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Planning innovative production development and innovation cost

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Abstract
A country's economic growth is not possible without production growth. However, the evaluation of the economic growth so far has failed to correctly reflect forthcoming economic processes. Improper assessment of economic results has led to the inflation rise and unemployment increase. The use of the method recommended in this paper would enable to avoid that negative effect.

It is known that production volume (P) depends on the scale of production cost efficiency (W) and on the amount of production cost used (K):

$$P = W \cdot K$$

With simple reproduction we have:

$$\Delta I_p = \Delta I_w = \Delta I_k = 0 \tag{1}$$

where respectively: ΔI_p, ΔI_w, and ΔI_k – increases of production, labour efficiency and production cost, thus:

$$I_p = I_w = I_k = 1 \tag{2}$$

where respectively: I_p, I_w and I_k – indices of increase of production, labour efficiency and production cost.

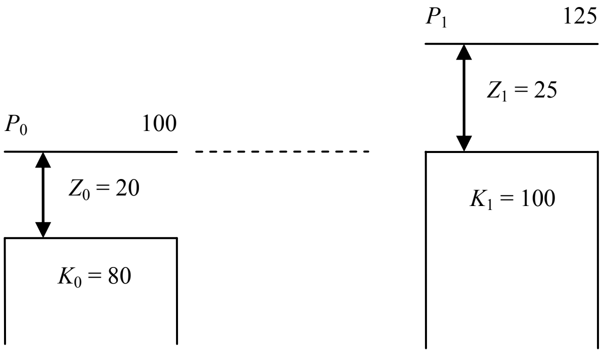

Fig. 1. Changes of production indices resulting from its extensive development (in conventional monetary units – cmu)

Expanded reproduction differs from simple reproduction by the presence of production increases on the basis of extensive, but intensive way of reproduction.

Expanded reproduction takes place as a result of additional investments into commodities and service production *without any change in the technological methods of production* (Fig. 1).

Where:

- P_0 – basic production level, $P_0 = W_0 \cdot K_0 = 100$ cmu;
- W_0 – basic production cost efficiency, $W_0 = P_0 : K_0 = 1.25$;
- K_0 – basic production cost level ($K_0 = 80$ cmu);
- P_1 – planned production level, $P_1 = W_0 \cdot K_1 = 1.25 \cdot 100 = 125$ cmu;
- K_1 – planned production cost level, $K_1 = K_0 + Z_0 = 100$ cmu;
- Z_0 – basic net profit, $Z_0 = P_0 – K_0 = 20$ cmu;
- Z_1 – planned net profit, $Z_1 = P_1 – K_1 = 25$ cmu.

Therefore, with extensive production development we have:

– production cost increase index:

$$I_k = K_1 : K_0 = 100 : 80 = 1.25;$$

– production cost efficiency index $W_1 = W_0$:

$$I_w = W_1 : W_0 = 1.25 : 1.25 = 1.0;$$

– index of production increase in market prices[1]:

$$I_p = P_1 : P_0 = 125 : 100 = 1.25;$$

or

$$I_p = I_w \cdot I_k = 1 \cdot 1.25 = 1.25;$$

– planned net profit will amount to:

$$Z_1 = P_1 - K_1 = 125 - 100 = 25;$$

net profit increase index:

$$I_z = Z_1 : Z_0 = 25 : 20 = 1.25$$

and a net profit increase: $\Delta Z = 25 - 20 = 5$ cmu.

Result: with an extensive production development the index of production in market prices is equal to the index of real labour cost increase and at the same time to net profit increase, while maintaining labour efficiency index ($I_w = 1$):

$$I_p = I_k = I_z = 1.25 \quad (3)$$

Intensive method of production development (Fig. 2) provides for innovation implementation which enables economizing on production cost (Variant *A*) or increasing production (Variant *B*).

