

Military off the shelf procurements: Classification, characteristics and implications

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Buying off the shelf procurements (OTS) has become an important part of the national acquisition strategy in several countries, and this paper seeks to bring empirical evidence on OTS as the preferred acquisition strategy by use of data from the 2015–2022 investment portfolio of the Norwegian Armed Forces. We develop definitions for three categories of procurement – OTS, modified OTS and development projects – as well as a method to classify projects into these categories. Our first finding is that the characteristics of OTS projects correspond to modified OTS and development projects. Our second finding indicates that OTS projects perform better when it comes to the completion of projects according to the initial schedule, compared to development projects.

Keywords: Off the shelf procurement; Modified off the shelf procurement; Development in procurement; Defense; Acquisition strategy; Norway

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1. INTRODUCTION

Buying defense materiel off the shelf (OTS)¹ rather than developing new products has become an important part of the national acquisition strategy in several countries. In the long-term plan for the Norwegian Armed Forces 2012–2016, the use of well-known technology and proven equipment is emphasized as a strategy for the acquisition of new, not state-of-the-art, defense materiel (Norwegian Ministry of Defence 2012). Extended use of OTS products is also incorporated in the USA's acquisition strategy (General Services Administration Department of Defense 2005). The agencies in the Department of Defense (DoD) conduct market research to determine the availability of OTS and, to the extent practicable, maximize OTS for the items supplied by contractors to the agency. Similar strategies can be found in Swedish white papers, stating that OTS acquisition of mature equipment should be prioritized (Swedish Ministry of Defence 2008). In the white paper *National Security Through Technology* (2012), the UK Ministry of Defence states that the UK would benefit from buying OTS products when appropriate, leaving the development of new products and technology for situations where the market cannot meet its needs. This increased focus on the use of OTS products in defense acquisition can be seen in relation to decreased defense budgets in many western countries in recent years. In times of austerity, cost awareness is increasingly important, making it relevant to explore the possibilities of OTS as an efficient acquisition strategy.

¹ Defined as products that do not require any development, and that have an existing production line. This definition is formulated for use in this study. Examples of OTS procurements with payments in Norway's investment portfolio 2015–2022 are the military transport aircraft Hercules C-130J together with its updates, some of the updates on the F-16 aircraft and communication equipment for the Norwegian ISTAR (Intelligence, surveillance, target acquisition and reconnaissance) force in Afghanistan. There are several other terms used for off the shelf, such as "COTS" (commercial off the shelf), or "MOTS" (military off the shelf). We have intentionally used the term "OTS" as we did not find it necessary to distinguish between these as products in all these OTS-categories hold the essential characteristics that they can be bought and put to use "as is" from an existing production line. Furthermore, in this study of Norway we did not find the need to distinguish between imported and domestic OTS, as could be the case for a country with a larger domestic defence industry.

There are both advantages and disadvantages from buying OTS. The three most commonly mentioned advantages are reduced procurement costs, reduced technological risk and a faster acquisition process. Reduced procurement costs from choosing OTS (Saunders 2014) comes through economies of scale, i.e. sharing fixed costs (such as the development cost or the cost of production infrastructure) over more units (Krugman 1980). Gains from economies of scale will therefore usually be largest in areas where the ratio of fixed cost to variable cost is large. This is typically true in capital-intensive production processes and/or production that require extensive technological development, as often is the case in the production of military equipment. An empirical study by Saunders (2014) finds that OTS procurements have a lower cost, supporting the theoretical argument. Also, risk related to acquisition cost estimations is generally lower when purchasing OTS products, as the estimates can be based on experience.

The second advantage from buying OTS is reduced technological risk², coming from OTS products having an existing production line (Baron 2006). Buying an existing product reduces risk, as the general performance of the product is already known. Furthermore, choosing OTS can also reduce the risk related to the supply of spare parts, as greater production in some cases implies a larger market for spare parts. When OTS products are procured by several countries, opportunities for international cooperation on maintenance and future product updates arise.

The third advantage from buying OTS is a faster acquisition process. The US Government Accountability Office (GAO) (2012) found that the timespan from when a contract was signed

² We use the term technological risk to distinguish uncertainty related to the technology from uncertainty related to cost and time. Some might regard Australian buy of Tiger helicopter and UK buy of Chinooks as examples of OTS procurement with large challenges. Following our definition and classification in chapter 2 these procurements are likely not to be classified as OTS as these procurements were bought in a domestic version and/or was not ready to be put to use "as is" from an existing production line. Still, there will always be examples of "outliers" of OTS procurements, where the benefits of lower risk and cost have been exchanged for large challenges due to different reasons. Furthermore it is far from given that any procurement will be more successful if OTS is chosen rather than developing new materiel.

to when the product was put to use was shorter for procurements of OTS products than for modified OTS products or development products. However, the study also found that the initial phases of procurement were more time consuming for OTS products, in part because they were less likely to leverage ongoing efforts and thus required additional time to identify, fund and contract for the solution. In the same study, all of the procurements of development products were delayed, while only half of the acquisitions of OTS products or modified OTS products were. The advantage from the time saved when choosing OTS is also mentioned in Baron (2006) and Saunders (2014).

