CHAPTER 5

NATO and Europe: Improving Efficiency

Abstract  The chapter provides details on European defence policy and the scope for improving efficiency and the impact on NATO. The features of defence industries are presented and the challenge of developing an efficient defence industrial policy in an alliance. Collaboration and its inefficiencies are reviewed.

Keywords  Defence industries • Collaboration • Action Plan

INTRODUCTION

Europe’s position in NATO raises efficiency and burden-sharing issues. This chapter focuses on efficiency issues. Efficiency is defined, defence markets are described and defence industries are reviewed. European defence policy is outlined and analysed, including its potential impact on the future of NATO. If European defence and defence industrial policy are successful, they might create an alternative to NATO with the possibility of the EU leaving NATO.

Understanding the efficiency issue starts from the fact that NATO members are independent nation states and not a single unitary (e.g. UK) or Federal state (e.g. the USA). As a result, there is no single political entity for the whole of NATO and it is an organisation which has to pursue its objectives subject to the constraints of nation states. Expressed
more formally, it seeks to maximise defence output subject to national constraints. These constraints take the form of national preferences (e.g. for independence), national defence budgets, national armed forces and national defence industries. Public choice analysis shows how political factors form policy constraints. Interest groups of defence ministries, armed forces and defence firms seeking budgets, incomes and rents have incentives to identify the military and economic benefits of buying weapons from domestic suppliers (e.g. jobs, technology, export benefits) which is the source of inefficiency in NATO defence markets.

Efficiency is central to economics and focuses on least-cost solutions. In principle, such solutions are achieved in defence markets which bring together buyers and sellers of defence equipment. But defence markets depart drastically from the economists’ competitive model which achieves economically efficient outcomes (a Pareto optimum where it is impossible to make one person better off without making someone else worse off). Defence markets have some distinctive features, namely, governments are major or monopsony buyers and often there is a national monopoly supplier. Efficiency in defence markets can be improved in three ways. First, where two or more nations agree to form a free trade area or a customs union including defence equipment (an international trade agreement). The economic benefits of such trading arrangements apply to purchases of all defence equipment reflected in lower prices from competition and scale effects. Governments will remain major or monopsony buyers but monopoly or oligopoly suppliers can be subject to state regulation to ‘improve’ their performance (e.g. regulation of prices and profits). Second, two or more governments can agree to combine their national orders to buy one or all types of defence equipment (e.g. aircraft; tanks). The economic benefits of cooperative purchasing include increased bargaining power relative to the contractor and lower prices from scale effects. Third, two or more nations might agree to collaborate for the development and production of one type of defence equipment (e.g. aircraft; helicopters; missiles). This is supply-side cooperation where there are economic benefits from sharing costly development and economies of scale and learning from combining production orders. Overall, improved efficiency in defence markets can result from international trade based on specialisation by comparative

1 Monopsony is a single buyer. An example is the demand for strategic nuclear submarines which are bought by national governments (e.g. France; UK; USA).
advantage (known as gains from trade)\(^2\) and/or from lower unit costs reflecting scale and learning economies. Here, problems arise where efficiency is defined from a cost or supply-side perspective. This approach ignores demand-side perspectives and a buyers willingness to pay for a commodity: efficiency has a role for buyers and the valuation they place on their specific demands or preferences.\(^3\)

Features of Defence Industries

Defence industries have some distinctive features which explain their conduct and performance. These include:

1. **Research and development (R&D) is costly forming total fixed costs.** Such total fixed costs have to be spread over a large output to reduce average unit R&D costs within total unit acquisition costs (i.e. development and production costs together form acquisition costs).

2. **The importance of quantity.** Defence industries are often decreasing cost industries meaning that unit costs decline with greater quantities. More specifically, production leads to economies of scale and learning so lowering average production costs. For example, learning economies in the aerospace industry result in a reduction of 5–10% in unit production costs for every doubling of cumulative output.

3. **Development costs are related to unit production costs for each type of equipment.** For combat aircraft, the ratio of total development costs to unit production cost might be 100–200:1; for helicopters, the ratio might be 120:1; for large fixed wing aircraft such as transports, tankers or electronic platform aircraft, the ratio might be 40:1; for air defence missiles, the ratio might be 500:1; and for armoured fighting vehicles, it might be a ratio of 250:1 (Pugh 2007).

4. **Cost trends.** Famously, Norman Augustine identified a trend of rising unit costs for advanced technology defence equipment. He forecast that unit cost trends were closely correlated with time rather than other

\(^2\) Free trade areas and customs unions can lead to gains from trade but some trade effects divert trade rather than create gains. Examples occur where tariffs lead to trade being diverted to higher cost sources of supply.

\(^3\) Consider the optimal use of private household toilets. A cost side perspective requires maximum use to minimise unit costs; but an allocatively efficient solution requires the minimum cost use preferred and chosen by consumers (including availability when required). In other words, allocative efficiency includes both demand and cost considerations.
explanatory factors such as speed, weight or manoeuvrability. More specifically, he forecast real unit costs rising by a factor of four every ten years for high-performance fighter and bomber aircraft as well as helicopters. The upward trend also applied to other high technology equipment such as ships and tanks but at a lower magnitude, namely, a growth factor of two every ten years. The result was the forecast of a single ship navy, a single tank army and Starship Enterprise or Battlestar Galactica for the air force (Augustine 1987; Hartley 2020; Kirkpatrick 1995).

5. **Defence equipment is costly.** For example, unit production costs for an aircraft carrier might be £8 billion, a nuclear-powered submarine might cost almost £3 billion per unit, a tank about £6 million, a strategic bomber £3.7 billion and an advanced combat aircraft over £100 million per copy (2019 prices: Hartley 2020). Examples are shown in Table 5.1. In addition to production costs, there are development costs. Both cost levels and trends provide incentives for weapons standardisation and collaboration.

