CONTRIBUTIONS TO THE EVALUATION OF THE INTEGRATED PRODUCTION SYSTEMS EFFICIENCY

Professor PhD **Cosmin DOBRIN**
Professor PhD **Nicolae ISTUDOR**
Professor PhD **Florea PARVU**
University Reader PhD **Vasile DEAC**
PhD Student **Cristian MOCANU**
The Bucharest Academy of Economic Studies, Romania

ABSTRACT

The companies that want to introduce new technologies and flexible systems in the production process face important issues in the process of economic justification for introducing these systems.

The issues they confront with are triggered by the lack of a finance and accounting quantification system of all the advantages of the flexible systems' implementation.

In the present paper we try to make a classification of the evaluation methods and to succinctly present the justifying analytical approaches.

1. Justifying approaches of the evaluation of FPS (flexible production systems) efficiency

The companies that want to introduce new technologies and flexible systems in the production process face important issues in the process of economic justification for introducing these systems.

The issues they confront with are triggered by the lack of a finance and accounting quantification system of all the advantages of the flexible systems' implementation

The difficulties are determined by the fact that:

- The advantages of introducing the flexible systems are quantitative ones, which can be easily evaluated, but also there are some qualitative ones, strategic, whose economic evaluation and measuring is a very difficult one;
- The correct estimation of the functioning time of the flexible systems represents a critical point;
- The decisional risks are related to the precision of the calculated results estimation.

The economic turbulence rise was in fact a source of the crisis of the traditional techniques applied in the finance and accounting analysis of the FPS investments which become in fact incapable to take into consideration the "strategic" advantages of introducing these kinds of systems like:

- ✓ The production system flexibility level;
- ✓ The products' quality;
- ✓ The minimization of the availability time of these products on the market.

These aspects become variable, more and more important, in the context of an increase of competition between the rivals on the market. Even if they apply in general, to all kinds of investments, they become critical in the case of investments in the flexible systems.

The "intangible" advantages which are traditionally considered to be side effects become the key factors in justifying the introduction of the new technological equipments.

Gerwin and Kolondny (1992)[1] suggest that the most proper approach in the issue of the "flexible production systems" evaluation is made according to different characteristics of SFF, which they classify into four groups.

1) *FPS characteristics that bring **level "0"** intangible benefits*; these being costs and benefits that can be very easily identified in any FPS;
2) *FPS characteristics that bring **level "1"** intangible* benefits; these being variables that can be identified in physical terms, but can't be transformed into economic terms;
3) *FPS characteristics that bring **level" 2"** intangible benefits*; these being characteristics that are identifiable, but they can't be qualified in any kind of terms;
4) *FPS characteristics that bring l**evel "3"** intangible benefits*, these being unquantifiable costs and benefits, which aren't impossible to anticipate, but instead, the source, form and the moment in which they appear are usually unknown.

When we deal with a FPS, the main kinds of benefits are classified as level 2 or 3 intangible benefits.

Likewise, Meredith and Suresch (1986) (figure 1), suggest three categories of justifying approaches: economic, analytic and strategic.

Another kind of approach presented in the specialty literature is based on the options theory.

In this line, the specialty literature refers to different methods of evaluating FPS. In order to do that, it's necessary to be used a set of criteria of importance for each methodology. In the context of the traditional methodologies is used a set of criteria of determining the funds flows rise as a result of introducing the FPS (Copeland and Weston, 1988), like in Table 1.

Criteria of importance to determine the funds flow rise as a result of FPS introduction

Table 1

No.	Original criteria presented by Copeland and Weston in 1988
1	All cash-flows must be considered.
2	Cash-flows should be reduced at the levels of the opportunity cost.
3	The evaluation technique must select out of a set of projects the one who maximize the benefit.
4	The managers should be able to select a program not relating it to the others.

2. The analytic justifying approaches

In the classification made by Meredith and Suresch (1986) (figure 1) can be identified another class of tools named *"analytic justifying approaches"*.

