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Original Paper

European Policies and the Space Industry Value Chain (Note 1)

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Abstract

The economics of contracting have received rather limited attention insofar as the implications for efficiency from the selection of types of contracts employed in the aerospace and defence sector are involved. The paper analyzes the challenges confronting the cost-plus/cost-reimbursement type of contracts of European Commission and intergovernmental organizations like the European Space Agency (ESA), who are involved in security and defence projects with significant multiplier effects within defence and security networks. The analysis indicates how institutional limitations result in contractual choice inefficiencies and anti-competitive practices that may affect the whole of the aerospace industrial base, including subcontractors. The paper concludes with policy implications and further research recommendation.

Keywords

Procurement, Industrial Organization, Aerospace

1. Introduction

The aim of this paper is to examine the procurement practices in the European space sector that has arguably been described as a raw model for intergovernmental collaboration leading to integration.

The analysis looks at how the intergovernmental nature of ESA politicizes the contractual aspects of its programs, but also the European value added chain, by both incentivizing the contractors to incorporate political objectives in their economic behaviour, but also through the challenges in employing contractual schemes with transparent monitoring and accountability.

The case of the European commercial airliners industry has received more public attention owing not simply to the success of the initial joint venture of Airbus that led the consolidation of the European aerospace industry first through EADS and since 2015 Airbus group, but also owing to the commercial nature of the sector. In contrast, the European space sector is heavily dependent not only in terms of the development efforts, but also in terms of the global market outlook both of which are government-centric. The European main institution for collaborative space programs has historically being the European Space Agency (ESA), more recently joined by the European Commission in what at times seemed an unclear and ad-hoc developing relationship (Note 2). ESA though is the main enabler in terms of technical expertise for European collaboration in space and for small countries virtually the only economical way of space involvement. This is owed to the sometimes controversial fair return principle that is typical of R&D programs in space and not only, whereby work allocation to national industries match the government contributions to joint undertakings.

ESA's intergovernmental nature results in scarce information being made public which is a further reason for the lack of attention by the literature. It is noteworthy that the space industry is critical for the aerospace sector as a whole not only due to its technical characteristics and multiplier effects (Zervos, 2011a), but also due to its embedding under common aerospace industrial integrators with expected benefits from synergies in R&D and economies of scale and scope (see Logsdon et al., 1998; and more recent OECD, 2012). This paper thus examines the process of procurement of ESA and how the industrial consolidation and effort of ESA to maintain its industry development role and procurement efficiency is a challenging multiple set of objectives.

The rest of the paper is organized as follows: key background information relating to the space sector are presented followed by procurement practices and challenges literature with space implementation specific analysis. The ESA institutional mandate to achieve fair return and assist industrial development and its implications for the value chain is then examined and an illustrative modeling example is used to indicate how under certain conditions a "from cradle to grave" control over the value added chain can pose some challenges by nullifying competitive pressures and emphasizing political influences that potentially might be counterproductive even for the objective of industrial development per se. The paper concludes with emphasis on more information availability and transparency requirements for conclusive analysis in view of the attributed significance of space programs for economic development and anticipated high technological externalities.

2. Background to the European Space Industry

The space industry in Europe has experienced a number of "artificial" (non-market) transformations leading to the first major multinational space integrator, namely Airbus. A number of mergers and acquisitions that drove industrial concentration at national level took place in the 1990s with noticeable examples Spain, Germany, the UK, France. During a second wave, national champions were then merged into EADS under the "Astrium" division for space products and services with few remaining outside this (e.g., cases like Thales Alenia). More recently, a third wave of newly sprung businesses has emerged with newly formed space companies, but on lesser than a space integrator scale (e.g., OHB-see CSIS, 2001; and Zervos, 2011a).

On the demand side, Europe prouds itself on being less dependent on government markets as opposed to the US and other space faring nations like China, Japan, India. Arguably the only less dependent space industry on (own) government sales was Russia for much of the post-Cold War period, whereby the sizeable and shrinking space industry survived on export and technology "sell-off" primarily to the West (US and Europe) in exchange for hard currency during times of post-Soviet economic turbulence and evaporating government budgets. The public sector role in developing and supporting technologically, financially and contractually the space sector is crucial, frequently citing infant industry arguments in favor of public support, but also technological externalities and security considerations driving arguments for autonomy. The industrial policy of perhaps the biggest European public customer, the intergovernmental ESA is a noteworthy example. The industrial and procurement policy of ESA has been a point of debate and contention between member states, as well as US industrial firms that claimed unfair competition from such practices as early back as the 1980s (Note 3).