**DEFENCE INDUSTRIAL POLICY IN A MILITARY ALLIANCE**

There is a considerable literature on the economics of military alliances focusing on their public goods benefits from collective defence, burden-sharing and free riding issues. Much less attention has been given to the opportunities for formulating an efficient defence industrial policy in an alliance. A starting point is the view that NATO is an inefficient military organisation with inefficiency embracing both its armed forces and defence industries. These are characterised by costly duplication in both spheres. In contrast, the former Warsaw Pact was often viewed as an efficient arms procurement organisation. Its efficiency resulted from central control of its armed forces which specialised in specific military roles and capabilities and its acquisition of a few standard types of defence equipment so allowing volume production. As a result, it avoided duplication of costly equipment developed and produced in small quantities. Overall military decision-making and allocation choices were the responsibility of the former Soviet Union which imposed its weapons choices on all Member States of the former Warsaw Pact.

Using the Warsaw Pact as a comparator, NATO appeared to be an inefficient military alliance. Each Member State deployed an independent
army, navy and air force with duplication between them (e.g. national Defence Ministries; duplication of military bases; training; support facilities). National defence industries each developed and produced costly equipment for their national needs with costly duplication and short production runs. Economic principles for an efficient military force and

Table 5.1 Defence equipment costs: levels and growth

| Equipment type                  | Absolute cost (£s 2019 prices) | Annual rate of cost increase (%) |
|---------------------------------|-------------------------------|---------------------------------|
| **Sea systems**                 |                               |                                 |
| Aircraft Carrier                | 8.0B                          | 3                               |
| Air Defence ship                | 934 mn                        | 2                               |
| Submarine: SSBN (launch of nuclear missiles) | 2.8B                         | NS                              |
| SSN (hunter-killer)             | 1.9B                          | 1                               |
| **Land**                        |                               |                                 |
| Main Battle Tank                | 5.8 mn                        | 1                               |
| Armoured Personnel Carrier      | 876 K                         | 2                               |
| **Air**                         |                               |                                 |
| Fighter/Strike Aircraft         | 102 mn                        | 4                               |
| Bomber Aircraft (strategic)     | 3.7B                          | 10                              |
| Primary Trainer Aircraft        | 8.8 mn                        | 7                               |
| Advanced Trainer Aircraft       | 24.8 mn                       | 4                               |
| Military Transport/Tanker Aircraft | 292 mn                    | 4                               |
| Reconnaissance UAV              | 36.5 K                        | 6                               |
| Attack Helicopter               | 35 mn                         | 5                               |
| Anti-Submarine Helicopter       | 29 mn                         | 6                               |
| Transport Helicopter            | 23.4 mn                       | 4                               |
| **Small arms**                  |                               |                                 |
| Rifle                           | 2.2 K                         | 2                               |
| Machine Gun                     | 5.1 K                         | NS                              |
| **Missiles**                    |                               |                                 |
| Cruise Missile                  | 6.6 mn                        | 8                               |
| Ballistic Missile               | 58 mn                         | 5                               |

Source: Pugh (2007)

Notes: (i) NS is not statistically significant; (ii) absolute costs in constant 2019 prices in pounds sterling: K is thousands, mn is millions and B is billions. Constant prices are based on the UK Retail Price Index; (iii) unit cost figures include development costs for warships (i.e. total acquisition costs comprising development and production). For all other equipment, unit costs are for unit production costs (i.e. excluding development cost); (iv) cost increases are in specific costs: £s per ton for ships; £s per tonne for tanks and personnel carriers; and £s per kilogram for aircraft and missiles. Cost figures are median values; (v) cost data are based on projects worldwide for which there is published data but most projects are from the USA and Europe.
defence markets suggest an optimal military alliance based on specialisation by comparative advantage for both armed forces and defence industries. On this basis, the USA might specialise in providing costly assets and military forces such as a complete range of strategic and tactical nuclear forces, strategic bombers, satellite surveillance, strategic tanker aircraft and ballistic missile defence. France and the UK might specialise in providing air defence, anti-submarine capabilities and a limited range of strategic nuclear forces; the UK might focus on special forces, aerial tankers and short take-off and vertical landing aircraft; Germany could provide armoured forces; Greece, Italy, Spain and Turkey might supply land forces; with the Netherlands and Norway providing naval escort forces.

The principle of specialisation by comparative advantage can also be applied to defence industries. On this basis, the US defence industry might specialise in high technology defence equipment such as aircraft, helicopters, missiles and space systems; France might specialise in combat aircraft; the UK might focus on aero-engine technology, armoured fighting vehicles and warships; Germany would specialise in tanks and submarines; and Italy in helicopters.

Two aspects of these proposals have to be addressed. First, the principle of specialisation requires trust between Member States. In the absence of a political union, Member States in a military alliance will prefer to retain their national independence reflected in an independent military force and national defence industry. Put simply, with specialisation based on comparative advantage, nations need to be certain that other Member States with their specialist military capability will turn-up in a conflict. Second, efficiency embraces both economic and technical efficiency. Economic efficiency does not necessarily mean weapons standardisation. Instead, it means that different national preferences in a military alliance are satisfied which suggests that duplication can be an efficient solution. Technical efficiency requires that production is undertaken on the lowest possible cost curve (X-efficient cost levels). In the Warsaw Pact model, it was assumed that production costs were minimised; but, in the absence of competition and the profit motive, Warsaw Pact production might have been X-inefficient (i.e. not least-cost). In contrast, privately owned and competitive NATO defence industries might operate at lower unit production costs even with smaller volumes compared with the Warsaw Pact.

