SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 226

THE CONCEPT OF MEASURING ENTERPRISE EFFICIENCY IN SUPPLY CHAINS

Janusz DĄBROWSKI

University of Gdańsk; Sopot; janusz.dabrowski@ug.edu.pl, ORCID: 0000-0003-2882-0804

Purpose: A company that is a member of supply chains cooperates with its suppliers and customers in a more intensive and diverse way than in the case of ordinary transactional relationships. This cooperation generates externalities for supply chain partners, which are not always adequately compensated. This distorts the actual efficiency of the company from the point of view of the entire supply chain. Active supply chain management requires objective information about the efficiency of its individual members. The aim of the article is to propose a method for objective measurement of enterprise efficiency in supply chains.
Design/methodology/approach: The study used the system analysis method for the interactions of supply chain participants. Various forms of effects of mutual interaction between the company and its first-tier suppliers and customers were identified. Next, the principles for including these interactions in enterprise efficiency measures were indicated.
Findings: The proposed method involves proper correction of the efficiency measures recorded in practice concerning the effects of the mutual interaction of the enterprise with its suppliers and customers.
Research limitations/implications: The effectiveness of this method depends on the scope of identification and accuracy of quantification of externalities.
Practical implications: The application of this method in practice can support supply chain management by objectively examining the contribution of a given enterprise to the efficiency of the entire supply chain.
Originality/value: The proposed concept for measuring the efficiency of the enterprise includes externalities, which allows for a more objective assessment of the contribution of the enterprise to the final outcomes of the supply chain.
Keywords: efficiency, externalities, enterprise, supply chain.
Category of the paper: Research paper.

1. Introduction

The purpose of supply chains is to create maximum added value for the final customer, entire supply chains, individual members and stakeholders (Witkowski, 2003). However, the most essential thing in supply chains is the benefit delivered to the end consumer.

That determines the demand for products and influences the added value of supply chains (understood as the difference between the total sales value and the value of purchased materials and services of all its members). The issue of the distribution of added value between participants in a specific supply chain is secondary but still crucial for managing the entire supply chain.

In supply chains, benefits/losses generated by one company are often transferred to another unit in the chain. This is due to the peculiarities of supply chains (trade-off dependencies, sub-optimization phenomena) that are the result of cause-and-effect relationships in the flow of goods processes. In supply chains, companies cooperate more closely with each other than in ordinary transactional relationships. They implement various strategies to integrate their activities, which affects the need to share costs and benefits. Incomplete compensation for the effects of such cooperation generates externalities that distort the actual efficiency of the enterprise in the supply chain.

The literature provides examples of many methods and their combinations used for measuring broadly understood supply chain efficiency, such as: balanced scorecard, SCOR model, AHP, DEA, benchmarking, among others (e.g. Reddy, Rao, Krishnanand, 2019; Mbang, 2013; Liang, 2006). A comprehensive measurement system should include both integrated measures and criteria for assessing individual chain elements so that it is possible to fully identify where problems arise and to take quick corrective steps (Tarasewicz, 2014).

The aim of this study is to propose a method for measuring the efficiency of an enterprise as a participant in a supply chain (considering interactions with a selected first-tier supplier and customer) or a supply network (considering interactions with many first-tier suppliers and customers). This method is designed to indicate the objective contribution of an enterprise to the efficiency of supply chains (its added value, resources used, costs incurred) by eliminating from its business results (recorded in practice) the effects of the impact of suppliers and customers on the enterprise (outside externality) and the impact of the company on suppliers and customers (own externality).

2. Interactions in supply chains

Companies operating in supply chains interact with each other, generating externalities. In the literature on this subject, externalities are defined as follows:

- an externality is the result of actions by a given entity affecting the level of well-being of another entity (Kisperska-Moroń, Płaczek, Piniecki, 2002),
- an externality occurs when someone's action affects the welfare of outsiders, and no one pays or receives compensation for it (Mankiw, Taylor, 2009),

- externalities occur when production or consumption activity has a side effect on the utility function or production function of another entity. The term "side effect" means that this effect is not the subject of exchange, and this transaction is not characterized by a specific price (Pawłowska, 2000).

