

Risk vs. Impact Analysis Applied to Aeronautical Suppliers: From Qualitative to Quantitative Approach

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10/18/2011Francesco Feminella
Alenia AeronauticaMarco Dell'Osso
Simmel Difesa Spa

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ABSTRACT

This paper presents a model of semi-quantitative analysis for risks and their associated impact caused by aeronautical suppliers in charge of specific work-packages (WP). Considering that many approaches to supply chain risk evaluation are qualitative (consequently subjective) and restricted to few functional areas of the supplier, the paper defines fifteen areas of functionality (production, finance, quality human resources etc.) for the supplying company. It then identifies specific risks for each area and measures them through predictive indicators. Therefore, taking in account the WP characteristics (size, technology, delivery and quality constraints, etc.), drivers are defined to evaluate the impact associated with each risk. The model is applied to the case of a supplier delivering structural parts. Finally, contingency actions to overcome the identified risks are illustrated and discussed.

INTRODUCTION

Today enterprise is considered as an entity strictly interconnected with several stakeholders, amongst which suppliers have a prominent role in the achievement of final goals along with the performance of their customers ([Sciabolini, 1974](#); [Pinto, 2007](#); [Smith, 2005](#); [Cremonesi, 1998](#)). Effectiveness and efficiency targets, inside a globalized scenario, assign a strategic role to the supply chain ([Sciabolini, 1974](#); [Bellandi, 1995](#)). Therefore, competitiveness should be intended as not only among enterprises but also among their supply chains ([Bellandi and Dulmin, 1997](#)). In fact, modern industry has undergone a

deep transformation in the last ten years. Big players have become integrators while less strategic (and highly labour-intensive) activities have been sought from local or foreign suppliers. Thus, taking in account the increasing role of the supply chain in terms of quantity of work and product value, supply chain management (SCM) has taken on a major role ([Bellandi, 1995](#); [Pinto, 2007](#)). This implies integration of different operational phases, from the purchasing of raw materials to the delivery of the final product, and involves a plurality of industrial stakeholders, not limiting itself to goods and commodities but also including financial and information flows ([Floreani, 2005](#)). Well practised SCM provides companies with immediate and tangible benefits such as quality, lead-time reduction, ability in customer satisfaction and cost reduction ([Cremonesi, 1998](#); [Romano, 2006](#); [Pinto, 2007](#); [Smith, 2005](#)).

In the aeronautical industry the role of well-integrated highly-performing suppliers is crucial. In fact, competitiveness forces the aeronautical integrators to pursue innovation while low value-added activities can be dismissed and transferred to local or low cost country-based suppliers, according to off-set policies (which play a significant role in setting up aeronautical supplies also in regions initially deprived of adequate skills). In this framework, risk analysis applied to single suppliers becomes strategic in order to increase the competitiveness and reliability of industrial programmes. Technology, political decisions, off-set and market policies, operative skills, planning and control represent crucial areas to be monitored in order to prevent the insurgency of risks ([Cremonesi, 1998](#); [Bellandi, 2000](#)). Technological

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obsolescence, workforce saturation and inadequate training represent examples of risks that need to be identified (together with the associated impact under the framework of a programme). Hence, aircraft manufacturers dedicate large efforts to monitoring their supply chain.

The application of quantitative models of risk analysis first requires that for highly-structured world-wide supply chains a huge amount of reliable data is collected and updated frequently, along with the implementation of complex models to compute (in terms of economical and timing damage) the consequences of risk occurrence in a well-defined aeronautical programme. Therefore, a qualitative risk analysis becomes preferable to a quantitative one and is largely diffused in aeronautics (Smith, 2005; Pinto, 2007). Nevertheless, qualitative models (frequently based on the Likert evaluation scales) limit themselves to only a few functional areas of an enterprise (production, human resources, finance), while the impact value seems disconnected from the characteristics of the work packages/activities assigned to the supplier. Moreover, Likert scales introduce three orders of problem: the notion of judgement can change significantly from one evaluator to another one; qualitative judgements do not really support investigations on the size of the risk causes; suppliers with similar characteristics cannot be really distinguished through a qualitative evaluation (neither can the Likert scales be excessively refined because of the evaluator's difficulty in using them).

