“A price-determining model for industrial “technology-push” innovations”

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A PRICE-DETERMINING MODEL FOR INDUSTRIAL "TECHNOLOGY-PUSH" INNOVATIONS

Abstract

The complexity of industrial markets in the Fourth Industrial Revolution necessitates new pricing approaches for R&D outcomes. "Technology-push" innovations often feature advanced technical parameters that are misaligned with customers' willingness to pay, creating a commercialization gap that requires models that integrate cost, competition, and perceived value. The aim of this study is to develop a price-determining model for industrial "technology-push" innovations. The authors' price-determining model for industrial "technology-push" innovations combines cost-plus pricing and competitive pricing with the Price Sensitivity Measurement (PSM) analysis. Empirical data from 2022 to 2025 in optical interferometry were used to validate the approach. In the case of "technology-push" innovations, a gap may exist between the perceived value of technical parameters and the price that industrial customers are willing to pay. The trade-off between technical parameters and price refers to the balance or compromise that customers and industrial marketers must consider when making a purchase. Setting the right price on industrial "technology-push" products requires a comprehensive analysis of customer preferences, competitive landscape, and cost structures. Customers' perception of value directly influences their willingness to pay for a product or service. Even if a product is technically superior or offers advanced features, its perceived value by customers ultimately determines the optimal price point. Aligning pricing with customer perceptions of value helps maximize revenue and profitability for both transaction participants. The authors' method enables the determination of the boundaries of the market price range for an innovation with sufficient accuracy. Combining traditional pricing methods with price sensitivity analysis of industrial customers can offer several advantages, leveraging the strengths of each approach to improve the price-determining process for industrial "technology-push" innovations.

Keywords R&D result, cost estimation, price sensitivity, customers' perception PSM-method, XYZ-analysis

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INTRODUCTION

With the rapid development of innovative technologies worldwide, amid globalization challenges and increased competition across many sectors of the economy, has demonstrated the need to reform views and approaches to managing countries' scientific and technological progress. Among the fundamental aspects, scientists and practitioners pay special attention to the transfer and commercialization processes of innovations and new technologies resulting from research and development activities, which reshape technological systems and affect the socio-economic development of regions. This area shows evidence of both technology-push and market-pull forces, which generate "technology-push" and "market-pull" innovations (Lubik et al., 2013).

A "technology-push" innovation, or "laboratory-push" innovation, refers to developing new products or solutions based on technological advances or scientific discoveries from research laboratories or academic institutions. A "technology push" describes a situation where an emerging technology or a new combination of existing technolo-

gies provides the driving force for an innovative product and problem solution in the marketplace. In some instances, it is even possible that the new technology, transforming into radical product or process innovations, achieves its market position. This new technology or technology combination could be in a research and development unit, an application-oriented development unit, a combination of both, or cooperation extending beyond the confines of a single company's R&D unit (Herstatt & Lettl, 2000).

In this approach, innovation is driven by internal research and development efforts, often without direct input from market demand. As usual, a "technology-push" innovation offers several advantages, including the ability to explore new frontiers of technology, drive scientific progress, and create breakthrough products or solutions that have the potential to disrupt industries. However, it also poses challenges, such as the risk of developing solutions that lack market demand or struggle to gain traction in competitive markets.

Developing laboratory-push innovations can be costly, involving significant investments in R&D activities and prototyping. Determining an appropriate pricing strategy to recoup these costs while ensuring competitiveness in the market can be challenging. That is why communicating the value proposition of innovative industrial products resulting from R&D to potential customers can be difficult, especially if the technology is complex or unfamiliar. Customers may struggle to understand the benefits or advantages of the innovation, making it challenging to justify the pricing.

As a result of R&D, innovative industrial products differ fundamentally from traditional industrial products, mainly in terms of cost structures and customers' willingness to pay. This requires rethinking the price-determining process, since conventional economic theories are no longer adequate. Rapid technological advancements and changes in market trends can pose a risk of obsolescence for laboratory-push innovations. Pricing the innovation too high may deter customers from adopting it, especially if there is a perception that newer, more advanced solutions may become available shortly.

Thus, the scientific problem addressed in this study is the lack of pricing models for industrial "technology-push" innovations that account for both technical parameters and customer willingness to pay.

1. THEORETICAL BACKGROUND

1.1. Traditional pricing approaches and their limitations

Pricing industrial "technology-push" innovations is a multifaceted problem that can be analyzed from the perspectives of economics, management, and marketing. The development of a price-determining model for such innovations is particularly important because traditional pricing approaches often fail to capture the balance between technological value and customers' willingness to pay. To better understand this issue, it is essential to review existing concepts and pricing methods that have been applied in the context of innovative products.

