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Details and conditions for specifying the price and economic effect of research and development projects (R&D)

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Abstract

It is indisputable that the main conditions for acceleration of the national economy growth involve an objective evaluation of the contribution of innovative projects to the increase of national wealth (*NW*) of a country and recognizing those contributions as income of science and technology enterprises.

This paper on the basis of a specific example presents the grounds for the justification and a methodology of determining a market price of an R&D project, the economic effectiveness of scientific and technical activities, as well as the contribution of such activities into raising country's national wealth (*NW*).

Every scientist ought to recognize that their work concerning the development of a country is the only, as well as an extraordinary source of free growth of a country's national wealth. This does not mean that the conduct of research and development work (R&D) costs nothing and that scientists do not need an adequate remuneration for the performance of R&D work. Production costs and profits in the sphere of R&D should be secured with the size of the economy of socially essential labour costs, and not with additional capital investments. The criterion of the size of that economy involves the volume of production costs required to ensure the same profit growth by way of an extensive production expansion.

To illustrate the phenomenon we are going to use the data quoted in [1].

We assume that the above enterprise was planning to implement an innovation in 2001 *which allowed it to reduce its production costs for the last year by 335 thou. PLN.*

It is also known that the innovation implementation at the Ordering Party's facility can be completed within 2 years and it involves the Innovating Party incurring costs amounting to 2460 PLN. It is also known that the share of fixed and current assets in production costs before the innovation implementation constitutes 61.1%, while following the innovation implementation that share is equal to 64.8%; other production costs respectively – 10.5%, and after the implementation they will remain unchanged.

In order to evaluate the innovation correctly, one needs to assess, above all, the expected production indicators in the year prior to and following its planned implementation.

On the basis of a precise prognosis simulation for "Income on sales" of production it has been demonstrated that the indicator of "Production cost" (K_t) has got the largest impact on changes in the values of possible exogenous variables. On the basis of K_t indicator a formula for the trend analysis of "Income on sales" determines:

Table 1. Income on sales and production costs of the company of "Polchem" SA in the years from 1986 to 1998 (in thou. PLN)

Indicators	Years												
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1006	1997	1998
Income	5673	6184	6921	6953	8155	9086	9736	11117	12417	13441	15150	16693	18413
Costs	4949	5429	5522	6562	6962	7690	8222	9494	10379	11234	12714	14469	15713
Net profit	258	305	349	168	474	620	614	634	779	867	981	929	1143

$$\hat{y}_{P_t} = -245.7 + 1.1952 \cdot K_t \qquad (1)$$

with a standard error of estimation $S_e = 267.6$ thou. PLN and a coefficient of random variation $V_s = 2.49\%$ with admissible 10%, while the formula for the forecast of "Production cost" for "Time" (t) factor:

$$\hat{y}_{K_t} = 2979.7 + 885.7 \cdot t \qquad (2)$$

with the parameters: $S_e = 761.2$ thou. PLN and $V_s = 8.29\%$ and admissible 10%.

For an indicator of "Net profit" of an enterprise (Z_n), the following formula reflects the trend of change for "Time" (t) factor:

$$\hat{y}_{Z_t n} = 98.6 + 75.2 \cdot t \qquad (3)$$

with the parameters: $S_e = 88.83$ thou. PLN and $V_s = 14.22\%$ and admissible 10%.

We assume that until such time when the innovation has been implemented, fixed and current assets in the production costs of "Polchem" enterprise amounted to 61.1%, and after the implementation – 64.8%.

The expected indicators of production operations for 2001 or with $t = 16$[1] are given in table 2, where the volumes of production, costs and net profit are presented on the basis of formulas (1), (2) and (3).