ESA follows a fair return industrial policy since the early days of its creation, following the ELDO/ESRO merging in the 1970s. Under this policy, member state contribution to the ESA budget for space programs and services is expected to lead to equi-proportionate returns in the form of contracts to the members state's industry (ESA, 2005). Clearly, this mechanism (typically employed in collaborative programs in high technology areas and defence) brings benefits in allowing national policy-makers to justify funding allocated to collaborative programs and facilitating thus the funding of projects. The criticism has been historically focused on the allocative efficiency of the funds, as this is on the basis of the origin, rather than on the basis of industrial/cost efficiency. ESA is thus frequently perceived as acting as an industrial developer for "infant" (or perhaps more accurately "more infant") industries. It is therefore possible that the contracting practices and allocation of resources takes place not only on non-market criteria, but also on project non-cost efficiency criteria (Zervos, 2011b).

The consolidation of the industry at the European level through the formation of a major space integrator and a small number of major space contractors was not matched throughout the value chain, since the lower tiers of the industry (space industrial base) does not seem to be subject to the same consolidation. As a result, it is quite possible that ESA's awarding of major projects to main contractors could potentially lead to an unintended geographical distribution of lower-tier contracts.

Further than that, contract monitoring and application of cost-plus and incentive type of contracts potentially can lead to high transaction costs in the form of lengthy negotiations across national policy-makers regarding accountability and reward allocation. ESA is generally perceived as practicing simple contract types like firm-fixed price, which in case of low technology readiness level or high risk projects can lead to inefficiencies. There is limited publicly available information on relevant practices and data is well-documented but not for public use/distribution. There is evidence that in practice non-fixed contracts are implemented throughout the lifetime of a project, a theme examined in more detail on section 3 within the framework of space sector contractual practices.

3. Background in Contracting Literature and Practices with Space Applications

In basic research and technology type of contracts, where the Technology Readiness Level (TRL) is low and there are high risks and unknown factors involved, the preferred type of contract is a cost-plus type of contract. This allows the customer to absorb the risk associated with the relevant technology developments, rather than the contractor. Programs under such contracts would shift the technology level and would thus be depicted along the dashed line in Figure 1.

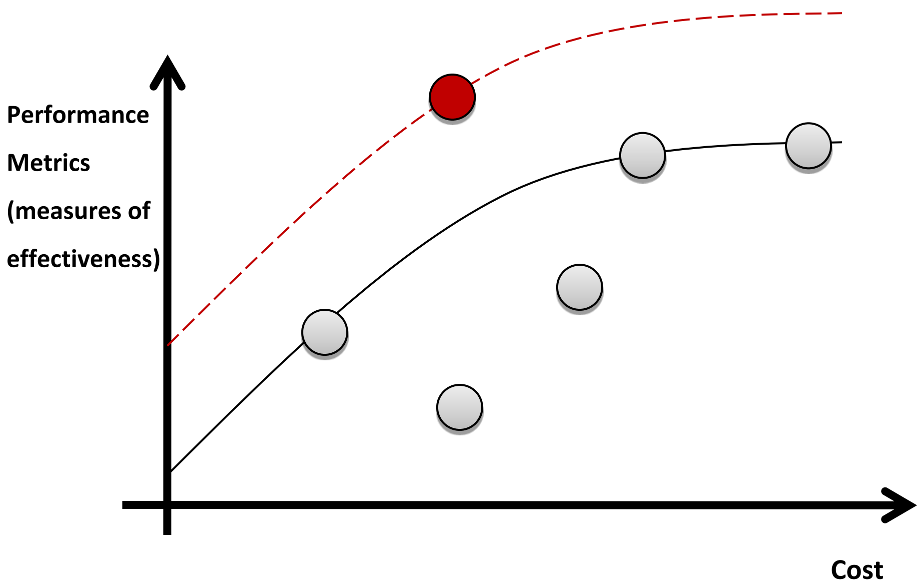

Figure 1. Performance versus Cost for Different Technology Levels

Source: Adapted from Zervos, 2011a.

Note. The dashed line represents a future, higher-level cost-effectiveness frontier, following investments in basic technology and relevant time-to-maturity. The continuous line represents the pareto-optimal trade-off frontier between cost and effectiveness under current technology.

The creation of new technology has external benefits to the project itself, hence high-technology projects are associated with market failures and government support.