Here are several traditional approaches for pricing new products: cost-plus, value-based, and competitive pricing. The most popular approach is cost-plus pricing, which involves calculating the total cost of production, including materials, labor, and overhead, and then adding a markup to determine the selling price. While straightforward, this approach may not capture the total value of an innovative industrial product and could potentially undervalue it (Halkiv et al., 2020). Calculating the production costs associated with developing and manufacturing an innovative industrial product is crucial. However, cost-plus pricing may not fully capture the value of innovative products (Chukhray & Mrykhina, 2020).

In the value-based pricing approach, the main task is to determine the value proposition of your innovative product. How does it solve a problem

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or meet a need for customers? Pricing should reflect the perceived value that customers attribute to your product (Chevrollier et al., 2023). The value-based Pricing Approach focuses on the perceived value of the innovative product to the customer rather than its production costs. This approach considers the benefits and advantages offered by the innovative product in comparison to alternatives on the market. With the Competitive Pricing Approach, the price of the innovative product is set based on the prices charged by competitors offering similar products or solutions (Gupta et al., 2021; Ali & Anwar, 2021). This approach requires thorough market analysis to understand competitors' pricing strategies and positioning. While competitive pricing can help ensure competitiveness, it may only partially capture the value of the innovative features of the industrial product.

In certain industries, dynamic pricing strategies that leverage real-time market data, demand fluctuations, or customer segmentation can optimize revenue and profitability (Cohen et al., 2020; Bastani et al., 2021). However, this method is not helpful in the industrial marketplace, where the price indicators obtained through its application are adjusted based on agreements between the parties. Nevertheless, this concept is a priori based on probabilistic and predictable data.

The income pricing approach requires data from future periods, which is increasingly complex to predict in the current environment. Most of the indicators used by appraisers within the income pricing approach may change significantly during the development of the innovation market.

It is essential to balance capturing value, staying competitive, and maximizing profitability to ensure the success of innovative industrial products in the marketplace. Setting the right price on industrial "technology-push" products requires a comprehensive analysis of market dynamics, customer preferences, competitive landscape, cost structures, and strategic objectives. Customers' perception of value directly influences their willingness to pay for a product or service. Even if a product is technically superior or offers advanced features, its perceived value by customers ultimately determines the optimal price point. Aligning pricing with customer perceptions of value helps maximize revenue and profitability.

1.2. Research gaps and the rationale for a new model

Therefore, to clarify the industrial price-determining process for such innovative products, it is necessary to consider additional crucial factors. In our opinion, one of these factors is the customer's price sensitivity to the technical parameters of this product.

Pricing industrial "technology-push" innovations is a multifaceted problem that scientists and researchers from various disciplines can analyze. The authors' scientific search and analysis of the literature showed that specialists needed to pay more attention to this problem. In world economic science, the issue of pricing innovations is primarily considered from the perspective of the practical implementation of the product (Yemelyanov et al., 2021; Prokhorova et al., 2024; Lim et al., 2021), overlooking the methodological aspects of the price-determining process.

Some scientific studies highlight the importance of considering consumer sensitivity to product prices within competitive industries or types of economic activity (Park et al., 2021; Stangl et al., 2020; Abela, 2020; Zhu et al., 2022; Yurdadön et al., 2022). Several scientific papers are devoted to the study of the phenomenon of price sensitivity in the context of consumer behavioral motives (Zinoubi, 2020; Wang et al., 2020; Yitian et al., 2022; Falahatimarvast et al., 2022; Rathore & Ilavarasan, 2020), and the global economy (Hardy, 2022; Bespalyuk et al., 2018).

An innovative approach to studying consumer sensitivity to product prices based on the time factor (Aretz et al., 2022), as part of a new product launch strategy (Fakhreddin et al., 2022). In general, methodological aspects in the field of the market launch of new products and the development of strategy for their market development have been published in the works of scientists (Cheng-Han & Jing-Yi, 2019; Ye Hua & Quan Yuan, 2022), in particular in the context of big data analytics (Hajli et

al., 2020; Jagtap & Duong, 2019; Zhan et al., 2018). The scientists showed drivers of the success of new products that indirectly consider consumer sensitivity to the product's price (Cooper, 2019). As scientists have revealed in certain articles, it is essential to examine the issue of pricing innovative products, considering the impact of customer sensitivity within the dynamic pricing framework (Xiao Yongbo et al., 2020).

Dynamic pricing is currently underrepresented in contemporary science and practice as one of the optimal approaches for evaluating industrial "technology-push" innovations. Mainly, scientific literature contains fragmented studies on this topic. For instance, Du et al. (2016) examine this issue within the context of competitive situations that an innovative product faces during market launch due to market imitators.

