EFFICIENCY FORMULAS OF CARGO FLOWS CONTAINERIZATION

Lievin, Sergey B., *director general of RRL LLC., Moscow, Russia.*

ABSTRACT

The article considers factors and criteria of economic efficiency of cargo flows containerization, shows its constituent elements, including those related to saving the cost of packaging, loading- unloading operations, acceleration of delivery, increasing safety and security of cargo. It shows effects of containerization, differentiated for cargo owners, transport companies, the country as a whole. The author describes formulas for estimating cost-effectiveness, their projections on the utility function, net profit, net present value, internal rate of return value, and others.

Keywords: multimodal transportation, sea transport, railway, water transport, road transport, economic efficiency, containerization of cargo flows, cost savings, accelerating the delivery of goods, safety, security, utility function, net profit, shadow interest rate, internal rate of return.

Background. *Experience shows that containerization is the most effective when containers are used for cargo delivery in mixed railway-water transportation, especially in export-import transportation in international traffic involving sea transport.*

As for the road transport, it is especially useful in single container transport system of the country to perform three basic operations. The first – shipment of containers to/ from terminals, stations, ports and marinas in mixed traffic with main line railway, water and air transport. The second – direct road container transportation in local, long distance and international traffic. The third – implementation of in-plant, in-port and other in-process technological transportation.

In river transport, given relatively short terms of navigation on many rivers, container transportation is more rational when vessels are used with high running speed and sufficiently adapted for quick loading and unloading operations. These conditions are mainly met by special container ships.

For freight delivery by any main line and local mode of transport containers organically fit into the technology of production or distribution, are loaded directly in shops at production units or warehouses of finished products and are unloaded at the place of consumption. In this case, maximum cost-effectiveness is reached, as at all stages of moving goods from a sender to a receiver processing of single pieces of cargo is eliminated or reduced to a minimum.

An important means to improve the efficiency of transport service is the use of special containers of various types and tonnage, including large-capacity. They are designed to carry one or a group of goods that are similar in their physical and chemical properties and transport conditions, and are, as a rule, owned by cargo owners.

Objective. *The objective of the author is to investigate containerization of cargo flows in terms of economic efficiency.*

Methods. *The author uses analysis, comparative method, evaluation approach.*

Results.

Approaches and criteria

The criterion of economic efficiency of container transportation should best reflect interests of economy. This means that the use of containers and associated technical means is designed to ensure full satisfaction of needs to move goods with high service quality and the lowest cost of a customer for their transportation.

Desired effect is determined by saving money and materials to packaging of goods, saving the cost of loading and unloading operations, saving capital investment in the construction of warehouses and other facilities. The use of containers provides acceleration of cargo delivery and cost reduction of cargo masses en route, reduces complexity of transport and warehouse operations, increases productivity, improves and facilitates working conditions, increases safety of transported goods.

1) Cost saving on packaging of goods.

It is first received by shippers who transport packaged goods in universal containers, not in covered wagons, ships or cars with containerless loading.

Transition to containers of packaged goods is an obvious reserve of containerization not only in the current five-year period, but for a long-term perspective. On railway transport such goods occupy about 6% of the total traffic and about 9% of the total freight turnover. Due to the higher cost of transportation as compared with other goods their share in general transport costs is up to 13%, which is especially necessary to note, loading- unloading operations with this category of goods remain the least power-driven and in labor intensity they occupy not less than 40% of the total volume of cargo operations. Every net tonne when carried in covered cars falls within on the average 200 kg of transport packaging, which dramatically increases the unproductive part of railway transportation work.

However generic composition of packaged goods is diverse and heterogeneous. Therefore consignors, deciding on appropriateness of the transfer of their products to containers should include the amount of possible savings on packaging.

Bulk cargo transportation give greater saving of wood, metal, fabric and other packaging materials. For example, saving of shaped timber when a number of goods is transported in containers (shoes, confectionery products, spare parts, fabrics, etc.) is 1,15–0,22 m ^{3} per 1 ton. The elimination of box transport packaging of small shipments will return to the matter an average of 10 kg of metal (packing tape, nails) per 1 ton.

2) Cost saving on loading-unloading operations.

The use of containers enables to carry out a complex mechanization of basic technological operations, greatly reduce their volume and reduce the cost. As a result, necessary number of mechanisms reduces, their utilization improves and capital expenditures for the purchase of mechanization means reduces. Reduction of the volume of cargo handling operations is facilitated by complete replacement of low-power electric cranes, introduction of automatic strapping of containers, development of transit delivery system, increased use of direct options of transshipment of local capacities, as well as advanced methods of sorting transit containers. By rationalization of processes for each tone of cargo moved by railway transport, labor intensity of operations reduces by an average of 4,2 persons / hour, labor productivity increases by several times.

