Monitoring of Efficiency of Innovative Activity of Industrial Enterprise

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SUMMARY

Questions of economic evaluation of the monitoring of innovative activity in industrial enterprise are considered. A system of indexes which estimate monitoring results from different perspectives is offered: economic, financial, administrative, market, social and ecological. We present a system for the monitoring of the infrastructure of innovative activity, internal and external innovative possibilities of industrial enterprise. The proposed system of economic evaluation of the results of innovative activity monitoring is proposed for machine manufacturing enterprises inUkraine.
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For the receipt of objective information about the innovative activity of an enterprise it is necessary to use a system of monitoring consisting of some aggregate of processes and indexes. In order to form and analyse such a system the following complications need to be taken into account:

- the methods for the calculation of indexes, which reproduce processes taking place in an enterprise, must develop some compatible method for foreseeing the use of the unique technology of receipt and treatment of weekend information;
- organization of collection and treatment of initial reliable information must be carried out promptly enough, otherwise data will lose its actuality and importance;
- the updating of information must be carried out at a certain frequency (mode of regularity), otherwise the monitoring system will lose divisibility.

Arising from these complications, it follows that for the development of innovative performance one formal estimation of index indicators may not be enough for necessary and expert estimation. Thus the simplest indexes are determined with the single concordance of opinions of experts. For more difficult indexes, influenced by market factors, macroindexes of the industry's nation and/or region, it is necessary to use a multistage survey with the calculation of weighed coefficients and to take into account the degree of the use of such indexes in administrative practice.

It is impossible to fully formalize an innovative sphere and describe it with the help of the system of indexes. In the opinion of Lokhanovoy [4], an attempt to comprehensively describe all aspects of innovative activity can result in the inadequate re-creation of reality tighten development of the monitoring system, so as to define the algorithm of determination of each index and its place in technology for acceptance of administrative decisions. This means that the amount of indexes for monitoring is limited by logical construction of the system, practical use of indexes, costs of their development and receipt of information, depending on the number and time involved.

The features of the informative providing of innovative activity determine the necessity to use a systematic approach for the development of the structure of monitoring indexes, which foresees the exposure of basic causes and addresses connections and contradictions during the realization of innovative activity within an enterprise, and which takes into account the potential consequences of innovative measures and complex decisions in tasks of innovative development by the complex presentation of aims, functions, resources and stages of the innovative process.

Monitoring the innovative activity of machine manufacturing enterprises, in our view, must include the presentation of each of the constituents that are rich in structural content, such as shown in Fig. 1.

Monitoring innovative activity using a rich-in-content structure for the case of a machine manufacturing enterprise (Fig. 1) does not assume the complete

noninteraction of separate blocks. Some can to a certain measure overlap (be duplicated). For example, research can be attributed to the resource constituent of innovative potential (resource of intellectual works), and the forming of this research can belong to one of the stages of innovative process; in different blocks the same evaluation indexes can be used in a similar way.

On the whole, the grouping of indexes presented in Fig. 1 provides clear choices for the monitoring of innovative activity and implementation of criteria, and in our view, re-creates the system of innovative activity within a machine manufacturing enterprise.

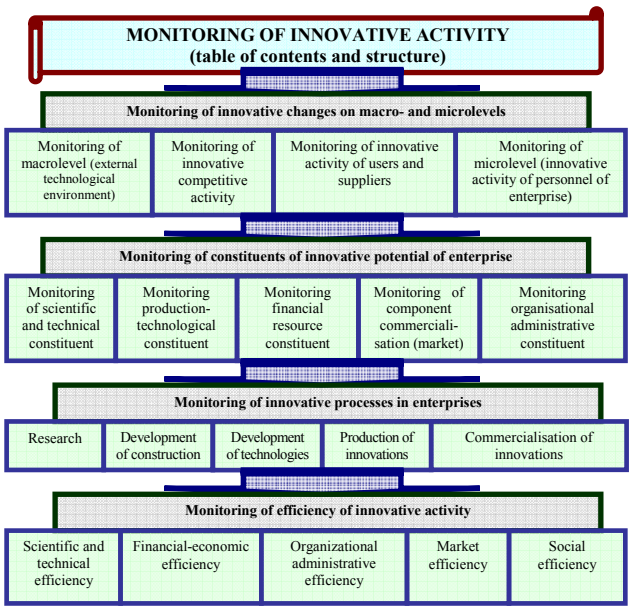

Figure 1. Rich-in-content structure for the monitoring of innovative activity in a machine-building enterprise

Monitoring the efficiency of innovative activity is characterized by the effectiveness of innovative activity of the enterprise as a whole. The indexes must reproduce the degree to which the goals of innovative activity are met, which, in our view, can be established as follows.