Table 2. Results of innovative project implementation with constant production volumes in the year of the innovation implementation (e.g. 2001)

No.	Indicators	Without innovation	With innovation
1	Income on sales, thou. PLN	20253	20253
2	Production costs, thou. PLN	17151	16816
3	of which: fixed and current assets	10479	10897
4	remuneration	4871	4055.3
5	Gross profit, thou. PLN	3102	3437
6	Income tax and other costs	1800	1863.7
7	Net profit, thou. PLN [acc. to formula (3)]	1302	1573.3
8	Cost profitability (net profit / costs) in %	7.59	9.35

With production costs reduced by 335 thou. PLN as a result of the innovation implementation, planned production costs will decrease by 335 thou. PLN (16 816 =17 151 – 335), while income tax will increase to 63.7 thou. PLN (335·0.19). Net profit increase: 1573.3 – 1302 = 271.3 thou. PLN.

[1] Ordinal number of the expected year in which the innovation will be implemented as of the first year for which the statistical data in table 1 are presented.

Note: in table 2 the figures under "Income tax and other costs" (point 6 table 2) are calculated as a difference between "Gross profit" (point 5) and "Net profit" (point 7).

It is assumed that after the innovation implementation the amount of "Other costs" remains unchanged.

From the point of view of the Ordering Party, its consent to the innovation implementation is beneficial not only for that enterprise, but also for the Innovating Party, as well as the state, because:

1. The Ordering Party is prepared to incur significant costs of the Innovating Party (2460 thou. PLN) with a return on investment (9.35%) irrespectively of the fact that an average costs profitability of production in the sector only amounts to 5.5%, for that reason the price of a given production of a science and technology enterprise (innovation price – C_{inn}) ought to be no higher than:

   $$C_{\text{inn}} = 2460 \cdot 1.0935 = 2690 \text{ PLN}$$

2. The social efficiency of an innovation project has been successfully demonstrated if the innovation implementation allows to maintain no fewer than 14.9 jobs annually within 2 years [(2690:90):2] in the science and technology sector, where 90 stands for expected average annual remuneration in the R&D sector.
3. The increase of the amounts owed to the state on account of income tax (CIT) will be to 113.1 thou. PLN, of which an increase of CIT on account of core activity with an additional gross profit of 335 thou. PLN will amount to 63.7 thou. PLN (335·0.19), while in science and technology production – 49.4 thou. PLN [(2690–2460)·0.19)].
4. The Ordering Party is prepared to wait 2 years for the innovation to be implemented and even to grant an interest-free loan to cover innovation costs.
5. In case of lack of understanding between the Innovative Party as to the prices offered, The Ordering Party has two alternative solutions regarding a net profit increase in the same amount.

The first option – involves investing the company's own capital into treasury bonds or into profitable stocks of other enterprises and investment funds.

If the Ordering Party chooses a less risky variant and makes a decision of investing its own capital into treasury bonds of e.g. 5% per annum, in order to generate income of equal value (335 thou. PLN), the amount of capital invested in this manner should be equal to:

335.0 : 0.05 = 6700 thou. PLN,

instead of the amount of 2963 PLN proposed to the Innovating Party.

Furthermore, putting this solution into practice will require that the Ordering Party of the investment implementation invests its annual net profit (1302.0 PLN) into these securities over the course of 5.1 years (6700:1302.0), and then (including investment income tax – 19.0%) still over the period of 24.7 years [(6700:335)·(1–0.19)] and wait for a return on the capital invested at bank.

Therefore, the total time required to obtain an annual net profit in the amount of 271.3 thou. PLN and a return on investment will be equal to 29.8 years (5.1 + 24.7).

The second option – involves extensive production expansion of own enterprise in order to achieve an increment of annual net profit at the amount of 271.3 thou. PLN on the grounds of additional investments of the company's own capital. In that case net profit ought to be equal to 1573.3 PLN. As table 3 demonstrates, the process will require 4.03 years [4 + (1573.3 – 1527.4) : 1602.6].

