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Abstract

Economic benefits of joint procurement arise from increased bargaining power relative to the contractor and from economies of scale in production. There is, however, a puzzle: why are such procurements so few? This paper introduces a bargaining model with forward-looking expectations about the scale of delivery contracts. It is shown that the price sensitivity of the scale of acquisition is favourable for the buying partnership as it tends to depress the bargaining price. Several explanations are proposed for why it is hard to align the buyers' incentives. First, the preferences concerning the properties of the products are country-specific with divergent implications for national security. Second, a country with a low valuation of the product has more bargaining power than a country with a high valuation and may expect a side payment from the partner of the procurement, while the latter may not have sufficient incentives to pay. Third, the gains from cooperative procurement in terms of economies of scale for the producer may not be sufficient to compensate for the conflicting preferences among the contractors. Fourth, while the future unpredictability of technologies or the future risks of deteriorating national security might support longer-term joint procurements, short-term opportunism tends to prevent long-term commitments.

JEL Classification: H12, H41, H56

Keywords: joint procurement, defence materiel, bargaining, national security

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1 Introduction

1.1 Policy background

Recently, pressures have intensified among the member states of the European Union to create multinational programmes in terms of cooperative defence procurements. Such a view was forcefully advanced by the President of the European Commission, Jean-Claude Juncker in his speech at the Defense and Security Conference, *In defense of Europe*, Prague, June 9, 2017, stating: "*There are 178 different weapon systems in the EU, compared to 30 in the U.S. We allow ourselves the luxury of having 17 different types of combat tanks while the United States is able to manage perfectly well with just one model. Absurdly, there are more helicopter types then there are governments to buy them! We must do better*."

The defense materiel has become more and more sophisticated and technically advanced. As a result, its unit costs are constantly increasing[14]. In 2014, the defense budgets of the European Defence Agency [1] (EDA) members totaled 195 billion Euros, of which defense investments amounted to 34.7 billion Euros[2] [9]. The speech by Juncker points out that in addition to better facilitating the control of defense expenditures, qualitative improvements can be obtained by reducing the heterogeneity of the materiel within European countries. Indeed, as it is well-understood, Europe's defense expenditures do not match their efficiency with the comparable US expenditures, with the European Commission estimating that the EU would not even be half as efficient as the USA [10].

Over the years, it has been suggested that the cost savings of collaboration in the development of new defense materiel may be significant [5]. A recent NATO report on international cooperation calculates 40 percent savings for the Alliance in an aircraft acquisition example comparing a sole developer and consortium scenario, when considering a 95 percent learning curve and transaction costs [24]. However, while this example is purely theoretical, the report states that "international cooperation is characterized by a striking lack of empirical data on cost savings and operational gain" and "the costing data are usually either classified, too complex to evaluate, or the before-and-

[1] All European Union member countries are also EDA members except Denmark.

[2] According to the statistics reported by the EDA, the UK (10.3 billion euro) and France (9.7 billion euros) were the dominating countries in European defense investments (including R&D expenditures) in 2014. Germany was the third (4.7 billion euro). The 35 per cent benchmark of the EDA in European cooperation was met only by Spain (46 per cent), Italy (40 per cent) and Belgium (35 per cent) calculated over a 10-year period. Of course, the European average is held up by the UK, France and Germany which carry out most of the defense investments. [9]

after costs are not comparable". About the only public calculations available with savings figures are the Nordefco webpages, which estimate 100 M€ cost savings in common development, purchasing and maintenance of defense materiel during a fifteen-year period[25].

Ten years ago in November 2007, the Ministerial Steering Board of the EDA approved four collective benchmarks for investment: (i) Equipment procurement (including R&D/R&T): 20% of total defense spending, (ii) European collaborative equipment procurement: 35% of total equipment spending, (iii) Defense Research & Technology: 2% of total defense spending, and (iv) European collaborative Defense R&T: 20% of total defense R&T spending [8]. Faced with austerity and decreasing military budgets in the aftermath of the 2008 financial crisis, in 2012 NATO launched the Smart Defence initiative for developing, acquiring, operating and maintaining military capabilities in a cooperative manner for cost savings and efficiency [23]. Corresponding efforts by the EDA are called pooling and sharing where pooling refers to having capabilities on a collective basis while sharing means that some countries relinquish some capabilities with the assumption or guarantees that other countries will make them available when necessary [7].

Collaboration in defense equipment purchasing is not a novel idea. In 2008 there had been 59 collaborative acquisition projects in Europe since the early 50s [12]. Two of the main challenges of collaborative procurement are the harmonization of operational requirements between the participating States, and the agreement on common timescales for the program[12]. In addition, European defense collaboration has been inefficient and inflexible due to the *juste retour* (fair return) principle, where the industry of each participating nation should get a work share that corresponds to the financial contribution of its own government[26]. Collaborative defense procurement programs often incur long delays, both before the actual start of the program and during the development process, thereby providing the required capability much later than expected [12]. The conventional view is that more partner nations make collaboration more complex and inefficient, although they cannot confirm this hypothesis with their admittedly limited number of cases [11].

Collaboration in armament production has been attempted and has taken place between arms producing countries especially in Europe – though countries protect their domestic production with *juste retour*.[4] Regarding the collaborative equipment procurement benchmark, however, the efforts have not been realized up to the stated targets as the share of European collaborative equipment procurement between 2005 and 2014 was on average 17 % (EDA, 2107).

In the current article, cooperative purchasing is used to refer to two or more countries purchasing existing defense equipment, i.e. military off-the-shelf equipment, in contrast to collaborative purchasing where countries jointly develop and manufacture the equipment that they purchase. As there is no product development, purchasing cooperation holds fewer risks and has a smaller economical minimum unit size, thereby making such cooperation more feasible between smaller nations than collaborative development. In addition to the potential economic gains in purchasing, such as increased negotiation power and sharing of evaluation costs and information, common equipment may facilitate other cooperation benefits in maintenance and in operation phases, such as in training and in maintenance. In an estimation of the potential for cooperative purchasing between the Nordic countries, the same obstacles of matching time-scales[5] as well as similar enough requirements due to independent, national defense planning processes and differences in military

[4] For an early analysis, see [16].