1. To the criteria of scientific and technical efficiency of innovative activity of industrial enterprise we recommend considering:
   a) probability of technical success of the most meaningful (as to costs, scale of use, actuality, efficiency) innovative developments of enterprise of B_{my}:
   $$B_{my} > max;$$
   b) patent cleanness (absence of violations of existent patent rights) of $ПЧ$ and patentability of $ППП$ (presence of high degree of novelty and possibility of patent defense of scientific development):
   $$ПЧ > 0;$$
   $$ППП > 1;$$
   c) level of novelty (unique development, at the level of the best adaptation, improvement to existing technology, etc.) of RN:
   $$RN > 1;$$
   d) cost and time of development of $ВЧ_{розр}$:
   $$ВЧ_{розр} > min;$$
   e) the presence of modern scientific and technical possibilities for the introduction of development of $M_{впр}$:
   $$M_{впр} > max;$$
   f) potential possibilities for development in the future ПМрозр:
   $$ПМрозр > max;$$
   g) possibilities of the use of scientific development in other spheres of production and commercial activity of enterprise (expansion of necessities).

In number the scientific technical results of innovative activity are characterized absolutely by calculation indexes. For the absolute indexes we recommend to take the following:

- the general amount of the patents obtained for scientific and technical developments and products of enterprises;
- the total costs or charges of the sale (for commercialization, transfer) of patents, licenses, commodity signs and other scientific and technical and intellectual achievements of industrial enterprise;
- specific relation of the certified products to the general volume of output of products of enterprise, calculated separately to national and international standards;
- the cost dynamics of immaterial assets of the enterprise;
- other factors such as the quality of academic degrees, any medals or certificates received by an enterprise, or other types of recognition based on results of scientific and technical activity.

The calculation-coefficient indexes of blocks of scientific and technical results of innovative activity in machine-building enterprises are shown below.

1.1. Coefficient of scientific maintenance of production of $K_{не}$:
$$K_{не} = B_н / B_Σ ,$$
where $B_н$ is the costs of enterprise for scientific and technical activity; $B_Σ$ represents the general costs of enterprise for production and commercial activity.

1.2. A coefficient of propensity to the innovative activity of enterprise is $K_{ін}$:
$$K_{ін} = B_н / O_p ,$$
where O_p is the annual volume of realization of these products of enterprise.

1.3. Coefficient of the use of own developments of $K_{вр}$:
$$K_{вр} = P_{вл} / P_Σ,$$
where $P_{вл}$ is the amount of own developments from within an enterprise; $P_Σ$ is the general amount of the enterprise's own scientific developments.

1.4. Coefficient of the use of purchased scientific developments of other enterprises $K_{пр}$:
$$K_{пр} = P_{прв} / P_{прΣ} ,$$

where $P_{прв}$ is the amount of purchased scientific developments within an enterprise; $P_{прΣ}$ is the general amount of purchased scientific developments of the enterprise.

1.5. Coefficient of update of the technological provisions of enterprise $K_{тп}$:

$$K_{тп} = ТП_{нв} / ТП_{Σ},$$

where $ТП_{нв}$ is the amount of new technological processes within an enterprise; $ТП_{Σ}$ is the general amount of technological processes which are used in an enterprise.

