complementarity.

On the basis of the presented empirical evidence, this thesis concludes that countries decrease their military spending, whenever they export arms, as they anticipate a positive security externality. This does not apply to NATO, and possibly other military alliances, which either eliminated the possibility of defense provision free riding or whose characteristics counteract free riding in another way. With regard to NATO, a raise in arms export causes an increase in military expenditure.

The theoretical and empirical testing of the hypothesis is not immune to criticism. The theoretical model only captures one of four possible combinations of security externality and arms trade. In a far more complex, multi-country model a simultaneous arms export and arms import decision of a country could be included, possibly by introducing defense good differentiation. Additionally, alliances and animosities between countries could be allowed for in a single model, which would add an additional layer to the arms trade decision of a country. With respect to the empirical model, it is uncertain, if the interaction term between arms export and the arms trade balance adequately fulfills its purpose. However, future research might pick up the idea of a proxy for security externality, on which the effect of arms trade can then be conditioned on, with the prospect of finding a more robust one. Moreover, the NATO data might be insufficient for the purpose of drawing general statements about the arms trade in alliances due to NATO´s many members, which trade none or only small amounts of arms. In general, this thesis relies heavily on the dataset provided by Nordhaus et al. (2012), for lack of an alternative data source. As the dataset was not set out to include arms trade, it potentially lacks crucial control variables. Although this issue was partially taken into account by including the arms trade turnover into the empirical model, other factors concerning the defense industry and arms production technology level might also play a role. Besides, the actual rate of the onset of war is omitted in Nordhaus et al. (2012). They find that the effect of the incidence rate of military disputes on military expenditure becomes insignificant, when the risk of armed conflict is controlled for. However, it is still discussed in the literature, if this is generally the case (Murdoch, 1995). In addition, the publicly available dataset in the International Organization Data Archive unfortunately does not contain a variable, which Nordhaus et al. (2012) use to track the number of combatant deaths.

Future research on the effect of arms trade on military expenditure might concern itself with one of the following issues. This thesis indeed showed that there is a significantly negative effect of arms export on national military expenditure. Still, it could not be determined, if the effect is inconsiderably small or hugely substantial. The fact that SIPRI measures arms trade in TIV units makes it impossible to quantify the effect of arms export in relation to military expenditure. Repeating the exact same or similar regressions as in this thesis, using reliable data on arms trade in PPP$ could solve this issue. Additionally, this could pave the way for a meaningful investigation of the effect of arms import on military expenditure. Furthermore, the presented explanations for a positive relation between arms export and military expenditure should succumb to empirical testing. Future regression models could, among other things, control for defense specialization and an ordinal ranking of the political cohesion within a military alliance. Also, a way needs to be developed to statistically measure and control for defense good complementarity. At last, the empirical analysis would greatly improve, if the global dataset reflected intra-alliance arms trade and accounted for military partnerships and alliances. Only then can the scaling down of the dataset to one particular military alliance, as done in this thesis, be avoided and the full potential of the dataset used. Countries in military alliances different from NATO might adjust their military expenditure differently, presumably downwards, when exporting arms. Measuring the effect of arms trade on military expenditure under positive security externality within different military alliances might then generate stronger and more resilient evidence in favor of the hypothesis of this thesis.

8. Appendix

A. $\frac{\partial \mathcal{L}_D}{\partial q_t} : \bar{\lambda}_1 = \frac{\bar{\lambda}_2}{p}, \frac{\partial \mathcal{L}_D}{\partial S_t} = \left(\frac{1}{1+r}\right)^t \frac{\beta}{\delta} = \bar{\lambda}_2, \frac{\partial \mathcal{L}_D}{\partial \lambda_{1,t}} = \bar{x}_D = D - p\bar{q}$

in $\frac{\partial \mathcal{L}_D}{\partial x_t^D} : 0 = \left(\frac{1}{1+r}\right)^t u_D'(D - p\bar{q}) + \left(\frac{1}{1+r}\right)^t \frac{\beta}{\delta}\frac{1}{p} = F(\bar{q}, p)$