Table 3. Calculation of expected net profit values on the basis of formula (3), thou. PLN

Year	Number in time series (t)	Net profit
2001	16	1301.8
2002	17	1377.0
2003	18	1452.2
2004	19	1527.4
2005	20	1602.6

In this case for time t = 15 + 4.03 = 19.03 the expected production costs amount according to formula (2) is equal to:

$$\hat{y}_{K_t} = 2979.7 + 885.7 \cdot t =$$
$$= 2979.7 + 885.7 \cdot 19.03 = 19{,}834.6 \text{ PLN}.$$

Next, according to formula (1), the volume of own production in 2001 ought to be equal to:

$$\hat{y}_{P_t} = -245.7 + 1.1952 \cdot K_t =$$
$$= -245.7 + 1.1952 \cdot 19{,}834.6 = 23{,}460.6 \text{ PLN}$$

which requires raising production costs by 4265.5 PLN or by 22.2% more than the increase expected in 2000.

Therefore, the implementation of this variant of events will require that the Ordering Party bears the following in mind:

– the expected annual increase in demand for goods ought to reach 6.84% in 4.03 years;
– with such dynamics of production volume increase only direct costs of production will rise by 3569.4 PLN (19 834.6 – 16 265.2) in relation to 2000, but they will not reach the amount of 2690 PLN proposed by the Ordering Party as the price for innovation.

In such circumstances, the Innovative Party's arguments regarding the innovation market price and its effectiveness need to derive from the following postulates:

1. A product market price reflects the amount of socially necessary labour costs (SNLC) for its production.

The implementation of R&D projects leads to a decrease of the SNLC of the company's products and an increase of its net profit in the amount of ΔZ_i.

In every enterprise the profitability of SNLC of its production (R_p) is determined as an amount of the distribution of annual net profit on sales from its production in relation to the market price of the products manufactured in that period.

An inversely proportional indicator to a production profitability indicator reflects the length of a period of production manufacture (T_i), for which the sum of annual net profit generated by the company will be equal to an annual reproduction volume of the consumed SNLC.

$$T_i = 1 : R_p \tag{4}$$

2. A saving (reduction of the SNLC) resulting from R&D project implementation while maintaining a basic volume of production output will eventually lead to:

– dismissal of production employees, i.e. unemployment growth;
– increase of the financial means unsecured in production in the same amount, i.e. to inflation.

For these reasons, only those R&D projects are to be recognized as economically effective which along with SNLC savings in the amount of ΔZ_i require the use of that economy for the increase of the country's national wealth, namely, the projects that determine the rise in the volume of production output of a given company or of another one in the same amount. The requirement is expressed by the following equation:

$$\Delta P = P_1 - P_0 = \Delta Z_i \tag{5}$$

where: P_1 and P_0 represent production sales volume before and after innovation implementation.

3. For the companies implementing R&D projects there is an alternative possibility of obtaining a sales volume increase (national income increase) in the amount of ΔP by using its annual net profit to that aim.

The company's net profit reflects the amount of SNLC savings and maintaining it without any increase in the national wealth – it also takes into account the shortcomings specified in Postulate 2.

However, with equal amounts of SNLC savings the company's production output achieved by way of employing extensive production expansion in the amount of ΔR_p can be realized only prior to the expiry of period T_i, and it will require the company incurring additional production costs in the amount of:

$$C_{\text{inn}} = \Delta Z_i \cdot T_i \tag{6}$$

where C_{inn} – market price of an R&D project.

4. A market price of an R&D project specifies a maximum amount of SNLC expenditure for innovation creation and implementation.

With outlays equaling K_{inn} spent on the creation and implementation of an R&D project in excess of C_{inn}, the variant of extensive production expansion becomes a more profitable way of innovation implementation.

When $K_{\text{inn}} = C_{\text{inn}}$, R&D projects and extensive production expansion are interchangeable, and with $K_{\text{inn}} < C_{\text{inn}}$ of R&D projects becomes economically effective. Net profit (E_{inn}) on innovation sale in the R&D area will be:

$$E_{\text{inn}} = C_{\text{inn}} - K_{\text{inn}} \tag{7}$$

The services of the financial sector and of the innovation Ordering Party with respect to financial intermediation and credit for innovation creation and implementation do not affect the composition of works and R&D projects effectiveness, thus they do not constitute proof of those service providers right to participation in net profit distribution from the use of the projects.