Figures 5.1(a) and (b) show an analytical framework for illustrating the relative cost positions of NATO and Warsaw Pact nations. Figure 5.1 (a) presents a single unit cost curve showing the cost advantages of large-scale
output. Figure 5.1 (b) shows different cost curves for NATO and the Warsaw Pact nations with cost curve LAC2 being the unit cost curve for the Warsaw Pact nations and LAC1 being the unit cost curve for NATO nations. In this case, Warsaw Pact output is Q2 produced at a unit cost of C1; but NATO with a smaller output of Q1 producing on a lower unit cost curve can achieve the same unit costs as the Warsaw Pact (C1). If through standardisation, NATO could achieve a larger output of Q2, unit costs would fall to C0. These cost curves show the benefits of large-scale production from economies of scale and learning and the gains from trade leading to lower unit costs.
Compared with the USA, EU defence markets appear to be inefficient in the provision of both armed forces and defence equipment. European inefficiency is reflected in duplication of military forces and defence industrial capabilities, all based on relatively small national markets. The USA has a single army, navy, air force and Marine Corps providing large-scale orders creating a large domestic market which allows US defence firms to achieve economies of scale, scope and learning. For example, for the Lockheed Martin F-35 combat aircraft, the three US services planned to buy 2663 aircraft compared with a planned UK buy of 138 aircraft. However, it should not be concluded that larger US scales of output necessarily mean greater efficiency: the US Armed Forces and defence industry might also be inefficient.

To assess the relative size of NATO defence industries, data are needed on such size indicators as industry sales and employment. There are the inevitable data problems since there is a general absence of government-supplied data on the size of their national defence industries. Industry size can be measured in terms of arms sales and employment, but it is not always possible to ensure that all size data are based on standard and uniform definitions of defence industries, their arms sales and identical definitions of defence industry employment. Employment data vary between numbers based on direct, indirect and induced jobs and it is not always clear which definitions are used. Data on the size of NATO defence industries and those in Russia, China and Sweden all based on employment numbers are shown in Table 5.2. The USA clearly dominates NATO defence industry employment as well as comparable numbers for Russia and China. Elsewhere in NATO, there are major defence industries in the UK, France, Germany, Italy and Spain (Hartley and Belin 2020).

**THE EUROPEAN DEFENCE INDUSTRIAL PROBLEM**

A visitor from Mars would be astonished at the massive inefficiencies in European defence markets and industries. They are characterised by small national markets, duplication of costly R&D and national production orders which are ‘too small’ to achieve economies of scale and learning.

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4 Using Fig. 5.1(b), the US scale of output on LAC1 could be Q2 and unit costs of C0 compared with a smaller European national output of Q1 on LAC2 and unit costs of C1. Or, a worst case scenario might place the European nation on a higher cost curve above LAC2 with unit costs higher than C1.
The resulting European defence industrial problem is that each European nation is unable to compete with its US rivals. The desire for European solutions has led to various historical institutional initiatives of varying degrees of success and failure.

**Developing a European Defence Policy and Armaments Agency**

Following earlier initiatives, the European Union’s Common Security and Defence Policy (CSDP) was agreed in 1999 involving military and civilian missions for peace, conflict prevention and international security. The EU and NATO have agreed a strategic partnership: 22 EU Member States are also NATO allies.

Various efforts have also been made at European arms cooperation and the creation of a European armaments agency. This was reflected in a standard rhetoric focusing on a desire to strengthen the European Defence Technological and Industrial Base (EDTIB), to cooperate in defence R&D, to open-up national defence markets and to promote a more efficient use of resources through harmonising equipment requirements. The

| Country    | Employment numbers          |
|------------|----------------------------|
| USA        | 2.3–4.1 million             |
| UK         | 260,000                    |
| France     | 200,000                    |
| Germany    | 90,000–120,000             |
| Italy      | 50,000                     |
| Turkey     | 44,740                     |
| Spain      | 40,000                     |
| Canada     | 27,000–59,800              |
| Poland     | 20,000                     |
| Norway     | 6700                       |
| Greece     | 5210                       |
| Russia     | 1.3 million–2 million       |
| China      | 1.7 million                |
| Sweden     | 30,000                     |

Source: Hartley and Belin (2020)

Note: (i) Data are for 2016/2017; (ii) range of numbers shows direct numbers (lower figures) and direct plus indirect employment (higher numbers). Figures are rounded; (iii) data not available for all NATO Member States
eventual aim was to promote arms co-operation by creating a single European Armaments Agency.

An initiative came in 1996 with the creation of OCCAR known as the Organisation Conjointe de Cooperation pour l’Armement or the Organisation for Joint Armament Co-operation. This agency specialises in managing collaborative defence equipment projects. Originally, OCCAR involved four nations, namely, France, Germany, Italy and the UK (effective legally in January 2001) but later, Belgium and Spain joined. Programmes managed by OCCAR include the A400M airlifter, the Boxer armoured fighting vehicle, COBRA (weapon locating system), FREM (France-Italy Frigate programme) and the Tiger helicopter (see Table 5.5).

**Single Market and EDTIB**

Current European defence industrial policy is based on policy initiatives for the European Defence Agency (EDA), the European Defence Technology and Industrial Base (EDTIB) and the Single Market. EDA was created in 2004. It is an inter-governmental agency of the European Council comprising most Member States (except for Denmark). It partly reflected pressure from European aerospace and defence firms for a strong armaments agency able to overcome the deficiencies of previous initiatives in the field (e.g. OCCAR). Originally, EDA was tasked with developing defence capabilities for crisis management, promoting European arms cooperation, strengthening the EDTIB and creating a competitive European defence equipment market. Also, it was viewed eventually as a possible central European purchasing agency.