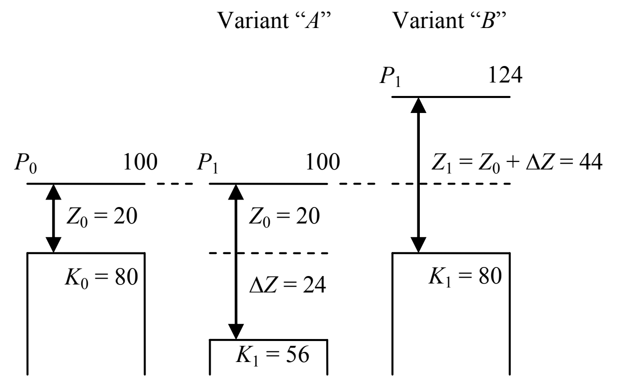

Fig. 2. Change of production indices in case of innovation implementation

Variant "*A*" (see Fig. 2) aims to reduce production costs by 24 cmu while maintaining the same basic values of production indices (P_0 = 100 cmu, K_0 = 80 cmu and W_0 = 1.25), and thereby increase profit (Z) to 24 cmu (ΔZ = 24 cmu).

When calculating planned changes of basic production parameters, one needs to bear in mind the following postulates:

a) the value of changes in production cost efficiency can only be assessed (measured) only when calculating the value of that index on the grounds of basic costs per production unit;

b) changes in production costs can only be assessed when calculating the value of that index per production unit produced in a reference period.

Taking into consideration the above postulates, increase of profit from innovation by 24 cmu corresponds to an increase of income from sale without a change of production costs.

In such circumstances, a planned increase of production cost efficiency is equal to:

$$\Delta W = 24 : 80 = 0.30,$$

while planned production costs efficiency amounts to:

$$W_1 = W_0 + \Delta W = 1.25 + 0.30 = 1.55.$$

Then, a planned production cost efficiency index accompanied by innovation implementation will be equal to:

$$I_w = W_1 : W_0 = 1.55 : 1.25 = 1.24$$

and the index of production cost efficiency increase will amount to:

$$\Delta I_w = I_w - 1.0 = 0.24 \text{ or } 24\%.$$

As previously mentioned, the assessment of the index of production cost change results from the comparison of costs per unit of base production.

However, a planned reduction of production costs by 24 cmu resultant from innovation implementation with base production cost efficiency (W_0 = 1.25) leads to production decrease:

$$\Delta P = 24 \cdot 1.25 = 30 \text{ cmu}.$$

It is evident that a net income increase on account of production cost reduction resulting from innovation implementation (ΔZ = 24 cmu) cannot compensate a planned decrease of income from sale of products in the amount of:

$$\Delta P^* = \Delta P - \Delta Z = 30 - 24 = 6 \text{ cmu}.$$

That is why, in order to maintain the balance of planned amount of proceeds from realization of products ($P_1 = P_0 = 100$ cmu) with $W_0 = 1.25$ it needs to be achieved by using net income increase from innovation implementation and then increase the volume of previously planned production costs (56 cmu) per ΔK^*:

$$\Delta K^* = \Delta P^* : W_0 = 6 : 1.25 = 4.8 \text{ cmu}.$$

Taking the above into consideration, the following constitute the value of expected production:

– Production cost:

$$K_1 = K_0 - \Delta Z + \Delta K^* = 80 - 24 + 4.8 = 60.8 \text{ cmu};$$

– Production cost savings:

$$\Delta K = K_0 - K_1 = 80 - 60.8 = 19.2 \text{ cmu};$$

[1] Market prices are reflected by socially essential labour costs, i.e. limited production costs, with which conducting production is profitable.

– Production cost index:

$$I_k = K_1 : K_0 = 60.8 : 80 = 0.76;$$

– Changes of production cost index (decrease):

$$\Delta I_k = 1 - I_k = 1 - 0.76 = 0.24 \text{ or } 24\%.$$

It is worth noting that the implementation of innovation without any increase of production volume, change of production cost indices and their efficiency are equal to:

$$\Delta I_k = \Delta I_w = 0.24 \quad (4)$$

However, when calculating the efficiency of planned production costs in accordance with current methodology, the value of the index is:

$$W_1^* = P_1 : W_1 = 100 : 56 = 1.7858.$$

One cannot agree with the result of $\Delta I_w^* = 0.4286$, since its value does not take into account the described real economic effects of production cost reduction resulting from innovation.