We find two main disadvantages of OTS in the literature. The first disadvantage is that OTS products typically are products with a shorter lifespan and operative relevance: so-called 'consumables'. Gansler and Lucyshyn (2008) mention the shorter lifespan of OTS as well as changes in the market that can lead to obsolescence of OTS components. Correspondingly, Saunders (2014) mentions the increased need for technology refresh and obsolescence management as among the challenges of OTS.³

The second disadvantage from buying OTS products is related to the fact that the products are not tailored to the customer's needs and requirements (Gansler and Lucyshyn 2008). When buying OTS, the Armed Forces have to make do with the existing products, without any alterations. This again will sometimes result in a number of unfulfilled requirements, a lower performance and products that are not fully fitted for the planned use. If the procurement of OTS products requires adaptations of existing infrastructure or other equipment in order for them to be used, the benefits of buying OTS products might quickly be outweighed by an increase in cost and time. Gansler and Lucyshyn (2008) point out this

³ OTS products having a shorter lifespan and operative relevance has also been referred to by the former Norwegian Chief of Defence Harald Sunde, in *Aftenposten* (2 November, 2013).

challenge in their study of OTS⁴ in the United States DoD, where the use of OTS could require a change of culture within the acquisition community. Before, the experience of most of the military personnel came from requirement-driven and custom-designed components and systems, whereas now they had to adapt to commercial systems.

Despite the increased importance of OTS as an acquisition strategy, only a few empirical studies on OTS are available, and those studies are based on a small number of acquisitions (Gansler and Lucyshyn 2008; Saunders 2014). Given the non-existence of extensive empirical studies of OTS, decision makers have only limited research to consider when choosing an acquisition strategy. Furthermore, the existing empirical studies often lack a clear definition of OTS, or they differ in the definition used. A starting point for this study was therefore to define three categories of procurement: OTS, modified OTS and development. From these definitions, we develop an operational method to classify the procurement projects in the entire investment portfolio of the Norwegian Armed Forces. We then use this data to analyze empirically the advantages and disadvantages of OTS discussed in the literature by use of the following two research questions:

1. What are the characteristics of OTS?
2. Do OTS procurements perform better when it comes to completion of the projects according to the initial schedule, compared to procurements in the other two categories?

Although the results in this paper are derived from the small-country perspective of Norway we regard our definitions, method for classifying projects and empirical findings as a useful foundation for studies of OTS also in larger countries with a larger domestic defence

⁴ Gansler and Lucyshyn (2008) use the term COTS (commercial off the shelf). We choose to use the term 'OTS', as we do not find it expedient to distinguish between imported and domestic products as both hold the essential characteristics that they can be bought and put to use "as is" from an existing production line.

industry.

The remainder of this paper proceeds as follows. In section two, we provide our definitions and method for classifying projects and present the additional data. In the third section, we analyze the characteristics of OTS by studying descriptive statistics. In the fourth section, we present a model on deviation between planned and actual completion projects, which answers if choosing OTS implies a faster acquisition process. In section five, we lay out the results of the model and discuss these. Section six provides the conclusion of the paper.

2. DEFINITIONS, METHOD AND DATA

2.1. Definitions

In the literature, there is no common, universal definition of an OTS product; different studies present their own definitions. Nevertheless, OTS products are commonly defined as products from an existing production line (Baron 2006; Trybus 2014). In order to conduct an empirical study on a large number of procurements, we needed clear and simple definitions for each category that later could be operationalized into classifying each project in the investment portfolio. Furthermore, most studies only distinguish between OTS products and developed products. However, distinguishing between only two categories will result in too broad a set of products in each of the two categories. We therefore needed a middle category, between OTS products and development products, namely the category of modified OTS. Our definitions are as follows.

An *OTS product* is a product that does not require any development. The product is defined as having an existing production line and can be both domestically produced or imported. Modifications of the product must be minimal, and limited to less than 10 % of the total procurement cost. In order to study military OTS, we needed to allow for modifications of less

than 10 % within this category, as nearly all procurements involve some adjustments before they can be put to operative use. If we had not allowed for any modification, every product would probably have been classified as either modified OTS or development, and we would not have been able to study OTS itself with only minor modifications.⁵ Examples of previous OTS procurements in Norway are the military transport aircraft Hercules C-130J and the Raven UAV-system.