[5] Defense equipment has long life cycle and renewal times and do not easily fall into same time-window. As an example of the timescales for decisions on fighter aircraft in the Nordic countries: Sweden has a fleet of JAS Gripens, Norway selected the F-35 in 2008, Denmark in 2016, while Finland plans to select an F-18 replacement in 2021.

tasks were found [18]. Valášek claims that decisions on how to co-operate and with whom should be rooted in a rigorous cost and benefit analysis, along with a thorough public discussion of their industrial and political impact [31]. However, these impacts are not easily quantifiable even if all the relevant data were unclassified.

1.2 Cooperative Purchasing

Cooperative actions been extensively studied both in private and public sectors but articles dealing especially with cooperation in purchasing are still quite rare [28]. Cooperative purchasing is definded as the cooperation between two or more organizations in a purchasing group in one or more steps of the purchasing process by sharing and/or bundling their purchasing volumes, information, and/or resources [27]. Through co-operative agreements, firms can take advantage of economies of scale in one or more of their production processes while remaining separate entities [22] and cooperation benefits such professionalism and information sharing [32] can be viewed as resulting from scale economies. A number of factors that facilitate more intense purchasing cooperation including a small number of participants, geographical proximity, and similarity in purchasing requirements [4]. Similarity in size also helps because when one big organization dominates, other participants tend to simply use its contracts. It is suggested that success factors for cooperative purchasing groups that include no enforced participation; all members contributing with knowledge and the fair allocation of savings [29]. The organizational form of purchasing cooperation may be determined by the degree of influence held by all members and the number of different purchasing activities involved [27]. In case of a low number of activities they identify a project group organization when all members have influence and a piggy-backing group when a large purchaser lets the smaller one(s) without much influence use its prices and contract [27]. The type of defense equipment purchasing cooperation in this article involves a low number of activities because a high number of activities would have a more intensive form and political implications.

1.3 Cases of Cooperative Purchasing of Defense Equipment

In recent years, there have been a few cooperative defense procurement initiatives in Europe. Table 1 contains a summary of such initiatives as well as their current status based on articles in Jane's Defense Weekly. The first column contains the equipment that the initiative aimed at procuring and if a selection has been made, the equipment type. Second column lists the countries involved while the third shows the publishing year of the source or, alternatively, the year of the project announcement. Then last column shows the latest status of the cooperative procurement initiative. Neither the purchase value nor number of units in question is shown because the former is not always announced while the latter may change before and even after signing the contract. Because the source contains initiative announcements in magazine articles, the table 1 may not be comprehensive.

Table 1. European cooperative defense procurement initiatives

Equipment	Countries	Year	Current Status
NH90 Helicopters	FIN, SWE, NOR, DEN	1999	Completed without DEN
JAS Fighters	CZE, SVK	2002	Cancelled
Transport Aircraft	CZE, SVK	2006	Cancelled
GM 403 Radar	FIN, EST	2009	Completed
IVECO Armored Vehicles	CZE, SVK	2009	Completed
UAV Global Hawks	15 NATO nations	2012	Agreed
A330 Tanker Aircraft	10 EDA nations	2012	NED, LUX agreed, NOR, POL, GER discussing
MAN Military Vehicles	SWE, NOR	2013	Completed with delays
Radar	CZE, SVK, (POL, HUN)	2014	Cancelled
Smart Bombs	Eight NATO nations	2016	Agreed (MoU)
Self-propelled K9 howitzers	FIN, EST	2017	Agreed

However, an overall picture emerges with just a few (11) cooperative purchasing initiatives regarding major defense equipment. Out of those initiatives, three involving the Czech Republic were cancelled while the other eight are either completed or at least not cancelled. Some initiatives have complicated histories with multiple twists and turns, such as the Nordic helicopter purchase with Denmark quitting the consortium, and the tanker aircraft where most of the initial initiative countries have pulled out, but now Germany intends to join again with an expected purchase decision by 2019 and the Rheinmetall MAN trucks initiative where reported issues included delays after Norway pulled out of the collaborative Archer project with Sweden as well as legal concerns with the deal. The Smart Bombs provided by the U.S.A. were enabled by a recent change in the American legal interpretation that until now excluded Foreign Military Sales to a consortium.

In terms of consortia, there are three large, multilateral projects involving NATO and EDA countries of which the Global Hawk is a Smart Defense initiative (Alliance Ground Surveillance) and the A330 Air Tanker is an EDA Pooling and Sharing initiative (Air-to-Air Refueling). The remaining initiatives in Table 1 include mostly just two, or in two cases, four small countries that are either Nordic or Visegard countries working together.

It would be natural to assume that given the small defense budgets of, say the Baltic states, cooperative procurements would be regularly adopted between these countries. Similarly, it would be expected that cooperative procurements would be typical among the Nordic countries. As Table 1 shows, this is not the case, and in fact the situation is quite to the contrary.

1.4 Research tasks

When it comes to considering the collaborative acquisition of materiel, i.e. collaborative R&D and production, the share of collaboration in the overall investment may be low because many countries want to protect their domestic industries and producers of the defense materials. There are also problems in the commitment to joint efforts within, say, NATO.[6] That there are so few cooperative purchases of materiel is harder to explain. It has been noticed that in a large number of cases, the advantage of cooperative purchasing outweigh the costs of cooperation and other disadvantages

[6] The free riding incentive in cooperative organizations has been analyzed by Holmström[13], 'Aspremont [6]and Jacquemin (1988), and Kamien, Muller, and Zang [15].

such as anti-trust (legal) issues and disclosure of sensitive information [29]. However, small and intensive purchasing groups do not flourish and such groups often prematurely end their cooperation. The economic benefits of a cooperative procurement as a joint venture arise from increased bargaining power relative to the contractor, and from reduced costs arising from economies of scale in production. They can be expected to provide economic incentives to participate in a procurement alliance. There are potentially other benefits like in collaboration, whose objectives may be grouped into three main categories: economic, operational and political ones [21].