In a seminal paper, Arrow discusses how non profit organizations are best placed to pursue knowledge associated with invention noting the challenges faced when cost-plus contracts are issued:

"A second example is the cost-plus contract in one of its various forms. When production costs on military items are highly uncertain, the military establishment will pay, not a fixed unit price, but the cost of production plus an amount which today is usually a fixed fee. Such a contract could be regarded as a combination of a fixed-price contract with an insurance against costs. The insurance premium could be regarded as the difference between the fixed price the government would be willing to pay and the fixed fee. Cost-plus contracts are necessitated by the inability or unwillingness of firms to bear the risks. The government has superior risk bearing ability and so the burden is shifted to it. It is then

enabled to buy from firms on the basis of their productive efficiency rather than their risk bearing ability, which may be only imperfectly correlated. But cost-plus contracts notoriously have their adverse allocative effects. This somewhat lengthy digression on the theory of risk bearing seemed necessitated by the paucity of literature on the subject. The main conclusions to be drawn are the following: (1) the economic system has devices for shifting risks, but they are limited and imperfect; hence, one would expect an underinvestment in risky activities; (2) it is undoubtedly worthwhile to enlarge the variety of such devices, but the moral factor creates a limit to their potential" (Arrow, 1962, pp. 613-614).

Hitch (1962) using examples from the military/space industry (Atlas and Titan program) presents the challenges associated with the issuing of cost-plus contracts resembling the famous thoughts of a US astronaut during launch on how reassuring he felt knowing that each component on the rocket was provided by the lowest bidder:

"Nevertheless, the new policy appears far from ideal. The aircraft companies risk nothing (even the cost of preparing designs is usually reimbursed). Because of the great uncertainties involved in any major development, it is hard to make a wise selection at the design stage. Companies have a natural tendency to be optimistic in estimating performance, cost, and availability at this stage—sometimes much more so than at other stages as Klein and Marshall and Meckling have shown. Arid the Air Force has a natural tendency to favor the more optimistic proposals. As a result, the specifications in the development contract are sometimes unrealistic to the point of causing inordinate delay. Moreover, once the winner has been selected, there is no more competition. The company may put its best team on the development for the sake of patriotism or its own long term reputation, but the powerful incentive of competition is lacking. Partly for this reason the Air Force, locked to a sole source with a cost-plus contract, has to exercise a kind and degree of control during the development process that is inconsistent with management prerogatives as they are understood and practiced in other parts of the free enterprise economy. I believe the inefficiencies resulting from these policies and procedures are serious, and worthy of much more attention by economists. It does no good simply to inveigh against the iniquities of cost-plus contracting and government risk bearing when we are unable to propose a practical alternative. Perhaps part of the answer lies in some form of risk sharing. What is badly needed here is an economics invention or, more probably, several of them. The government is going to be in the business of supporting research and development on a large scale for a long time, and it is important that it use policies that take advantage of the incentives present in the economy" (Hitch, 1962, p. 626).

It is clear that the issue of contract monitoring for cost-plus contracts is critical for performance. This comes at a cost. In the US, the concept of Earned Value Method System (EVMS) has been developed for Federal contracts. This concept is simple in its principle, but rather complicated and costly in its implementation. The monitoring costs are often cited a major obstacle in monitoring performance and could result in even higher transaction costs in the form of legal disputes (Zervos, 2011b).

In Europe, primarily the UK is employing the EVMS model (MoD), while the major space agency ESA follows a far more complicated and origin-based approach. Specifically, ESA owing to its intergovernmental nature is perceived as subject to political influences from national industrial policies, hence could be far more challenging to monitor and assign accountability to subcontractors, since part of the *raison d'être* of its operations is to advance industry and development (through fair return) not to achieve cost efficiency. Therefore, locking the contract profile at an early stage is preferred to having a tedious and politically sensitive with added high transaction costs and potential disputes monitoring system required for cost-plus contracts.

Though official data is unavailable, since ESA only publishes data agreed upon by all member states, it is estimated that up until the early 2000s the majority of contract value was awarded under Fixed-Price (FP) contracts. More recently, a novel type of contract was developed namely the "ceiling price to be converted to fixed price" contract (CP-FP). This contract invention was generated out of the high transaction costs associated with the lengthy and sometimes controversial negotiations of the typical FP contract applied to a new-technology space program where a cost-plus type might have been more suitable on economic grounds.

Zervos (2011b) describes the process as follows: *"The process of a typical contract can be summed up as follows: a firm-fixed-price contract is negotiated and agreed upon between ESA, followed by a the initiation of the programme's early phases (Phase A and B- see NASA 2007). At a later point in the programme's phases (during Phase C, or D for example, NASA, 2007), where advancements in technological risky/uncertain areas have developed, an Engineering Change Proposal (ECP) is put forth and subjected to a technical evaluation by the programme manager who then needs to put it through a cost-assessment and approval process, following which, a CCN* [ed. Contract Change Notice] *is added as a new clause to the contract. For example, in 2005 ESA placed 778 contracts and 353 work orders, but over 2300 contract change notices (Reynaud, 2005). Despite the fact that most of those programmes were placed under a firm-fixed price regime, the change notices that occur cause de-facto variations relating to the original contract scheme. In addition, Reynaud, 2005 reveals that the direct negotiation contracts (251) are less than the open competition ones (238). Competition is a challenge for ESA and European national space agencies, given the consolidated national and European space industrial base, coupled with the fair return principle. This is highlighted by the cases where lack of competition in contracting is justified by ESA's guidelines"* (ESA, 2008, pp. 23-25). ibid.