A *modified OTS* product is an OTS product that has been modified at a cost equal to or higher than 10 % of the total acquisition cost. We do not allow for any development costs in this category. A challenge in this category is products where OTS components are modified to the extent that the result is an entirely new product, although there was no development of new technology. The majority of the costs in these products are modification costs, and the OTS components only represent a small share of the costs. In our definition of modified OTS, we set the limit for modification costs to be 90 % or less, as the result of any greater modifications would be a new product without an existing production line. An example on modified OTS is the Norwegian purchase of used main battle tank (Leopard 2A4) from the Netherlands. The reason behind the use of this middle category is that we find it necessary to study the difference between OTS and OTS that is not put directly to use “as is” but modified. This middle category of modified OTS is still different from developing new materiel.

A *development product* is defined as a product where there has been technological development as part of the acquisition, and/or the product is not in use by anyone and lacks an existing production line. This implies that, although a product may be produced using only existing technology, it can still be classified as a development product. If a large number of subsystems based on existing technology are put together to create a new product or system,

⁵ The definition of COTS (commercial off-the-shelf) in General Services Administration Department of Defense (2005) also allows for minor modifications.

and the design or integration costs contribute to a considerable share of the total costs, the product will be classified as a development product. Examples Norwegian procurements classified as development is the F-35 aircraft, the main battle tank for the Army and primary communications for ISTAR⁶.

2.2. Method for classification of projects

There is no established operational method for classifying procurement projects; thus, we needed to develop a method to classify the projects in our dataset. Our starting point for analyzing OTS procurements was the Norwegian Armed Forces investment plan for the period 2015–2022, which contains a total of 268 procurement projects. None of these projects were labeled ‘OTS’, ‘modified OTS’ or ‘development’ according to our definitions, and we also had limited data available for each project. We started developing our method for classification by working out a list of criteria that described the inherent nature of each of the three categories according to our definitions. Due to the limited data on each project, we consulted 6 experts from the investment division of the Norwegian Ministry of Defence in order to classify the projects according to our three categories. To ensure that all of the experts used our definitions, we developed the criteria into a set of questions. By using a consistent set of 5 questions for each project, we also minimized the influence from the experts’ own subjective perception of what an OTS project is and what it is not. With this operative method, we were able to classify the entire investment portfolio, thus enabling this large-scale study of OTS projects.

In the previous section, we defined three categories of *products*. In the Norwegian Armed Forces investment portfolio, the procurements are divided into projects – not products – and

⁶ Intelligence, surveillance, target acquisition and reconnaissance (ISTAR).

these projects may in turn consist of different products. We still classified the entire project, to the extent possible, by asking experts from the investment division about the composition of the products within the project. We then followed our definitions at a project level, meaning that we asked about development costs or modification costs *for the project*.⁷

The set of questions we asked the investment experts was as follows:

1. Do you know of any development costs for this project? (We specified that the question did not refer only to technological development, but also to the costs of taking existing technology into a new type of materiel and/or starting a new production line.)
2. Do you know whether the modification costs have exceeded 10 % of the total costs in this project? (The investment experts used their qualified estimates on the share of modification costs to answer this question.)

The following questions 3–5 were control questions used for projects in which the investment expert did not know the amount of development or modification costs in the project.

3. Is Norway the first buyer of this version of the materiel, alone or together with other nations? (This question was highly relevant in cases where the answers to the first two questions were ‘no.’ If Norway was alone in buying the materiel in question, it indicated that there were development or modification costs in the project. We also emphasized that the time of signing the contract should be the premise for the answer. This was to avoid wrongly classifying materiel that did not exist when the contract was signed as OTS, in cases where development was shared with other nations that

⁷ We considered dividing all projects into products or systems/sub-systems to be too time consuming an exercise that would have had little impact on the results. This is partly due to the challenge of defining what an actual system is, and partly because several projects are still in the planning phase and the actual composition of products is not yet decided. In order to classify these projects we used the current procurement strategy as reported by the experts from the investment division.

started using the materiel before Norway.⁸)

4. Is there a need for technological development in the procurement of this materiel? (If the answer was 'yes', the materiel was classified as a development product.)
5. Is the main version of the materiel in use somewhere else in the world? (If the answer was 'yes', it indicated that this was an OTS rather than a development product.)

For example, if a project was to be classified as OTS, the answers had to be 'no' to the first four questions, and 'yes' to the fifth question. By using these questions we were able to classify a large number of projects to an acceptable accuracy and timeframe.

2.3. Data

In order to study the differences between OTS procurements and the two other categories, we gathered data on a number of different variables for each project, such as investment cost, deviation from initial planned completion of the project, cost overruns and lifespan of the materiel. A project's investment cost is the expected cost including management costs.

Deviation from initial planned completion of the project is defined as the deviation between the planned completion at the establishment of the project and the planned completion of it according to the current schedule. The deviation can be both positive (the project is delayed compared to initial plan) and negative (the completion of the project has been accelerated).

We study the investment plan for 2015–2022, thus the projects are naturally not yet completed. We therefore used the current state of the project as reported by the project leaders in the MoD's investment database to measure deviation from the initial plan.

