УДК 656.2:656.08:338.

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DOI: 10.32702/2306-6806.2022.3.73

DEVELOPMENT OF SCIENTIFIC AND METHODOLOGICAL APPROACH TO PRICING ON THE BASIS OF THE ENTERPRISE VALUE CRITERIA

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РОЗРОБКА НАУКОВО-МЕТОДИЧНОГО ПІДХОДУ ДО ЦІНОУТВОРЕННЯ НА ОСНОВІ КРИТЕРІЮ ВАРТОСТІ ПІДПРИЄМСТВА

The article develops a scientific and methodological approach to pricing based on the criterion of the firm (business) value and constructs economic and mathematical models of the optimal price for various conditions. The study is based on the fact that the criterion of business value, the firm should set prices in such a way as to maximize the market value of its entire property complex. For modelling purposes, this value can be determined based on a profitable methodological approach to valuation. That is, the optimal price level can be called one that corresponds to the solution of the optimization problem, where the objective function is the value of the entire property complex of the firm, and the variables are the prices of its products. Price models are based on the fact that according to the income methodological approach, the value of the integral property complex of the firm is defined as the current value of future net cash flow generated by the business that will use this integral property complex. From the standpoint of this criterion, the firm should set prices in such a way as to maximize the market value of its entire property complex. For modelling purposes, this value can be determined based on a profitable methodological approach. That is, the optimal price level can be called one that corresponds to the solution of the optimization problem, where the objective function is the value of the entire property complex of the firm, and the variables are the prices of its products. The author developed a general view of the objective function of this optimization problem for discrete and continuous models of cash flow, as well as approaches to business cash flow modelling depending on the nature of the relationship between demand for products (services) and their price, which is key to price modelling. A number of economic and mathematical price models have been developed for various conditions, which take into account the nature of the relationship between demand and price (including price demand elasticity), the structure of operating costs (primarily semi-fixed and variable parts), the need for investment, cost of capital, risk level and other factors. The application of the developed methodological approach and economic-mathematical models in the practice of pricing will increase the market value of the firm.

В статті розроблено науково-методичний підхід до ціноутворення на основі критерію вартості підприємства (бізнесу) та побудовано економіко-математичні моделі оптимальної ціни для різноманітних умов. Дослідження грунтується на тому, що позицій критерію вартості бізнесу підприємству доцільно встановити ціни таким чином, щоб забезпечити максимізацію ринкової вартості свого цілісного майнового комплексу. Для цілей моделювання ця вартість може визначатись на базі дохідного методичного підходу до оцінки. Тобто оптимальній рівнем ціни може бути названий такий, який відповідає рішенню оптимізаційної задачі, де цільовою функцією є вартість цілісного майнового комплексу підприємства, а змінними є ціни на його продукцію. Моделі ціни будуються виходячи з того, що за дохідним методичним підходом вартість цілісного майнового комплексу підприємства визначається як поточна вартість майбутнього чистого грошового потоку, що породжується бізнесом, який використовуватиме цей цілісний майновий комплекс.

Автор вважає, що підприємству доцільно встановити ціни таким чином, щоб забезпечити максимізацію ринкової вартості свого цілісного майнового комплексу. Для цілей моделювання ця вартість може визначатись на базі дохідного методичного підходу. Тобто оптимальним рівнем ціни може бути названий такий, який відповідає рішенню оптимізаційної задачі, де цільовою функцією є вартість цілісного майнового комплексу підприємства, а змінними є ціни на його продукцію. Розроблено загальний вигляд цільової функції вказаної оптимізаційної задачі для дискретної та безперервної моделей грошового потоку, а також підходи до моделювання грошового потоку бізнесу залежно від характеру зв'язку попиту на продукцію (послуги) та її ціни, який є ключовим для моделювання ціни.

Розроблено ряд економіко-математичних моделей ціни для різноманітних умов, які враховують характер зв'язку попиту та ціни (в тому числі еластичність попиту за ціною), структуру операційних витрат (перш за все, умовно-постійну та змінну частини), потребу в інвестиціях, вартість капіталу, рівень ризику та інші чинники. Застосування розробленого методичного підходу та економіко-математичних моделей в практиці ціноутворення сприятиме зростанню ринкової вартості підприємства.