The causes of externalities vary and depend on the specificity of a given activity. An enterprise in supply chains may deal with two groups of sources of externalities. The first group concerns every enterprise operating on the market. The most important causes of externalities include: production technology, technological progress and innovation, synergy effects, complementarity of goods, network effects, common resources (Mankiw, Taylor, 2009; Stiglitz, 2004; Droniak, 2002).

The second group of causes of externalities is related to the active management of activities performed within supply chains and the relationships between individual companies. The main assumptions of the supply chain management concept come down to cooperation between suppliers and customers, integration of business processes and focus on serving the end consumer to achieve their satisfaction (Szymczak, 2015). The supply chain management concept is dominated by a philosophy based on widespread cooperation leading to close integration between individual entities and the principle of reciprocity (sharing risks and benefits).

Cooperation between members of supply chain can be implemented on two different levels: stimulating and supporting the development of suppliers by the enterprise and engaging the potential and knowledge of suppliers in improving the competitiveness of the enterprise. Analogous relations occur between the entrepreneur and the customers.

An enterprise can influence the development of suppliers in various ways (Dąbrowski, 2015). Indirect methods involve the use of market mechanisms and economic tools to stimulate the development of suppliers (e.g. competitive pressure, supplier assessment and certification system, motivation system). Direct methods involve the enterprise's investment involvement in the activities of suppliers. Among the activities that can potentially generate externalities, the following should be mentioned:

- investments in tangible assets. They consist of investing the company's financial resources in the purchase of suppliers' assets that improve the production process, implementation of new technologies, reduction of resource consumption standards, compliance with environmental standards by suppliers;
- financial investments. The scope of these investments can be very diverse: from advances on future deliveries, granting loans, guaranteeing credits, to the purchase of bonds and other debt securities of the supplier;
- investments in intangible assets. These primarily include training the supplier's employees, visits of the company's specialists to the supplier to solve various problems, joint research and development projects, sharing know-how.

In turn, supplier involvement in the company's operations can be manifested through (Dąbrowski, 2015):

- early supplier involvement. This involves the company engaging suppliers in the process of developing new products or modifying existing products at the initial stages of their design or while introducing changes;
- supplier suggestion programs. Suppliers can contribute to the improvement of production, logistics, supply, and distribution processes, quality improvement, and even to the growth of the company's sales thanks to the improvement proposals they formulate;
- buyer-seller improvement teams/projects. The knowledge of suppliers participating in projects improving the company's operations is particularly useful in terms of reducing costs, inventory, improving quality, and reducing delivery times in areas where they cooperate on an ongoing basis;
- on-site supplier representative. Permanent supplier representatives can help manage inventory, transport, and purchases and provide technical support for the company's operational activities.

Analogous to the forms of cooperation between a company and its suppliers presented above, there are relationships between an enterprise and its customers. The success of such programs depends on a fair distribution of effects between the company and its suppliers and customers.

All mutual impacts can lead to contribute to the creation of outside and own externalities of the enterprise (Figure 1).

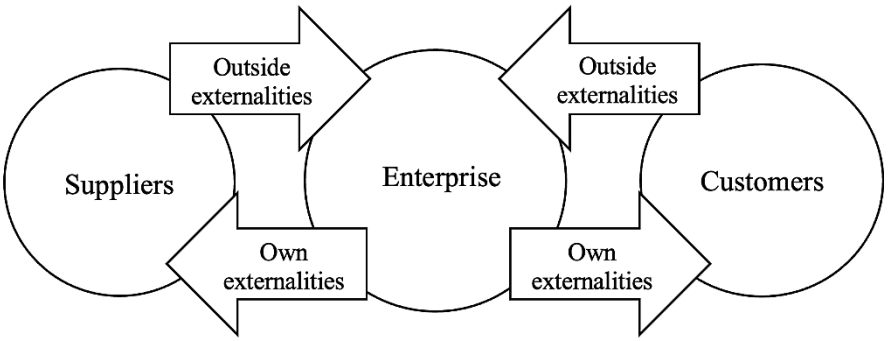

Figure 1. Mutual interactions of an enterprise with suppliers and customers in supply chains.
Source: own study.