Dynamic pricing has been explored by researchers as a strategic element in company development (Sun et al., 2022; Chen et al., 2020; Zhao et al., 2021; Soytaş et al., 2022, and others). In the work by Sun et al. (2022), a two-stage dynamic pricing strategy model is presented where the seller interacts with strategic consumers under a reference price effect. Consumers evaluate the product's utility over two consecutive periods, based on the expected future retail price in the second period and the current retail price in the first, which influences their purchase timing decisions. Thus, the authors of this model simulate the product's market behavior strategy. However, these studies do not consider the dependency of consumer perception and willingness to purchase the product based on its technical and technological characteristics.

In several studies (Kool et al., 2022; Bae et al., 2024; Friesen et al., 2024; Ghosh et al., 2020), specific cases illustrate the nuances of dynamic pricing application. This work merits attention for its use of individual pricing methodological elements. Yet, their industry-specific focus limits the universal applicability of these investigations.

The issue we have identified is also worth examining from the perspective of studying and forecasting the behavior of industrial "technology-push" innovations, which form a significant basis for pricing such products. In this area, researchers propose various approaches. For instance, Chung et al. (2024) investigate how governments should combine two different subsidies – one for technology promotion and the other for stimulating demand. The authors' approach outlined in the article could be one element of a broader pricing concept for industrial "technology-push" innovations. Nonetheless, the specific issue of resolving situations related to pricing these products remains open.

A study by Ho et al. (2024) presents an interesting analysis of the dynamics of technology emergence in innovation networks. The researchers argue that studies representing innovative events solely on a linear calendar time scale cannot capture the causal relationships, the importance, and the convergence of innovative intermediaries.

Thus, integrating insights from these studies could potentially contribute to a more comprehensive understanding and approach to pricing strategies for industrial "technology-push" innovations, taking into account both governmental policies and the dynamics within innovation networks.

A study of the existing developments among scientists and practitioners in the field of industrial "technology-push" innovations suggests that there are currently no methodological approaches that provide a sound basis for pricing such products in relation to customer sensitivity to their technical parameters. Despite numerous models and methods aimed at justifying prices for innovative goods, specific methodological foundations for industrial "technology-push" innovations remain underdeveloped. These innovations are characterized by complex dynamics, including high initial investment costs, uncertain market acceptance, and evolving competitive environments, which make their pricing particularly challenging.

Thus, while many methods have been proposed for pricing innovative goods in general, there are still no sufficient methodological foundations for industrial "technology-push" innovations. The central challenge is to create a price-determining model that incorporates both the technological parameters of R&D results and customers' price sensitivity. Addressing this gap defines the scientific contribution of the present study and sets the stage for the following methodological framework.

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1.3. Methodological approach: development of a model using PSM

Accordingly, the aim of this study is to develop a price-determining model for industrial "technology-push" innovations based on consumer price sensitivity. Such a model is expected to support inventors and industrial marketers in better understanding pricing mechanisms within the industrial innovation ecosystem and in setting appropriate price levels for industrial "technology-push" innovations.

To achieve this objective, the following working hypothesis is proposed: in order to clarify industrial customers' requirements and expectations, Price Sensitivity Measurement (PSM) analysis can be applied. This method will enable industrial marketers to determine the boundaries of the market price range with sufficient accuracy and to generate alternative pricing options for industrial "technology-push" innovations.

Proving hypotheses involves several tasks, in particular:

- to create the price-determining model for industrial "technology-push" innovations, taking into account the price sensitivity of the consumer to their technical parameters;
- to develop an algorithm for implementing the PSM analysis into the price-determining model for industrial "technology-push" innovations, we validated this model by using the example of the industrial "technology-push" innovation – the technology for interferometric determination of the refractive index of crystalline materials in the optical range.

The essential tool we will use in our study to develop a price-determining model, considering the price sensitivity of industrial consumers to technical parameters, is the consumer-oriented method known as Price Sensitivity Measurement (referred to as PSM analysis).

Previous experience with PSM analysis has proven its effectiveness and yielded promising results in the price-determining process in the B2C market (Chukhray & Bespalyuk, 2012). The authors provided research based on PSM analysis in pricing a new dosimeter by the Lviv Scientific and Production Private Enterprise "Sparring-West Centre" in 2012. In this case, PSM analysis resulted in pricing decisions that maximize profitability by balancing price with demand elasticity and cost considerations in the market for individual dosimeters. In the case of pricing on an innovative Ukrainian Master's degree Program in 2022, the PSM analysis helped the authors gain a competitive advantage by identifying pricing strategies that differentiated the MBA program from competitors and attracted students based on perceived value rather than price alone (Halkiv et al., 2022).