There is thus a puzzle. Why are cooperative procurements of defense materiel so rare? [7] The current paper therefore asks three questions. First, under what conditions do the incentives in creating procurement joint ventures arise? Second, why do the cooperative procurement efforts so often fail? Third, when are cooperative procurement coalitions stable? To address these issues, a theory of cooperative procurements in terms of their impact on national security of the acquiring countries should be developed. The previous analytic literature on collective procurement is rather limited and no such a theory has been suggested in terms of an analytic approach. To develop such a theory, one has to introduce the trade-off between the cost savings and the impact of the procurement on national security in a case where the option of cooperative procurement is available but where the countries are heterogeneous with regard to their preferences.[8] Some data work is available. A study of the opportunities for cost savings arising from procurement co-operation between the Nordic countries finds – and this goes against the conventional wisdom – that the cost savings are quite limited as the Nordic countries tend to purchase equipment which are heterogeneous and aligned to national defense preferences [18]. Additionally, even if the national preferences are aligned for common equipment, the timing of purchase must be aligned, too. When legacy equipment with long life-cycles is replaced, it is rather unlikely that the timing of replacement needs would match between two countries. Of course, this is not a problem with new technology, which certainly is an enabling factor in the case of the Global Hawk UAV (Table 1).

In the development of the analytic model of the current paper, the following mechanisms are introduced. The defense structures in organizing national defense are typically nation-specific. Such a heterogeneity may result from the need for differentiated products and may require side payments

[7] Cooperative procurement represents an action which has some similarities to cartel formation. It is of interest, however, to point out that joint procurements do not violate EU legislation. The difference compared with, say the formation of a cartel (monopsony), is, however, that no gains in terms of price undercutting arise from a deviation from the partnership. Another analogy from non-defense industries would be consumer and producer cooperatives.

[8] It has been reported that in the case of NH90 helicopters, Finland was searching for a transportation helicopter, Denmark for a rescue helicopter, Norway for a helicopter for catching submarines, and Sweden wanted a helicopter with all these properties conditional that the helicopter would have Saab systems [19]. As an amusing anecdote was asuggestion by one of the countries that the helicopter should have an option for toilets while another country demanded that the option should include a toilet both for male and female soldiers [20]. The final offer by the producer included the option for a toilet but was so expensive that the toilet option was disregarded on short notice. There was more to it. Of the 18 NH90 TTH helicopters ordered by Sweden, 13 were of high cabin versions facilitating surgery operations to be carried out by taller male doctors [17].

("bribes") between the members in the joint venture to make it sustainable.[10] This appears a harsh requirement. The potential opportunism in collective procurement may be controlled and commitment sustained if the interaction between the coalition and the producer is repeated and if the partners adopt appropriate punishment strategies for sustaining the partnership, such as abstaining from future commitments in a credible manner. Folk Theorem suggest then that the set of feasible potential contracts is rather large but that some punishment strategies are needed to secure the survival of the partnership. Such a punishment may include the exclusion of the deviating partner member from the economic benefits from the subsequent cooperative procurements. The paper shows, however, that long-term commitment may be even more difficult to achieve not least because of the uncertainties attached to the future development of the defense needs in strengthening national security and the unpredictability of the advancement of new defense technologies.

There is a further subtle issue. At the negotiation table, the participants apparently understand that the unit price to be settled will have an impact on the scale of the acquisition. The paper plans to address this issue. It will show that the price sensitivity of the scale of acquisition is favorable for the buying partnership as it tends to depress the bargaining price.

2 Cooperative procurement: an economic analysis

2.1 Basic set-up

In this section, the option of establishing a joint venture on cooperative procurement between several (two) countries in considered. There are some basic issues to be analyzed. The question of as to how the incentive to establish a joint venture for procurement may arise is analyzed first. It is then asked, whether the incentives to commit the country to a joint venture can survive or fail.

In the model world of the current paper, there are three countries *A, B* and *C*. Countries *A* and *B* are the potential buyers, country *C* is the delivering country.[11] The time-line of the model world is as follows. There are four stages (0, 1, 2, 3). In stage 0, country *C* evaluates whether it is worthwhile to develop a new product. The expected future revenue has to cover the development cost, *D*. In stage 1, countries *A* and *B* establish a joint venture to scrutinize the products available. Initially, they have private information on their defense needs. In stage 1, both countries, however, prepare a "list" of the preferred properties of the product under study thereby revealing their country-specific preferences.[12] The venture learns about the quality of the products produced by country *C*. The

[10] The economic theory of coalition formation has highlighted the free riding incentive.

[11] By focusing on joint acquisitions and in order to keep the theoretical model analytically tractable, the model thus abstracts from domestic production of defense materiel. It therefore is most relevant for the case of small countries.

[12] Backward induction will be applied to solve the two-stage decision-negotiation problem. Because the decision process involves expectation mechanisms, the model is quite involved. For this reason and to obtain analytic solutions in various stages, the basic structure of the model is kept as simple as possible. The backward induction procedure guarantees that the solution is time-consistent and that the expectations of the partners in the model world are rational.

products are multidimensional and technologically sophisticated and the product comes in two varieties, a basic one and a more sophisticated one.[13]

In the spirit of the statement by President Juncker (cf. Introduction), the preferences of the buyers do not (necessarily) coincide, in which case the countries need to evaluate the benefits and costs of whether to enter the price negotiation as a team or individually in stage 2 with country *C*. If the benefits exceed the costs despite the differences in preferences and if the variety to be chosen for the cooperative procurement can be agreed, the countries negotiate collectively. In stage 3, the countries decide individually on how many units of the materiel to buy.

Let the varieties be denoted by 1 (a more sophisticated variety) and 2 (a less sophisticated variety). Country A prefers the more sophisticated product to the less sophisticated one. With country B, it is the opposite. Denoting the country-specific valuations with v^A and v^B, it holds that

$$v_1^A > v_2^A, v_1^B < v_2^B. \quad (1)$$

A sufficient matching between the qualities of the product and the national preferences enhances welfare more than a more limited match. *The valuation of the product can be thought of being related to the substitutes available in the market for the defense material.* The contracting process may be repeated in the future when or if such a need arises for countries *A* and *B*.