In this study, for the purpose of further analysis, the following terms will be introduced. The outside gross externality of the enterprise will be understood as the effect of the impact of suppliers and customers on the results of the enterprise's activity. In turn, own gross externality of the enterprise will determine the effect of its impact on the activities of suppliers and customers. If these effects are not completely compensated, the remaining part will be called outside/own net externalities of the enterprise (see Figure 2).

3. Efficiency and structure of an enterprise's effects in supply chains

Economists interpret the efficiency category in different ways. In the narrowest sense, efficiency is understood in a similar way to the concept of "economy" in praxeology, i.e. as the ratio of achieved results to inputs. In a slightly broader sense, efficiency is identified with benefit (the difference between achieved effects and incurred costs) and “economy”. In an even broader sense, efficiency is presented as effectiveness (the degree of implementation of set goals), benefit and “economy” (Grzesiak, 1996). In the broadest sense, efficiency also includes the qualification of the effect obtained from the perspective of market utility, i.e. added value for the customer (Blaik, 2010). Nowadays, the concept of efficiency, especially in the dynamic sense, includes such aspects of business activity as creativity, innovation, adaptability, reactivity and flexibility, knowledge acquisition, as well as ethics (Tarasewicz, 2014).

To conduct an analysis and assessment of multidimensional business activity, various categories are certainly needed. However, it seems that efficiency should not replace other concepts that more precisely characterize various aspects of the company's activities and supply chains than the term "efficiency". The common understanding of the efficiency category comes down to the relationship between the effects (outcomes of activity) and the costs incurred to obtain them. Efficiency refers to the ability of an organization to produce goods for direct consumers at relatively low costs and with full use of resources. The definition of organizational efficiency can be extrapolated to the supply chain level because supply chain stakeholders are involved in organized and coordinated activities aimed at increasing the ability to reduce costs and enable good use of resources in business processes because these processes are extended to the entire supply chain (Negi, 2021).

Pasieczny and Więckowski (1987) underscore that the effects of economic activity are specific products and services with a given assortment and quality structure. The category of effect can, therefore, be understood as a product of labour, its utility value, i.e. a thing or service that meets a specific social need. The problem of measuring the utility value of goods has not yet been solved by science, which is why natural units of production are often used to measure it. From the point of view of value, the form of expressing the economic result of an enterprise can be the achieved revenue, added value or profit.

Matwiejczuk (2006), in turn, extends the interpretation of this concept. He believes that efficiency also depends on the operating conditions created by the environment. It seems that the effects should express the complete results of economic activity, both planned and unintended. The effects of an enterprise are the total impacts of its activity, both those that are reflected in the company's records and those that affect the activities of other entities and have an economic, social or ecological dimension.

From the above-mentioned definitions of externalities, it follows that they are the result of the activity of one entity, which affects the level of costs, employed resources, revenues and utilities of other entities and remains uncompensated by the party generating them. Externalities can cause positive and negative effects on other entities. Positive externalities (external benefits) are reflected in cost savings, increased revenues and income, or other forms of benefits, not necessarily economic. Negative externalities (external costs) bring additional costs, losses, or other inconveniences to the entity's environment. Figure 2 presents a diagram of the effects of the enterprise from the point of view of its interactions with other entities in supply chains[1].