The idea behind the PSM method is that a price for a product should be set at a level at which the majority of consumers (experts) will consider it neither too high nor too low. After all, if the price is too low from the point of view of the consumer (expert), they may doubt the quality of the product (inconsistency of product parameters) and, as a result, refuse to buy it.

The PSM method allows us to determine the boundaries of the market price range with sufficient accuracy and offer different options for innovations. Setting the optimal price helps to ensure stable market positions and high profitability. The level of the product's price increases or decreases depending on the manufacturer's strategy, market specifics, competitive environment, and, of course, the functional and cost properties of the product itself. The authors combined PSM analysis with other research methods and sources of information to obtain a comprehensive understanding of consumer preferences, evaluate product features, and inform strategic decisions in marketing, product development, and pricing.

2. RESULTS

In this part, the results are outlined step by step in accordance with the research subsections. This structure highlights the internal logic of the study and demonstrates how each stage contributed to addressing the overall research objective.

2.1. The algorithm of the price-determining model for industrial "technology-push" innovations based on the consumer price sensitivity

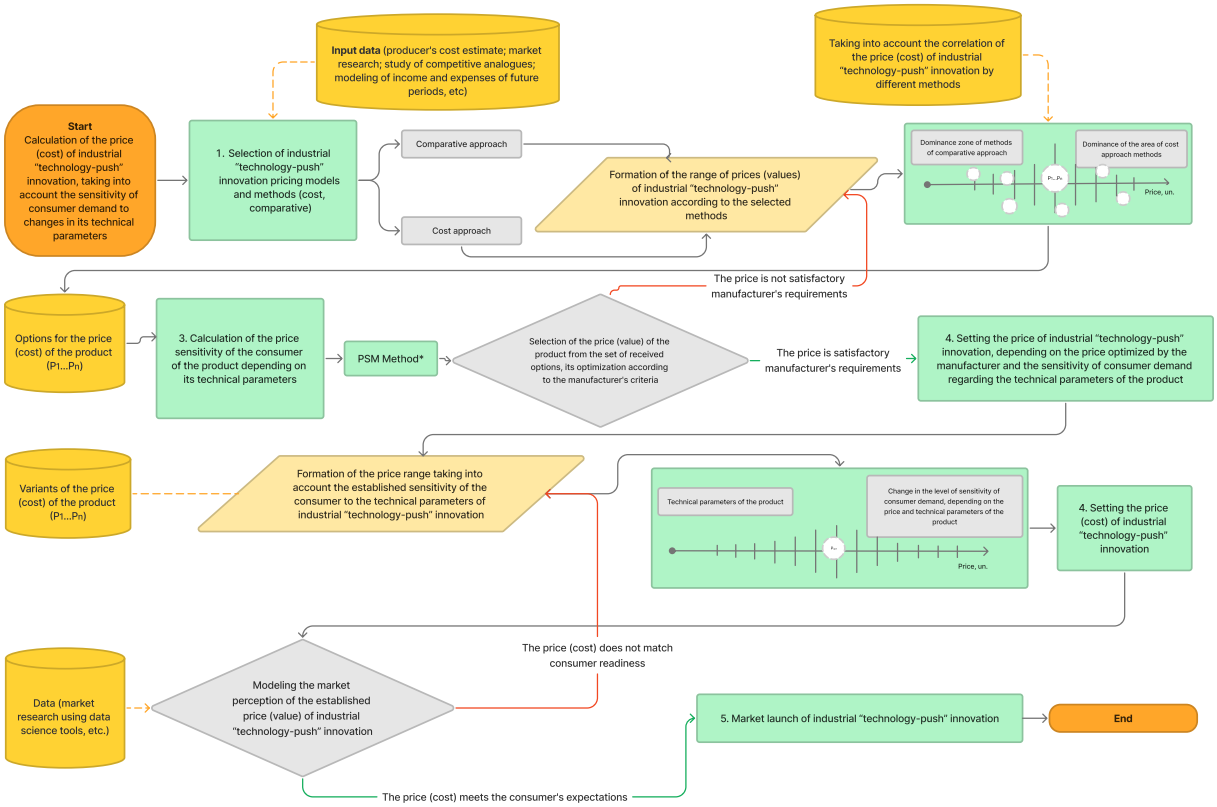
The authors developed a price-determining model for industrial "technology-push" innovations based on consumer price sensitivity. This model comprises two key components: a price-determining process and setting the optimal price for industrial "technology-push" innovations, based on consumer price sensitivity. Figure 1 illustrates the price-determining process and the setting of prices for industrial "technology-push" innovations, based on consumer price sensitivity.