Since Hitch (1962), there has been a substantial spectrum of literature that sprung out of the economics discipline, but has largely focused on procurement and effort (see for example Laffont & Tirole, 1993), rather than the inventions referred to by Hitch.

In summary, the differences between cost-plus, fixed-price (with CCN) and CP-FP appear to be not as important as the different titles suggest, but certainly presenting different challenges to the sharing of risk and the efficiency of the process. A critical factor appears to be the actual implementation practice followed, rather than the generic "title" of the contract. Clearly a fixed price contract that is subject to CCNs is a renegotiated contract based on ad-hoc cost-related information that is not necessarily considered at the time of the drafting (or accurately estimated). Thus, a cost-overrun by definition changes the nature of the contract and voids it as a FP. Similar renegotiations can take place for a CP contract, despite the more degrees of freedom allowed with regards to cost uncertainties, or even for a CP-FP type. For example, the non-full funding commitment by the principal at the time of the initial signing of the contract introduces lock-in elements and challenges for investment specificity:

"A cost-plus contract typically allows for the contractor to spend a proportion above the expected value, but on this overrun there is no profit, hence no incentive for such overruns. However, when successfully negotiated if a contract does not 'lock' in terms of its funding profile by full commitment of the funding authority, then the contractor effectively is facing an annual re-negotiation process for each incremental funding period. In effect, the cost-overruns become part of next period's profile and thus are never treated as overruns. The overrun is real in terms of the overall project, but has little impact on the contractor's profitability, or incentives. The same can be said about ESA's contract with ceiling price to be converted into fixed price (CP-FP). To illustrate this, what would be considered contract overruns under a well-defined, cost-plus, or fixed-price contract at the signing of the contract, become 'additional information' leading to a de-facto re-drafting of the contract terms. For NASA, this takes place on an annual basis, for ESA's CP-FP contracts this institutionally is supposed to happen once" (Zervos, 2011b).

However, in the absence of relevant information, it cannot be excluded that CCNs are taking place under ESA CP-FP contracts resulting in high transaction costs and challenges in estimating contract efficiency.

Importantly, though, despite the challenges associated with contracting types and choices, the line of accountability within the principal agent framework in the classic model runs from the government to the space agency to the contractor and the subcontractors in a linear mode. It would seem obvious that in the opposite case, where non-linearities are present, there would be scope for blurred lines of accountability and authority. For example, traditionally, the responsibility for the selection of the prime rests with the space agency (Note 4). Despite possible indirect political pressures by potential higher political entities to influence the process, direct interference under many political systems could be seen as legally and politically abnormal. In a similar manner, the contractor is responsible for the subcontractors if the line of accountability is to be fully exhausted on him by the principal for contract performance.

This changed formally by ESA in 2012 with the introduction of best practices guide, where effectively ESA attempted to apply the fair return principle across the value chain. Given the presence of high value programs and a consolidated contractor tier, this certainly appears to have benefits in the form of actual rather than nominal application of the fair return principle. Given the early experiences of the integrators in terms of corporate governance and the presence of government within the governing and funding mechanisms it seems likely that distortions in the allocation and potential conflicts could arise that would not be compatible with the fair return approach adopted by the principal, but with national industrial policies (rather than with competitive considerations).

More specifically, in 2012, a best practices guide was introduced in ESA's procurement practices and became available through its electronic procurement network (EMITS). At the core of the process is the presence of an Industrial Procurement Plan (IPP) that would among other things allow ESA to assess the make-or-buy decisions of the contractor, both in terms of the actual decision, but also of the method of implementation (competitive contract, direct placement, etc.):

"a) The IPP will be established by the Prime Contractor as part of his proposal, at the date required by the Agency and will:

-take into account all pertaining requirements such as, but not limited to, geographical distribution, Industrial policy and special measures introduced by the Agency at the time of its ITT/RFQ; and,

-develop the strategy proposed to achieve these requirements.

b) The proposed IPP will be evaluated as part of the tender evaluation process and will be negotiated by the Agency with the Prime Contractor prior to the placing of the contract by the Agency" (ESA, 2012, pp. 10-11).