METHOD

The proposed method can be classified as a mix. For the quantitative part, a set of risks was defined for fifteen functional areas of the supplier after which, in order to quantify each risk, sets of indicators were established in such a way that their high values were *predictive* of risk insurgence (risk proxy indicator). Moreover, in order to make the indicators easy to manage, these were classified as *strategic*, changing on a long term-basis and relating to the supplier's structure, and *tactical*, changing on a short term-basis and relating to short term management of the supply company (Bellandi, 1995, 2000). As the quantitative evaluation of risk consequences (impact) in terms of economical damage, delivery delay and quality degradation is extremely difficult to achieve, the model proposes "impact drivers". These are indicators whose value is qualitatively assessed (through a Likert scale) by evaluators such as programme managers, supply chain managers and supplier accounts that are informed of the WP characteristics as well as the programme needs. This corresponds to the qualitative part of the model which establishes, under the framework of a well-identified programme, the relationship between the risk area and associated impact drivers. Finally, Likert scales were limited to evaluate risk impacts and to fix weights (of area,

risk and proxy indicators), when no quantitative alternatives were available.

FUNCTIONAL AREAS

Multiple experiences of supplier performance analysis suggested the setting up of an assessment method looking at the supplier under multiple perspectives. This was due to the consideration that performance in a well-defined area (for example production) is affected by performance in the human resource area (in particular level of skills, experience, quality of training, etc.), finance (capability to invest in performing technologies and training) or research (collaboration with universities, ability to carry innovation projects to success). The interconnection between functional areas is high in small companies, as typically in the aeronautical industry. Functional areas are listed in Table 1. Weights measure the contribution of each area to the supplier risk and have been defined according to the priorities set by the Procurement Dept. of Alenia Aeronautica (further developments of the method could consist in applying Analytic Hierarchical Process, AHP, to consolidate the process of weights set-up, T. L. Saaty, 1990).

AREA RISKS

Risks have been identified for each functional area, except those due to causes outside the direct responsibilities of the supplier (such as risks related to political and catastrophic events), or those not directly related to the industrial production performances (for example, risk of unauthorized disclosure of information and know-how to third parties). All these could be considered in a risk analysis performed at level of programme's general management. Table 2 lists functional areas and corresponding risks with their weight (assigned by the Authors according to a Likert scale ranging from 1, minimum importance, to 5, maximum importance). To quantify risk probability while making this analysis manageable, risk indicators were defined in order to be predictive (i.e. as descriptive as possible of the risk occurrence). Addressed by a robustness analysis (which aims to establish a minimum set of indicators through the evaluation of the comprehension of the indicator, cost of the information, significance, frequency and structure, Bellandi, 1995), these, in turn, are obtained as a ratio of two variables and range from 0 (minimum probability of risk occurrence) to 1 (maximum probability). Values of elementary variables used to set up each risk indicator are provided by the supplier through a group of fifteen worksheets (one per area), then copied onto another set of fifteen spreadsheets which are dedicated to computing the value of predictive indicators (and, in ultimate analysis, risks). Data gathering requires suppliers to set up adequate information systems, able to monitor functional areas frequently and assure the flow of reliable data. More than fifty risks are computed through about 130 elementary variables, whose accuracy has been verified where possible. Each risk is the linear combination

Table 1. Functional areas. Weight refers to a Likert scale ranging from 1 (less important) to 5