[1] Gerwin, D. Kolodny, H., *Management of Advanced Manufactory Technology, Strategy, Organization & Innovation*, 1992

Through this kind of methodologies the researchers try to gather more information than those gathered through the traditional finance and economic approaches that have a pretty high rate of uncertainty. These kinds of methodologies are usually more realistic but they rely on subjective data that make them lose their credibility.

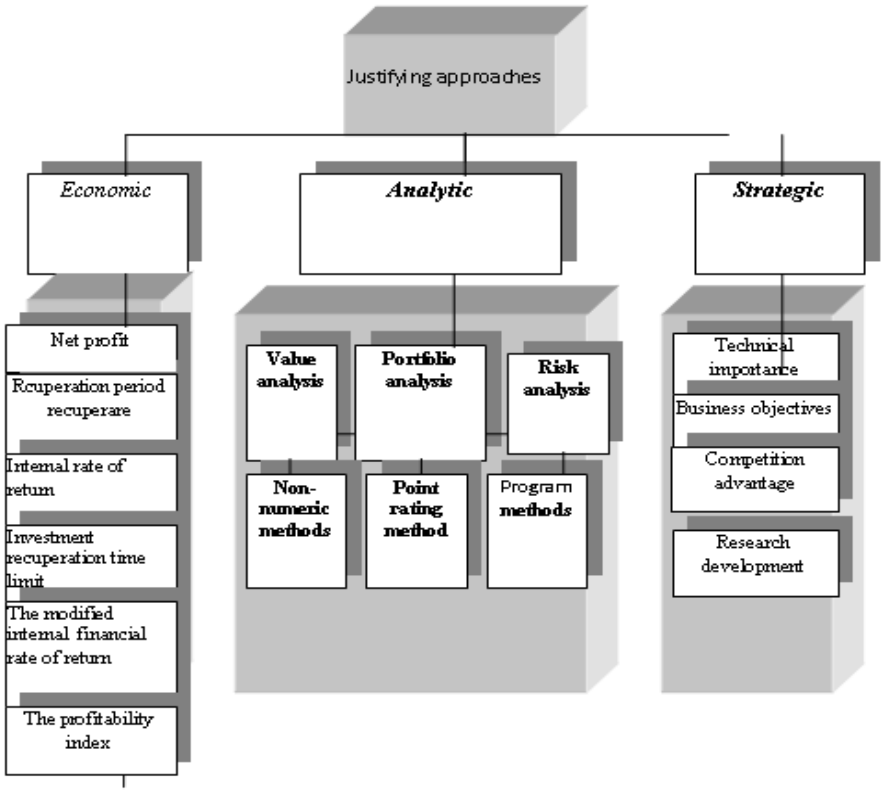

Figure 1 Justifying approaches

Certain researchers characterize the evaluation methods of investments in FPS based on financial criteria as being unprofitable.

These authors recommend the replacement of the fund flows updating especially when the flexible systems are analyzed with other evaluation techniques which were grouped in two types in the context of the analytic justification:

- portfolio's analysis
- risk analysis.

2.1. Portfolio analysis

The portfolios are tools of making decisions frequently used in strategic analysis. In general, there are two types of methods used in this domain:

- ✓ Non numerical methods
- ✓ Point rating methods.

A. Non numerical methods

Canada suggests that, related to the FPS, each investment from the portfolio to be evaluated according to two criteria and these are:

- Business contribution;
- Technologic contribution.

Business contribution is related to the long term benefits: costs' decrease, productivity increase, user's satisfaction increase, creation of competitive advantage, creation of new products, better organization, etc.

Technological contribution can be evaluated having in mind: aligning to the technological standards, the accepting on the market of the used technologies, system security, quality, flexibility, its complexity.

The two criteria are represented on a system of rectangular axes (on axe X is taken the contribution in technology, on axe Y the contribution in the business domain). In this plan can be represented each investment from the portfolio as a circle which is proportional with the net updated income of the investment. The bigger is the net updated income, the bigger is the circle. This way, a synthetic image of the investment portfolio is obtained.

Quadrant I covers investments with small contributions in the business domain, and in the technologic domain.

Quadrant II covers investments with major contributions in technologic domain, but which have a minor contribution in the business domain.

Quadrant III covers the investments with big contributions both in the business domain and in the technologic domain.