Correspondingly, cost overrun is defined as the difference between planned cost at the

⁸ An example here is the F-35 aircraft.

project's establishment and the current actual cost, measured in constant prices.⁹ The lifespan of the materiel is how long the materiel is expected to be used by the Armed Forces.

Because the data on the variables in question is not stored in a single database, we had to collect data for each project from a number of different sources,¹⁰ both for each variable and for each data point within the variable. For many of our data points, we also consulted different experts within the defence sector. This method involved some uncertainty, as the result relies on a single person's definition of, for example, the lifespan of materiel.

The combination of different sources might affect the quality of the data for some of our variables. To make sure that we could still perform comparisons between the categories, we studied the distribution of sources between each category on the relevant variables. We found that the different sources were equally distributed. Thus it was possible to compare the results between the categories for the variables in question, in spite of the difference between sources.

Together with the quantitative analysis of the investment portfolio, we conducted interviews with personnel from different positions in the Norwegian Armed Forces to survey perceptions and opinions regarding OTS procurements in order to provide background for our research questions.¹¹

3. DESCRIPTIVE STATISTICS

In the interviews, our respondents from the Norwegian Armed Forces emphasized the following two perceptions regarding OTS. First, nearly everything has to be modified or

⁹ Measured in NOK million (2015). The actual costs are defined as current costs as reported in the Norwegian Ministry of Defence investment database.

¹⁰ The sources were project documentation from the different stages of the procurement process, interviews with different people within the defence sector and investment databases used by project managers.

¹¹ In the interviews, we presented our definition of OTS and asked the respondents to use this, in order to make the answers comparable with the rest of the study.

developed in order to be used by the Norwegian Armed Forces. This perception corresponds to the literature, where it is mentioned that OTS products are not tailored to the customer's needs and requirements (Gansler and Lucyshyn 2008). Second, the respondents held that OTS procurements typically are low-cost with a short lifespan, so-called 'consumables'. Gansler and Lucyshyn (2008) mention the shorter lifespan of OTS as well as changes in the market that can lead to obsolescence of OTS components. Correspondingly, Saunders (2014) mentions increased need for technology refresh and obsolescence management as one of the challenges from OTS.

In this section, we start by looking at the share of the three categories in the Norwegian investment portfolio, to see whether the category of OTS projects is of substantial size. We then study the descriptive statistics for each category of procurement for different variables to answer our first research question: What are the characteristics of OTS?

3.1. OTS in the Norwegian Armed Forces' investment portfolio

The share for each category in the Norwegian Armed Forces' investment portfolio for the time period 2015–2019 can be seen in table 1. Shares are measured by the number of projects and investment costs, respectively. Three projects¹² that were substantially larger than average have been excluded in the second row showing 'adjusted portfolio' in table 1. The excluded projects are all classified as development projects, with the smallest of these having investment costs 20 times larger than the average project in the rest of the portfolio. When the three projects are included, we observe a considerable change in the share of development projects, measured in costs. One can argue that projects of this magnitude are not a regularity

¹² These development projects are the F-35, the main battle tank for the Army and the submarine project. The smallest of these projects is 20 times larger than the average project in the rest of the portfolio. One could argue that any typical year has large investment projects, but, in the case of a small country such as Norway, the largest projects are of such substantial size compared to the rest of the portfolio that they dominate all results.

in the portfolio and we therefore show the ‘adjusted portfolio’, as excluding these projects gives us more representative results for a typical year. Furthermore, the purpose of table 1 is to show the shares of each category for a representative year. We therefore chose a timeframe of five years (2015–2019) to limit disturbance if one category (likely OTS) were dominated by shorter projects or projects that were not planned far ahead in time compared to for example development projects.

[Table I near here.]

Given the perception that nearly every product has to be modified or developed, the share of OTS procurements is surprisingly high in the adjusted portfolio (41 %).¹³

3.2. The characteristics of a typical OTS project

The second notion from the literature and our interview subjects was that OTS procurements typically are low-cost consumables with a short lifespan. To find out if these are the true characteristics of OTS we now look at table 2, where we can see investment costs and lifespan of a typical project in each of the three categories.¹⁴ In addition, the table shows the deviation from the initial planned completion of the project across the three categories.¹⁵ Table 2 contains data for all projects in the portfolio (2015–2022) as we are interested in the characteristics of a typical project in each category, and not to show the shares of each category for a representative year as was the case for table 1.

¹³ Within the OTS category, 32 % of the projects contain materiel bought from Norwegian industry. We did not collect data on whether it was *defence* industry.

¹⁴ Because costs are included in this section, we cannot link these to examples as it would result in classified information.

¹⁵ We use ‘deviation’ rather than ‘delay’ as some projects are completed ahead of schedule.

[Table II near here.]

The following three features in table 2 are of note. First, the average investment cost in OTS projects is larger than the average cost for modified OTS projects (310 vs. 250 million 2015-NOK). The maximum investment costs (5 000 million Norwegian kroner) also shows us that OTS projects can be of substantial size.¹⁶ This result shows that Norway has chosen OTS also in larger procurements, and goes against the perception of the respondents in our interviews. However, when we include all projects the largest development project is still about 7 times larger than the largest OTS project.