Labor costs for container transport in a perspective will further reduce through the use of high- capacity containers, development of through container- packet transportation, introduction of specialized rolling stock,

the latest technical equipment in various modes of transport.

3) Acceleration of cargo delivery.

Time saving is a determinant of the effectiveness of any reparative or organizational and technical process that is associated with improvement of transport production.

In many cases, containerization of cargo transportation assists in keeping with such a task for transition from warehouse to transit form of consumer's goods supply bypassing intermediate links of distribution network. This not only dramatically reduces the total cost of transport, but also accelerates the delivery of products to the place of consumption with relatively long routes for 5–6 days. As a result, the savings from reducing the cost of the cargo mass en route increases several times.

4) Increase in security of cargo. Practice shows that loss, damage, and other types of unpreserved goods, except for perishable goods, arise mainly in the process of transshipments. Transported in containers they in the mechanized transshipments are not exposed to immediate external impact. The use of containers, e. g. for transportation of packaged goods has almost fully eliminated losses. For example, 50 thousand units account for only one case of non safety. And these cases are caused usually by supply for loading of faulty containers or incorrect loading of cargo.

Differentiation of effects

Analysis and suggestions for improving the current system of container transportation should include an assessment of the whole complex of costs and benefits associated with the implementation of new ideas. It is therefore important to think of ways in which such a problem can be solved.

Any economic approach to the assessment of an investment project is, in fact, a comparison of costs and benefits. This is most clearly demonstrated in static deterministic case when both costs and benefits are realized at the same time and there is no ambiguity. In such an embodiment profit (P) from the project is assessed as a simple difference between benefits (B) and costs (C): P = B – C. The decision as to whether to force a proposed idea is made based on a comparison of profit with zero. The project should be carried out, if the profit is non-negative, and it is not worth doing it – if it does not exist.

When it is necessary to evaluate two mutually exclusive projects, it is necessary to compare their profits and choose the one that brings great benefits.

Despite a seeming simplicity of the approach, it has nevertheless many undercurrents. They are related to the fact that it is necessary to properly recognize and take into account both benefits and costs of the project.

In most cases, not all potential sources of benefits and costs are easy to recognize, and after recognition to assess properly. They are usually limited to purely technical aspects. For example, in the construction of a new container terminal costs are likely to be costs of building materials, wages of builders, etc.

To assess benefits it is necessary to take into account a possible increase in demand for container transportation due to the convenience of a new terminal for some shippers and consignees. In large infrastructure projects a task is further complicated by the fact that many parts affect non-market aspects of human life, and so, therefore, have a weak correlation in prices observed in the market, on the basis of which it will be possible to make quantitative evaluations of certain benefits and costs (table 1).

For example, the construction of separate railway line, in addition to direct commercial results in the form of goods transported, costs of its operation, charges paid by new freight forwarders, and so on has numerous «external effects», that is not taken into account in market prices. Let's suppose that a main line may lead to push for economic development of areas adjacent to the railway track, and of course, any attempt to decide whether the construction of such a line is reasonable, should take these effects into account.

The difficulty in finding cash equivalents for such externalities encourages many researchers to find other evaluation methods of «competitiveness' of the project, which are distinct from economic methods.

Traditionally numerous criteria are introduced by which with the survey of experts it would be possible to evaluate a project (for example, its profitability, process safety, environmental safety, indicators of economic growth in surrounding areas). An attempt is made to identify the most important factors affecting the desirability of changes, a function is determined that aggregates criteria to obtain cumulative numerical results for decision-making.

The choice of such a function is usually quite arbitrary, although economic theory provides opportunities to remove problems that arise, namely, lead all operations of aggregation to its monetary equivalent.

Do not think that since some of issues (e. g., environmental safety) are far from the market and at the same time are closely related to the emotional reaction of a person, they cannot be expressed in monetary terms. No matter if people are guided by lofty matters in decision-making, a final result is still a compromise of possible alternatives taking into account the limited resources involved. Therefore, there is always a hidden (shadow) comparison of different services, goods and products that can be presented, including in monetary equivalent.

Unconventional calculation

The questions of real investments rarely get reduced to a static situation. A typical situation is when the majority of costs are made at the initial stage of the project, while return (profit) from it comes much later.

Nontrivial dynamics in this case requires the ability to compare costs and benefits in different time periods. Which approach is offered in the modern economic theory?