Furthermore, in order to avoid non-production cost and R&D projects costs, credit rates offered by financial institutions ought not to take into account the costs of risk insurance. The payment of these additions does not change the conditions of obtained return, it will not reduce the amount of financial advance payments and it will not improve project implementation conditions. In fact, it is an additional way of insuring creditor's personal liability at the expense of scientific organizations.

5. At the end of the period of an effective use of an innovation, the rights to further use of the net profit generated on innovation implementation without any additional payments ought to be transferred from an R&D project creators to the Party ordering such a project.

Let us consider an algorithm of determining innovation market price on the basis of the analysed example.

Because the innovation will result in production cost savings to the amount of 335 thou. PLN, in order to avoid any increase of unemployment and any inflation growth in the country, an increase of demand and production ought to amount to the same sum of 335 thou. PLN at the very least. Such a situation is presented in column 4 of table 4.

Table 4. Results of innovative project implementation with constant tax deductible costs, in thou. PLN

No.	Indicators	Without innovation	With innovation
1	Income on sales, thou. PLN	20253	20588
2	Production costs, thou. PLN	17151	17151
3	of which: fixed and current assets	10479	11114
4	remuneration	4871	6037
5	Gross profit, thou. PLN	3102	3437
6	Income tax and other costs	1800	1863.7
7	Net profit, thou. PLN [acc. to formula (3)]	1302	1573.3
8	Cost profitability (net profit/ costs) in %	6.43	7.64

With an increase of production revenue (increase of national income) by 335 thou. PLN and basic production profitability of 6.43% we have:

Period of production output (T_i), which according to formula (4) is equal to:

$$T_i = 1 : R_{pi} = 1 : 0.0643 = 15.55 \text{ years.}$$

Innovation market price, which according to formula (6) is equal to:

$$C_{\text{inn}} = \Delta Z_i \cdot T_i = 335 \cdot 15.55 = 5209.3 \text{ m PLN}$$

and not 2690 PLN previously proposed to the Innovative Party by the Ordering Party.

The price of the innovation, standing at 5209.3 PLN, will not change even if an increase in demand exceeds 335 thou. PLN, because any additional production increase can only be achieved on the basis of additional investments made by the Ordering Party (apart from investment implementation) into additional extensive production expansion.

However, if marketing research demonstrates that an increase in demand for the company's production will be lower than the savings made on production costs $\Delta P_t < \Delta Z_i$ (in the example $\Delta P_t <$ 335 thou. PLN), the time of return on innovation or the time of effective use of the innovation T_i need to be increased (adjusted) by an indicator of a permanent effect change from innovation (L_t), which will amount to:

$$L_t = \Delta Z_i / \Delta P_t \quad (8)$$

Then determination of a minimum planned marked price is presented by the following formula:

$$C^*_{\text{inn},\,p} = \Delta P_i \cdot T_e \cdot L_t \quad (9)$$

In case of multi-annual fluctuations of the indicator L_t, innovation market price ($C^*_{\text{inn},\,p}$) can be calculated on the basis of the following formula:

$$C^*_{\text{inn},\,p} = \sum_{t=1}^{T_e} \Delta P_i \cdot L_t = \Delta P_i \cdot \sum_{t=1}^{T_e} L_t = \Delta P_i \cdot T^*_e$$

$$\text{where } L_t \geq 1 \quad (10)$$

It is apparent, as has been mentioned before, that if demand for production exceeds growth capability on the grounds of the innovation ($\Delta P_t > \Delta P_i$), then the price of the innovation will remain unchanged and any additional increase in production ($\Delta P = \Delta P_t - \Delta P_i$) will only be possible on the basis of additional investment into new innovations or into extensive production expansion.

An example of calculating the price of innovation on the basis of formula (10) is given in table 5.

$0.594^* = (335:310)\cdot 0.55$; $199.0^{**} = 335\cdot 0.594$.