EDA has special responsibility for developing a European DTIB viewed as something more than the sum of its separate national parts. It regards national equipment requirements, duplicate and costly national R&D programmes and small-scale national procurement as economically unsustainable. Instead, EDA is tasked with creating an EDTIB which is capability-driven, competent and competitive within and outside Europe (the three Cs). It expects centres of excellence to emerge from a market-driven process, moderated by policy considerations including the requirement to achieve an appropriate regional distribution; but originally, it did not envisage a future EDTIB as a ‘Fortress Europe’ (EDA 2007, pp. 1–2).

The European Commission has a central role in creating a Single Market for the procurement of defence equipment (European Defence Equipment Market: EDEM). This is being achieved by a series of Defence
Procurement Directives aimed at promoting greater competition by opening national defence markets to cross border competition. The creation of the EDEM requires an appropriate legal framework specifying the rules for contract awards: for example, contracts awarded on the basis of the most economically advantageous offer. In the European Commission’s view, the relationship between the EDEM and EDTIB involves the gradual establishment of the EDEM as essential for strengthening the EDTIB: the view is that closed and fragmented national defence markets create extra costs and inefficiencies which have negative impacts on the competitiveness of the EDTIB (EC 2009).

There are, though, major constraints on the creation of the EDEM. These take the form of specific exemptions from the Single Market rules which allow for the protection of a nation’s essential security interests when purchasing arms, ammunition and war materials, including intelligence services. These exemptions were reflected initially in Article 296 which was replaced by Article 346 in 2009.

The European Commission issues Defence Procurement Directives aiming to create a more open, competitive and efficient European defence equipment market. Such a Market is expected to “help suppliers to achieve economies of scale, optimise production capacity and lower unit production costs, thus making European products more competitive on the global market. This should, in turn, strengthen the competitiveness of European defence industry, by fostering consolidation across national boundaries, helping to reduce duplication, and enhancing industrial specialisation” (EC 2016, p. 14).

Problems arose because Member States used exemptions, especially Articles 296 and 346, to ensure that the procurement of military equipment was not subject to EU public procurement rules aimed at ‘opening-up’ national defence markets. In reality, derogations which should have been the exceptions became the rule. In 2016, the Commission reviewed whether Articles 296 and 346 continued to form major barriers to creating a Single Market in defence equipment: a very significant share of defence procurement expenditure was being made outside the Defence Procurement Directive. It concluded that the objectives of the Directive had only partly been achieved and that its application remained uneven across Member States. Nor was there any evidence that overall, the Directive had fundamentally changed the development of the EDTIB and enabled SMEs to be more successful in winning defence contracts. Overall, the Commission found that a significant share of defence procurement
expenditure was still undertaken outside of the Directive. Often, Member States used offsets/industrial return requirements under Article 346 to justify their reluctance to award defence contracts on the basis of competition.

The typical European Commission response to identifying problems in creating a Single Market is to formulate more legal procurement rules aimed at achieving compliance and ‘good’ behaviour. In this context, actions are required on concerns about security of supply, offsets and on sub-contracting. Further concerns arise from the opportunities for discriminatory technical specifications which favour national suppliers. Policy implementation is achieved by the threat of sanctions through references to the European Court of Justice. However, a new policy initiative was announced in late 2016, namely, the Action Plan for European Defence.

THE ACTION PLAN

The European Defence Action Plan of November 30th, 2016 outlined specific proposals to support a strong and innovative European defence industry and defence capabilities agreed by EU states. The Plan has three components. First, a European Defence Fund for collaborative research projects and the joint development of defence equipment and technologies. Second, supporting investments in defence supply chains, especially through finance for SMEs and encouraging the development of regional clusters of excellence. Third, ensuring that Europe has an open and competitive Single Market for defence. Overall, the Action Plan was viewed originally as a ‘game changer’ for more European defence co-operation (EC 2016). A related development was the creation in 2017 of PESCO or Permanent Structured Cooperation which allows Member States to pursue structural military and defence integration through shared initiatives and the pooling of resources. It is designed to fill capability gaps in areas such as cyber and joint training.

The European Defence Fund was a major initiative involving both research and capability windows. The research window will fund collaborative research on innovative defence technologies such as electronics, metamaterials, encrypted software or robotics. For 2017, the Commission proposed an initial research budget of Euros 25 million rising to a planned total of Euros 500 million per year after 2020. The capability window will provide funds for Member States to acquire and jointly own specific and costly assets, with a possible budget of Euros 5 billion per year. This
window aims to provide joint funding of development and procurement of strategic capabilities (i.e. prototypes, development and procurement of products and technologies resulting from the research window).

The European Defence Action Plan aims to address the lack of interoperability, technology gaps and insufficient scale and learning economies in production. Some 80% of European defence procurement and 90% of defence research and technology is undertaken on a national basis. The resulting fragmentation of European defence equipment markets has led to Europe being less competitive than the US defence industry. For example, Europe has 180 different types of equipment compared with 30 for the USA. This total includes 29 types of frigates versus 4 in the USA; 17 types of battle tanks versus one in the USA; 20 types of fighter aircraft in Europe compared with 6 in the USA; 20 types of European armoured fighting vehicles compared with 2 in the US; and 13 types of European air-to-air missiles compared with 3 in the USA (EC 2016).