First of all, theorists believe that the question of investment advisability in the economy should be considered from the point of view of increasing the well-being of ultimate consumers. The simplest formula for the utility function, specifying their preferences can be represented as:

$$U = \sum_{t=0}^{\infty} \beta^t u(c_t), \qquad (1)$$

where c_0,.., c_t,..is consumption flow.

This formula takes into account, on the one hand, that the effect of today's consumption (t = 0) is more significant than the consumption of tomorrow, the day after tomorrow, etc. – its effect in terms of utility is discounted by a coefficient $0 < \beta < 1$. On the other hand, the utility function has intertemporal stability – its implementation does not depend on the time period from which starts the implementation of needs starts (project idea).

Let's suppose that an issue of investments in the project is considered, which ensures flow of resources over time x_0.., x_t, ... Conclusion on the feasibility of its implementation is reduced to comparison of corresponding values of utility functions (2) – (3):

$$U_1 = \sum_{t=0}^{\infty} \beta^t u(c_t) \qquad (2)$$

$$U_2 = \sum_{t=0}^{\infty} \beta^t u(c_t + x_t) \qquad (3)$$

Table 1

Effects of containerization of cargo flows [2]

	Cargo owners	Transport companies	Economic complex of the country as a whole
Acceleration of cargo operations with enlarged pieces of cargo			
Reduced requirements for strength and stiffness of the packaging of carried goods. Possibility of application of primary packaging, non-rigid containers or bulk cargo transportation			
More reliable and stable accommodation of pieces of cargo in vehicles			
Reduction of likelihood of damage or breakage of cargo			
Reduction of likelihood of cargo theft			
Simplification of cargo documentation			
Reduction of insurance costs			
Reducing the need for covered warehouses due to opportunity of outdoor storage of containers			
Increase in efficiency of multimodal transportation and competitiveness of this type of transportation on the transport service market			
Possibility to develop systems of production, warehousing and distribution logistics based on container technologies			
Acceleration of freight and goods movement			
Possibility of rational management of freight flows between modes of transport			
Increase in competitiveness of national transit communications			
Increase in competitiveness of national export			
Reduction of harmful impact of transport system on the environment			

If utility until emergence of the project U_1 is more than utility after its implementation (U_2), then it is worth tackling, and vice versa.

In fact, we can go further in this reasoning. Indeed, from the perspective of an end user in the economy of the country, the effect of the investment project (even large infrastructure projects) for his life will be negligible. This means that we can assume all values x_0..., x_t ... as infinitesimally small as compared with the flow of consumption c_0,..., c,... (4). In other words,

$$U_2 = U_1 + \sum_{t=0}^{\infty} \beta^t u'(c_t) x_t . \qquad (4)$$

Thus, the net profit of the investment project in terms of utility is given by formula (5):

$$\sum_{t=0}^{\infty} \beta^t u'(c_t) x_t . \qquad (5)$$

If we wanted to express this value in monetary terms of the period 0, the project profit would be:

$$\sum_{t=0}^{\infty} \beta^t \frac{u'(c_t)}{u'(c_0)} x_t . \qquad (6)$$

Introducing «shadow» rate of interest:

$$r_{t,t-1} = \frac{u'^{(c_{t-1})}}{\beta u'(c_t)} - 1 , \qquad (7)$$

between periods t – 1 and t, we obtain reduced income from the project, or, as it is often called, net present value of the project in the form of:

$$\sum_{t=0}^{\infty} \frac{1}{(1+r_{1,0)}} \cdots \frac{1}{(1+r_{t,t-1})} x_t . \qquad (8)$$

Let's explain why $r_{t,\,t-1}$ is called shadow rate of interest. Suppose that in our economy function efficient capital markets. In particular, at each time moment t – 1 an opportunity exists to take (or to lend) means at a rate K, to receive back in the next time period t the sum ($1 + r_{t,\,t-1}$) K. In other words, $r_{t,\,t-1}$ acts as a factual interest rate between these two time periods, which prevails in the capital market. In this case, a consumer, receiving a stream of income over time y_0,..., y_t..., will actually solve a following problem on optimization (redistributing funds from one period to another, using the capital markets available to him):

$$\sum_{t=0}^{\infty} \beta^t u(c_t) \to max, \qquad (9)$$

where optimization occurs in the space of variables c_0..., c_t... in the presence of budget constraints (due to the ability to borrow and lend money from period to period):

$$\sum_{t=0}^{\infty} \frac{1}{(1+r_{1,0)}} \cdots \frac{1}{(1+r_{t,t-1})} (y_t - c_t) = 0. \qquad (10)$$

Solving this problem it is not difficult to verify that interest rates $r_{t,\,t-1}$ are equal to previously entered shadow interest rates:

$$\frac{u'^{(c_{t-1})}}{\beta u'(c_t)} - 1. \qquad (11)$$

So, regardless of presence or absence of efficient capital markets, profit (or, more traditionally, net present value) of the investment project should be assessed according to the formula (8):

$$\sum_{t=0}^{\infty} \frac{1}{(1+r_{1,0})} \cdots \frac{1}{(1+r_{t,t-1})} x_t$$

As interest rates $r_{t,t-1}$ are taken either actual rates in the capital markets, or shadow interest rates in the absence of efficient capital markets.