2. The financial-economic results of innovative activity of enterprise can be appraised with the use of the following criteria:
   - ➢ scientific maintenance of products produced within an enterprise, which is characterized by specific costs of research in the structure of unit cost or in a structure sale and which allows maximum use of the innovative possibilities of enterprise (the optimum size reproduces the level of the industrially developed countries of $M_н \rightarrow opt$);
   - ➢ costs for the acquisition of patents, licenses, know-how and other scientific products, for the necessities of innovative production ($B_{нп} \rightarrow opt$);
   - ➢ any change in the volume of requirements for innovative developments, products and services of enterprise, from the side of foreign users $ΔП_{in}$ in a "*t*" year as compared to (t-1) a year (in absolute $ΔП_{in} = П_{int} – П_{in(t-1)} \rightarrow max$ or relative $ΔП_{in} = (П_{int} – П_{in(t-1)})/ П_{in(t-1)} \rightarrow max$ measurements);
   - ➢ reduced cost per unit of products $ΔC_{од}$ due to innovations in a "*t*" year as compared to an earlier year (t-1), for factor such as expenditure on energy, cost of basic materials, and organizational costs (in absolute $ΔC_{од} = C_t – C_{t-1} \rightarrow max$ or relative $ΔC_{од} = (C_t – C_{t-1}) / C_{t-1} \rightarrow max$ measurements);
   - ➢ any increase in volume of net income of $ЧП$ due to innovations $ΔП_{чп}$ in a "*t*" year as compared to a year (t-1), by the types of innovations: food, technological, organizational, market (in absolute $ΔП_{чп} = ЧП_t – ЧП_{t-1} \rightarrow max$ or relative $ΔП_{чп} = (ЧП_t – ЧП_{t-1}) / ЧП_{t-1} \rightarrow max$ measurements).

Special attention is needed for the last criterion, so that its exact meaning can reveal additional efforts and costs in the utilization of separate accounts for specific types of products that could be carried out at multitop-level production. Taking into account features of the calculation of this index, it can be positive enough in terms of the general reduction in volume of income from production and commercial activities of industrial enterprise.

To the calculation-coefficient innovative performance of monitoring of this block of result indicators the following is required.

2.1. The coefficient of increment of immaterial assets of enterprise *HA* in a "*t*" year as compared to the year (*t-1*) of $K_{нм}$:

$$K_{нм} = (HA_t - HA_{t-1})/HA_{t-1}.$$

2.2. The coefficient of increase in annual volume in the sale of products of enterprise $ΔN$ in a "*t*" year as compared to a year (*t-1*):

$$ΔN = (N_t - N_{t-1})/ N_{t-1}.$$

2.3. Is there a coefficient of increase of the labour productivity on enterprises $ΔПП$ in a "*t*" year as compared to a year (*t-1*):

$$ΔПП = (ПП_t - ПП_{t-1})/ ПП_{t-1}.$$

2.4. Profitability of costs of enterprise for research $IRR_{НДДКР}$:

$$IRR_{НДДКР} = ΔП_{чп} / B_{НДДКР},$$

where $B_{НДДКР}$ is the general costs of enterprise for conducting research.

An analogical method can be the expected indexes of profitability of immaterial assets (relation $ΔП_{чп}$ to the cost of immaterial assets) and profitability of the realization of innovative products (relation $ΔП_{чп}$ to the production of innovative goods cost).

2.5. Part of the volume of realization $Д_{ін}$ from the sale of innovative products of $N_{ін}$ in a general volume sale of $N_Σ$:

$$Д_{ін} = N_{ін} / N_Σ.$$

2.6. A coefficient of autonomy of enterprise is in financing of innovative activity $K^{ІД}_{авт}$:

$$K^{ІД}_{авт} = B^{вл}_{ІД} \Big/ B_{ІД},$$

where $B^{вл}_{ІД}$ is the costs of the enterprise for the financing of its own innovative activity; $B_{ІД}$ is the general expenditure of enterprise on innovative activity.

2.7. Coefficient of debt circulation $K_{об}$ of creditor *КЗ* and debtor *ДЗ*:

$$K_{обКЗ} = N / КЗ;$$
$$K_{обДЗ} = N / ДЗ.$$

3. For organizational administrative factors in the results of innovative activity it is recommended to reproduce the following criteria:
   - ➢ the volume of net income of $ЧП_{інн}$ due to innovations, in the category of innovation (food $ЧП^{пр}_{інн}$, technological $ЧП^{техн}_{інн}$, organizational $ЧП^{орг}_{інн}$, market or marketing $ЧП^{марк}_{інн}$) - $ЧП_{інн} \rightarrow max$, $ЧП^{пр}_{інн} \rightarrow max$, technological $ЧП^{техн}_{інн} \rightarrow max$, organizational $ЧП^{орг}_{інн} \rightarrow max$, market or marketing $ЧП^{марк}_{інн} \rightarrow max$);
   - ➢ a share of clear profits is from the innovative activity of enterprise of $ЧП_{інн}$, which is the per employee management sphere in general