Since 1986, there has been a reduction in the number of major European arms firms. The number of main battle tank producers declined from 13 in 1986 to 6 in 2016; for combat aircraft, numbers declined from 16 firms in 1986 to 6 firms in 2016; and for warships the corresponding numbers were from 16 firms in 1986 to 8 firms in 2016. The lack of European arms co-operation was reflected in the costs of non-Europe in defence which was estimated to cost annually between Euros 25 billion and Euros 100 billion. This is because of inefficiencies, lack of competition and lack of economies of scale in production. Some 80% of European defence procurement is undertaken on a national basis leading to costly duplication of military capabilities (EC 2016).

The Action Plan appears to be a major improvement on previous policy initiatives. The EU has earmarked budgets for defence research and capabilities. But, appearances are deceptive. The collaborative research budget is small, even after 2020 and achieving the capability budget will be even more demanding. The costs of funding the 2020 corona virus pandemic and the associated economic recovery will affect adversely the size of future European defence budgets. Delays in implementation will follow and over time, the Action Plan will be quietly forgotten as yet another failed EU defence initiative. There is also the problem of determining spending priorities within the Action Plan. Inevitably, European defence choices will be the result of preferences reflected by its Member States where there are incentives to free ride and shift costs to the larger nations. The resulting defence priorities will reflect compromises and bargaining.
skills and not necessarily an assessment of the ‘true’ threats facing Europe: outcomes will reflect the bargaining environment of a political club. Ultimately, however, only nation states have the final responsibility for their national defence: they are responsible for assessing threats and providing security and protection for their citizens. European defence solutions require a single European state able to provide a single agreed view of threats to Europe and their solutions. Without a single European state, the inefficiency of national state solutions will continue to be reflected in the costly duplication of military capabilities and defence industries. Problems arise since the European Commission and its agencies are applying a model of a non-existent single European state to a large set of independent national European states. The challenge for the EU is to create the market and industry structures of a single market based on a group of Member States which act as autonomous and independent nations. The so-called problems of fragmentation and duplication of costly R&D arise from applying a non-existent and hypothetical model of a single European nation to the reality of independent nation states.

**European Defence Industries**

The starting point of the European Action Plan in assessing European defence industries is the lack of co-operation, with most defence research and defence procurement operated on a national basis. The European Action Plan aims to change this outcome by promoting and funding collaborative defence research and technology. Further efforts to promote European defence co-operation through the Action Plan are based on developing the capability window. Descriptive statistics for the major European defence firms and European defence expenditures are shown in Tables 5.3 and 5.4; data for European defence *industries* are shown in Table 5.2.

Data on the top 25 arms firms in NATO are shown in Table 5.3. American arms firms accounted for five of the top six in 2018 with only one European firm in the top six (BAE Systems). Similarly, there were 15 US firms in the top 25 in NATO compared with 10 European firms in the top 25. The average size of the US arms firms in the top 25 was almost twice the average size of the top European firms in the top 25. These size differences suggest substantial excess capacity in the European arms industry. For example, with US productivity levels for their top 15 applied to the total output from the top 10 European firms, then this output could
be produced by about 5 US-equivalent firms rather than the current ten European firms. Also, in 2018, American firms were more dependent on arms sales than their European equivalents: median arms sales shares of 70% in the USA and 51% in Europe.

### Table 5.3 NATO top 25 arms firms, 2018

| Company               | Nation     | Arms sales (US$ millions) | Arms sales as share of total sales (%) |
|-----------------------|------------|---------------------------|----------------------------------------|
| Lockheed Martin       | USA        | 47,260                    | 88                                     |
| Boeing                | USA        | 29,150                    | 29                                     |
| Northrop Grumman      | USA        | 26,190                    | 87                                     |
| Raytheon              | USA        | 23,440                    | 87                                     |
| General Dynamics      | USA        | 22,000                    | 61                                     |
| BAE Systems           | UK         | 21,210                    | 95                                     |
| Airbus Group          | Trans-European | 11,650              | 15                                     |
| Leonardo              | Italy      | 9820                      | 68                                     |
| Thales                | France     | 9470                      | 50                                     |
| United Technologies Corporation | USA      | 9310                      | 14                                     |
| L3 Technologies       | USA        | 8250                      | 81                                     |
| Huntington Ingalls    | USA        | 7200                      | 88                                     |
| Industries            |            |                           |                                        |
| Honeywell International | USA      | 5430                      | 13                                     |
| Leidos                | USA        | 5000                      | 49                                     |
| Harris Corporation    | USA        | 4970                      | 73                                     |
| Booz Allan Hamilton   | USA        | 4680                      | 70                                     |
| Rolls-Royce           | UK         | 4680                      | 22                                     |
| Naval Group           | France     | 4220                      | 99                                     |
| Rheinmetall           | Germany    | 3800                      | 52                                     |
| MBDA                  | Trans-European | 3780              | 100                                     |
| General Electric      | USA        | 3650                      | 3                                      |
| Textron               | USA        | 3500                      | 25                                     |
| CACI International    | USA        | 3490                      | 70                                     |
| Safran                | France     | 3240                      | 13                                     |
| Babcock               | UK         | 3180                      | 46                                     |
| Average US (n = 15)   | USA        | 13,568                    | 70                                     |
| Average European (n = 10) | European | 7505                      | 51                                     |

Source: SIPRI (2020)