Key words: value criterion, cash flow, price modelling, economic and mathematical modelling, capital, elasticity of demand.

Ключові слова: критерій вартості, грошовий потік, моделювання ціни, економіко-математичне моделювання, капітал, еластичність попиту.

PROBLEM STATEMENT

The work is aimed to form a methodical approach to pricing based on the criterion of firm (business) value and construction of economic and mathematical price models for various conditions, which in the long run helps to maximize the market value of the firm.

REVIEW OF SCIENTIFIC SOURCES

The authors say that market investors prefer conservative fair values [1].

The scientist [2] shows that fair value measurement is shown to incorporate both market-based and entity-specific dimensions. IASB's measurement practices are more in line with semiology's framework of two complementary inputs (the market and the entity), than with the CFED's two dichotomous outputs (fair value or value-in-use), and the market/entity contrast is thus conceptually fractured.

The authors [3] investigate the role of internal finance in determining firms' fixed capital investments in an emerging economy. The degree of investment-cash flow sensitivity significantly varies with the monetary policy stance. While the investment-cash flow sensitivity declines during periods of expansionary monetary policy for financially constrained firms, the evidence is not conclusive for less-constrained firms that can access external finance relatively easily. They also find that investment-cash flow sensitivity declines when broader macro-financial conditions are relatively supportive. Furthermore, firms' cash flow needs grow considerably during recessionary periods (e.g., the GFC) compared to expansionary periods due to less availability of external funds.

An innovative approach is presented by authors [4] to prognosticate and to generate project cash flow based on both type-2 fuzzy extension of dependency structure matrix for project scheduling with overlapping activities and extended alternative queuing method under type-2 fuzzy environment to adopt the best scenario. Moreover, type-2 fuzzy numbers are applied to address the uncertainty of activities.

The property value assessment in the real estate market still remains as a challenges due to incomplete and insufficient information, as well as the lack of efficient algorithms. The scientists [5] proposes to fuse urban data, i.e., metadata and imagery data, with house attributes to unveil the market value of the property in Philadelphia. Specifically, two deep neural networks, i.e., metadata fusion network and image appraiser, are proposed to extract the representations, i.e., expected levels, from metadata and street-view images, respectively. A boosted regression tree (BRT) is adapted to estimate the market values of houses with the fused metadata and expected levels.

The authors [6] have investigated the implications of temporal shifts in accrual properties and operating environment for cash flow predictability. Three key insights emerge. First, cash flows consistently outperform earnings in predicting future cash flows. Second, accruals and its components, including those capturing non-articulating events, have incremental (albeit small) predictive ability over cash flows. Third, earnings' ability to predict future cash flows has increased over the period 1989-2015, due to changes in operating environment rather than accrual properties.

Several multi criterion decision making techniques are available to facilitate the decision maker arrive at a best alternative by ranking the alternatives in an order of preference. However, with the addition of new alternatives or deletion of existing alternatives, the ranks of the available alternatives, indicating their suitability to a particular set of requirements, is not maintained addition of new alternative/s or deletion of existing alternative/s creates a modified order of preference which may, sometimes, lead to erroneous decisions/results. The authors [7] have proposed method is thus capable of preventing the rank reversal phenomenon, arising out of change in available alternatives.

The authors [8] have considered the problem of pricing equity warrants in a firm with debt when the price of the underlying asset follows the Merton's jump-diffusion process. Using the martingale approach, based on the firm value, its volatility, and parameters of the jump component, the authors propose a valuation framework for pricing equity warrants with different maturity of the debt. The authors have provided estimation methods for obtaining these desired variables based on observed data, such as stock prices and the book value of liability.