As table 5 shows, sporadic decrease in the values of annual revenue will lengthen the time of return on product implementation from T_i to T_i^*, which will cause the innovation market price to rise from 5209.3 thou. PLN to:

$$C^*_{\text{inn},p} = 335\cdot 16.05 = 5376.8 \text{ PLN}.$$

The possibility of an innovation market price change requires that limits of those changes be designated along with a proposed probability.

As already mentioned, the grounds for calculating the innovation market price involves forecasting the expected values of the three endogenous indicators: income on sales, production costs and net profit for the year of innovation implementation. Calculation of those indicators on the basis of previous years' data guarantees reflecting random components of costs and benefits of production along with the inflation in the innovation price.

The presence of random changes requires such exogenous variables for each endogenous variable which minimize the value of standard error of estimation (S_e), i.e. deviations of values of an endogenous variable from the value of its trend.

Intervals of change of each endogenous variable can be determined with a set probability in accordance with formula (11):

$$\hat{y}_T - S_e \cdot t_s \cdot k \leq \hat{y}_T \leq \hat{y}_T + S_e \cdot t_s \cdot k \quad (11)$$

where: t_s – student's indicator, the value of which can be calculated according to a table of "Normal distribution function", constituting a supplement to textbooks on statistics and value of desired probability. Thus, with a desired probability $P = 0.9859$ in order to determine possible intervals of endogenous variables, one needs to assume $t_s = 2.46$; k_T – correction coefficient for a linear trend is defined by the following formula:

$$k_T = \sqrt{\frac{n+1}{n} + \frac{(T-\bar{t})^2}{\sum (t-\bar{t})^2}}$$

where: n – length of an analysed time series (in the examined example $n = 13$); T – number of forecasted year in a time series (in the examined time series 2001 is the year of innovation implementation and it is numbered $T = 16$); t – numbers of years in initial time series.

Value k in the examined example will equal to:

$$k_T = \sqrt{\frac{n+1}{n} + \frac{(T-\bar{t})^2}{\sum (t-\bar{t})^2}} =$$

$$= \sqrt{\frac{13+1}{13} + \frac{(16-7)^2}{182}} = 1.234$$

Then on the basis of (1) and (11) with the probability of 0.9859 one can conclude that the realized production value will not exceed:

$$20253 - 267.6\cdot 2.46\cdot 1.234 \leq 20253 \leq 20253 + 267.6\cdot 2.46\cdot 1.234$$

or

$$20253 - 812.3 \leq 20253 \leq 20253 + 812.3$$

Table 5. Determining the price for an innovation with the parameters $\Delta P_i = \Delta K_i = 335$ and $T_e = 15.55$ with non-identical expected (or actual) values of production increase ΔP_t (a conventional example)

Indicators	Values													Total
Year (t)	1	1	1	1	1	1	1	1	1	1	1	...	0.55	15.55
ΔP_t	322	325	328	326	347	388	331	344	352	328	345	…	310	×
$L_t = \Delta P_i / \Delta P_t$	1.04	1.031	1.021	1.028	1.00	1.00	1.012	1.0	1.00	1.021	1.0	...	0.594^*	16.05
$\Delta C^*_{\text{inn},\,p}$	348.4	345.1	342.2	344.4	335	335	339	335	335	342.2	335	...	199.0^{**}	5376.8

It can be found that during the year of innovation implementation ($T = 16$) under the influence of external random factors, including inflation, a change of income on sales from production will not exceed the following value:

$$\varphi_T = \frac{S_e \cdot t_s \cdot k_T}{\hat{y}_T} \quad (12)$$

In the analysed example we have:

$$\varphi_{16} = \pm (812.3 : 20253) = \pm 0.04.$$

Since the assumed production growth resulting from innovation implementation is to equal only 335 thou. PLN, thus accounting for the listed random variations, the bottom limit of production increase resulting from the innovation implementation with a performance probability of $P = 0.9859$ may amount to:

$335 \cdot (1 - 0.04) = 321.6$ thou. PLN and $L_{16} = 1.04$.