Notes: (i) Based on SIPRI Top 100 arms producers in 2018; (ii) arms shares for average US and European firms are based on medians; (iii) subsidiaries are excluded; (iv) Saab is excluded since Sweden is not a NATO member. Saab sales in 2018 were $3240 mn, placing it in the same rank position as Safran.
Table 5.4  European defence spending, 2014 Euros, millions

| Country | Defence R&T | Defence R&D | Equipment procurement expenditure | European collaborative defence R&T spending | Collaborative equipment procurement as share of total equipment procurement (%) |
|---------|-------------|-------------|-----------------------------------|------------------------------------------|--------------------------------------------------------------------------------|
| France  | 764         | 3563        | 6134                              | 123                                      | 33                                                                          |
| Germany | 483         | 846         | 3781                              | NA                                       | NA                                                                          |
| Italy   | 0           | 103         | 1956                              | 5                                        | 40                                                                          |
| Poland  | 10          | 217         | 1811                              | 2                                        | 2                                                                           |
| Spain   | 42          | 75          | 1258                              | 21                                       | 65                                                                          |
| Sweden  | 61          | 106         | 1178                              | 9                                        | 9                                                                           |
| UK      | 493         | 3753        | 6553                              | 1                                        | 28                                                                          |
| All EU  | 1953        | 8791        | 25897                             | 170                                      | 22                                                                          |

Source: EDA (2016)

Notes: (i) R&T is research and technology; R&D is research and development; equipment procurement is defence equipment procurement expenditure; (ii) European totals are for all Member States of the EDA. NA is not available. All data in Euros millions.

BAE Systems was the largest European arms firm but it was considerably smaller than Lockheed Martin as the world’s largest arms firm in 2018. The remaining major European arms firms were even smaller relative to Lockheed Martin. The top European firms had varying degrees of dependency on arms sales, ranging from as little as 13% (Safran) to almost 100% dependency (Naval Group) with a median of some 50% arms dependency. In comparison, Lockheed Martin had a defence dependency of some 88%.

European defence spending is concentrated in a small number of nations, namely, France, Germany, Italy, Poland and the UK. These five nations accounted for some 80% of European procurement spending. The degree of concentration was greater for EU defence R&D spending, with France and the UK accounting for about 80% of such expenditure. However, the figures are misleading since the EU totals are based on all Member States when the reality is that the total comprises a set of independent nation states and not a single EU state. In contrast, the USA forms a single Federal state where its defence R&D and procurement spending are designed to provide defence capabilities for the armed forces of the single nation state and not for each of the constituent states of the
US Federation. Also, the data show the dominance of the UK in the EU totals and the possible impact of Brexit on EU defence. The UK is a major defence market within the EU, with BAE forming Europe’s largest arms company. The UK has also been a major participant in European collaborative equipment programmes.

**IS COLLABORATION THE ANSWER?**

Collaboration is a major feature of the European Defence Action Plan embracing both collaborative defence research and procurement. The simple economics of collaboration appear attractive. Compared with a single nation solution, the theory of ideal or perfect collaboration offers the prospect of cost savings from sharing fixed R&D costs and lower unit production costs from combining production orders. For example, two equal nations would share R&D costs and combine their production orders to double output leading to greater scale and learning economies. On this basis, a collaborative project’s R&D costs of, say, Euros 10 billion would be shared equally between two nations with each contributing Euros 5 billion (a 50% saving or Euros 5 billion for each nation). In addition, if each nation required, say, 100 units, then the total order would double from 100 units to 200 units, leading to possible reductions of 5–10% in unit production costs. Further national cost savings would be available if the number of partner nations increased from, say, two to four or six or more.

Reality departs from the ideal model. Compared with a national project, actual collaboration leads to inefficiencies resulting from the work-sharing arrangements. Each partner nation will demand its ‘fair’ share of the high technology work on the project. For example, on collaborative aerospace projects, each nation will demand an involvement in high technology work on the airframe, engine and avionics. Partner nations will each require a flight test centre. The resulting work-sharing based on equity criteria will not be economically efficient. Such inefficiencies are accentuated where a partner nation lacks the relevant technology and uses collaboration to fund the acquisition of new knowledge (which might already exist amongst other partner nations). The costs of acquiring the technology will be shifted to the other partner nations and its taxpayers. Further collaboration inefficiencies arise in production work. Each partner nation will demand a ‘fair’ share of production work, including a national final assembly line, leading to duplicate final assembly lines. And, some
production work might be awarded to a partner nation to fulfil its work-sharing requirements across the collaborative project, even where the partner might lack competitiveness in the relevant field.

Collaboration inefficiencies also arise from the industrial management arrangements (the supply side). Partner nation governments will specify which of their arms companies will be involved in the collaborative project and will determine the form of industrial organisation for the joint project. Again, equity criteria will dominate, requiring that no single company acts as prime contractor. The result is an industrial organisation and management arrangement specific to the collaboration with the options ranging from some form of *ad hoc* industrial partnership or consortium to a new project-specific international company. Examples included the joint venture to develop and manufacture the Anglo-French Jaguar (SEPECAT for the airframe comprising Breguet and BAC) with the engine for Jaguar supplied by a joint venture of Rolls-Royce and Turbomeca; and the formation of the four-nation Eurofighter company responsible for the management of the Eurofighter programme. The efficiency of the industrial management arrangements also depend on the voting rules for decision-making with the options ranging from unanimity rules to majority voting.

A further source of collaboration inefficiencies results from the arrangements for procurement management (the demand side). The partner governments have to determine how to organise the management, monitoring and policing of the collaborative procurement. The inevitable result is the formation of international committees responsible for the procurement with their associated decision-making rules (unanimity versus majority voting). An elaborate international committee will add to transaction costs and to delays, especially where the collaboration involves new partner nations (the costs of conducting international business with strangers). Public choice analysis with its various interest groups of governments, armed forces, bureaucracies and producers appears to be a more acceptable model for explaining collaboration.