The analysis of the current section focuses on the case where the sophisticated version will be the object of the contract between the joint venture and the delivering country. The analysis of the case where the basic product would be acquired is analogous.

As the preferences differ between the countries *A* and *B* they have thus two options in stage 2. They can negotiate separately (and have lower bargaining power). Alternatively, one of the countries, say *Country A* with a preference for the more sophisticated product can offer a side payment ("bribe"), $s > 0$, to country *B* to keep it in the team in order to have greater negotiation power against the delivering country *C*.[14] If it is the basic version of the product which is acquired, country *B* may end up paying a side payment to country *A*.

If the two countries negotiate collectively their joint bargaining power is θ_H while it is θ_L if they negotiate separately. It therefore holds that

$$\theta_H > \theta_L. \quad (2)$$

[13] Alternatively, the heterogeneity of the varieties may result from the different timing preferences of the delivery.

[14] When it is country *A* which prefers the more sophisticated product while country *B* does not, it may have to compensate country B for its participation through some compensation mechanism. Of course, country B may join even in the absence of a compensation if the gains from the cooperation exceed the opportunity cost of not participating.

Despite such a natural assumption, it is not solely decisive for the results of the current paper. Analogously, the bargaining power of the delivering country is denoted by $1-\theta_H$ and $1-\theta_L$. The absolute value of the bargaining power of the delivering country is related to its market power.[15]

To develop and produce the product, the delivering (firm of) country *C* faces a sunk cost for the development, a fixed cost for production and a variable cost. If only to simplify the notation and without loss of generality, the development cost *D* is set to zero. The fixed cost is set to $F > 0$ and the variable cost nk where $k > 0$ is the marginal cost of production.[16] The total production cost is thus

$$TC = F + nk \tag{3}$$

Thus, economies of scale are assumed in the cost structure in that the average cost of production, $AC = TC/n = F/n + k$ declines in output *n*. Notice that there are cost savings for the producer if the producer delivers one type only, otherwise not.

2.2 National security and welfare

The national security, *S*, of countries *A* and *B* represents a public good and is assumed to be related to the scale of the delivery contract, *n*. Each unit of arms contributes to the national security but at a declining rate at the margin. Therefore, it is convenient to allow the production function of national security, *S*, be represented by

$$S^i = \sqrt{\alpha n^i v^i}, \quad \alpha > 0, i = A, B \tag{4}$$

where $\alpha > 0$ is a measure of the (technical) effectiveness of the defense materiel acquired and v^i is the country-specific valuation of the material.[17] The demand for the defense material will be price-sensitive, $n^i = n^i(p)$. Denote $S = S^A + S^B$. For the subsequent analysis, a notation for the negative security effect of a higher unit price of defense materiel on the partnership is introduced as follows

$$\Delta S = \frac{\partial S^A}{\partial p} + \frac{\partial S^B}{\partial p} < 0. \tag{5}$$

From (4),

$$\frac{\partial S^i}{\partial p} = \frac{1}{2}\sqrt{\frac{\alpha v^i}{n^i}}\left(\frac{\partial n^i}{\partial p}\right) < 0. \tag{6}$$

[15] A great producer can benefit from the economies of scale in production. The greatest producer of the defense materiel in the world is the United States. Among top 100 producers of defense materiel, the share of US firms is 57 % while that of Great Britain is 10 %, France has 4 %, and for example the share of the Swedish firms is 0.7 %[30].

[16] Apart from the role of the declining average cost, another mechanism for the economies of scale is provided by the so called "learning by doing" hypothesis [1].

[17] Differences in the valuation variable may also arise from different timing of when a country needs to have access to the new materiel.

In stating the price effect on the national security in (6), acknowledgement is introduced concerning the subsequent price effect on demand, $\left(\frac{\partial n^i}{\partial p}\right)$, which will be analyzed below in Section 2.3.

Now let $\lambda > 0$ denote the social cost of public funds per unit of tax revenue.[18] Then the social welfare function serving as a criterion for the decision making of country *A* and country *B*, assumed to be cardinal, can be expressed as

$$w^i = \sqrt{\alpha n^i v^i} - (1+\lambda) n^i p, \quad i = A, B \tag{7}$$

The country-specific decision variables are n^A, n^B. It is assumed that the benefit/cost ratio of the national security is greater than one, i.e.

Assumption 1. $w^i > 0, \quad i = A, B.$

2.3 Optimal scale of acquisition in buying countries

To obtain the time-consistent solution, the model will be solved by backward induction. Once the contract has been signed, the price p is determined and the countries identify the welfare maximizing scale of the acquisition.[19] An evaluation of the first-order condition from

$$max_{n^i}\, w^i, \quad i = A, B, \tag{8}$$

gives the solutions as

$$n^{i*} = \frac{\alpha v^i}{4(1+\lambda)^2 p^2}, \quad i = A, B. \tag{9}$$

The comparative statics are as follows. A high valuation v^i and high degree of effectiveness of the defense material α enhance the optimal scale of acquisition for the desired product. In cases where the material becomes more expensive, there is a fall in the quantity demanded. From (9), the price elasticity is

$$e_p = \frac{\left(\frac{\partial n}{\partial p}\right)}{\left(\frac{n}{p}\right)} = -2. \tag{10}$$

Notice that though the price elasticity is a constant parameter, the price sensitivity

[18] This approach is typical in the public finance literature.

[19] Trade in defense material is, of course, often used as an instrument for political power. Our paper is welfarist in that the public choice issues will not be discussed.

$$\frac{\partial n}{\partial p} = -\frac{av}{2(1+\lambda)^2 p^3} < 0 \qquad (11)$$

can be small or large by its absolute value. Moreover, a high tax cost $(1+\lambda)$ depresses the demand,

$$e_\lambda = \frac{\left(\frac{\partial n}{\partial \lambda}\right)}{\left(\frac{n}{\lambda}\right)} = -2(1+\lambda) < 0. \qquad (12)$$

Inserting the solution (9) into (4) and (7), the implications for national security and welfare are summarized as

$$S^i = \frac{\alpha v^i}{2(1+\lambda)p},\ w^i = \frac{\alpha v^i}{4(1+\lambda)p}. \qquad (13)$$

In principle, this relationship can be used to quantitatively evaluate the impact of the new defense material on national security.