In quadrant IV are placed the investments that are efficient from the business point of view, but which don't bring anything new from the technological point of view.

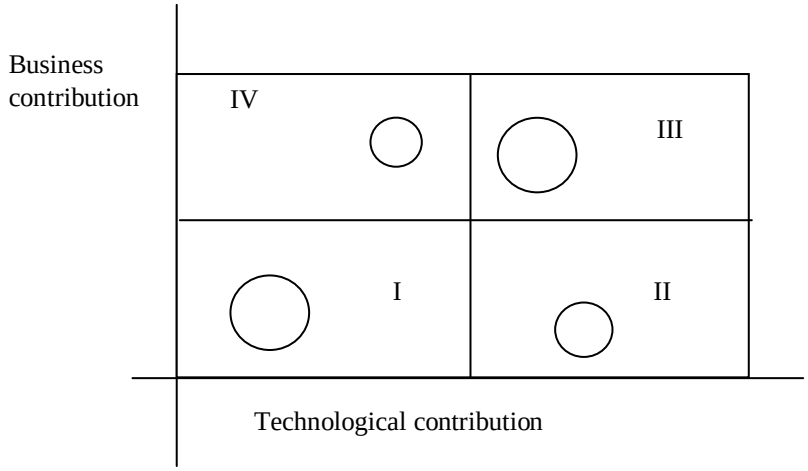

Figure 2 Investment representation in FPS

This method is used for choosing the investments that ensures the biggest efficiency on long and short term, therefore the investments that are placed on the quadrant III and IV will be preferred

B. **Points ratings method**

Using the points rating method in analyzing the flexible production systems is based on the assign of any technological alternative a numerical point rating. [1].

[1] Bejan, G., *Flexible production systems*, 1997

The method presupposes covering three stages:

1) Defining a complex of objective like, for example, improving the flexibility, the efficiency, the profitability, etc. The relative importance of each "i" objective is expressed by its normalized weighting factor, p_i
2) Estimating the investment contribution „j' at the objective „i" expressed according to the rating point P_i on a numerical scale;
3) The total score if the suggested investment „j" is determined as an average fixed-ratio score of the score that are related to each objective.

$$P_j = \sum_{i=1}^{N} P_{ji} \times P_i$$

According to this criterion, a company must choose the investment that has a bigger rating point, this being the most appropriate for its competitive strategy.

Others variants of the rating point, which meant to measure the economic efficiency of FPS were elaborated. Among these, the method suggested by McGinnis, Gardiner and Jesse is particularly interesting, because it tries to combine the investment economic analysis with the strategic position of the company and with the dynamic of the company extern ambient.

The method elaborated by McGinnis, Gardiner and Jesse use the rating points methods with finance analysis. This method involves covering three stages.

In the first stage, there is assigned a rating point to all the alternative investment projects analyzed by the company. The rating points assign is made according to the principles I have described above in the context of rating point method, its objective being the identification of the investment that corresponds the most to the company's competitive position. For that, a list with the alternative investments, ordered by the rating points obtained by them is made.

In second stage, the decisional factor will establish how many *k* alternatives must be taken into consideration and analyzed in great detail. This decision is subjective and must be based on the uncertainty degree of the competitive analyzed system. When the system is an uncertain one, a smaller value will be attributed to *k* and when the system will be predictable a bigger value will be assigned to *k*.

In the third stage, the *k* alternatives that will have the higher rating point and which, implicitly, will be considered to coincide with the company's strategy, will be compared with each other using the traditional financial method I previously described.

The FPS with the biggest net updated income will be chosen.

From the conceptual point of view, this method is based on the separation of the rating point method from the financial analysis. The rating point method contributes to determine the group of *k* alternatives that are similar from the point of view of their capacity to contribute to the company's strategic objectives, while the financial analysis will contribute to choosing the most profitable of them.

The model is based in the supposition that, when the competitive system isn't predictable, the financial evaluation doesn't reflect the reality, because the estimations that were done aren't based on real data. As a result, *k* is chosen to be a reduced value and this way the decision is based in special on the strategic value of the alternative that is given by the biggest rating point. From the other hand, when the competitive system is predictable, the economic and financial analysis must be considered to be the main decisional criterion. This way, the *k* value is established to be a big one, and the strategic analysis plays the role to eliminate these alternatives that are clearly unsatisfying.