The second feature is that materiel in the average OTS project has a marginally longer lifespan than materiel procured in the other two categories (17 vs. 15 and 16 years). This is our least anticipated finding, as it goes against the literature when it comes to OTS materiel being described as typically short-lived consumables. Here we expected the materiel in OTS projects to have a considerable shorter lifespan than in the two other categories. We can also see that the distribution of the variable lifespan is similar across the three categories.¹⁷

Regarding deviations, the third feature is that on average all projects are delayed, but OTS projects are less delayed compared to projects in the two other categories (1.4 vs. 2.3 and 3 years). In fact, projects in the development category are on average twice as delayed as OTS projects. This result can be seen in light of the reduced technological risk when buying OTS, compared to developing new materiel that does not have an existing production line. On the other hand, we can also see that the project with the maximum delay is an OTS project (at 11 years, compared to 10 and 9), thus we see examples in our dataset of OTS projects being considerably delayed.

¹⁶ See also figure A.2 in the appendix for the distribution of investment cost between the categories.

¹⁷ See also figure A.1 in the appendix.

The first two features regarding investment cost and lifespan in the summary statistics in table 2 do not support the perception that OTS materiel is limited to only being low-cost consumables with a short lifespan. This again could imply that OTS can be considered as an acquisition strategy by decision-makers for larger procurements with materiel that has a long lifespan. Norway is a small country that procures most of its OTS materiel from the international market (68 %). Our findings are therefore primarily transferable to similar countries that also procure OTS materiel from the international market, but might not be applicable to different defence acquisition contexts.

In procurements where decision-makers have the option of choosing among the three categories, our third feature from the summary statistics is often crucial. Delayed projects will in general entail a cost to the Armed Forces from factors such as loss of the materiel's relevance and defense capability. Faster acquisition processes have been mentioned as one of the advantages of OTS compared to other categories of procurement (Baron 2006; Gansler and Lucyshyn 2008; Saunders 2014). In the following section, we analyze deviation from initial planned completion across the three categories by use of an econometric model, to study whether OTS projects are less delayed compared to the two other categories.

4. THE MODEL

Our data measures the deviation between the planned completion at the establishment of the project and the planned completion of it according to the current schedule of the project, and the variable is therefore limited to an indicator of the actual delivery of the materiel to the Norwegian Armed Forces.¹⁸ We use the term 'deviations' instead of 'delays', as some

¹⁸ The model does not specifically exclude large projects, but due to complexity and division into several projects we did not obtain data on F-35 delays, neither on the submarine project as this project will not start until 2019.

projects in our dataset are due to be completed ahead of the initial schedule.

To study deviations, we make use of a model where, in addition to a multi-level dummy for our three categories, the explanatory variables are: a dummy variable for change in the projects' scope, investment cost and a multi-level dummy variable for organization based on the five different divisions in the Norwegian Defence Logistics Organization (NDLO).¹⁹ The dummy variable for change in scope controls for deviations from the initial schedule due to substantial changes in the project that can affect its completion.²⁰ The variable investment cost is used to control for the different size and complexity of the projects, as estimates on completion of larger and more complex projects can be more uncertain. In the case of the multi-level dummy for organization, the main difference between the five divisions of the NDLO is the type of materiel procured, for example Land materiel such as battle tank and ammunition in the Land division and Sea materiel such as submarines and frigates in the Sea division. Apart from this, there should be no difference in how the divisions are organized. Still, we wanted to include this variable in a second iteration to see whether controlling for any differences between the divisions might have an effect on the results.

Regarding the explanatory variable of most interest; the dummy variable for categories, we found no plausible reason to use a variable that described an ordinal relationship between the different types of projects. Choosing a dummy variable limits our interpretation of the results on category to an interpretation of differences in means between the groups of projects. This limitation applies to all variables in the model, except the variable for investment cost.

Our entire dataset consists of 268 projects, but we only have data on all the variables in our model for 151 of the projects.

¹⁹ The five divisions are: 1=Land division, 2=Information infrastructure (INI) division, 3=Sea division, 4=Air division, 5=Soldiers equipment, Logistics and Special operations forces.

²⁰ Change in scope is defined by a reduction or increase in the project's budget of 50 % or more, compared to the initiation of the project. We considered the quality of the continuous data on cost overruns to be unsatisfactory; thus, we did not trust this variable to indicate the *level* of cost overruns in our model.

Our second research question is tested by the model, and is as follows: Do OTS procurements perform better when it comes to completion of the projects according to the initial schedule, compared to procurements in the other two categories?