Inefficiencies also arise with similar national projects. Here, the counterfactual creates methodological problems. What is the standard of comparison between national and collaborative projects: what would have happened in the absence of collaboration? There are at least two possibilities. First, a similar or identical national project is assumed. However, often it is assumed that the similar national project is a ‘perfect’ programme which encounters no cost overruns, no delays and no performance shortfalls. Such ‘perfect’ national programmes do not exist and all
high technology arms projects encounter cost, schedule and performance problems. In some cases, national projects are based on work sharing where some work is allocated to high unemployment areas. National procurement agencies are also far from perfect, subject to delays and changes in procurement policy.

Nor will a nation involved in a collaborative project develop a similar national programme which can be used as a comparator. However, comparisons can be made between similar national projects developed in other nations. For example, comparisons can be made between a collaborative project and similar US projects. Examples include comparisons between the collaborative Typhoon aircraft and similar US combat aircraft (e.g. F-15; F-16; F-18; F-22; F-35). Or, comparisons can be made between a collaborative project and similar European national projects: for example, between Typhoon and the national Gripen and Rafale aircraft.

Various performance indicators are needed for any comparisons. Possible examples include total development costs and unit production costs, development time scales and exports as an indicator of international competitiveness. Most performance indicators have their limitations. Data might not be available in the public domain, especially cost data. Development time scales seem an attractive indicator but there are problems of definition. For example, the starting point of a project might vary according to definitions; the date of first flight might reflect aircraft at differing stages of development (e.g. without avionics); and entry into service might also reflect aircraft which might not be combat ready. Even exports have their limitations: their prices might reflect subsidies and financial assistance to the buying nation and might include varying amounts and types of offsets.

Some of the complexities of assessing collaborative arms projects are shown in Table 5.5. Collaborative arms projects differ and include a range of aircraft, helicopter and missile types, different partner nations, different industrial arrangements and different procurement management systems. European defence collaboration for missiles is organised around a single European company namely, MBDA. For completeness, Table 5.5 presents two European national comparators, namely, the Swedish Gripen and French Rafale combat aircraft. Both these combat aircraft demonstrate that Europe has the technical and industrial capability to undertake the national development and production of a modern technically advanced aircraft and to demonstrate their international competitiveness through export orders. These facts confirm that France and Sweden were willing to
### Table 5.5 Examples of major aerospace collaborative programmes

| Project                | Date of service entry | Partner nations                  | Industrial organisation                               | Final assembly                  | Total output | Exports |
|------------------------|-----------------------|----------------------------------|------------------------------------------------------|--------------------------------|--------------|---------|
| Typhoon                | 2003                  | Germany; Italy; Spain; UK         | Eurofighter (airframe); Eurojet (engine)             | Germany; Italy; Spain; UK       | 623          | 151     |
| A400M                  | 2013                  | Belgium; France; Germany; Lux; Spain; Turkey; UK | Airbus Military (airframe); Europrop (engine); OCCAR (procurement) | France; Germany; Spain; UK     | 174          | 4       |
| Tiger                  | 2005                  | France; Germany; Italy; Netherlands | Airbus Helicopters; NH Industries; NAHEMA (procurement) | France; Germany; Italy; Netherlands | 286          | 46      |
| NH90                   | 2007                  | France; Germany; Italy; Netherlands | Saab Dassault BAE; Rolls-Royce; Leonardo; MBDA; Sweden | France; Germany; Italy; UK Sweden | 543          | 227     |
| Gripen                 | 1997                  | Sweden; France; UK               | Saab Dassault BAE; Rolls-Royce; Leonardo; MBDA; Sweden | France; Germany; Italy; UK Sweden | 427          | 153     |
| Rafale                 | 2001                  | France; UK                       | Saab Dassault BAE; Rolls-Royce; Leonardo; MBDA; Sweden | France; Germany; Italy; UK Sweden | 493          | 198     |
| Tempest                | 2035 (estimated)      | Sweden; UK; Italy; MBDA          | Saab Dassault BAE; Rolls-Royce; Leonardo; MBDA; Sweden | France; Germany; Italy; UK Sweden | 427          | 153     |
| Future Combat Air System (FCAS) | 2040 (estimated) | France; Germany; Spain         | Saab Dassault BAE; Rolls-Royce; Leonardo; MBDA; Sweden | France; Germany; Italy; UK Sweden | 493          | 198     |

Notes: (i) Typhoon is a combat aircraft; A400M is an airlifter; Tiger is an attack helicopter and the NH90 is a multi-purpose helicopter. Gripen and Rafale are national combat aircraft shown as comparators; (ii) output and exports are volume figures (units), including orders and estimated output. Numbers for Gripen include E/F types; also 26 Gripen were leased from Sweden to Czech Republic and Hungary and were not included in the export figures; (iii) NAHEMA is NATO Helicopter Management Agency for procurement of NH90 helicopter; (iv) MBDA date is for formation of the European company. NA is not available: output data not available for different types of missiles; (v) Tempest and FCAS are both planned collaborative future European fighter aircraft. At the time of writing, no more details were available.
pay the price of independence. In fact, by 2020, the collaborative Typhoon had achieved a larger total output than each of Gripen and Rafale but its export numbers were lower than Rafale. Interestingly, if the nations involved in Gripen, Rafale and Typhoon had combined their orders and acquired one type, there would have been one development bill and a production run of over 1500 units of one type (compared with a maximum production run of over 600 units for the Typhoon). Duplicate development projects also are likely in the future. European nations are currently developing duplicate future combat aircraft (FCAS and Tempest). Critics of collaboration favour the US model based on the F-35 programme: they suggest a single prime contractor with a few partners, say, two partners (BAE Systems and Northrop Grumman on the F-35) so reducing the transaction costs of collaboration.