$\Delta ЧП_{\Sigma}^{упр}$ and those engaged in innovative activity $\Delta ЧП_{інн}^{упр}$:

$$\Delta ЧП_{\Sigma}^{упр} = ЧП_{інн} / Z_{упр} \rightarrow max;$$

$$\Delta ЧП_{інн}^{упр} = ЧП_{інн} / Z_{упр}^{інн} \rightarrow max,$$

where $Z_{упр}$, $Z_{упр}^{інн}$ are the amount of workers of management sphere in general and those engaged in innovative activity, respectively;

- the predicted future of managerial staff $\Delta Z_{упр}^{інн}$ is in its general quantity $Z_{уп}$, which is those engaged in innovative activity of enterprise $Z_{упр}^{інн}$:

$$\Delta Z_{упр}^{інн} = Z_{упр}^{інн} / Z_{уп} \rightarrow opt.$$

- the level of professional preparedness of managerial staff for realization of innovative activity:

$$ПП_{упр} = \frac{\Delta ПП_{упр}^{вища} + \Delta ПП_{упр}^{30\ 45} + \Delta ПП_{упр}^{\geq 5} + \Delta ПП_{упр}^{д+к} + \Delta ПП_{упр}^{інн} + \Delta ПП_{упр}^{техн}}{5} \rightarrow max,$$

where $\Delta ППП_{упр}^{вища}$ is the part of administrative workers of the enterprise with degrees in higher education; $\Delta ППП_{упр}^{30-45}$ is the part of administrative workers aged 30-45 years; $\Delta ППП_{упр}^{\geq 5}$ is the part of administrative workers with five or more years experience of administrative work; $\Delta ППП_{упр}^{д+к}$ is part of administrative workers that have scientific degrees of Doctor or Candidate of Sciences; and $\Delta ППП_{упр}^{інн}$ is the part of administrative workers with more than a year's experience in managing innovative activity.

For monitoring the calculation-coefficient innovative performance for this block of result indicators, the following applies

3.1. There is a part of managerial staff of УП in the general quantity of personnel of ПП of enterprise ΔУП:

$$\Delta УП = УП / ПП.$$

3.2. The coefficient of fluidity of managerial staff on the whole $K_{уп}^{пл}$ and those engaged in innovative activity $K_{уп\ інн}^{пл}$:

$$K_{уп}^{пл} = Z_{уп}^{зв} / Z_{уп};$$

$$K_{уп\ інн}^{пл} = Z_{уп}^{інн\ зв} / Z_{уп}^{інн},$$

where $Z_{уп}^{зв}$, $Z_{уп}^{інн\ зв}$ are the amount of exempt management workers during a year on the whole and engaged in innovative activity, respectively.

3.3. The part of vacant administrative positions, both total and for engagement in innovative activity.

3.4. The [art of management workers accepted in an enterprise with the use of the system of testing (this is recommended for analyses for the last five years).

3.5. The part of management workers, activity of which answers the system of growth operating in an enterprise.

3.6. The part of workplaces of management workers that are provided with the informative resources of the personal setting: Internet access, local informative network, networks for special branches, professional magazines and journals, reference books, normative and regulative materials, special literature of the professional setting, and so on.

3.7. The part of workplaces of management workers that are provided with hardware which promotes the efficiency of administrative labor: computers, fax, telephone, transport vehicles, photocopiers, shared office space and separate offices, and so on.

3.8. The part of costs for organizationally administrative provision of innovative activity.

4. The market results of innovative activity are recommended to reproduce the following criteria:

- appeal of products of enterprise $\Delta N_{конк}$, the competitiveness of which meets the best world standards:

$$\Delta N_{конк} \rightarrow max;$$

- index of growth of market of $I_{ринк}$ share:

$$I_{ринк} = \frac{N_p^t / N_{\Sigma}^t}{N_p^{t-1} / N_{\Sigma}^{t-1}} > max$$

where N_p^t, N_p^{t-1} are the volume of the realized products of enterprise in the target market in "*t*" and (t -1) periods of time; N_{Σ}^t, N_{Σ}^{t-1} are the general volume of the realized products in the target market in "*t*" and (t -1) periods of time;

- the level of satisfaction of necessities of target market in innovative products $I_{пот}^{інн}$:

$$I_{пот}^{інн} = N_p^{інн} / N_{\Sigma}^{інн} > max,$$

where $N_p^{інн}$ is the volume of products realized by an enterprise in the target market of innovative products; $N_{\Sigma}^{інн}$ is the value of credible service for innovative products (it is determined by an enterprise during market research).