The authors [9] have showed that the fair value model for investment property is more often chosen by firms with greater needs for accounting discretion. Post-adoption, they find that fair-value-adopting firms engage in earnings smoothing using unrealized gains and losses from investment properties. Utilizing a difference-in-difference research design, they also find that fair-value adopting firms increase their likelihood of meeting or beating earnings benchmarks (zero earnings and zero earnings change) from pre— to post-adoption compared to matched control firms. In summary, these results indicate that the new accounting standards on fair value reporting for investment property should cause concern when implemented in China, as Chinese firms appear to adopt fair values for discretionary purposes. They have found evidence that Chinese firms have motivations for their implementation of fair value that differ from firms in many developed economies. Contrary to the belief that the adoption of fair value for investment property would improve financial reporting quality, we show that allowing fair value reporting for investment property in China could in fact invite firms with histories of need for accounting discretion to adopt fair value reporting and consequently use the flexibility within the new standards to meet their earnings goals. The authors have offered interesting evidence on the debate over fair value accounting, as they have showed that fair value reporting for investment property is motivated by managerial opportunism in China.

STATEMENT OF BASIC MATERIALS

As you know, modern management concepts put forward maximization of the welfare of firm owners, which is expressed in maximizing the firm market value as the main purpose of the firm. This provision best realizes the financial interests of business owners. Factors of time, profitability and risk are reflected in this main purpose, which is a more complete reflection of the motivation of the firm activity than profit or other partial goals [10]. Therefore, the criterion of the firm value as an integral property complex can be the basis of economic and mathematical model of the price of its products.

From the standpoint of this criterion, the firm should set prices in such a way as to maximize the market value of its entire property complex. For modelling purposes, this value can be determined based on a profitable methodological approach. That is, the optimal price level can be called one that corresponds to the solution of the optimization problem, where the objective function is the value of the entire property complex of the firm, and the variables are the prices of its products. Given that according to income methodological approach, the value of the integral property complex of the firm is defined as the current value of future net cash flow generated by the business that will use this integral property complex [11, 12], this objective function in the general case has the form:

For a discrete function of cash flow:

$$V = \sum_{t=0}^{\infty} \frac{NCF(P)_t}{(1+R)^t} \xrightarrow[p]{} \max \quad (1),$$

for the case where the cash flow can be described by a continuous (partially continuous) intensity function:

$$V = \int_0^{\infty} f_{NCF}(t,P) \cdot e^{-R \cdot t} dt \xrightarrow[p]{} \max \quad (2),$$

where V — the value of the entire property complex of the firm (excluding assets that do not participate in the formation of cash flows taken into account in the model);

$NCF(P)_t$ — net cash flow for equity for the period from time t to time (t — 1), the value of which is determined depending on the price vector;

P — price vector for the products of the firm;

R — the rate of discount that corresponds to the value of the firm`s equity;

t — duration of the time period from the current moment (date of assessment), in general case according to the principle of the operating enterprise it is expedient to consider term of activity of the enterprise unlimited;

$f_{NCF}(t,P)$ — intensity function of net cash flow over time depending on product prices.

Net cash flow for equity in each interval is defined as the gross cash flow (from operating activities) less the cash flow from equity for investing activities. In turn, gross cash flow is defined as the sum of net income and depreciation. That is, net cash flow in each time interval is determined by:

$$NCF = RV - C - T_{IN} + A - K - \Delta WC + \Delta LD \quad (3),$$

where RV — operating income;

C — operating expenditures;

T_{IN} — income tax;

A — depreciation of non-current assets;

K — capital investments (investments in non-current assets);

ΔWC — increase in working capital (equity investments in current assets);

ΔLD — increase in long-term liabilities.

For modelling purposes, operating income should be taken into account only in part of income from sales of products (services). That is, you can determine by the formula:

$$RV = \sum_{i=1}^{n} Q_i \cdot P_i \quad (4),$$

where Q_i — volume of sales of products (services) of the i-th type;

P_i — price of products (services) of the i-th type;

n — number of types of products (services).

Accordingly, operating costs can be represented by the formula:

$$C = CC + \sum_{i=1}^{n} Q_i \cdot UVC_i \quad (5),$$

where CC — total amount of semi-fixed costs;

UVC_i — specific variable costs per unit of product (service) of the i-th type.

Income tax is determined by the formula:

$$T_{IN} = (RV - C) \cdot r_{InT} \quad (6),$$

where r_{InT} — income tax rate.