Clearly, the contractor must take into consideration the fair return approach and implement it accordingly in negotiation with the principal. The guidelines specify the process as follows:

"IPP content:

i. The categorisation of each 'make' or 'buy' proposal with the justification for such categorisation in consideration of the programme specific criteria (including geographical requirements);

…

vii. For activities/products categorized as 'buy' outside Europe, a detailed justification of the reasons why it cannot be 'buy' in Europe" (Ibid.).

The implementation is based upon the operations of a tender evaluation board by the contractor to select sub-contractors with the possible inclusion of an ESA representative as follows:

"…iii. (A) representative(s) of ESA will be designated by the ESA Project Manager to participate as member(s) of the TEB" (ibid.).

The contractor under this scheme is to recommend to the agency for a decision with limited ability for appeal, as the ombudsman concept has low applicability as follows:

"i. The Contractor's recommendation for selection will be made on the basis of the evaluation results of the TEB -also when it was an ESA lead TEB- and any other constraints and considerations of the programme, including if any the geographical distribution objectives or special measures defined by the Agency at the time of the issuing of the ITT/RFQ.

iii. This recommendation shall be send to the Agency's Project Manager and Agency's Responsible Contracts Officer by secured means and addressed to the Agency's Responsible Contracts Officer".

…"i. Upon receipt of the recommendation, the Agency shall decide within a period of five working days, (unless justified circumstances prevent such response) either to endorse the recommendation or

to request that it be submitted for decision to a Joint ESA/Industry Senior Procurement Board with a possibility of appeal at higher management level in case of persisting disagreement.

ii. The Agency shall always have the right to request, if so desired, a new evaluation, in such case the Agency shall notify both the Prime Contractor and the interested Contractor of the reasons for its decision.

…

ii. The Ombudsman shall not be competent for receiving complaints concerning disputes between the Agency and Industry in the frame of Best Practices.

iii. The Ombudsman shall not be competent to receive and investigate complaints based on questions of Industrial Return and Geographical Distribution" (Ibid, pp. 11-13).

This change is expected to have long-run implications for the European space-industrial complex. The linear, classic model of government-agency-contractor-subcontractor in terms of accountability and management practices is expected to evolve in a more matrix-type format (Figure 2). This may result in accountability issues with non-discreet decisions implications at management and governance levels. As the space sector is best characterized as an "opaque" operations sector in terms of its corporate governance owing to security considerations, but also the dominant role of the government, the absence of arm's length contractual relationships between the space agency and the SIB may have challenges for efficiency in the future.

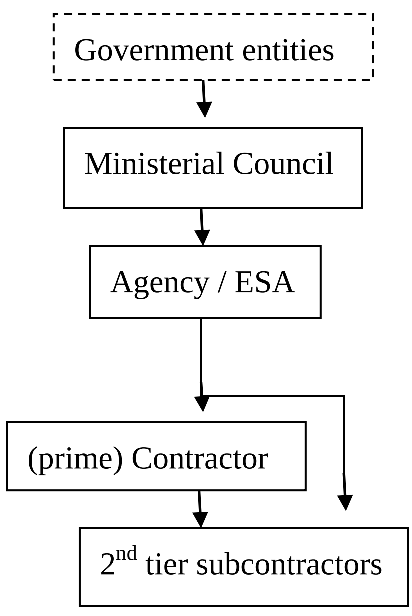

Figure 2. Procurement Process in the European Space Value Chain and Industrial Complex

Overall, both the absence of a formal monitoring system for what effectively constitutes cost-plus contracts and the matrix framework throughout the value chain point to a complex partnership-based, rather than market-based model (Note 5). This can potentially nullify cost-risk based competition that in the absence of a market and a contestable framework can enhance moral hazard and adverse selection problems.

4. A Model Application

The implications of the lower-tiers of the space industrial base for the efficiency of the space markets can be significant depending on whether subcontractors represent a competitive, or vertically integrated segment. A model can be used to draw some illustrations since the conduct of the space agency like ESA can determine the degree of vertical integration. Specifically, a model can be used to analyze and compare across different structures related to lower-tiers of the US and the European space industrial base (LSIB) on the performance of the respective industries in commercial and public markets as well as, on public procurement (Note 6). We thus compare the results of four industrial structures:

1) The US and European integrators openly subcontract work to either the US, or the European LSIB (open US and European integrator's markets).

2) US or European integrators merge with their subcontractors, while the other area's integrators face a monopoly from the domestic LSIB.

3) Both the US and European integrators vertically integrate (merge) with their subcontractors.