Area	Description	Weight
Facilities	Status of shops, offices, warehouses and production lay-out	1
Technology	Process automation and process completeness	2
Research & Development	Innovation capability and research collaborations	2
Production	Manufacturing capacity	5
Tooling	Management of tools and jigs	2
Logistics	Logistics inside the plant and from/to sub-tiers and customers	4
Procurement	Procurement policies and management of goods and services	5
Quality	System and product quality and procedures to maintain quality	5
Performance	Effectiveness of anticipated, on-time and delayed delivery	5
Planning & Control	Capability to control internal and external processes	4
Information System	Hardware/software with skills to support information processes	4
Human Resources (HR)	Recruiting and training policies and managerial skills	2
Finance	Results of the economical and financial management	4
Market	Market policies and characteristics of market shares	1
Investments	Investment capability and role of funding sources	4

through the weights, of one or more indicators. Weights are established through a Likert's scale according to the priorities set at the Procurement Dept. of Alenia Aeronautica in relation with the role assigned to the suppliers. As an example, risks in the Finance area are reported in Table 3: the rigidity risk is strategic (s) and tracked by means of only one indicator (the ratio of fixed costs to total costs of the company in the fiscal year). According to the values of the variables used to set it, the risk occurrence approaches certainty (value 1). On the other hand, the risk that monetary changes will occur for the examined supplier is minimum (0,03), due to its minimum amount of turnover outside the Euro market. Finally, it should be remarked that the "area's risk" (for example, "technology risk") doesn't correspond to a physical event because it results from a linear combination, through adequate weights, of the single risks that have been identified for that area (for example technological obsolescence or poor training, etc.), these last ones only being well associated to physical facts.

ASSOCIATED IMPACT AND ROLE OF THE DRIVER

Impact is difficult to estimate in rigorous quantitative terms, because all the consequences of a risk should be known in terms of delivery delay, quality degradation and cost increase. Therefore a qualitative approach is preferable to complex mathematical simulations, especially in the case of extensive risk analysis like the one proposed here. To evaluate the consequences of risk (i.e. impact) this model introduces the notion of the impact driver, which provides a qualitative estimation based on the characteristics of the work-package and on the programme needs. For example, if the assembly factory of the supplier is small, the risk of "inadequacy of production spaces" (in "Facilities" functional area, Table 2) will be high. Nevertheless, the impact of this risk depends on the WP size, that is if the supplier has to assemble large parts of the WP inside a small shop the impact will be high (5 in a

Likert scale) but, on the other hand, if the supplier has to assemble small components, the risk of "inadequate production spaces" will have a limited impact on the programme (1 in the Likert scale). Therefore, the WP size is an impact driver. Drivers should be evaluated by the programme managers. A set of fourteen drivers (Table 4) has been identified to address the risks of all the areas identified in this paper, according to the framework of correspondence shown in Table 5. As for the "risk of area" concept above introduced, The impact-of-area notion is a linear combination (through adequate weights) of all the drivers associated to each physical risk and, although deprived of physical sense (as for the risk of area defined), helps to perform macro-analysis of risk.

RESULTS OF THE METHOD

This method of risk vs. impact analysis was applied in 2009 to four suppliers of aero-structural parts involved in four different industrial programmes operated by Alenia Aeronautica. For reasons of confidentiality, results are displayed anonymously and limited to only one supplier, hereafter named Supplier 2, being a small company specialized in milling and assembling aeronautical components. Figure 1 shows its most critical areas: delivery performance (risk value of 0,92) and finance (0,74). Risk and impact are normalized to 1. Inadequate performance depends on poor service (long delay) while the "financial risk" is obtained as a linear combination of five specific risks (rigidity, debt, exposition, liquidity and change), the most significant being rigidity due to its high value of the supplier's short-term debt. Limiting to the most innovative programme supported by Supplier 2, impact (value of 3,5) associated to the "performance risk" is less than that of finance (value of 4) because while delays in delivering parts can be recovered with little effort, the significant involvement of the supplier in the industrialization phase of the examined programme requires an adequate capacity to fund the