The study has shown that the price-determining model should be developed based on a combination of cost-plus and competitive approaches. These approaches will ensure the comprehensiveness of the assessment: on the one hand, the cost-plus pricing approach allows setting a lower price limit below which the price of an industrial innovation cannot be set, and on the other hand, the competitive pricing approach helps to put a price that will justify the place of this innovative product in the industrial marketplace.

The research on pricing approaches (Chukhray et al., 2022) has shown that the income pricing approach is not effective for innovations at the earliest levels of technology readiness (TRL 4-6). Innovative industrial products that originate from laboratory research carry a high level of risk and uncertainty.

In this research, the authors considered "technology-push" innovations from the perspective of further determining consumer price sensitivity, which led to several challenges: 1) a high level of innovativeness can introduce uncertainty into pricing models; 2) adoption barriers; 3) a high level of risk associated with innovative industrial products stemming from laboratory research.

All these challenges can make the price-determining process more challenging due to the uncer-



Note: *The sequence of applying the PSM method is detailed later in this article.

Figure 1. The price-determining model for industrial "technology-push" innovations based on consumer price sensitivity

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tainty, complexity, and lack of historical data associated with innovative products. Therefore, setting the right price for an industrial "technology-push" innovation based on a combination of traditional cost-plus and competitive pricing approaches is insufficient. "Technology-push" innovations often bring unique value propositions to the market that may not be adequately captured by cost-plus or competitive pricing approaches. Understanding the value the innovation delivers to customers and pricing accordingly can lead to better alignment between price and perceived value. The price-determining process needs to be adaptable to industrial customer preferences, which traditional pricing approaches may not adequately address. This considers the level of price sensitivity of the consumer to the critical technical parameters of the innovation, which may significantly impact its subsequent market launch, commercialization, and diffusion.

2.2. PSM analysis in the price-determining model for industrial "technology-push" innovations

While cost-plus and competitive pricing approaches provide valuable insights into pricing decisions, setting the right price for "technology-push" innovations requires a more comprehensive and adaptable approach that considers customer perceptions and market acceptance. For this purpose, we decided to use PSM analysis, which was described in Section 3.

PSM analysis is chosen for pricing on industrial innovations because it provides valuable insights into customer perceptions, quantitative analysis, and competitive positioning, ultimately helping companies to set prices that maximize profitability and market acceptance.

An algorithm for implementing the PSM analysis into the price-determining model for industrial "technology-push" innovations is given further (see Figure 2).

PSM analysis offers quantitative insights into price sensitivity, enabling data-driven pricing decisions. This helps avoid the subjectivity and biases that may arise with qualitative approaches to pricing. PSM analysis also helped in understanding how industrial customers perceive the value of the innovation and how sensitive they are to price changes. This understanding is crucial for setting the right price that maximizes profitability while ensuring the acceptance of industrial customers.