4) The US and European integrators subcontract work only to the domestic LSIB.

It is clear that these scenarios represent different procurement and industrial policy regimes. For example, Scenario 1 would require changes in export restrictions regulations (Note 7) and procurement in the US, such as the "Buy American Act" and extension of Foreign Acquisition programs at subcontractor's level, and Europe, such as the "fair return" industrial policy. Specifically, for the fair return changes, it seems as if the new policy changes of ESA are augmenting the fair return principle, hence arguably, the scenario closer to developments could be considered to be the last one (scenario 4). This is reinforced by the presence of regional industrial interests and groups represented in the US Congress, which is the analogous of the ESA ministerial council, meaning is the funding body for the agency budget. Thus, in both these cases, whether institutionalized (ESA fair return), or through a more open political negotiation process, for both NASA and ESA regional returns play a crucial role for the funding providers of their budgets.

It is expected that scenario 4 would be a poor choice by integrators, as they both face a monopoly in terms of their subcontractor markets.

We assume the presence of two oligopolistic contractors (integrators) supplying one (domestic) government market and one commercial market (where they compete) and two major subcontractors (one US and one European). The cost of integrators is characterized by the presence of just one input whose amount is proportional to final space product production (for public and commercial goods), with assumed proportion 1 to 1. Subcontractors face constant per unit costs, while integrators face economies of scale and scope. Subcontractors when facing competition are assumed to compete in price, which is set equal to per unit cost, justified due to the highly contestable market (in this case, prices for subcontractors are competitive, similar to a Bertrand price competition, and equal to per unit costs, assumed zero for simplicity). Under contestable sub-contractors markets, cost of subcontractor input to integrators is normalized to zero, while when inputs are derived from vertically integrated integrators with in-house production, the cost to the integrator is normalized to 1 (assuming no economies of vertical integration present). In contrast, when the subcontractor enjoys a monopoly, then the cost of his input to the integrator is variable. We further assume that a subcontractor merged with an integrator does not supply the other integrator, but instead become exclusive, in-house producer.

The cost characteristics of the US and European integrators depend on production technology and thus do not vary depending on different market structures at the integrators level, but do vary, depending on the price paid for inputs from subcontractors. Note that for simplicity it is assumed that one unit of input by subcontractors equals one unit of output. Assuming that the price paid for each unit of input by each subcontractor is A, the TC function for the integrator takes the following form:

$$\mathrm{Ci} = \mathrm{Ai}(\mathrm{qi} + \mathrm{qdi}) + \mathrm{F} + \Phi(\mathrm{qi} + \mathrm{qdi}) + \alpha\mathrm{i}(\mathrm{qi2} + \mathrm{qdi2}) + \alpha\mathrm{ii}(\mathrm{qiqdi}) \quad (1)$$

where i = 1 (US integrator), 2 (European integrator)

Ai = Cost of integrator “i” for each unit of input, which equals the price charged by the subcontractor.

F = fixed costs

αii = coefficient denoting economies of scope

αi = coefficient denoting economies of scale

qi = the quantity of the commercial space good supplied by integrator “i”

qdi = the quantity of the government purchased space good by the US and the European public sectors.

Assuming the per unit costs of the subcontractors are constant and normalized to zero, the profits of the subcontractors when they are a monopolist supplier of subsystems for the respective space integrator are assumed to be given by the following:

$$\mathrm{Pi} = \mathrm{Ai}(\mathrm{qi} + \mathrm{qdi}) \quad (2)$$

Where Pi = profits of subcontractor “i”

For the case of competitive pricing this is assumed to be equal to zero, while in the case of subcontractor being a monopolist, Ai is solved for maximizing profits (Pi), given qi, qdi. The value of the quantities are derived from the competition in the integrators market. Following the assumption made with respect to the subcontractors market their profitability is zero, assuming competition between them (contestability), while in the case of in-house production the value of A for the respective integrator in (1) is set to 1, representing higher cost from in-house production of sub-components.

The inverse demand function for the commercial space good is assumed to be of the following form:

$$\mathrm{p} = \mathrm{a} - \mathrm{b}(\mathrm{q1} + \mathrm{q2}) \quad (3)$$

where p = price of the commercial space good and a, b are assumed greater than zero.

The inverse demand functions (government) for the USA and European firms are assumed to be of the following form:

$$\mathrm{pdi} = \mathrm{c} - \mathrm{d}(\mathrm{qdi}) \quad (4)$$

where pdi = the price of the domestic public space good in the US and the European markets respectively, and c, d > 0.