2.4 Cooperative procurement

The suggestion that the contracting parties are forward-looking makes the analysis of the bargaining process more complicated than anticipated. Several mechanisms are involved. It turns out that the bargaining price in equilibrium will be conditional on the scale of the deliveries through the price expectations. To develop the insight on results, it is, however, helpful to also limit consideration to a situation where the negotiating partners focus on the price, disregarding the forthcoming price effect on demand. Before looking into this case, the general bargaining model needs to be worked out first.

Understanding the forthcoming scale of the delivery (9) in countries *A* and *B*, this section introduces the price bargaining between the partnership and the producer. Recall that we consider the case where it is the variety which is preferred by country *A* which is to be negotiated. The easiest way of thinking about the negotiation is that there is an agent who represents the diverging interests of the partnership with, say, equal weights, ½. Then, a generalized Nash bargaining solution can be stated as[20]

$$max_p\ \Gamma = w^{\theta_H} u^{1-\theta_H} \qquad (14)$$

where the value of the contract to the joint partnership is provided by the weighted average

[20] The solution to such a negotiation is called a Nash bargaining solution (Nash (1950, 1953)). A Nash bargaining solution is a Pareto efficient solution to a Nash bargaining game. In this game, the solution consists of each player getting her status quo payoff (i.e. the noncooperative payoff) and an addition to a share of the benefits occurring from cooperation. Many applications of the Nash bargaining process allow for differences in the negotiation power. This idea is also built into the model of the current paper.

$$w = \frac{1}{2}w^A + \frac{1}{2}w^B \quad (15)$$

and the value to the delivering country is

$$u = np - (F + nk). \quad (16)$$

The threat point in the bargaining game is thus assumed to be (0,0). Having a positive threat point for the partnership would complicate the notation unnecessarily without any essential further insight. To highlight the threat point for (the firm or country) *C*, it will not participate in development or delivery unless the cost of development and the production cost are expected to be covered by the contract.

In the cooperative procurement, the scale of the contract is given by

$$n = n^A + n^B. \quad (17)$$

Taking the logarithms,

$$p^* = \arg max_p \; log \; \Gamma = \theta_H \log(w) + (1 - \theta_H) \log(u) \quad (18)$$

The function Γ is continuous for all $p \geq 0$ and has the first and second derivatives in that domain. Its concavity in the price is no issue because of the logarithmic transformation. The first-order condition is given by

$$\theta_H \frac{w_p}{w} + (1 - \theta_H) \frac{u_p}{u} = 0. \quad (19)$$

The contract is subject to the incentive constraints of country *B* in participating, country *A* in paying a potential side payment (to be analyzed below), and country *C* in developing the product. The first-order condition for the bargaining price can be developed as follows

$$\theta_H \frac{\partial(S^A + S^B - (1 + \lambda)np)/\partial p}{S^A + S^B - (1 + \lambda)np} +$$

$$(1 - \theta_H) \frac{\partial\big(np - (F + nk)\big)/\partial p}{np - (F + nk)} = 0.$$

When evaluating the derivatives, recall $n = n(p)$ from (9) and $S = S^A + S^B$. Multiplying the denominators, the condition can be stated as

$$ap^2 + bp + c = 0 \tag{20}$$

with parameters

$$a = -(1+\lambda)\left(\frac{\partial n}{\partial p}\right)n > 0$$

$$b = \theta_H\left[\Delta S n + (1+\lambda)(F+nk)\left(\frac{\partial n}{\partial p}\right)\right] + (1-\theta_H)[S + k(1+\lambda)n]\left(\frac{\partial n}{\partial p}\right) - (1+\lambda)n^2 < 0$$

$$c = \theta_H[-\Delta S + (1+\lambda)n](F+nk) + (1-\theta_H)\left[n - k\left(\frac{\partial n}{\partial p}\right)\right]S > 0.$$

Solving (20) for the bargaining price,

$$p^* = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}. \tag{21}$$

The solution must be a real number instead of a complex one, therefore the parameters of the model have to satisfy the condition $b^2 - 4ac \geq 0$. The parameter space of the model is rich enough in that combinations of parameters exist which satisfy such a condition. To state explicitly,

Assumption 1. The solution is examined in the case where

$$b^2 - 4ac \geq 0.$$

However, there are still two solution candidates given by the two real roots, say $0 < p_1 < p_2$. As $-b > 0$ and $\sqrt{b^2 - 4ac} < -b$ (because $ac > 0$), it follows that the bargaining process must have one maximum in terms of the negotiation price, and one minimum. As

$$\frac{\partial \log \Gamma}{\partial p}_{|p=0} > 0,$$

it follows that only the smaller root qualifies as the maximum and the greater root represents the minimum. We state:

Lemma 1. Of the two candidates, the smaller one

$$p^* = \frac{-b - \sqrt{b^2 - 4ac}}{2a} \tag{22}$$

qualifies as the solution for the bargaining price.