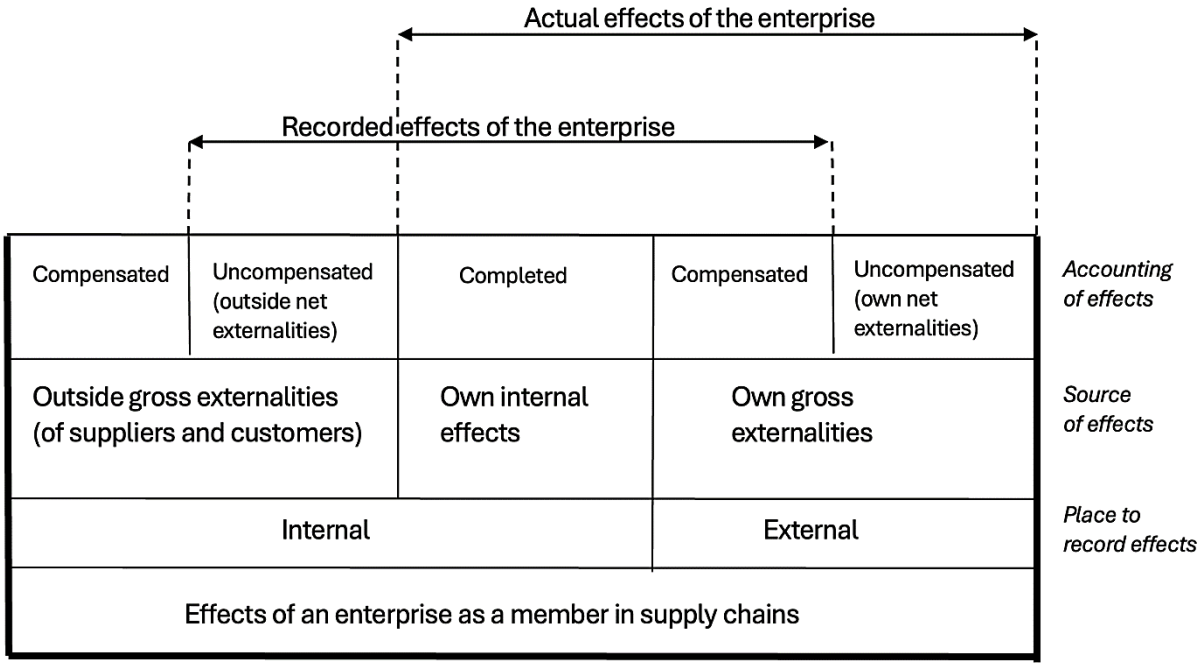

Figure 2. Structure of enterprise effects in supply chains.

Source: own study.

The internal effects of a company are the result of its own activity (own internal effect) as well as the effect of the interaction of suppliers and customers (gross outside externality). The consequences of the company's activity reach beyond its borders, creating the so-called own gross externalities on suppliers and customers. Not all effects of the company's interaction with the environment are quantified and compensated. After considering the redistribution of effects, we can talk about the outside net externality of the enterprise and the own net externality of the enterprise.

Recorded effects of an enterprise are the effects included in the records of the enterprise in accordance with applicable regulations and legally belonging to the enterprise. They should be the result of the enterprise's own activity only. The results of the interaction of other entities on the enterprise (outside net externalities) should be eliminated from the measurement, and own net externalities (uncompensated own externalities) should be included. Their significance is important when measuring and assessing the company's actual effects (Figure 2).

4. The concept of objectivizing the measurement of enterprise efficiency in supply chains

Enterprises most often measure and evaluate various aspects of their activities using groups of KPIs (Key Performance Indicators). KPIs mainly characterize the effectiveness and efficiency of an enterprise. To calculate efficiency, measures expressing the relationship between effects and inputs in various ways can be used. Comparing effects and costs in a differential form only expresses efficiency to a certain extent. The enterprise's profits depend on two factors: the amount of resources used and the efficiency of their use. That is why profit only expresses the quantitative aspect of efficiency. In relative terms, effects and inputs can be calculated based on average or incremental values. This arrangement best reflects the essence of efficiency and indicates the qualitative aspect of efficiency. Other methods of comparing effects to inputs, such as relative savings on resources (costs) or measures indicating what part of the effect is the result of increased efficiency, only partially characterize efficiency because they take the form of an effect and the quality of the increase in effect and do not express the essence of efficiency.

There are also other measures of efficiency in the literature, such as the cost-to-resource ratio or the index of increase in effects (production, profit). It seems that the first relation, from the point of view of the definition of efficiency adopted at work, cannot be considered a measure of efficiency[2]. The second relation has some justification in the fact that the improvement of efficiency should be associated (according to some authors) with an increase in positive effects. However, the increase in effects may be the result not only of the improvement in efficiency but also the scale of the resources involved.

Determining the proper way of comparing effects and inputs does not exhaust the issue of correct efficiency measurement. There should be a cause-and-effect relationship between inputs and effects, and these components should be complete, i.e. include all component elements.