It has been previously demonstrated that with regard to basic production conditions implementing an innovation enables improving production cost efficiency from $W_0 = 1.25$ to $W_1 = 1.55$.

It has also been shown that, while maintaining base production, in order to compensate for the losses of profit expected in this case, the value of expected production costs should amount to 60.8 cmu.

That is why:

1. In the period of planning a real index of production cost efficiency will be:

$$I_w = \frac{P_0}{K_1} : \frac{P_0}{K_0} = \frac{K_0}{K_1} = \frac{80.0}{60.8} = 1.24$$

while the index of production cost efficiency increase will be equal to:

$$\Delta I_w = I_w - 1 = 0.24 \text{ or } 24\%.$$

2. An error in assessing the increase of production cost efficiency according to current methodology will be:

$$\Delta I_w^* - \Delta I_w = 0.4286 - 0.24 = 0.1886,$$

and it exceeds the standard value of the index:

0.4286 : 0.24 = 1.7858 times or per 78.58%.

Furthermore, it needs to be noted that innovation implementation provides for decreasing production costs in the amount of 19.2 cmu. Because this example does not provide for an increase of demand for production made, thus a decrease of production costs in the amount of 19.2 cmu is going to lead to rise of unemployment (as a percentage on base production volume) in the amount of:

$$(19.2 : 100)\cdot 100 = 19.2\%.$$

It is also evident, that an increase in unemployment is going to reduce demand for its products, therefore causing inflation rate to rise in the same volume.

Variant "*B*" differs from Variant "*A*" by the fact that it provides for taking advantage of production cost economy in order to increase production activity. If until innovation implementation the efficiency of production costs unit amounted to:

$$W_0 = 100 : 80 = 1.25,$$

then after innovation implementation the efficiency of a production cost unit will rise by:

$$\Delta W_0 = 24 : 80 = 0.30 \text{ or to } 30\%.$$

Then a planned value of production cost efficiency unit (W_1) will amount to:

$$W_1 = W_0 + \Delta W_0 = 1.25 + 0.30 = 1.55;$$

while a planned production volume on the basis of the innovation amounts to:

$$P_1 = P_i = K_0 \cdot W_1 = 80 \cdot 1.55 = 124 \text{ cmu}.$$

Production result we receive (P_i = 124 cmu) can serve as a basis for calculating annual net profit (ΔZ_i) since innovation implementation

$$\Delta Z_i = Z_1 - Z_o = (124 - 80) - 20 = 44 - 20 = 24 \text{ cmu}$$

The following equality $\Delta Z_i = \Delta P_i$ proves that each monetary unit of net profit has an equal security in commodity, i.e. it corresponds to a production increase unit.

Because the given variant does not provide for using production costs in the amount of basic volume ($K_1 = K_0$ = 80 cmu), innovation implementation will not lead to unemployment or inflation growth in the country.

What is more, it must be pointed out that in the given variant of the plan as well as in „Variant *A*" the equality of production cost efficiency unit and of production cost reduction value will be maintained:

$$\Delta I_{w,i} = \Delta I_{k,i} = 0.30 \quad (5)$$

The identity of formulas (4) and (5) cited in textbook [1] at innovation implementation is not coincidental, but regular. On the grounds of its regularity the author has formulated a law on mutual connection between indices of cost efficiency increase and production cost decrease (6).

$$I_w = 2 - I_k, \quad I_k = 2 - I_w \quad (6)$$

However, the disclosure of regularities (6) *has so far (!) not found a practical use*, and expected results of innovation development are assessed on the basis of two incorrect evaluations: "**general**" and "**conservative**".