Two comments have to be made concerning the solution for the contract price (22). First, as the demand for the product is negatively related to the contract price in the next stage of the contact, this dependency is essential for rational price negotiation in the previous stage. Second, the result (22) does not represent a closed-form solution to the negotiation price but instead provides an informative *characterization* of the solution at the equilibrium. The reason is that the right-hand side of (22) includes the price variable implicitly through the *a*, *b* and *c* -parameters.[21]

The solution (22) suggests in which way the contract price depends on the effectiveness of the defence materiel (α), the level of bargaining power (θ_H), the social cost of public funds (λ), and the buyer's price-sensitivity: $\left(\frac{\partial n}{\partial p}\right)$. Under given expectations, the effects of exogenous parameters on the negotiation price can, in principle, be traced by studying their effects on the *a*, *b*, and *c* -parameters. The logic of the model requires, for example, that the efficiency of the defence materiel in sustaining national security increases, ceteris paribus, the willingness to pay a higher bargaining price, $\frac{\partial p}{\partial \alpha} > 0$. Parameters -*b* and *c* indeed are positively related to α through national security, *S*, and accordingly, so is the bargaining price p^* through these parameters. The effect of increased bargaining power of the partnership, ceteris paribus, leads to mutually offsetting price effects through -*b* and *c* parameters and the net effect depends on the price sensitivity of demand. The effects of the cost of public funds λ increases the value of *a*, thereby reducing the bargaining price as it should. However, its impact through the -*b* and *c* parameters again is the opposite, resisting the negative price effect. The reason for such complications is that the contract price is not immune to the what the negotiating partners expect of its effect on the scale of delivery in the implementation stage of the contract, $\left(\frac{\partial n}{\partial p}\right)$. Sharper conclusions on the comparative static effects are available where the price effect on demand $\left(\frac{\partial n}{\partial p}\right)$ is very small, namely when the availability of substitutes makes the valuation of the product more limited, or where the bargaining partners simply ignore it. Therefore, introduce $\left(\frac{\partial n}{\partial p}\right) = 0$ as the limiting case in (22). This also implies that $\Delta S = 0$. Then, the bargaining price simplifies to

$$p = \frac{\theta_H[(1+\lambda)(F+nk)-S]+S}{(1+\lambda)n}. \qquad (23)$$

The profit condition of the producer, $np > F + nk$ and the welfare condition of the partnership imply

$$(1+\lambda)(F+nk) - S < (1+\lambda)np - S < 0.$$

Therefore, it follows from (23) that $\left(\frac{\partial p}{\partial \theta_H}\right) < 0$. We have established that

[21] Such a characterization is typical in other fields of economics – in optimal tax theory in particular.

Proposition 1. *Even though the price effect on the scale of delivery is small or ignored, increased bargaining power of the partnership results in a more favorable contract price.*

The supplier is able to make the cost of production, $F + nk$, be capitalized in the bargaining price, $\frac{\partial p}{\partial F} > 0, \frac{\partial p}{\partial k} > 0$. An increase in the scale of the acquisition, tends to reduce the unit price as the fixed cost per unit of output *F/n* is reduced. This effect can be seen by dividing both the numerator and the denominator by *n*. (We state "tends" as there is also an opposite effect.) Improved security of the partnership, *S*, raises the negotiation price. The effect of the tax cost $(1 + \lambda)$ remains somewhat ambiguous, though one would expect intuitively a negative impact. Finally,

Increased bargaining power of the partnership should reduce the bargaining price, $\frac{\partial p}{\partial \theta_H} < 0$. The numerator of (23) is indeed reduced. However, there is also a similar effect in the denominator. This means that the it is possible to verify the claim with full certainty, not at least in the case where the demand effect is ignored.

The results derived for the case where the bargaining parties simply ignore the subsequent quantity effects do not disappear when anticipatory behavior is taken into account but there will be additional mechanisms through the demand function (12) in terms of the national security effect in the model.

In summary, the conflicting interests between the producer and the partnership in the price negotiation are balanced by the economies of the scale effect and the security effect. The solution (21) suggests that the solution for the price is unique and stable – even though the general solution (20) involves feedback mechanisms between the price and demand. Our model suggests, that *the contracting process balances the economies of scale effects of the producer and the security effect of the buyers.*

The intuition suggests that the contracting price is low when the price sensitivity of the partnership, $\left(\frac{\partial n}{\partial p}\right)$, is high and that it is higher when the price sensitivity is low. To examine, write the solution for the price as

$$p = \left(-\frac{b}{2a}\right) - \sqrt{\left(-\frac{b}{2a}\right)^2 - \frac{c}{a}}.$$

After some algebra, the first term can be evaluated as

$$\left(-\frac{b}{2a}\right) = \frac{-1}{\left(\frac{\partial n}{\partial p}\right)}(1+\lambda)n[-\theta_H \Delta S n + (1+\lambda)n^2] + \varphi > 0,$$

where φ is a positive constant.

2.5 Country-by-country negotiation

The above analytic model can be employed to cope with country-by-country negotiation. Recall that country *A* values (the sophisticated) product more than country *B*. This means that it is willing to buy more of it than county *B*, $n^A > n^B$ (recall the demand function (12)). If country *B* also enters a deal, it buys the basic product better matching its preferences (and potentially with a different effectiveness parameter α). The producer has, however, to pay twice the fixed cost to the extent the production lines must be duplicated and thereby it loses some of the economies of scale. In individual bargaining, the bargaining power for both *A* and *B* is reduced. In the general model with solution (20), there are again mutually offsetting effects obscuring the total effect somewhat. Resorting to the limiting case (21), the following conclusion is available:

Proposition 2: *Vanishing bargaining power in individual country-by-country bargaining always result in a higher price $p^A > p$ for country A and $p^B > p$ for country B. Cooperative procurement always results in a lower contract price than country-by-country bargaining.*

In the general model, the price effect reduces the demand. Both buyers face a higher price. Country *A* is definitively a loser. However, the country security effect on country *B* is positive as it obtains the variety it prefers. It may actually gain from country-by-country negotiation, even though it faces a higher price. It therefore follows:

Corollary 1. *Country A always loses in the country-by-country negotiation while country B may gain or lose. Therefore, country A with a higher valuation of the product always has an incentive to enter the joint bargaining.*

As country *A* values the product more than country *B,* cooperative procurement results in an externality for country *B.* Country *B* has to pay an overly high price for the product which it does not prefer. This makes country *B* strong in terms of negotiation power within the cooperative procurement. Can country *B* benefit of its position? Yes: it can demand a side payment from country *A* to be analyzed in the next section. Unless country *A* is ready to accept the side payment, the cooperative procurement fails. It thus fails, if the incentive constraint of either country is violated. When it is country *B* whose incentive constraint is violated, country *A* can attempt to "bribe" country B to collaborate in the acquisition.