Considering that the object of the efficiency measurement is an enterprise in supply chains, only those effects and inputs that are the result of the activity of this organization should be the subject of interest. The concept of objectifying the measurement of the efficiency of an enterprise in supply chains presented below is based on an appropriate correction of efficiency measures used in practice. At the base of this concept lies the structure of the company's effects presented in Figure 2. Correction of efficiency measures should be carried out in accordance with the following principles[3]:

- in order to determine the actual effects of the enterprise's activity in supply chains, own net externalities should be added to its recorded effects, and outside net externalities should be subtracted;

- externalities should be calculated as current effects (changes in revenues, costs, individual types of costs) and as capital effects (changes in fixed assets, current assets, labour resources). Depending on the type of measure, externalities should be presented in total (for a synthetic efficiency measure) or only their appropriate part (for partial efficiency measures);
- the correction of efficiency measures by the amount of outside net externalities is based on identifying them and subtracting them from the recorded effects of the enterprise and performing operations in the remaining efficiency components (costs and resources) that are the opposite of those that actually occurred (the principle of neutralizing the impact of external factors);
- the correction of efficiency measures by the size of the enterprise's own net externalities is based on identifying them and adding them to the recorded effects of the enterprise with a simultaneous correction of the remaining efficiency components (costs and resources) related to the implementation of externalities.

According to the adopted concept, the actual efficiency of the enterprise in supply chains should be expressed by measures (resource and cost) of the following general construction, formulas (1) and (2):

$$E_{en}^{r} = \frac{E_{re} - E_{ne}^{ou} + E_{ne}^{ow}}{R_{en} + R_{ex}^{ou} - R_{ex}^{ow}} \tag{1}$$

$$E_{en}^{c} = \frac{E_{re} - E_{ne}^{ou} + E_{ne}^{ow}}{C_{en} + C_{ex}^{ou} - C_{ex}^{ow}} \tag{2}$$

where:

E_{en}^{r} – resource efficiency measure,
E_{en}^{c} – cost efficiency measure,
E_{re} – current recorded effect of the enterprise,
E_{ne}^{ou} – current outside net externality,
E_{ne}^{ow} – current own net externality,
R_{en} – enterprise resources,
R_{ex}^{ou} – outside capital externality,
R_{ex}^{ow} – own capital externality,
C_{en} – enterprise costs,
C_{ex}^{ou} – outside current (cost) externality,
C_{ex}^{ow} – own current (cost) externality.

In practice, various measures are used to determine the efficiency of companies: synthetic and partial; value, natural and value-natural; static and dynamic; average and incremental; gross and net. The efficiency of an enterprise can be more fully expressed by a system of measures. This system should meet several requirements. The selection of measures,

their number and level of detail should depend on the purpose of assessing efficiency. Partial measures should characterize the efficiency of using individual types of resources and costs, types of activity and complement each other. The priority of measures in the system should correspond to the economic goals of the company and the supply chain strategy. All measures used to determine the efficiency of the company in supply chains should be corrected for the effects of the company's interaction with suppliers and recipients.

5. Summary

Measuring the efficiency is an extremely difficult task, both theoretically and practically. This results from the multi-aspect nature of economic processes, the impossibility of full quantification of effects and inputs and maintaining their comparability, and even the lack of an unambiguous interpretation of the concept of "efficiency". In addition, enterprises do not consider the indirect effects of their activities, both negative and positive. The basis for their decisions are the so-called private, not social, marginal costs and benefits. This results in the need to apply not only various regulatory mechanisms in the economy but also to correct the measurements and assessments of the activities of economic entities. This situation occurs especially in the case of supply chains, where the cooperation of entities is more intensive and diverse, and the principle of common risk, sharing inputs and benefits is not always fully implemented.

The concept presented in this article is theoretically simple, but its implementation requires quantification of externalities generated by both the suppliers and customers of the enterprise, as well as the effects of the enterprise itself recorded by its partners from the supply chain. Not all effects of impacts are easily measurable. The greater the scope of externalities considered in the corrections of the measures, the more objective the actual efficiency of the enterprise in the supply chains will be.

In the current era, the assessment of the economic efficiency of business activity alone is insufficient. The pursuit of sustainable development by societies forces enterprises to change their approach to efficiency. The concept of economic effects is expanding from the manufactured market product to all effects of the enterprise's activity. The presented concept of objectivization of the measurement of the efficiency of an enterprise in the supply chains should also consider (in its own externalities) the ecological and social effects of its activity. The study of the interaction of the enterprise with the environment requires further detailed development, in particular, the identification and measurement of externalities and the integration of economic and social aspects of business activity.