In "**general**" variant the following formula constitutes the basis for assessment:

$$I_w = \frac{1}{I_k} \qquad (7)$$

Then, with the value of production cost index I_k = 0.70, obtained as a result of innovation implementation, the expected index of production cost efficiency (I_w) amounts to:

$$I_w = \frac{1}{I_k} = \frac{1}{0.7} = 1.4286.$$

Subsequently, with I_w = 1.4286, a planned production cost efficiency index amounts to:

$$W_1 = W_0 \cdot I_w = 1.25 \cdot 1.4286 = 1.7858$$

while planned (expected) production volume (P_1):

$$P_1 = K_0 \cdot W_1 = 80 \cdot 1.7858 = 142.86 \text{ cmu}.$$

In this case an expected clean profit amounts to:

$$Z_1 = P_1 - K_1 = 142.86 - 80 = 62.86 \text{ cmu}$$

which, according to figure 2, is higher than the expected net profit value (44 cmu) by 18.86 cmu or by 44.9%.

It is evident that realization of such a plan is not secured with resources and it is only possible as a result of forcing up market prices of conducted production.

Consequently, it will lead to an increase of inflation of a given production by 15.21% [(18.86:124.00)·100].

A production plan prepared on the basis of a "**conservative**" approach provides for the use of the economy of production costs in the amount of 24.0 cmu, featuring basic production cost efficiency (W_0 = 1.25), will enable to increase production by 20.0 cmu ($\Delta P_0 = \Delta K_0 \cdot W_0 = 24.0 \cdot 1.25 = 30.0$).

Consequently, assuming the basic production costs are maintained (80 cmu), planned production volume ought to amount to:

$$P_1 = P_0 + \Delta P_0 = 100 + 30 = 130 \text{ cmu}$$

or

$$P_1 = (K_0 + \Delta K_0) \cdot W_0 = (80 + 24) \cdot 1.25 = 130 \text{ cmu}.$$

In this case an unjustified net profit increase (ΔZ), with production costs maintained, will be lower and it will amount to:

$$\Delta Z = (130 - 80) - (20 + 24) = 6 \text{ cmu}$$

while expected inflation growth 4.84% [(6:124)·100].

A comparison of the plan variants under consideration can be conducted on the grounds of table 1.

As presented in the table, the difference between the types of extensive and intensive production expansion involves in the first case an unchanging basic cost efficiency, and in the second case – it changes (it rises). This change brings about an economy of production costs, the use of which will lead to increase of production increase and national wealth (a variant of extensive expansion and variant *B*) or to increase of unemployment and inflation (last variants).

As has been mentioned in the example of "Variant *B*", the use of an economy of production costs obtained as a result of innovation implementation is not associated with the possibility of maintaining basic labour efficiency for them. On that account production increase *ex post* at the expense of the economy of socially essential labour costs (SELC) will lead to rising production level and net profit only to the volume equal to the economies of production costs (24 cmu).

It is evident that an analogous increase of clean profit can be obtained by way of an extensive production expansion, if the generated annual clean profit is allocated to production extension (Table 2).

On the grounds of the figures from table 2, it is easily noticeable that with extensive production expansion an additional increase of clean profit by 24 cmu will occur over the period of innovation

Table 1. Results of different variants of plans for production expansion

Indicators	Basic year (in cmu)	Planned year									
		Extensive development		Variants of intensive production development (on the basis of an innovation)							
				A		*B*		„General"		„Conservative"	
		(in cmu)	Rise (in %)	(in cmu)	Rise (in %)	(in cmu)	Rise (in %)	(in cmu)	Rise (in %)	(in cmu)	Rise (in %)
P	100	125	125	100	100	124	124	142.86	142.86	130	130
K	80	100	125	56	70	80	100	80	100	80	100
Z	20	25	125	44	220	44	220	62.86	314.3	50	250
W	1.25	1.25	1.00	1.786	1.429	1.55	1.24	1.786	1.429	1.625	1.30

Table 2. Records of production volume and net profit increase with extensive production expansion

Indicators	Base year	Planned period			
		1	2	3	4
W	1.25	1.25	1.25	1.25	1.25
P	100	125	156.25	195.31	244.14
K	80	100	125	156.25	195.31
Z	20	25	31.25	39.06	48,83
ΔZ	–	5	6.25	7.81	9.77
$\sum\Delta Z$	–	5	11.25	19.06	28.83

effective use $T_e = 3.534$ years [3 + (24 – 19.06) : 9.77].