Search for simplicity

We already know that the question of whether or not to implement a product is simply testing whether its net present value is non-negative or not. It is also easy to see that the question of choice of several mutually exclusive investment projects is reduced to the choice of one with the highest net present value. That is the simplest task is estimation of the net present value of the project in the presence of efficient capital markets.

In this case, it suffices to take equilibrium market interest rates and substitute them into the formula for net present value. The problem, however, occurs even in efficient markets in the presence of uncertainty. Then the one-period interest rates are accurately known only for the very first time period. Often at this point it is assumed that future interest rates will not change much, because they use the same interest rate for all periods $r_{t,t-1} = r$. In this case, the formula for the net present value is simplified:

$$\sum_{t=0}^{\infty} \frac{1}{(1+r)^t} x_t . \qquad (12)$$

Another difficulty is related to the presence of uncertainty – the presence of many different interest rates in the capital market. Differences lie in the discrepancy of risks associated with the respective borrowers.

Ideally, interest rate used in the evaluation of the net present value should reflect all known risk enclosed in this investment project. However, in each case, it is difficult to estimate (although it is necessary to try), so minimal requirement for each company, making investment decisions, is the use of their own interest rates (i. e., the cost of capital available to it) because they, at least take into account risks known to the capital market players, which is associated with the company, although not related to the project.

In this situation, the transformation of Ministry of Railways in JSC «Russian Railways» had a definite advantage, because now in the presence of capital market, given to the corporation on a commercial basis, determination of the risks associated with the operation of railways can be put on the shoulders of this market.

Along with the net present value, which is considered as «gold standard» in the economy, financial experts in companies often use other tools. The most popular of these is internal rate of return r_{int}, which is defined as the solution of the equation:

$$\sum_{t=0}^{\infty} \frac{1}{(1+r_{int})^t} x_t = 0. \qquad (13)$$

In other words, internal rate of return is such a hypothetical interest rate at which the present value of the project will be equal to 0.

The popularity of this criterion in comparison with the net present value is easily explained. Indeed, if there is a standard life cycle of the investment project in the start-up period of time (as long as there is a building of railways, container terminals, border crossings and customs warehouses), the flow of resources in the project is costly (i. e., $x_t < 0$), and only after a certain stage when construction works are completed and operation of new facilities begins, the project becomes able to bring a positive return ($x_t > 0$), works as an equivalent of a loan from the company: money are lent, and after some time are gradually returned. Internal rate of return acts as a percent on the loan, and as the role of the corporation is akin to the role of the lender, it is interested in the largest possible percentage.

Moreover, it is easy to make comparisons with actual costs of company capital (i. e. interest rate at which the corporation may acquire capital), and large internal rates of return always look like a very profitable investment of relatively inexpensive (lower interest rate) borrowings.

Of course, a temptation is big of two mutually exclusive projects to choose the one with the greater internal rate of return. Who prefers to lend money to, say, at 10% per annum, when they can be given at 20%? The problem lies, however, in the fact that, unlike bank deposits real investment projects are fixed in amounts, and it can occur that in the project with internal rate of return of 10% per annum can be invested 1 billion rubles and the next year profit of 100 million can be obtained, while in the project with profitability of 20% per annum only 1 million rubles can be invested and next year a profit of only 200 thousand rubles can be obtained.

A greater problem is less traditional profiles of resource flows over the lifetime of the project. For example, in a very extreme case, with positive return in the current year with subsequent costs in subsequent periods, the company implementing the project, acts not as a lender, but in fact as a borrower. In this role, it should be interested in lowering interest rates, that is, internal rate of return for itself.

Conclusions. The most general conclusion is equally simple and complex: alternative evaluation criteria of investment attractiveness of projects (for example, internal rate of return) should be treated very carefully and it is more preferable to use described above net present value in all matters.

Net present value methodology allows with a well-known resource flow, generated by investment project, to build a just assessment of the profitability of the proposed action. Problems, solved within the framework of this approach, involve the right choice of discount factors related to interest rates.

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Information about the author:
Lievin, Sergey B. – Ph.D. (Eng.), Director General of RRL LLC, Moscow, Russia, +7 (495) 2691818.

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