Thus, for the purposes of modelling it is necessary to present volumes of realization of products (services) through functions $(m(p))$ of demand depending on a price level:

$$Q_i = m_i(P_i) \quad (7).$$

It is also necessary to model the dependence of other components of cash flow on sales of products (services), and, accordingly, on the price level. For example, capital investments should reflect investments in simple reproduction of non-current assets and investments in the production expansion during volumes increase (a step-like dependence). Semi-fixed costs may change accordingly. Depreciation depends on the already formed value of fixed assets, the rate of their disposal and the size of investments. Increase in the working capital can be associated to change in operating costs. Other relationships of model parameters can also be taken into account (for example, investment costs affect the quality of products (services), which in turn affects demand, which can be reflected by the parameters of the corresponding function). For modelling purposes, in our opinion, it is appropriate to assume that the source of investment financing is equity, but it may also be taken into account the typical for the firm or industry capital structure (due to the change indicator in long-term liabilities). We used the concept of basic (fixed) prices, which must be set.

Thus, model (1) can be represented as:

$$V=\sum_{t=0}^{\infty}\left[\frac{\left(\sum_{i=1}^{n}m_{i.t}(P_{i.t})\cdot P_{i.t}-\left(CC_t+\sum_{i=1}^{n}m_{i.t}(P_{i.t})\cdot UVC_{i.t}\right)\right)\cdot(1-r_{InT})+A_t}{(1+R)^t}-\frac{K_t+\Delta WC_t-\Delta LD_t}{(1+R)^t}\right]\xrightarrow[p]{}\max \quad (8).$$

Let us consider model (8) in certain special cases.

The simplest case is a situation characterized by such signs:

— production is single-product;

— dependence function of demand on price does not change over time and is decreasing linearly;

— entire volume of demand for products can be met by the available production capacity, investment in expanded reproduction is not required, only non-current assets investment in simple reproduction is needed.

Under such conditions, model (8) can be represented as a perpetuity. In this case, the average annual investment in the simple reproduction of non-current assets in the long run can be accepted at the level of depreciation.

The demand function for these conditions is set by the formula:

$$Q_i=m_i(P_i)=a-b\cdot P \quad (9),$$

where a,b — model parameters $(a,b>0)$.

Thus, in the simplest case, model (8) corresponds to the optimization problem:

$$V=\frac{((a-b\cdot P)\cdot P-(CC+(a-b\cdot P)\cdot UVC))\cdot(1-r_{InT})}{R}\xrightarrow[p]{}\max \quad (10).$$

After algebraic transformations, problem (10) takes the form:

$$V=\left(-b\cdot P^2+(a+b\cdot UVC)\cdot P-CC-a\cdot UVC\right)\cdot\frac{(1-r_{InT})}{R}\xrightarrow[p]{}\max \quad (11).$$

To find the extremum of a function (V), its derivative is recognized and equated to zero:

$$\frac{dV}{dP}=(-2b\cdot P+(a+b\cdot UVC))\cdot\frac{(1-r_{InT})}{R}=0 \quad (12).$$

Solving equation (12) makes it possible to establish the point of extremum:

$$P=\frac{a+b\cdot UVC}{2b} \quad (13).$$

In this case, given the type of function (11), a parabola with a maximum at the turning point, it is obvious that at the point that is being determined by formula (13), the cost function acquires a maximum. Thus, formula (13) is a model of the optimal price for the above conditions.

Let us consider a case characterized by similar conditions, but in which the invariant is the coefficient of price elasticity of demand. As you know, given the declining nature of the dependence of demand on price, the point coefficient of demand elasticity is expressed by the dependence:

$$E=-\frac{dQ}{dP}\cdot\frac{P}{Q} \quad (14),$$

where E — coefficient of price elasticity of demand $(E>0)$.

Having solved the differential equation (14), we obtain the following function that describes the dependence of demand on price:

$$Q_i=m_i(P_i)=D\cdot P^{-E} \quad (15),$$

where D, E — model parameters.