At the competitive, commercial market, the US and European space industries compete "a la Cournot", meaning that they choose the level of output each will produce taken as given the rival's level of production and then they compete in prices. By incorporating Ai, the resulting "augmented" model essentially introduces quasi-strategic variables across different market structures, as any of the two integrators is assumed to be able to choose Ai, but the Ai it will end-up with, depends on the Ai chosen by the other integrator. If, for example, starting from an initial stage of open subcontractor markets, the US integrator vertically merges with the US subcontractor, then this leaves the European integrator facing an uncompetitive market, where the European subcontractor is a monopolist, unless the European integrator merges with its subcontractor as well. Any integrator therefore has a choice: it can buy-out its subcontractor (or begin in-house production on existing contracts forcing the subcontractor to close down, or be acquired), which results in increased costs, compared to the case where he faced a contestable subcontractor's market structure, but at the same time this leaves the other integrator facing a monopoly by its subcontractor. This is not monopolization of the market, as the non-merged integrator faces a monopoly, but not by the merged firm (assuming of course that the integrators face open procurement choices and are not confined to using domestic suppliers as is currently the case) (Note 8).

Based on the scenarios perceived as most relevant earlier, four such calibrations are performed and compared (Table 2). As the comparison reveals, integrators facing a monopoly will choose to merge with the subcontractor, thus reducing the number of compared outcomes, leaving as the only remaining decision for the integrators whether to merge, or not (Note 9). However, there is one market structure whereby joint profitability of the respective space industries, which includes profits of contractors and subcontractors is maximized. The fourth scenario is therefore desirable for both integrators and subcontractors, provided the winners (subcontractors) compensate the losers (integrators), which leaves both parties better-off. This option is however unlikely to exist without the assistance by the public sectors to monitor such transfers, effectively controlling the SIB (Note 10).

Table 1. US and European Space Integrators Performance Under Different Subcontractors Scenarios

Different Subcontractors Market- Structures Facing Space Integrators and Respective Values for A_1 (US) and A_2 (Europe)		Equilibrium Results for Space Integrators Markets								
		Prices			Quantities				Profits	
		P	p_{d1}	p_{d2}	q_1	q_2	q_{d1}	q_{d2}	profit1	profit2
1	Both subcontractors markets open (contestable) A1 = 0; A2 = 0	51	31.6	31.6	12.2	12.2	4.6	4.6	400	400
2	US Integrator merged, EU faces a monopoly (*A_2 solved for*) $A_1 = 1$; *$A_2 = 23$*	58	31.5	43	14	6.7	4.6	1.7	526	74
3	Both Integrators merged with their domestic subcontractors $A_1 = 1$; $A_2 = 1$	52	32	32	12	12	4.5	4.5	386	386
4	Both Integrators face a monopoly from their domestic subcontractor (*A_2 and A_1 solved*) $A_1 = 26$; $A_2 = 26$	67	44	44	8.2	8.2	1.4	1.4	130	130

Note. The values of A_i in italics in the first column of the Table are being solved for in the model, the other values (0, or 1) represent the price integrators have to pay for subsystems procured from a competitive subcontractors market, or built in-house. The values of profits, and prices are in monetary terms.

Table 2 shows how both integrators have an incentive to consolidate with regards to their industrial base. There is ample evidence on this, notwithstanding the newly formed SpaceX vertical integration model of production, while in Europe, as we saw since 2012 this process is effectively further influenced by the public sector (ESA). The dilemma faced by the integrators in such a strategic environment is whether to merge, or not. Both integrators decide depending on what they expect their rival to do. As a result, in the absence of commitment mechanism, such as a binding agreement, or appropriate government policies prohibiting their acquisition of the subcontractors they both end-up merged.

It is noted that formal vertical merging is not necessary, but can be an option, as is other scenarios depending on the discretion and conduct of ESA, that is not necessarily time-consistent. In view of the complex political environment and multiple stakeholders, lack of transparency and level of control over the industry this is clearly a promising area for further empirical analysis.

Table 2. Profits for US and European Integrators under Different Alternatives

(Profit US Firm, Profit EU firm)

		US Space Integrator	
		Merged	Not Merged
European Space Integrator	Merged	(386, 386)	(74, 526)
	Not Merged	(526, 74)	(400, 400)

Note. Profits are in monetary units (US$). The first number in the parenthesis represents the profits at each state of the US space integrator, while the second number the profits of the European space firm.

ESA procurement policies since 2012, but also the vertical integration of newly sprang launching firms in the US that are potentially competing for the same markets as the US monopoly (ULA, recently augmented by SpaceX, with potential for a future duopoly market) reinforce scenario 4, whereby a vertically integrated supply chain that is geographically confined emerges in the US and European markets.