For monitoring calculation-coefficient innovative performance in this block of result indicators the following is recommended:

4.1. The coefficient of update of products as a result of innovative activity Конов:

$$К_{онов} = N_{інн}^{оновл} / N_{тов},$$

where $N_{інн}^{оновл}$ is the volume of output of new products (as a result of innovative activity); $N_{тов}$ is the general commodity issue of products of enterprise.

4.2. The part of costs for marketing and advertising in the lump sum of innovative expenditure of $Ч_{мр}$:

$$Ч_{мр} = B_{мр} / B_{ІД},$$

where $B_{мр}$ is the costs of enterprise for marketing and advertising; $B_{ІД}$ is the general expenditure of enterprise on innovative activity.

4.3. The volume of financial receipts within an enterprise from the transfer of innovative technologies and commercialization of the created objects of intellectual property.

4.4. Appeal of innovative products shipped to users in markets abroad $I_{інн}^{зед}$:

$$I_{інн}^{зед} = N_p^{інн\ зед} / N_p^{інн},$$

where $N_p^{інн}$ is the general volume of the innovative products realized within an enterprise; $N_p^{інн\ зед}$ is the volume of innovative products shipped by an enterprise to user abroad.

4.5. Presence at the target market of the ramified network of sale of innovative products.

5. Social and ecological results of innovative activity, which must be in the sphere of attention of monitoring, can be reproduced by the following criteria:

➢ index of social efficiency (improvement of terms of labor of workers engaged in the sphere of production (creation) $I_{інн}^{вироб}$ and drawing (consumption) $I_{інн}^{спо}$ on the results of innovative activity of enterprise) $I_{інн}^{соо}$:

$$I_{інн}^{соо} = I_{інн}^{вироб} + I_{інн}^{спож} = (П_{в.інн}^{покр} - П_{в.інн}^{погірш}) / ПП_{вироб} + (П_{сп.інн}^{покр} - П_{сп.інн}^{погірш}) / ПП_{спож} \to \max,$$

where $П_{в.інн}^{покр}$, $П_{в.інн}^{погірш}$ are the number of workers of enterprise whose labour conditions improved or worsened, respectively, in the sphere of production (creation) of results of innovative activity of enterprise; $ПП_{вироб}$, $ПП_{спож}$ are the mean value of work in the sphere of production and consumption of results of innovative activity of enterprise, respectively.

By the condition (by limitation) of the offered model of index of social efficiency of innovative activity of enterprise, there must be an observance of inequality:

$$I_{інн}^{соо} > 0.$$

Taking this limitation into account it is possible to establish an interval of change in the index of social efficiency $I_{інн}^{соо}$ in the interval of 0...2;

➢ the index of ecological efficiency, which reproduces the decline in level of ecological harm in the sphere of production (creation) $I_{еко}^{вироб}$ and drawing (consumption) $I_{еко}^{спож}$ on the results of innovative activity of enterprise $I_{інн}^{еко}$:

$$I_{інн}^{еко} = I_{еко}^{вироб} + I_{еко}^{спож} = (ПР_{вироб}^{\Sigma} \quad ПР_{вироб}^{шкідл}) / ПР_{вироб}^{\Sigma},$$

$$+ (ПР_{спож}^{\Sigma} \quad ПР_{спож}^{шкідл}) / ПР_{спож}^{\Sigma} \to \max$$

where $П_{вироб}^{шкідл}$, $П_{спож}^{шкідл}$ are the volume of hazardous wastes of production in a calculation per procut unit in the sphere of production (creation) and drawing (consumption) on the results of innovative activity of enterprise, respectively; $П_{вироб}^{\Sigma}$, $П_{спож}^{\Sigma}$ are the general costs in natural resources per product unit in the sphere of production (creation) and drawing (consumption) on the results of innovative activity of enterprise, respectively.