B. $p'(q_t) = \frac{\partial p}{\partial \bar{q}} = -\frac{\overbrace{-u_D''p}^{>0}}{\underbrace{-u_D''q}_{>0}\underbrace{-\frac{\beta}{\delta p^2}}_{<0}} < 0$, if $\left|\frac{\delta p^2 \bar{q}}{\beta}\right| < \left|\frac{1}{u_D''}\right|$

C. $\frac{\partial \mathcal{L}_S}{\partial x_t^S} : -\left(\frac{1}{1+r}\right)^t \frac{u_S'(\bar{x}_S)}{c'(\bar{x}_S)\bar{x}_S + c(\bar{x}_S)} = \bar{\mu}_1, \frac{\partial \mathcal{L}_W}{\partial S_t} : \left(\frac{1}{1+r}\right)^t \frac{(d + e\bar{S})}{\delta} = \bar{\mu}_2, \frac{\partial \mathcal{L}_W}{\partial \mu_{2,t}} : \bar{S} = \frac{\bar{q}}{\delta}$

in $\frac{\partial \mathcal{L}_S}{\partial q_t} : 0 = p'(\bar{q})\bar{q} + p(\bar{q}) - \frac{u_S'(\bar{x}_S)(c'(\bar{q})\bar{q} + c(\bar{q}))}{c'(\bar{x}_S)\bar{x}_S + c(\bar{x}_S)} + \frac{d + e\frac{\bar{q}}{\delta}}{\delta} \equiv F(\bar{q}, \bar{x})$

D. $\frac{\partial \bar{x}_S}{\partial \bar{q}} = -\frac{p''\bar{q} + 2p'(\bar{q}) - \frac{u_S'(\bar{x}_S)}{c'\bar{x}_S + c(\bar{x}_S)}(c''\bar{q} + 2c') + \frac{e}{\delta^2}}{-\frac{\{[c'\bar{x}_S + c(\bar{x}_S)]u_S'' - [c''\bar{x}_S + 2c']u_S'\}(c'\bar{q} + c(\bar{q}))}{[c'\bar{x}_S + c(\bar{x}_S)]^2}}$, assuming $p'' = c'' = 0$; $u'' < 0$

$$\frac{\partial \bar{x}_S}{\partial \bar{q}} = -\frac{2p' - \frac{u_S' 2c'}{c'\bar{x}_S + c(\bar{x}_S)} + \frac{e}{\delta^2}}{-\frac{\{u_S''[c'\bar{x}_S + c(\bar{x}_S)] - 2c'u_S'\}\left(c'\bar{q} + c(\bar{q})\right)}{[c'\bar{x}_S + c(\bar{x}_S)]^2}}$$

Denominator: $-\frac{\overbrace{\{u_S''[c'\bar{x}_S + c(\bar{x}_S)] - 2c'u_S'\}}^{<0}\overbrace{\left(c'\bar{q} + c(\bar{q})\right)}^{>0}}{\underbrace{[c'\bar{x}_S + c(\bar{x}_S)]^2}_{>0}} > 0$, assuming $c' > 0$

Nominator: $\overbrace{2p'(\bar{q})}^{<0} \overbrace{- \frac{u_S' 2c'}{c'\bar{x}_S + c(\bar{x}_S)}}^{<0} + \frac{\overbrace{e}^{>0}}{\delta^2}$, assuming $u' > 0$

$\frac{\partial \bar{x}_S}{\partial \bar{q}} < 0$, if $\left|\frac{u_S' 2c'}{c'\bar{x}_S + c(\bar{x}_S)} - 2p'(\bar{q})\right| < \left|\frac{e}{\delta^2}\right|$, i.e. the nominator is positive.

9. Data Sources

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Declaration of Authorship

Hiermit erkläre ich, dass ich die Arbeit selbstständig und ohne Benutzung anderer als der angegebenen Quellen und Hilfsmittel angefertigt habe.

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