References

1. Blaik, P. (2010). *Logistyka. Koncepcja zintegrowanego zarządzania*. Warszawa: PWE, pp. 411-416.
2. Dąbrowski, J. (2015). Strategie rozwoju i integracji dostawców w zarządzaniu łańcuchami dostaw. *Gospodarka Materiałowa i Logistyka*, *No. 3*, pp. 16, 18-21.
3. Droniak, A. (2002). *Zastosowanie analizy kosztów i korzyści w ocenie projektów publicznych*. Katowice: Wydawnictwo Akademii Ekonomicznej w Katowicach, p. 84.
4. Grzesiak, S. (1996). Efektywność funkcjonowania przedsiębiorstw – aspekty prakseologiczne i ekonomiczne. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, *No. 17,* p. 57.
5. Kisperska-Moroń, D., Płaczek, E., Piniecki, R. (2002). *Koszty zewnętrzne logistyki w zarządzaniu łańcuchem dostaw*. Katowice: Wydawnictwo Akademii Ekonomicznej w Katowicach, p. 14.
6. Liang, L.F., Yang, F., Cook, W.D., Zhu, J. (2006). DEA models for supply chain efficiency evaluation. *Annals of Operations Research, Vol. 145, No. 1*, pp. 35-49.
7. Mankiw, N.G., Taylor, M.P. (2009). *Mikroekonomia*. Warszawa: PWE, pp. 267, 273-274.
8. Matwiejczuk, R. (2006). *Zarządzanie marketingowo-logistyczne. Wartość i efektywność*. Warszawa: C.H. Back, pp. 79, 82.
9. Mbang, J.-J.A. (2013). Supply chain efficiency evaluation: a contemporary theoretical model. *World Academic Journal of Business and Applied Sciences - Journal of Supply Chain Management, Vol. 1, No. 1*, pp. 1-10.
10. Negi, S. (2021). Supply chain efficiency framework to improve business performance in a competitive era. *Management Research Review, Vol. 44, No. 3*, pp. 477-508.
11. Pasieczny, L., Więckowski, J. (1987). *Ekonomika i analiza działalności przedsiębiorstwa*. Warszawa: PWE, p. 14.
12. Pawłowska, B. (2000). *Zewnętrzne koszty transportu. Problem ekonomicznej wyceny*. Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego, p. 12.
13. Pogorzelski, A. (2007). Procedury analizy finansowej. In: J. Żurek (Ed), *Przedsiębiorstwo. Zasady działania, funkcjonowanie, rozwój* (p. 309). Gdańsk: Fundacja Rozwoju Uniwersytetu Gdańskiego.
14. Reddy, J.M., Rao, N.A., Krishnanand, L. (2019). A review on supply chain performance measurement systems. *Procedia Manufacturing, Vol. 30*, pp. 40-47.
15. Stiglitz, J.E. (2004). *Ekonomia sektora publicznego*. Warszawa: PWN, p. 256.
16. Szymczak, M. (2015). *Ewolucja łańcuchów dostaw*. Poznań: Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, p. 18.
17. Tarasewicz, R. (2014). *Jak mierzyć efektywność łańcuchów dostaw?* Warszawa: Szkoła Główna Handlowa w Warszawie, pp. 42, 139.
18. Witkowski, J. (2003). *Zarządzanie łańcuchem dostaw. Koncepcje, procedury, doświadczenia*. Warszawa: PWE, pp. 27-28.

Footnotes

1. In Figure 2, the structure of economic effects is presented, assuming that the effects are positive and expressed in net terms (e.g. profit). The above assumptions were made to simplify the diagram.
2. This relation is called the cost intensity of assets. Including it among the efficiency measures results from the interpretation of costs as an "unfinished" effect, as a condition for achieving final effects (Pogorzelski, 2007).
3. For the sake of simplicity, the assumption was made that the effects of the company's activity are measurable, positive and expressed in net terms. Negative effects should be treated in the opposite way to positive effects (where positive effects are added, negative effects should be subtracted). In the case where both positive and negative effects are generated, the total effects constitute their algebraic sum. If the effect is expressed in gross terms, then it is not possible to fully consider all the impacts of the company and its partners (i.e. those affecting the company's costs and resources).