Canada and Sullivan (1989) cover a wide range of these kinds of methods in their book, but all of them present the same weaknesses. The major weaknesses of these kinds of

methods rely in the fact that they are determined by the managers' subjectivity in assigning the rating points, and errors and inconsistencies might happen. On the other hand, these weaknesses can be considered to be advantages, because they offer the managers control and discretion in evaluating and justifying the investments from their departments.

2.2. Risk analysis

There are very few known elements in economic practice. Almost every important decision taken by the firm's manager refers to average and long term periods and necessitates prognoses related to the demand and the technological evolution. The information technology is a very dynamic domain and the information according the consumers' behavior and past technological modifications, no matter how complex they might be, are not enough to prognosticate their evolution in the future.

Taking a decision of investment in flexible production systems represents a "bet" with the future, founded on the manager's anticipations and hopes of profit. An investment project's anticipations can be compromised by events with multiple sources, which force the firm's management to take into consideration the risks and the uncertainty.

In the present, the decisional factors from various companies are gambling on the FPS' implementation as main factors that contribute to the organization's success. Unfortunately, economic influences, like the race of reducing the prices, wounded most deeply the FPS's developing strategies.

One of the theories related to the risks of the flexible production systems was elaborated by F. Davis. In his conception, the risk results from three factors:

The users The application's type	▪ the smaller is the risk, the bigger their experience in the domain; ▪ the risk is smaller in the administrative operations' case, of those in which various calculations are done and bigger in the complex systems' case: systems that determine a decision, expert systems; ▪ risk is smaller if the activity is more stable, the procedures are well established and the number of processing centers and the number is users are reduced, the period of achieving the project is smaller. The risk is an increased one if the activity is a complex one, the objectives are vague, the procedures are insufficiently defined.

In order to establish the risk level associated to a project, F. Davis suggests filling in the questionnaire presented in Table 2.

The questionnaire used in a risk case

Table 2

Mark	**1**	**2**	**3**
Necessary effort (people x months)	< 20	Between 20 and 100	> 100
Achieving period (expressed in years)	Smaller than1 year	Between1 and 2 years	Over 2 years
The business impact	Competitive advantage, new products	A high efficiency related to the environment	Higher internal efficiency
Number of services involved	1	2	3 or over 3
Is the new system essential for the users to lead their activities?	Facultative	Highly useful	Essential

Mark	1	2	3
If there is a system already, which percent of the functions of the previous system are capable to substitute the functions of the new system?	Over 50%	Between 25% and 50%	Under 25%
Must the users modify their working habits?	No	A little	A lot
Does the system provide the users the information they need?	Always	Most of the cases	sometimes
Is the system user-friendly?	Yes	In part	No
Are the information provided in a useful format?	Yes	In part	No
Users' attitude	In favour of the system	Indifferent	Hostile
The project chiefs' attitude	In favour of the system	Indifferent	Hostile
New equipments	None	Flexible machine tools	Flexible production systems
Experience in using the flexible systems	Good	Limited	None
The user's competence in the domain	Good	Limited	None
Is there any documentation for the used system?	Yes	In part	No

Each criterion is assigned a mark from 1 to 3. Also, each criterion is assigned a ratio, depending on its importance. The rating point assigned to each project is calculated making the weighted sum of the given marks. The higher the obtained rating point, the riskier the project. For each project, beside the risk degree, the benefits are calculated, too. According to the benefits and the risks, there are obtained three groups of projects:

- with great benefits and small risks. It's better to select these kinds of projects, but there aren't many;
- with small benefits and very risky. These kinds of projects stand small chances to be finalized, therefore they should be avoided;
- with great benefits/ high risks or small benefits/ small risks. These kinds of projects are the most numerous. The projects that are going to be selected depend on the manager's attitude toward risk, if he fears risks, he will select the less risky projects, if he's an optimist, he'll select those projects whose risk degree is higher.

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