For monitoring the calculation-coefficient indexes of the efficiency of innovative activity of this block of results we recommend taking the following factors into account.

5.1. The coefficient of decline of frequency of injury to workers Кчт:

$$Кчт = (m(t-1) - mt) / ПП,$$

where mt , m(t-1) are the number of accidents leading to the loss of capacity on one day “t” and (t - 1) period of time, respectively.

5.2. The coefficient of decline of the proportion of workers in harmful and dangerous workplaces, Кшн:

$$Кшн = (Пш(t-1) - Пш\ t) / ПП,$$

where Пш t , Пш(t-1) are the number of workers in harmful and dangerous workplaces in “t” and (t -1) periods of time, respectively.

5.3. The coefficient of the maintained or additionally created workplaces $K_{рм}^{ІД}$ due to innovative activity of enterprise:

$$K_{рм}^{ІД} = \sum_{i=1}^{i=n} t_{i1} N_i / Ф_{1ПП},$$

where t_{i1} is the labor intensiveness of unit of innovative products «*i*»; N_i is the annual production of innovative products «*i*»; *n* is the nomenclature of innovative wares (rank); $Ф_{1ПП}$ is the annual working hours of one worker.

5.4. The part of workers which promoted the production qualification or level of education as a result of the enterprise carrying out innovative activity Чкв:

$$\text{Чкв} = \text{Пкв} / \text{ПП},$$

where $П_{кв}$ is the number of workers in the enterprise whose qualifications or levels of education were raised.

5.5. Coefficient of reducing production waste $K_{відх}^{інн}$:

$$K_{відх}^{інн} = \left(B_{t-1}^{інн} - B_t^{інн}\right) \Big/ B_{пр}^{інн},$$

where $B_{t\ 1}^{інн}$, $B_t^{інн}$ are the wastes of production of innovative goods in (t -1) and "t" periods of time; $B_{пр}^{інн}$ is the production volume of innovative goods.

5.6. Profitability of nature protection constituent of innovative activity $P_{пр.охор}^{інн}$:

$$P_{пр.охор}^{інн} = \frac{П_{відх} + \Delta E}{ОФ_{пр}^{відх} + ОЗ_{пр}},$$

where $П_{відх}$ is the income from realization or repeated utilization of wastes of production; ΔE is an annual economic effect (reduction of economic losses) in the national economy from the introduction of results of innovative activity of enterprise; $ОФ_{пр}^{відх}$ is the cost of capital production assets involved in enrivonmental protection activities, taking into account funds from collection, storage, purveyance and utilization of the wastes and by-products of innovative activity of enterprise; $ОЗ_{пр}$ is the average annual amount of money in circulation from protection of the natural environment.

5.7. Coefficient of eco-friendliness of innovative products of enterprise $K_{еко}^{інн}$:

$$K_{еко}^{інн} = 1 - \sum_{i=1}^{i=n} \frac{B_i^{шкідл}\ \gamma_i^{шкідл}}{ПР_{i1}^{інн}\ N_i^{інн}},$$

where $B_i^{шкідл}$ is the annual volume of unused waste of «*i*» kind located in an environment; $\gamma_i^{шкідл}$ is the likelihood of relative danger (harmfulness) of «*i*» kind; $ПР_{i1}^{інн}$ - actual cost of natural resources on unit of mined-out innovative products of «*i*» kind; $N_i^{інн}$ - annual production of innovative products of «*i*» kind.

5.8. The coefficient of patents providing for the eco-friendliness of innovative production $K_{пат}^{еко}$:

$$K_{пат}^{еко} = F_{відх}^{еко} \Big/ F_{\Sigma},$$

where $F_{відх}^{еко}$ is the amount of patents owned by an enterprise that provide for innovative utilization of by-products of production; F_{Σ} is the general amount of patents owned by an enterprise.

It follows also that the social and ecological consequences of innovative activity of an enterprise also depend a great deal on macrofactors such as:

- legal provision for innovative activity, so that it is not contradicted by current legislation;
- a positive (negative) influence on of innovative activity can arise from prospective legislation;
- a positive (negative) reaction in public opinion can influence the innovative activity of an enterprise.

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