Proposition 3. *A country with a low valuation of a sophisticated product has strong negotiation power and may demand a side payment to participate in the cooperative procurement. If the country-specific valuations of the product are sufficiently different, the cooperative procurement fails.*

The graphical presentation below illustrates the outcome of the negotiation process under individual and collective bargaining. The *FF* -curve describes the available surplus under the two scenarios.

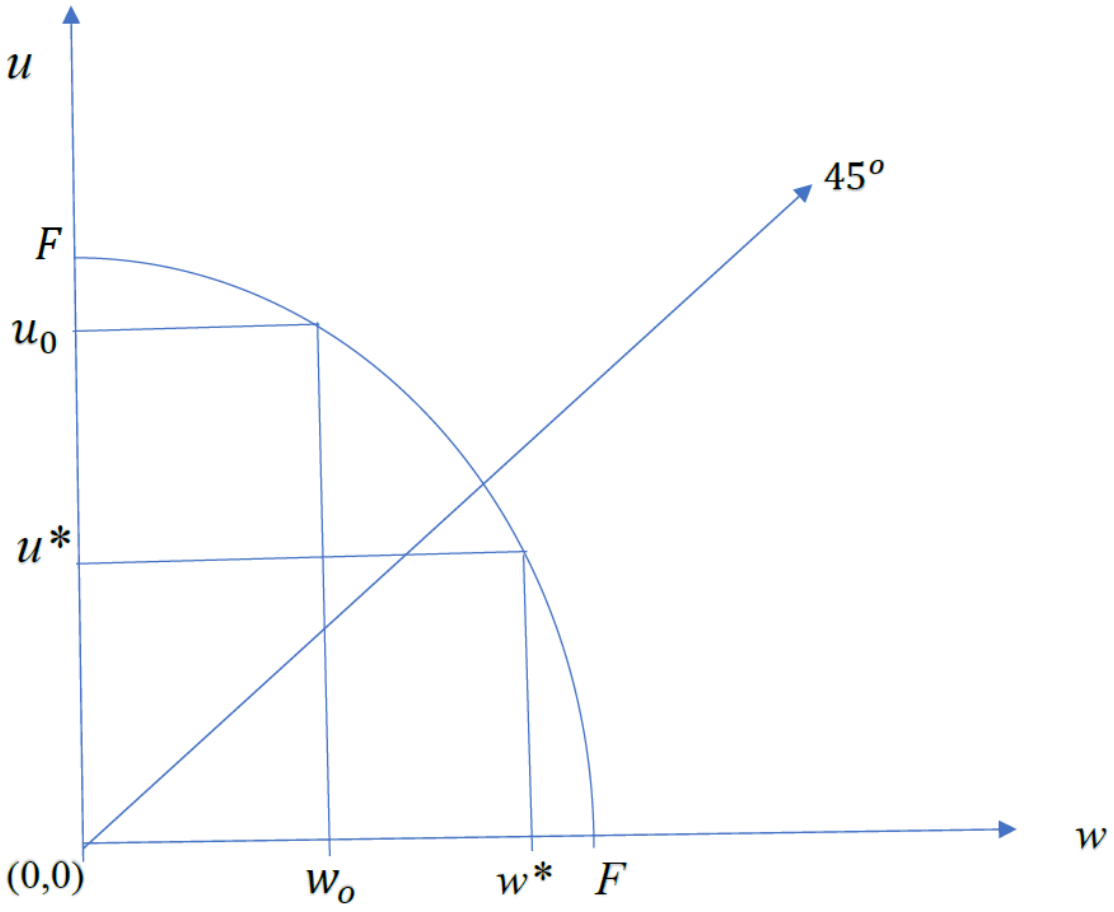

Figure 1. The outcome of price bargaining with individual (w_0, u_0) and collective (w^*, u^*) bargaining.

Under individual bargaining, the producer has a rather strong position and is able to capture a substantial share of the available surplus. Under collective bargaining, the cooperative procurement shares the surplus more in favor of the buyers.

2.5 The economics of side payments

In the model above, it is assumed that the negotiating partners are forward-looking in that they pay attention to the price effect on their desired scale of the delivery. When this effect is small, it was possible to confirm that individual bargaining definitively results in a higher price for both *A* and *B*. The national security of *B* and thus its welfare could, however, be increased because through individual bargaining *B* has access to the preferred product. The incentive for *B* to join the partnership is dictated by the welfare gain,

$$w_c^B - w_0^B, \tag{23}$$

where w_c^B is the welfare under cooperative procurement and w_0^B is the welfare under country-by-country bargaining.

If (23) is positive, *B* may prefer the partnership solution even without a side payment. However, if (23) is negative, it will join only if *A* commits to pay a sufficient side payment.

Consider the incentive constraint for country *B*. A less expensive and less sophisticated product would satisfy its needs, but as a partner it has to participate in a contract which is less expensive but does not sufficiently match with its needs. The incentive constraint for country *B* for participation can therefore be stated as

$$w_c^B + s - w_0^B \geq 0 \tag{24}$$

The incentive for country *A* to commit to the partnership is that the side payment which it has to pay to country *B* satisfies

$$w_c^A - s - w_0^A \geq 0 \tag{25}$$

where w_c^A is the welfare under cooperative procurement and w_0^A under country-by-country bargaining.

To conclude,

Proposition 4. *For the coalition to be sustained, it is necessary for a partnership member with a higher valuation of the product to have an incentive of committing to pay a side payment to the partnership member with a lower valuation of the product in the case where the incentive constraint of the latter country is violated.*

3. Future defense needs and repeated bargaining: Is a longer-term view relevant?

The above results help to explain the real-world experience in that cooperative procurements are not that frequent. Our analysis was based on a one-shot interaction between the candidate countries for cooperative procurement. It is not, however, excluded that longer-term commitment to cooperation might have its benefits. Why would a longer-term commitment appear lucrative? The answer is obvious: uncertainty about the future. Indeed, future needs to strengthen defense capacity are subject to uncertainty and countries are not aware of those future needs at any particular point in time. The evolution of the needs may arise from unpredictable advancements in technology making earlier defense equipment obsolete suggesting that it should be updated periodically. The need to update the defense materiel may alternatively arise from a deterioration in national security. Therefore, the option for commitment to long-term partnerships vs short-term opportunism might arise. Political reasons or military developments may support longer-term partnerships. This section, explores such a prospect.