To answer this research question we study the following static model:

$$Y = \beta_0 + \beta_1 C + \beta_2 S + \beta_3 I + \beta_4 O + e \quad (1)$$

Y^{21} is deviation from the planned completion of the project, measured in years; C is a multi-level dummy for the three categories – OTS, modified OTS and development; S is a dummy variable controlling for changes in the project's scope (where 1=change, 0=no change); I is a continuous variable on investment cost, measured in NOK million (2015). The fourth variable; O is the multi-level dummy variable following the Norwegian Armed Forces' logistics organization's five divisions. This variable is included in the second iteration of the model to control for differences within the procurement organization.

OTS projects should intuitively be less delayed compared to both modified OTS and development projects (see chapter 1), thus we expect the coefficients for the latter two categories to be positive. As for the other variables, our prediction for the variable that controls for change in scope (S) is a positive coefficient due to increased administration from either a reduction or an increase of the projects magnitude. We expect the variable investment costs (I) to have a positive coefficient as time estimates for larger and more complex projects intuitively should be more uncertain than for smaller projects. For the variable controlling for differences within the procurement organization (O) our intuitive prediction is no effect on delays from the inherent nature of the different materiel in the divisions.

²¹ The completion of the project is defined as when the projects termination report is written according to the current schedule reported in the database of the Norwegian Ministry of Defence.

5. RESULTS AND DISCUSSION

Table 3 shows the results for the effect of category, change in scope, investment cost and organization on deviation from planned completion of the project.

[Table III near here.]

We see that the coefficient on development is positive and significant²², predicting that the average development project will be on average 1.35 years delayed compared to an OTS project (the reference category). This finding corresponds with one of the results from the US GAO, where the initiatives that met or were expected to meet the schedule consisted only of OTS and modified OTS (GAO 2012, 14). In the second iteration, where the variable for organization (O) is included, the results imply that adjusting for organizational difference according to type of materiel procured could reduce the difference in delays between OTS and development projects.

The coefficient on investment is significant, and its magnitude suggests that the size of the project is negatively correlated with deviations from planned completion of the project. This result predicts that an increase in the projects investment costs implies less delay.²³ This might be a surprising result, given our intuition that the estimates for completion of a larger and more complex project are more uncertain. On the other hand, larger projects are often more prestigious thus giving the project leader both access to more resources and incentives to prioritize the completion of these projects according to the initial plan.

The coefficient for modified OTS (C_2) is positive but not significant, a result that proposes no difference in expected average delay between OTS and modified OTS. Further,

²² At a 5 % level and 10 % level for the two iterations, respectively.

²³ Note that the coefficients magnitude is only -3.68e-10.

change in scope (S) has a non-significant coefficient, implying that change in a projects scope will not have an effect on delays. Except for projects in the Information Infrastructure division (INI), neither of the coefficients for the variable organization (O) are positive. This result from the second iteration predicts that INI projects on average are 1.44 years delayed compared to projects in the Land division. The share of development projects in the INI division is close to 65 %, measured in investment costs, something that suggests that some of the delay for development projects in the first iteration originate from development projects in the INI division.

From the Ramsey RESET test results (Ramsey and Schmidt 1976), suggest that the results from the first iteration do not suffer from misspecifications of the model. Given that the Ramsey RESET test does not in all cases discriminate between alternative models (Hill et al. 2008), we performed an F-test and a likelihood-ratio test for both iterations. Together, the results of these tests suggest that the more restrictive model in the first iteration is preferable compared to the second iteration.

Optimism bias, where the agent systematically underestimates the risk of negative events when planning the future, is a much-studied phenomenon in several academic disciplines (Puri and Robinson 2007; Sharot 2011). Controlling for optimism bias in our model would be too challenging an exercise for the scope of this study, but it is still interesting as a possible explanatory factor behind delays.

In addition to literature suggesting less risk concerning time in OTS procurements (see Baron 2006; Gansler and Lucyshyn 2008; Saunders 2014), our interview respondents emphasized the following four reasons for projects delays: lack of funding, offsets, lack of personnel and producer delays (outside the organizational delays). The first three reasons are typically organizational delays, where common sources are reorganization or change in the

investment portfolio due to tight budgets. A fourth organizational delay can be the Armed Forces' lack of readiness to receive the new materiel, thus delaying the project. If these types of delay have a different distribution between our three categories, they could also explain the delay.

6 CONCLUSION AND FUTURE RESEARCH

6.1. Conclusion

This study adds to the existing literature on OTS procurement by using data from the entire 2015–2022 investment portfolio of the Norwegian Armed Forces to bring empirical evidence into the debate on OTS acquisitions as the preferred acquisition strategy.

As there is no established operational method to classify procurements as OTS, another contribution of this paper is the method we developed. From a list of criteria that described the inherent nature of each of the three categories, we developed a set of questions. We then presented the questions to experts from the investment division of the Norwegian ministry of defence, in order to classify each project into one of our three categories. With this operational method, we were able to classify the entire investment portfolio, thus enabling this large-scale study of OTS procurements. This method of using a questionnaire with an investment expert can be applied to classify investment projects in any country. However, some of the questions²⁴ we used might not be applicable for larger countries with a large domestic defence industry, such as the United States or Russia, and should therefore be modified to fit the country in question. For smaller countries similar to Norway the questions we used in this paper can be applied.