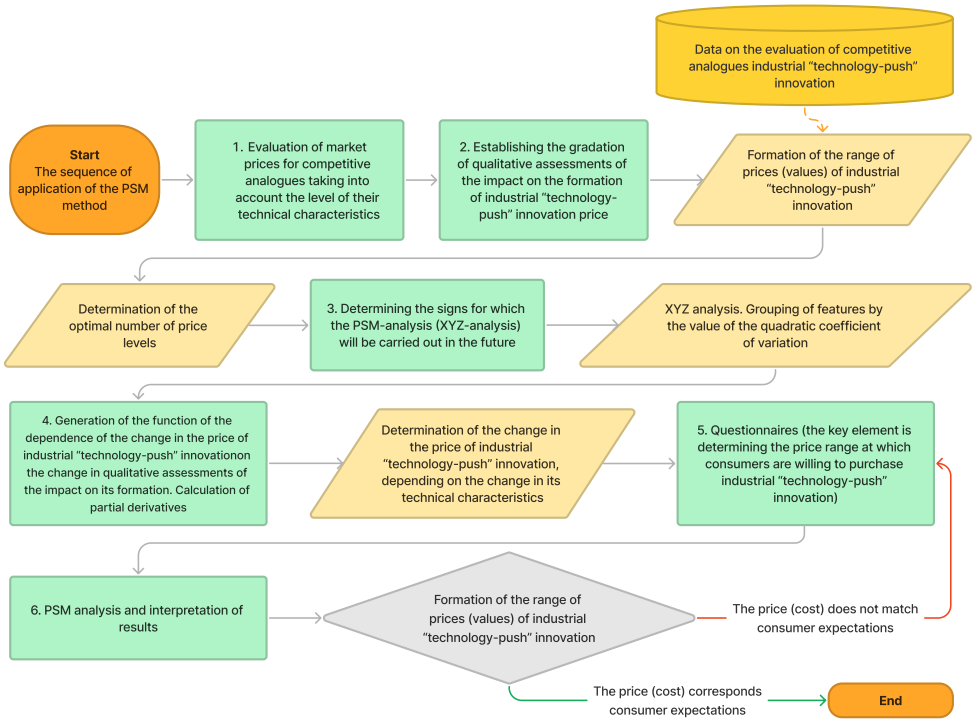

Figure 2. An algorithm for implementing the PSM analysis into the price-determining model for industrial "technology-push" innovations

2.3. Validation of the price-determining model for industrial "technology-push" innovations based on the consumer price sensitivity

The research's last task was to adjust the authors' price-determining model. We have effectively validated this pricing model, ensuring it is robust, accurate, and capable of achieving the desired objective in industrial market conditions, as demonstrated by the technology for interferometric determination of the refractive index of crystalline materials in the optical range.

The research began with a PSM analysis. A sample of respondents was selected from experts who could potentially decide to purchase a device for interferometric determination of the refractive index of crystalline materials in the optical range to conduct the survey. These are enterprises and research institutions whose business is interferometry. An example of a questionnaire developed to determine the price sensitivity of experts is shown in Figure 3.

It is proposed to use a questionnaire with four questions for the survey, where industrial respondents need to choose from the proposed price range: too cheap offer (as a result, refusal to purchase due to doubts about the quality and parameters of the industrial innovation); inexpensive offer (successful purchase); not cheap offer (expensive, but if possible, the decision to purchase the innovation will be positive); costly offer (refusal to buy).

Table 1 presents the evaluation results and market prices for competitive analogues of the device used for interferometric determination of the refractive index of crystalline materials in the optical range. The minimum price on the market is available from NanoFocus AG (x_{min}) and amounts to USD 3.56 thousand. The price of the device is USD 3,560.

As we can see, the device of this company is significantly inferior in technical parameters to the author's device (developed at Lviv Polytechnic National University), especially in the third, fourth, and seventh features, which are record high in the author's device compared to the competitors and, according to the data in Table 2, have a substantial impact on the formation of the price of the R&D result. The company Carl Zeiss set the market's maximum price (xmax) at USD 21,000.

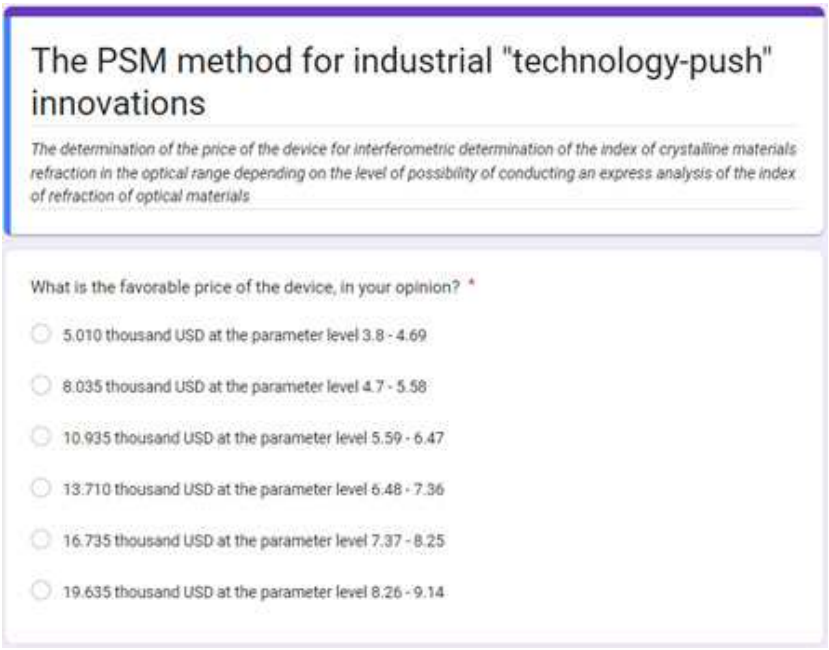

Figure 3. Questionnaire for determining the level of price sensitivity of experts regarding the device for interferometric determination of the refractive index of crystalline materials in the optical range

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Table 1. Results of estimation of technical and economic parameters of competitive analogues of the device for interferometric determination of the refractive index of crystalline materials in optical (European enterprises)