**THE TRANSACTION COSTS OF COLLABORATION**

The various sources of inefficiency outlined above can be presented in terms of the additional transaction costs of collaboration. Transaction costs reflect the costs of ‘doing business with strangers’ in the form of different partners and different industrial organisations. Transaction costs are the costs of creating, running and monitoring the multi-national organisation. Complex contracts are inevitable in such international organisations: they are incomplete contracts which allow agents opportunities for pursuing their self-interest. Each partner nation will seek business for its national champions, including favourable work shares especially of high technology work. Bargaining will lead to games of bluff, chicken and brinksmanship with nations threatening to withdraw from the programme. Collaboration has further attractions to the participants, namely, the benefits of international travel to attend meetings of procurement staffs and industrialists. Such behaviour is predicted by public choice analysis.

What is the possible magnitude of collaboration inefficiencies? Two guidelines are available. First, the *square root rule* for development costs suggests that compared with a national project, the development costs on a collaborative project can be estimated by applying the square root of the number of partner nations. On this basis, the development costs of a collaboration comprising four equal partner nations might be twice the costs for a national project. These total development costs are shared between the partner nations so that the costs per nation will be lower than for a national project, but the cost savings are lower than predicted by the ideal
or perfect collaboration scenario. Second, a similar guideline applies to development time-scales. This suggests that compared with a similar national project, delays on collaborative projects can be estimated by applying the cube root of the number of partner nations in the collaboration. For example, an eight nation collaboration might take twice as long as a national project (Hartley and Braddon 2014).

These guidelines are difficult to operationalise. An alternative approach to assessing collaborative projects focuses on their cost overruns, delays and performance shortfalls. Table 5.6 presents some UK examples based on comparisons between collaborative projects and national ventures. This is a limited sample of projects but it shows some national projects with higher cost increases compared with collaborative projects and similar delays, although the collaborative A400M airlifter was subject to substantial delays.

The collaborative A400M airlifter is an interesting example involving a seven nation collaboration making it one of the largest international ventures based on the number of partner nations. It was developed by a division of Airbus (Airbus Military; now known as Airbus Defence and Space) with procurement managed by OCCAR. Originally, it was expected that Airbus with its international reputation as a world leader in large civil jet airliners would have been able to develop the A400M successfully. In fact, the A400M encountered major schedule, cost and technical problems. Its

Table 5.6 Costs and performance for UK Projects, 2015

| Project             | Original estimated costs (£mn) | Latest cost figures (£mn) | Cost increase (%) | Delays (mths) |
|---------------------|--------------------------------|---------------------------|-------------------|---------------|
| A400M               | 2238                           | 2710                      | +21               | +79           |
| Typhoon             | 15,173                         | 17,341                    | +14               | +54           |
| Astute submarines   | 2233                           | 3536                      | +58               | +58           |
| 1–3 Aircraft Carriers | 3541                         | 6212                      | +75               | +31           |
| Total UK Projects (n = 17) | 60,281                     | 65,833                    | +9                | +29           |

Source: HCP 488 (2015)

Notes: (i) A400M and Typhoon are European collaborative aircraft. Astute is a nuclear-powered submarine and the Aircraft Carriers are for two ships; (ii) total UK Projects is based on 17 UK major defence equipment projects for 2015. Latest costs are at 2015; (iii) data based on National Audit Office Major Projects Report. After 2015, NAO changed to reporting on MoD 10 year Equipment Plans, no longer publishing Major Projects Reports.
first flight was originally planned for 2008 but took place in December 2009. Service delivery was planned for 2009 but was delayed until August 2013. Costs have risen. There was a government bail-out of Euros 3.5 billion for the project in 2010 and Airbus confirmed a Euros 2.2 billion charge on the A400M for 2016 (estimated at Euros 6 billion in total charges for Airbus). Technical and operational problems have also arisen. Technical problems affected the engine and its propeller gearboxes as well as fuselage cracks. Operational problems arose over in-flight refuelling for helicopters. Cost increases led to reductions in planned orders from 25 to 22 for the UK, from 60 to 53 for Germany whilst South Africa cancelled its export order. Critics suggested that Airbus under-estimated the engine problems, especially for an inexperienced engine consortium. Overall, the A400M has been regarded as an unsatisfactory programme with an unsatisfactory contract and by no means an example of a successful collaboration (Hartley and Belin 2020).

CONCLUSION

Efforts to create a Single European Market are constrained by the existence of independent nation states. Here, the US model is informative with its Single Market for defence equipment and a single US Army, Navy, Air Force and Marine Corps. The European equivalent requires a federal state with a single European Army, Navy and Air Force, able to reduce duplication in development and large enough to achieve economies of scale and learning in defence markets.

The challenge of improving efficiency in NATO defence markets is firmly located in the European Union. The USA does not have the problems of fragmentation, duplication and small scale which typify European defence markets leading to NATO being an inefficient defence market. NATO inefficiency forms one of its major future challenges. Whilst the focus is on Europe, it does not follow that the US defence market comprising its armed forces and defence industries is a model of efficiency.

In an era when defence equipment is costly and where costs continue to rise, military alliances offer prospects for economising on defence budgets. As a military alliance, NATO can improve the efficiency of its armed forces and defence industries. Economic theory suggests two principles for a more efficient organisation of its armed forces and defence industries. First, the principle of specialisation by comparative advantage offering gains from competitive international trade. Second, gains from volume
production in defence industries reflecting economies of scale and learning. After 70 years, NATO remains an inefficient organisation for providing armed forces and supplying defence equipment. But inefficiency is only one of the future challenges for NATO.

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