In order to determine indicator T_e formula (8) can be used.

$$\frac{Z_0 + \Delta Z_i}{Z_0} = W_0^{T_e} \tag{8}$$

In the example under consideration it gives:

$$\frac{20+24}{20} = 1.25^{T_e} \quad \text{or} \quad 2.2 = 1.25^{T_e}$$

Once a logarithm is found:

$$\ln 2.2 = T_e \cdot \ln 1.25 \quad \text{or} \quad 0.7885 = T_e \cdot 0.2231,$$

where $T_e = 3.534$ years.

Thus, with extensive production expansion an increase of net profit by 24 cmu can be obtained within $T_e = 3.534$ years and with an increase of demand (ΔP_0) for production in the amount of:

$$\Delta P_0 = P_0 \cdot \left(W_0^{T_e} - 1\right) \tag{9}$$

In the example under consideration is gives:

$$\Delta P_0 = 100 \cdot (1.25^{3.534} - 1) = 120.0 \text{ cmu.}$$

The same essential value of production increase in $T_e = 3.534$ years can be obtained on the basis of the figures in table 2:

$$195.31 + (244.14 - 195.31) \cdot 0.534 - 100.00 = \\ = 120.0 \text{ cmu.}$$

If marketing research demonstrates a possibility of a rise in demand of given production within T_e = 3.534 years by 120 cmu or more, then the variant of extensive production expansion can be considered as an alternative to the variant of using the innovation.

What is more, the timeframe of $T_e = 3.534$ years can be considered as a minimum period prior to which an increase of net profit resulting from innovation implementation cannot be achieved by way of extensive production expansion. It is a period of an effective use of innovation in the course of which net profit increase belongs entirely to the Innovating Party conducting R&D. In this case a minimum market price of innovation (C_i^*) will amount to:

$$C_i^* = \Delta K_i \cdot T_e = \Delta P_i \cdot T_e \tag{10}$$

In the examined example is gives:

$$C_i^* = 24 \cdot 3.534 = 84.8 \text{ cmu}$$

If production costs of the Innovating Party are equal to $K_{\text{inn}} = 75$ cmu, the profitability of that Party's production will amount to 0.116 [(84.8–75.00) : 84.8] or 11.64%.

However, if marketing research demonstrates a possibility of reducing demand of given production to the dimension of ΔP_t, not as necessary for carrying out an alternative (extensive) production expansion (ΔP_0), the period of an effective use of innovation or comparability period T_e ought to be adjusted by an indicator of a permanent effect change from innovation (L_t):

$$L_t = \Delta P_0 / \Delta P_t \tag{11}$$

In that case determining a minimum market price is reflected by the following formula:

$$C_i = \Delta Z_i \cdot T_e \cdot L_t = \Delta Z_i \cdot T_e^* \tag{12}$$

where $$T_e^* = T_e \cdot L_t \tag{13}$$

Assuming that marketing research demonstrated a possibility of an increase in demand for the period of $T_e = 3.534$ years, which will amount to only $\Delta P_t = 90$ cmu, an adjusted time of effective use of innovation will be as follows:

$$T_e^* = T_e \cdot L_t = 3.534 \cdot 120/90 = 4.712 \text{ years,}$$

and a minimum price of innovation:

$$C_i = \Delta Z_i \cdot T_e \cdot L_t = 24 \cdot 3.534 \cdot 120/90 = 113.1 \text{ cmu.}$$

That is why in the course of drawing up contracts for use of an innovation personal remarks must set forth an option of switching to assessing innovation price in accordance with formula (12).

For instance, with $\Delta P_t = \Delta P_i = 24$ cmu, a price of a given innovation ought to amount to $C_i = 24$ 3.534·120/24 = 424.1 cmu.

<u>Attention</u>: accounting of innovation price requires, as quoted, the existence of the following equation $\Delta P_t = \Delta P_i = \Delta K_i$. With $\Delta P_t > \Delta P_i$, an innovation price is not subject to change, because the above production increase ΔP_i may only be realized by way of extensive production expansion, and not on the grounds of the economy of production costs resulting from innovation implementation.