Parameters	Enterprises								Author's device
	Renishaw Plc.	NanoFocus AG	OptoTech Optikmaschinen GmbH	Optodyne	Carl-Zeiss	Status Pro	Olympus	Tosei Engineering Corp.	
1. Software that allows you to receive results in digital form and visualize data	8.2	7.4	7.1	7.1	8.9	7.3	6.7	5.9	8.3
2. Compactness and precision of the device manufacturing elements	7.9	8.2	7.9	7.9	9.3	7.4	9.1	6.8	8.9
3. Possibilities to measure plane-parallel and non-plane-parallel (wedge-shaped) samples	8.9	7.2	6.9	7.0	8.9	8.3	6.0	5.9	9.1
4. Highly accurate refractive index measurements at a given wavelength in the visible range; refractive index measurement accuracy (up to five decimal places)	6.1	6.8	6.5	6.3	9.1	8.9	7.1	6.3	9.1
5. Measurement of refractive indices of isotropic and anisotropic materials	4.3	4.8	3.3	4.2	5.9	5.0	3.2	3.4	6.5
6. Taking into account the refractive index of the environment in which the prototype is located	6.3	4.9	5.1	5.9	8.3	7.2	5.4	5.3	8.2
7. Possibility of rapid analysis of refractive indices of optical materials	5.3	5.8	4.9	3.8	8.1	8.2	70	6,.1	9.1
Price, thousand USD	10.42	3.56	9.18	12.45	21.0	15.24	5.43	13.58	20.04

Table 2. Grading of qualitative assessments of the impact of an innovative industrial product on price setting

Grading of impact assessments	Characteristic meaning (range 1...9.9), points
The weakest impact	1.0–1.9
Weak impact	2.0–3.9
Average impact	4.0–5.9
Significant impact	6.0–7.9
Strong impact	8.0–9.9

Let's discuss the features related to the accuracy and specificity of measurement. Only the fourth feature is comparable to the author's device, while the other two are inferior. However, a deeper analysis reveals that the characteristic consumer characteristics (the first and second features) are inherent in the most expensive device on the market and are slightly superior to the original. At the same time, the price difference between them is only 5%.

Roughly, the optimal number of price levels is determined using standard procedures, including the Sturgis formula:

$$m = 1 + 3.30259 \lg n = 1 + 3.30259 \lg 36 = 6.1398, \quad (1)$$

where n is the population size (thirty-six enterprises competing in the European market, including the author's development of Lviv Polytechnic National University; m is the number of intervals. Thus, six intervals were taken for further calculations.

The step (value) of the interval will be:

$$h = \frac{x_{max} - x_{min}}{m} = \frac{21 - 3.56}{6} = 2.9 \ thousand \ USD. \quad (2)$$

To determine which attributes should be used for PSM analysis, we will first conduct an XYZ analysis (Table 3), which measures the degree of variation of an attribute from its mean value by calculating the coefficient of variation.

The quadratic coefficient of variation (3) and standard deviation (4) is calculated by the expressions:

$$V_{kv} = \frac{\sigma}{x} \cdot 100\%, \quad (3)$$

$$\sigma = \sqrt{\frac{\sum\left(x_i - \bar{x}\right)^2}{n}}, \quad (4)$$

where n is the number of companies competing in the European market (n = 9); x_i is the value of the attribute for different manufacturers; $\bar{x}$ is the average value of the attribute.

The next step is to group the features by the value of the squared coefficient of variation. This stage is poorly formalized. In the scientific literature, there is a relatively significant difference of opinion regarding the recommended numerical values of the boundaries for groups X, Y, Z. Thus, Bek (2003) proposes the following division of groups according to the degree of homogeneity of the population under study: group X – coefficient of variation less than 10% (insignificant variation); group Y – coefficient of variation from 10% to 30% (average variation); group Z – coefficient of variation over 30% (significant variation).

However, the researchers often define groups as follows:

- group X includes goods (services, technologies, etc.) with a coefficient of variation of less than 10%;
- group Y includes goods with a coefficient of variation from 10% to 25%;
- group Z includes goods with a coefficient of variation of more than 25%.
- The interpretation of the division into groups according to the XYZ analysis in this paper is as follows:
- group X – shows stable estimates of features and high accuracy in forecasting their impact on price formation;
- group Y – shows variable estimates of the features and average accuracy of forecasting their impact on price formation;
- group Z – shows heterogeneous estimates of the features and low accuracy in forecasting their impact on price formation.

The results of the XYZ analysis of the accuracy of forecasting estimates of the impact on innovation formation are presented in Table 3.