Longer-term cooperation might result in benefits which are not exploitable under short contracts. To make a commitment credible, however, there obviously need to be some punishment strategies in place for the case of breaking the cooperation pact. It has been suggested in the theory of repeated games that the so-called tit-for-tat strategy is particularly successful in repeated games to sustain efficient cooperation.[22]

To explore longer-term relations, assume again two countries, *A* and *B*, with current valuations in terms of the national security, w_A, w_B, for a defense product. Due to technological development, the future valuations may, however, be unpredictable. Let the expected valuations of the future needs be denoted by w_A^e, w_B^e. Let r denote the social rate of time preference for the countries.[23] Then, the present values of a permanent side payment contract between countries *A* and *B* are

$$\left(\frac{w_A^e - s}{r}, \frac{w_B^e + s}{r}\right).$$

It was concluded above that country *A* always prefers cooperative procurement over individual bargaining while *B* may not support the partnership in a once-and-for-all negotiation. In a repeated interaction, the case is more complicated as *B* might reconsider the future gains – and they might outweigh the gains from short-term opportunism,

[22] Using computer simulations, Axelrod) had observed that the tit-for-tat strategy was the most successful in its ability to maintain long-term cooperation in repeated games [2 ,3]. The tit-for-tat strategy means choosing cooperative action in the first round, and in subsequent rounds of a game, choosing the action that the other player chose in the previous round. This strategy results in a situation where cooperation is sustained once it begins, but noncooperative behavior is punished by a lack of cooperation in the next round of the game.

[23] Asymmetric deterioration of national defense may make the national time preferences diverge from each other.

$$\frac{w_B^e+s}{r} \geq w_B + \frac{(1+r)w_{B0}^e}{r}. \quad (26)$$

The left-hand side gives the long-term gains for *B* from the long-term relationship. The first-term of the right-hand side stands for the welfare of a one-period delivery contract when negotiating alone with country *C* in future periods. Short-term opportunism arises from a current valuation of the replacement technology, say with a lower contract price. The cost of such opportunism is captured by the second term in (26) where in the spirit of the tit-for-tat punishment means that the partnership gains are no longer available and the expected benefits drop to w_{B0}^e once country *B* has deviated from the joint contract. Therefore, the conditions (26) state the incentive condition for country *B* to stay in the partnership.

A sufficient side payment by country *A* facilitates a long-term partnership. Is country *A* willing to pay? It is if the required side payment s^* is sufficient to satisfy

$$\frac{w_A^e-s}{r} \geq w_A + \frac{(1+r)w_{A0}^e}{r}, \quad (27)$$

where the notation is analogous to that in (26).

It is well-known from the theory of the repeated games that the gains from cooperation can be shared in a number of ways ("the Folk Theorem"). The real issue is whether the cooperation can be made sustainable. The country *A* is able to prolong the partnership relationship by raising the side payment but there is a limit to this. For this reason we state,

Proposition 5. *Long-term partnership procurement contracts are not viable if the expected future defense needs between potential partners deviate substantially. A high social discount rate makes the alignment less expected as it makes the partners attach a low valuation to the distant future.*

A country which realizes that its future need has been reduced more than that of its partner, may have an incentive to deviate from the joint partnership to take the advantage of its currently lower valuation and hence of the resulting increased bargaining power relative to the partnership member. This is country *B* in our model. Then, a country with an increased valuation (this is country *A* in our model) may have to pay a higher side payment and has to evaluate whether it is worthwhile doing it. It may also try to eliminate such an opportunistic incentive for its partner by adopting a tit-for-tat punishment strategy breaking the venture forever. [24]

[24] In the current analysis, it has been assumed that the buying countries are independent. A point can be made that within an alliance there is a further gain from joint procurements not discussed here: joint procurement tends to enhance the compatibility of the defense material acquired. The case of the Baltic states – all NATO members – however, points surprisingly to the opposite case: those states decide on their materiel acquisitions purely on a national basis without paying attention to the compatibility gains arising from joint procurements.

4. Summary and concluding remarks

The paper has summarized the cooperative defense procurement initiatives than have been launched in Europe in recent years. There have been only a few of them and this is a puzzle. The economic benefits of cooperative procurement are evident: it increases the bargaining power relative to the contractor, and the economic scale effect points to lower prices. The cost savings can be expected to be substantial. To address the issue, the paper has introduced a bargaining model with forward-looking expectations concerning the scale of the potential contracts. Such a model can be used to answer several questions, (i) under what conditions can there be sufficient incentives in building procurement joint ventures? (ii) why are these not sufficient to generate more cooperative procurements? (iii) can cooperative procurement coalitions be stable arrangements despite changes in the technologies or national security?

To summarize, the paper has identified several reasons why it is hard to align the incentives of the buyers. The fundamental problem with cooperative procurements appears to be the heterogeneity of preferences concerning the qualities of the defense products. With independent national decision making and country-specific needs, it is hard to achieve compatibility between defense material between buyers. To take an example, an important source of heterogeneity apparently arises from different timing requirements as to when acquisitions are needed in various countries.

It is highly plausible that cooperative procurement would result in increased bargaining power of the buyers relative to the producer. However, the results of the analysis have shown that these gains may not be sufficient to compensate for the loss of compatibility of the product because the preferences of the buyers are country-specific. This holds true even though the economies of scale effects are partly shared by the producers with the partnerships of the buyers. The paper has further shown that side payments may facilitate the sustainability of the partnership, but it is easy to understand how difficult such a procedure would be in practice. Finally, the paper has shown that long-term commitment may be even more difficult to achieve not least because of the uncertainties attached to the future development of the defense needs in strengthening national security and the unpredictability of the advancement of new defense technologies. A long-term commitment to repeated cooperative actions between independent nations would necessitate trust between nations to the extent that future expected gains would exceed short-term costs.

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