In this case, model (8) corresponds to the optimization problem:

$$V=\frac{\left(D\cdot P^{-E}\cdot P-\left(CC+D\cdot P^{-E}\cdot UVC\right)\right)\cdot(1-r_{InT})}{R}\xrightarrow[p]{}\max \quad (16).$$

After algebraic transformations, problem (16) takes the form:

$$V=\frac{\left(D\cdot P^{1-E}-CC-D\cdot P^{-E}\cdot UVC\right)\cdot(1-r_{InT})}{R}\xrightarrow[p]{}\max \quad (17).$$

To find the extremum of (V) function, its derivative is recognized and equated to zero:

$$\frac{dV}{dP}=\left((1-E)\cdot D\cdot P^{-E}+E\cdot D\cdot UVC\cdot P^{-E-1}\right)\cdot\frac{(1-r_{InT})}{R}=0 \quad (18).$$

Solving equation (18) makes it possible to establish the point of extremum:

$$P=\frac{E\cdot UVC}{E-1} \quad (19).$$

It is obvious that model (19) can be used only under the condition that the demand elasticity coefficient is greater than 1 $(E>1)$, i.e. in the conditions of elastic demand.

The demand elasticity coefficient is usually characterized by a direct relationship with the price (increases with increasing price). If this dependence can be described by a linear function, the dependence (14) takes the form:

$$E_0 + k \cdot P = -\frac{dQ}{dP} \cdot \frac{P}{Q} \quad (20),$$

where E_0, k — parameters of the dependence model of demand elasticity coefficient on price $k>0$.

Having solved the differential equation (20), we obtain a function that describes the dependence of demand on price:

$$Q_i = m_i(P_i) = D \cdot P^{-E_0} \cdot e^{-k \cdot P} \quad (21).$$

In this case, model (8) corresponds to the optimization problem:

$$V = \frac{\left(D \cdot P^{-E_0} \cdot e^{-k \cdot P} \cdot P - \left(CC + D \cdot P^{-E_0} \cdot e^{-k \cdot P} \cdot UVC\right)\right) \cdot \left(1 - r_{InT}\right)}{R} \xrightarrow[p]{} \max \quad (22).$$

After algebraic transformations, problem (22) takes the form:

$$V = \frac{\left(D \cdot P^{1-E_0} \cdot e^{-k \cdot P} - CC - D \cdot P^{-E_0} \cdot e^{-k \cdot P} \cdot UVC\right) \cdot \left(1 - r_{InT}\right)}{R} \xrightarrow[p]{} \max \quad (23).$$

To find the extremum of (V) function, its derivative is recognized and equated to zero:

$$\frac{dV}{dP} = \begin{pmatrix} (1-E) \cdot D \cdot P^{-E_0} \cdot e^{-k \cdot P} - k \cdot D \cdot P^{1-E_0} \cdot e^{-k \cdot P} + \\ + E_0 \cdot D \cdot UVC \cdot P^{-E-1} \cdot e^{-k \cdot P} + k \cdot D \cdot UVC \cdot P^{-E_0} \cdot e^{-k \cdot P} \end{pmatrix} \cdot \frac{\left(1 - r_{InT}\right)}{R} = 0 \quad (24).$$

Solving equation (24) with the choice of the positive root makes it possible to determine the optimal price:

$$P = \frac{1 - E_0 + k \cdot UVC + \sqrt{\left(1 - E_0 + k \cdot UVC\right)^2 + 4 \cdot k \cdot E_0 \cdot UVC}}{2 \cdot k} \quad (25).$$

The previously considered individual cases of price optimization were based on the assumption that at the moment there is no need for investment. However, if the current volume of sales does not coincide with the optimal, during transition to the optimal level we can at least expect the need to change working capital. The optimization problem with this in mind (for other conditions that correspond to those discussed above) has the form:

$$V = \left[\begin{matrix} \dfrac{\left(m(P) \cdot P - \left(CC + m(P) \cdot UVC\right)\right) \cdot \left(1 - r_{InT}\right)}{R} - \\ - \dfrac{m(P) \cdot UVC - Q_0 \cdot UVC}{K_{WC}} \end{matrix} \right] \xrightarrow[p]{} \max \quad (26),$$

where Q_0 — the basic volume of sales, which corresponds to demand at the current price level;