With $\Delta P_t < \Delta P_i$ (in the example it would be: $\Delta P_t < 24$ cmu) the price of innovation rises as a consequence of reducing the possibility of extensive production expansion. Nevertheless, in this case *innovation implementation will cause unemployment increase. In order to offset the result of unemployment growth, a state law must provide for an enterprise to transfer the difference ($\Delta P_i - \Delta P_t$) for the benefit of tax authorities, which will then allocate such funds towards welfare expenditure related to unemployment.*

Two factors contribute to innovation price rise: production profitability until innovation implementation[2] and the scope of planned demand.

For instance, if until innovation implementation a profit of the enterprise under consideration was equal to $Z_0 = 5$ cmu, then:

– according to formula (8) we have:

$$\frac{5+24}{5} = 1.25^{T_e} \quad \text{or} \quad 5.8 = 1.25^{T_e}$$

hence $T_e = 7.88$ years.

– according to formula (9) we receive:

$$\Delta P_0 = 100\cdot(1.25^{7.88} - 1) = 480.0 \text{ cmu}$$

– according to formula (10) we receive:

$$C_i^* = 24\cdot 7.88 = 189.12 \text{ cmu.}$$

If within those 7.88 years production increase ΔP_0 is equal to 480 cmu, and not just 200 cmu, talking about the profitability of extensive production expansion is futile, while the innovation price according to formula (12) ought to be:

$$C_i = \Delta Z_i \cdot T_e \cdot L_t = 24\cdot 7.88\cdot 480/200 = 453.9 \text{ cmu.}$$

It is evident that with even lower production profitability the price of innovation and the time of its return will only continue to rise.

That is why, with production profitability close to zero the price of innovation ought to have a limited maximum value. Adoption of this principle should also prevent the state from a decrease in average production profitability level for a given industry or for a type of production activity.

It is known that on the basis of information regarding an enterprise's production profitability (Z_{PP}) according to formula (14) it is possible to determine the time of doubling (T_{PP}) socially essential labour costs of production.

$$T_{PP} = 1/ Z_{PP} \tag{14}$$

Assuming that for the industry under consideration an average production profitability level (Z_{PB}) is equal to 0.055 or 5.5%, doubling the capital of entrepreneurs of a given industry at the expense of net profit will be realized in:

$$T_{PP} = 1 / Z_{PP} = 1 / 0.055 = 18.2 \text{ years.}$$

[2] The lower the production profitability, the higher the innovation price.

Because innovation implementation guarantees an increase of annual net profit in the amount of ΔZ_i, a maximum price of investment must not be higher than:

$$C_{\text{inn, max}} = \Delta Z_i : Z_{PB} = \Delta Z_i \cdot T_{PB} \tag{15}$$

Thus, for a given example a maximum price of innovation cannot exceed:

$$C_{\text{inn, max}} = 24 : 0.055 = 24\cdot 18.2 = 436.4 \text{ cmu.}$$

Conclusions

It is clear that while implementing an innovation at enterprise featuring above-average production profitability for a selected industry or type of production activity, innovation price must be calculated on the basis of formula (10). A risk of error in calculating a market price of innovation in this case is minimum, because the proposed condition: $\Delta P_i = \Delta K_i$ exceeds unemployment growth in the country.

Furthermore, adopting indicator Z_{PB} in formula (15) as a bottom standard of production profitability for new innovations guarantees that no decrease in average production profitability level for a given industry or for a type of production activity occurs in the country. The condition on the one hand protects entrepreneurs from a dictate of prices by innovation creators, but on the other hand, it forces them to adopt innovations of efficiency not lower than the average in a given industry. Together it prevents: an increase of production costs in social-economic and science-technology spheres, a reduction of production profitability rate and inflation growth.

Calculating the price of innovation according to formula (10) proposed for enterprises with a profitability level of $Z_{PP} > Z_{PB}$ protects enterprises with a high profitability level from overpaying for an innovation, hence from inflation growth as well.

It is worth noting that passing the act on implementation of a given evaluation method of an innovation price will enable to apply the rule of democratic centralism in the management of the country's innovation development, according to which innovative activity of separate enterprises will guarantee effective development of the country's economy.

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