²⁴ This especially applies to questions 3 and 5. Regarding question 3, if for example the United States is the first buyer of a version of the materiel, it does not exclude the possibility of the product being OTS due to the large domestic defence industry. The same logic applies for question 5; if the country has a large domestic defence industry the main version of the materiel does not necessarily have to be in use somewhere else in the world for it to be an OTS product.

In addition to our method for classification of projects, there are two main findings from the analysis of the quantitative data in this paper. The first finding is derived from descriptive statistics where the characteristics of OTS projects correspond to the two other categories on both investment costs and lifespan of the materiel, implying that OTS materiel is not limited to low-cost consumables with a short lifespan only.

When OTS is found to have corresponding characteristics to projects in the two other categories²⁵, decision-makers can consider OTS as an acquisition strategy for larger procurements also, where the materiel has a considerable lifespan.

The second finding is derived from our model on project time deviations. The estimation results indicate that OTS projects perform better when it comes to completion of the projects according to the initial schedule compared to development projects, where the average deviation compared to OTS was 1.35 years longer in the first iteration and 0.97 years in the second iteration.²⁶ This finding is useful for decision-makers concerning possible gains from choosing OTS, as delayed projects in general entail a cost to the armed forces in the form of factors such as loss of the materiel's relevance and defense capability.

In terms of limitations to our work, the small size of a country such as Norway will naturally have an effect on the aggregate share of OTS procurements in the investment portfolio, thus making it incomparable with large countries with a correspondingly larger domestic defense industry. Furthermore, Norway is a small country that procures most of its OTS materiel from the international market (68 %). The results on characteristics of OTS can therefore be transferable to similar countries that also procure OTS materiel from the international market, but might not be applicable in different defence acquisition contexts.

²⁵ See also figures A.1 and A.2 in the appendix.

²⁶ The coefficient in the second iteration was significant at the 10 % level.

6.2. Future research

As military OTS procurement is a topic that has not had an extensive amount of literature on it, there are several possible extensions for future research. As we see it, the two most prominent topics are cost overruns and implications on lifecycle costs from OTS procurement. Another relevant topic is OTS procurements in large countries with extensive domestic defense industries, as the benefit from developing products is likely to be different from that in countries with smaller industries.

Factors contributing to schedule deviations in investment projects are also relevant as topics for further studies. Related to the model in this paper we discussed factors such as optimism bias and different organizational delays, such as lack of funding and the Armed Forces not being ready to receive the new materiel. Knowledge regarding the impact from such factors on schedule deviations across different categories of procurement would be valuable to decision makers.

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7 Tables

TABLE I: Projects in the Investment Portfolio for the Years 2015–2019: Share of OTS, Modified OTS and Development Projects

Variables	OTS (%)	Modified OTS (%)	Development (%)
<i>Share of total procurement costs</i>			
Entire portfolio	12	9	79
Adjusted portfolio	41	29	30
<i>Share of number of procurements</i>			
Entire portfolio	34	24	42

Notes: The number of projects that has a payment in the years 2015–2019 in the entire investment portfolio of the Norwegian Armed Forces; N = 203. N = 200 for the adjusted portfolio where the three largest projects are excluded. These projects are all development projects: the F-35, the main battle tank for the Army and the submarine project. Data does not include the share of OTS projects that contains lethal military equipment vs. the share of non-lethal military equipment.

TABLE II: Descriptive Statistics for the Projects in the Investment Portfolio for the Years 2015–2022

Variables	Mean	Std. dev.	Median	Min.	Max.	Obs.
Investment cost <i>entire portfolio</i>	774	3 246	190	5	37 711	268
OTS	314	576	163	5	4 975	107
Modified OTS	256	319	162	6	2 010	80
Development	1 867	5 683	282	23	37 711	81
Investment cost <i>adjusted portfolio</i>	420	828	187	5	5 924	265
OTS	314	576	163	5	4 975	107
Modified OTS	256	319	162	6	2 010	80
Development	737	1 287	261	23	5 924	78
Lifespan (years)	16	7	15	2	35	217
OTS	17	7	15	2	35	87
Modified OTS	15	7	15	2	30	64
Development	16	7	15	3	30	66
Deviation (years)	2	3	2	-5	11	187
OTS	1,4	3	1	-5	11	75
Modified OTS	2,3	3	2	-2	10	50
Development	3	3	3	-4	9	62

Notes: All values in million 2015-NOK. N = 268 in the entire 2015–2022 investment portfolio of the Norwegian Armed Forces. N = 265 for the adjusted portfolio where the three largest projects are excluded. These projects are all development projects: the F-35, the main battle tank for the Army and the submarine project. Different variables have different number of observations due to lack of data for some projects.