K_{WC} — working capital turnover ratio (to costs);

If the demand function is described by model (21), the optimization problem (26) takes the form:

$$V = \left[\begin{matrix} \dfrac{\left(D \cdot P^{-E_0} \cdot e^{-k \cdot P} \cdot P - \left(CC + D \cdot P^{-E_0} \cdot e^{-k \cdot P} \cdot UVC\right)\right) \cdot \left(1 - r_{InT}\right)}{R} - \\ - \dfrac{D \cdot P^{-E_0} \cdot e^{-k \cdot P} \cdot UVC - Q_0 \cdot UVC}{K_{WC}} \end{matrix} \right] \xrightarrow[p]{} \max \quad (27).$$

To find the optimal price, the equation $(V' = 0)$ is solved.

$$\frac{dV}{dP} = \left[\begin{matrix} \dfrac{\left(1 - r_{InT}\right)}{R} \begin{pmatrix} \left(1 - E_0\right) \cdot D \cdot P^{-E_0} \cdot e^{-k \cdot P} - k \cdot D \cdot P \cdot P^{-E_0} \cdot e^{-k \cdot P} + \\ + D \cdot E_0 \cdot UVC \cdot \dfrac{P^{-E_0}}{P} \cdot e^{-k \cdot P} + k \cdot D \cdot UVC \cdot P^{-E_0} \cdot e^{-k \cdot P} \end{pmatrix} + \\ + \dfrac{E_0 \cdot D \cdot UVC}{P \cdot K_{WC}} \cdot P^{-E_0} \cdot e^{-k \cdot P} + \dfrac{k \cdot D \cdot UVC}{K_{WC}} \cdot P^{-E_0} \cdot e^{-k \cdot P} \end{matrix} \right] = 0 \quad (28).$$

After algebraic transformations from equation (28), we obtain a quadratic equation:

$$\left[\begin{matrix} k \cdot K_{WC} \cdot \left(1 - r_{InT}\right) \cdot P^2 - \\ - \left(\left(1 - E_0 + k \cdot UVC\right) \cdot K_{WC}\left(1 - r_{InT}\right) + K \cdot R \cdot UVC\right) \cdot P - \\ - E_0 \cdot UVC \cdot \left(\left(1 - r_{InT}\right) \cdot K_{WC} + R\right) \end{matrix} \right] = 0 \quad (29).$$

The root of equation (29), which satisfies the price constraint, is determined by the formula:

$$P = \frac{\left[\begin{matrix} \left(\left(1 - E_0 + k \cdot UVC\right) \cdot K_{WC}\left(1 - r_{InT}\right) + K \cdot R \cdot UVC\right) + \\ + \sqrt{\left[\begin{matrix} \left(\left(1 - E_0 + k \cdot UVC\right) \cdot K_{WC}\left(1 - r_{InT}\right) + K \cdot R \cdot UVC\right)^2 + \\ + 4 \cdot k \cdot K_{WC} \cdot \left(1 - r_{InT}\right) \cdot P^2 \cdot E_0 \cdot UVC \cdot \left(\left(1 - r_{InT}\right) \cdot K_{WC} + R\right) \end{matrix} \right]} \end{matrix} \right]}{2 \cdot k \cdot K_{WC} \cdot \left(1 - r_{InT}\right) \cdot P^2} \quad (30).$$

Thus, the use of price models that can be built based on the optimization problem (8), will take into account both the cost component, demand and other factors, including the investment component.

CONCLUSIONS

The paper proposes a scientific and methodological approach to economic and mathematical modelling of the price of products (works, services) of the firm based on the criterion of maximizing the firm value. A number of economic and mathematical price models have been developed for various conditions, which take into account the nature of the relationship between demand and price (including price elasticity of demand), the structure of operating costs (primarily semi-fixed and variable parts), the need for investment, cost of capital, risk level and other factors.

The application of the developed methodological approach and economic-mathematical models in the practice of pricing will increase the market value of the enterprise.

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Стаття надійшла до редакції 12.02.2022 р.