In view of the implications of this for efficiency, but also for the distribution of benefits of the value chain that are considered important for high-tech areas, it is important that further analysis takes place in the European space sector in regards to the industrial policies across the overall aerospace sector value chains. This is reinforced by the critical role not only controversial economic return literature and reports claim, but by (still to this date) studies with limited examination of the allocation and its efficiency available (Logsdon et al., 1998, p. 432).

Finally, the limited number of detailed analysis on such industrial externalities through modeling and causality analysis, does not allow the comparative assessment of the present with alternative scenarios in terms of economic return. Such alternative scenarios would be necessary to examine more precisely the economic implications of the fair, return, best practices, contractual allocations for the European space sector. Even more important perhaps is the implications of this for the aerospace sector in general that shares similar corporate roofs as space firms and also engages in highly competitive global aerospace markets.

5. Strategic Considerations and Policy Implications

Internal mechanism, clarity in political objectives and their implementation for the decision-making framework and publicly available contracting information are potentially measures for diminishing transaction costs and enhancing efficiency.

In addition, it can be argued that based on such selecting approaches and implementation, the relationship between the contractor and the agency resembles more of a PPP than a market transaction.

Clearly this is not supported by the contractual relationship, but arguably, the de-facto limitations of the subcontractors selection process imposes restrictions that may affect accountability of the contractor in contractual performance.

Finally, this practice of subcontractor selection faces yet another challenge, whereby the (prime) contractor might be making selections based on strategic considerations. For example, the contractor might be competing with a candidate subcontractor in other market segments. The presence of economies of scale and scope can potentially complicate relevant arguments and competition rationales, involving the agency in anti-competitive framework discussions and disputes, which have far-reaching implications, also for other (aerospace) markets. Future analysis may well consider the public regulation and policies implications as they may act as proxies for behavior under market structures that may have undesirable effects to stated objectives and efficiency.

6. Conclusions

The aim of this paper is to analyze the procurement practices and challenges faced by the European intergovernmental space agency, ESA. Specifically, the consolidation of the industry challenges the application of its "fair return" objective. The policy of exercising control over the entire value added chain in the European space sector is seen as a method to mitigate this, but clearly with potential drawbacks. These can take the form of blurred accountability in contractor performance and added transaction costs throughout the supply chain, but also augmented moral hazard and adverse selection challenges. Further analysis and transparency in information is recommended for a more complete analysis of the implications of contracting and selection practices not just in the sector, but the aerospace industry performance as a whole.

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Notes

Note 1. A version of this paper was presented at the 19th International Conference on Economics and Security 2015, Grenoble, France.

Note 2. This became all evident under the Galileo program and the formation of the Galileo Joint Undertaking (GJU) as a public-private-partnership between these two European partners. The role distinctions were not clear from the very beginning, but there were also differences in terms of their culture and mandate of the Commission with regards to the preference for open competition, as opposed to fair return approached in procurement employed by ESA.

Note 3. Transpace versus Arianespace, see Reagan, 1985; and Zervos, 2002; Van Fenemma, 1999 for further discussion and implications.

Note 4. See Zervos 2011b for a description of a two-step process in contracting and procurement in the presence of a space agency.

Note 5. The complexity term is well justified in the case of Europe, more so perhaps than the original US-based derivation of the term "industrial complex" by examining the political landscape of Europe (even compared with US, or other Federal system whereby Congress encapsulates geographical/regional industrial considerations).

Note 6. "The hypothesis set is whether there is a need for public policy in Europe and the US to prevent high profile, vertical consolidation of their domestic space industries. The answer to this cannot be negative, based on arguments of the presence of monopolization of a market in the face of such consolidation, as such mergers can lessen competition in the subcontractors markets, but not in favor of the merged entity, as other integrators can also establish in-house production" (Zervos, 2000, p. 2).

Note 7. See for example, CSIS, 2008 for challenges associated with the policy, that despite recent reforms and developments is still under discussion. European and other nations have similar policies, but arguably less open to public debate.

Note 8. This "augmented" model results in an increase in the number of combinations of different market structures, taking into account both integrators and subcontractors market changes. For example, the model can be solved for open US public space market, closed EU public space market, open US subcontractors market, closed EU subcontractors market, etc. There is a total of nine combinations (assuming "open US", "closed EU" give symmetric results to "closed US", "open EU" at both integrators and subcontractors markets, otherwise there would be 16 combinations).

Note 9. It would be expected that this happens as it makes no sense for them to voluntarily face a monopoly.

Note 10. In terms of competitive outcome for the public and commercial final output markets, this market structure can be described by paraphrasing Adam Smith as a major conspiracy between suppliers (and bureaucracy) against the public interest.