TABLE III: Model Results (Response Variable: Deviation from Initial Planned Completion of the Project, Years)

Variables	Coefficients iteration 1	Coefficients iteration 2
β_0	1.54 (0.38)	2.85 (0.66)
Modified OTS (C_2)	0.58 (0.49)	0.34 (0.56)
Development (C_3)	1.35** (0.59)	0.97* (0.57)
Change in scope (S_1)	-0.13 (0.63)	-0.15 (0.64)
Investment (I)	-3.68e-10*** (1.14e-10)	-2.86e-10*** (1.22e-10)
INI¹ (O_2)		1.44** (0.73)
Sea (O_3)		0.00 (0.72)
Air (O_4)		-0.40 (0.69)
SOF, SOS, Logistics (O_5)		0.22 (0.68)
Ramsey RESET test for omitted variables	0.43 (p-value)	0.69 (p-value)
Test for multicollinearity	1.12 (Mean variable inflation factor (VIF) ²)	1.50 (Mean variable inflation factor (VIF) ³)
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	0.02 (p-value)	0.06 (p-value) ⁴
F-test C_2, C_3	0.07 (p-value) ⁵	
F-test O_2,O_3,O_4,O_5		0.16 (p-value) ⁶
Likelihood-ratio test		0.17 (p-value) ⁷

Notes: N = 151. The base for our dataset is the entire 2015–2022 investment portfolio of the Norwegian Armed Forces, in total 268 projects, but the models sample consists of the 151 projects where we have data on all the explanatory and response variables. Due to complexity and division into several projects we did for example not obtain data on F-35 delays, neither on the submarine project as this project will not start until 2019. The number of observations for each variable can be seen in table II. The base for interpretation of the coefficients of the multi-level dummy-variable C (Category) in both models is an OTS-project (C_1), and for the multi-level dummy-variable O (Organization) the base for interpretation is Land (O_1). ***p<0.01, **p<0.05, *p<0.1.

1 The share of development projects in the Information infrastructure (INI) division is close to 65 %, measured in investment costs.

2 VIF min/max: 1,01 and 2,24.

3 VIF min/max: 1,02 and 2,06.

4 From the test results, we cannot reject constant variance. From investigating the residual plot we decided to continue to use robust standard errors.

5 Separate p-value for C_2 and C_3 is 0,24 and 0,02, respectively.

6 This result suggests that there is no significant contribution from the variable O in the second iteration.

7 This result suggests that the more restrictive model in the first iteration fits the data significantly better.

7 Appendix

Figure A.1: Distribution of Lifespan of the Materiel Procured: OTS, Modified OTS and Development

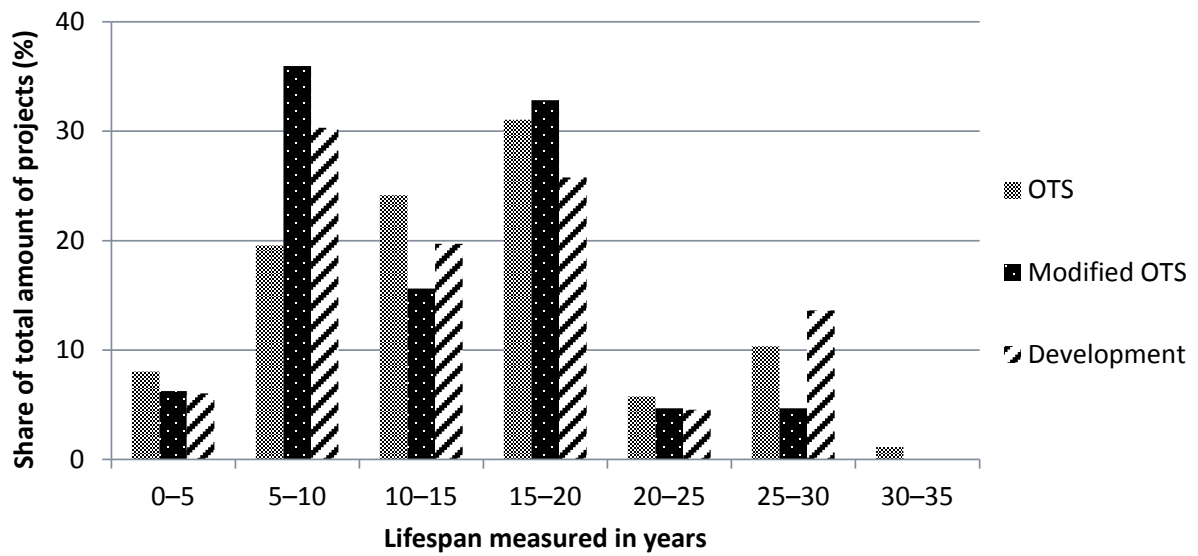


Figure A.2: Distribution of Investment Cost: OTS, Modified OTS and Development