It is evident that the production volume resulting from the innovation implementation during the year $T = 16$ changes only by 335 thou. PLN, and its new planned value ($\hat{y}_T + 335 = 20\,588$ PLN) will remain unchanged in the period T_i. Yet, the value of coefficient φ_T and deviation intervals from the expected value ($\hat{y}_T + 335 = 20\,588$ PLN) will be rising annually as a result of a change of coefficient k_T according to formula (11) in the amount I_T:

$$I_T = k_T : k_{T-1} \quad (13)$$

Thus, for the second year of profitability period ($T = 17$) the bottom limit of production increase will be $\pm(0.04 \cdot 1.036) = \pm 0.0414$, while coefficient $L_{17} = 1.0414$ etcetera.

The entire interval of profitability period $T^*_{e,\lim}$ for the innovation will be:

$$T^*_{e,\lim} = T_e \cdot \{1 + \varphi_T \cdot [1 + (T_e - 1) \cdot (I_T - 1)]\} \quad (14)$$

For the example given we have:

$$T^*_{e,\lim} = 15.55 \cdot \{1 + 0.04 \cdot [1 + (15.55 - 1) \cdot (1.036 - 1)]\} =$$
$$= 10.64 \cdot \{1 + 0.04 \cdot 1.409\} = 15.55 \cdot 1.056 = 16.5$$

On the basis of (14) an interval market price of the innovation will amount to:

$$C^*_{\text{inn,lim}} = \Delta P_i \cdot T^*_{e,\lim} = = 335 \cdot 16.5 = 5527.5 \text{ thou.PLN} \quad (15)$$

With comparable values of production increases resulting from the innovation implementation, the price of innovation is higher for enterprises with lower production profitability.

For instance, if production profitability of enterprises considered for innovation implementation amounted to $R_{PB} = 0.03$, then according to formulas (4) – (6) we have:

$$C^*_{\text{inn}} = 335 \cdot 27.65 = 9262.75 \text{ PLN}.$$

However, it is clear that with still lower production profitability the price of innovation and the time of its payment will only continue to grow.

That is why, with production profitability $R_P < R_{PB}$, the price of innovation ought to have a limited maximum value. Adoption of this principle should also safeguard the state from a reduction in average production profitability level for a given industry or for a type of production activity.

Therefore, a maximum price of innovation ought not to be higher than:

$$C_{\text{inn,max}} = \Delta P_i \cdot T_{PB} \quad (16)$$

where: T_{PB} – average time in a given industry for capital accumulation on the basis of net profit in the amount of annual production output;

$$T_{PB} = 1 / R_{PB}.$$

If we assume that for the analysed industry $R_{PB} = 0.055$ and in the given example $R_P = 0.0643$, then maximum innovation price must not exceed:

$$C_{\text{inn,max}} = 335 : 0.055 = 6091 \text{ PLN},$$

since an excess will lead to a decrease in average industry profitability.

Conclusions

It is evident that the most probable price of innovation must be calculated on the basis of formula (6). The risk of error in calculating innovation market price in this case is minimal, as:

- the price is calculated on the grounds of final statistical data regarding company's operating activities along with a proposed probability, that is, it reflects the impact of fortuitous events;
- calculation of the market price of the innovation on the basis of the net profit indicator provides a possibility of computing extraordinary gains and losses, i.e. financial consequences occurring as a result of unforeseeable events, aside from the company's operating activities and unrelated to overall risk of running the company.

In order to reduce the risk of error, a contract on innovation ought to set forth a condition that the final financial settlement is to be effected on the grounds of actual implementation results (Table 5) and taking into account condition (10).

The proposed condition: $\Delta P_i = \Delta K_i$ – exceeds unemployment growth in the country.

Furthermore, the grounds for assuming indicator R_{PB} in formula (16) as a bottom standard value for production profitability for new innovations was an attempt at preventing a reduction in average production profitability of a respective industry or a type of production activity in the country. On the one hand, that condition 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 a reduction of production profitability rate and inflation growth.

Calculating the price of innovation according to formula (10) or (15) and on the basis of table 5 proposed for enterprises with a profitability level of $R_p > R_{PB}$ 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 the application of the principle 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 economics.

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