It is advisable to conduct additional analysis due to the significant variation in the scores for the fifth and seventh attributes. As can be seen from Table 1 and Table 2, the impact on the price of the university device is significant (for the fifth attribute) and strong (for the seventh attribute), and in both cases, the highest among competitive analogues.

According to the fifth feature:

- Interval step (size) $h = (x_{max} - x_{min})/m$ = (6.5 – 3.2)/6 = 0.55 points.
- Intervals: [3.2 – 3.75); [3.75 – 4.3); [4.3 – 4.85); [4.85 – 5.4); [5.4 – 5.95); [5.95 – 6.5].

According to the seventh feature:

- interval step (size) $h = (x_{max} - x_{min})/m$ = (9.1–3.8)/6 = 0.89 points,

Table 3. The results of the XYZ-analysis of the accuracy of forecasting estimates of the impact on the formation of the innovation

№	Qualitative assessments of the signs of influence on the price formation of R&D results at different European enterprises, points									Sum	Average, points	Dispersion	Average, points	V, %	Groups
1	8.2	7.4	7.1	7.1	8.9	7.3	6.7	5.9	8.3	66.9	7.43	0.736	0.86	11.54	Y
2	7.9	8.2	7.9	7.9	9.3	7.4	9,1	6.8	8.9	73.4	8.16	0.596	0.77	9.46	X
3	8.9	7.2	6.9	7.0	8.9	8.3	6	5.9	9.1	68.2	7.58	1.397	1.18	15.60	Y
4	6.1	6.8	6.5	6.3	9.1	8.9	7,1	6.3	9.1	66.2	7.36	1.487	1.22	16.58	Y
5	4.3	4.8	3.3	4.2	5.9	5.0	3,2	3.4	6.5	40.6	4.51	1.197	1.09	24.25	Y*
6	6.3	4.9	5.1	5.9	8.3	7.2	5,4	5.3	8.2	56.6	6.29	1.532	1.24	19.68	Y
7	5.3	5.8	4.9	3.8	8.1	8.2	7.0	6.1	9.1	58.3	6.48	2.711	1.65	25.42	Z

Note: *the fifth feature is more inclined to group Z, according to the calculated coefficient of variation.

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- intervals: [3.8 – 4.69); [4.69 – 5.58); [5.58 – 6.47); [6.47 – 7.36); [7.36 – 8.25); [8.25 – 9.14].

Using the empirical method, we generate a function of the dependence of the change in the price of R&D results on the change in qualitative assessments of the impact on price formation (expression (5)).

$$Y = 0.11x_1 + 0.17x_2 + 0.11x_3 + 0.18x_4 + 0.12x_5 + 0.17x_6 + 0.14x_7, \quad (5)$$

where $x_{1...}$ x_7 – accordingly, the values from the first to the seventh features.

The weights of the indicators are substantiated based on the results of the study on the device for interferometric determination of the refractive index of crystalline materials in the optical range, as presented by Chukhray et al. (2022).

We will use the method of calculating partial derivatives, as it allows us to index some parameters while considering the impact of changes in others. Thus, the partial derivative, for example, for the fifth technical attribute, will show how the resultant attribute (the price for innovation) will increase depending on the change in the factor attribute (measurement of refractive indices of isotropic and anisotropic materials). Similarly, let us apply a partial derivative for the seventh characteristic (the ability to rapidly analyze the refractive indices of optical materials). The partial derivatives for the fifth and seventh features are shown in expressions (6) and (7):

$$\frac{\partial y}{\partial x[5]} = 0.12 \cdot \Delta x, \quad (6)$$

$$\frac{\partial y}{\partial x[7]} = 0.14 \cdot \Delta x. \quad (7)$$

Since this study determined that the attributes grow evenly, the price change for the fifth attribute will be USD 0.55 thousand or $550 in each interval, and for the seventh characteristic, USD 0.89 thousand or $890 in each interval.

Table 4 shows the results of calculating partial and total derivatives for two attributes. The price for stepwise changes in the attributes was determined at the midpoint of each initial price interval, with the addition of the change in value corresponding to the change in the attribute.

With the scale shown in Figure 3, respondents were asked the next three questions:

1. What is the favorable price of the device, in your opinion?

2. What price is expensive for the device, but you will buy it?

3. What is the price of the device that is too high and you will refuse to buy it?

Respondents can give one answer to each question or leave the question unanswered. This explains the difference in the total number of votes for the first and last blocks.

The study's results are summarized in Table 5, which reflects the respondents' perception of each item on the price scale, compared to the level of technical parameters according to the seventh feature, which has the most dynamic impact on price changes.

We divided the columns into four large blocks according to the proposed price characteristics. Each of them consists of three columns:

Table 4. Changes in the price of a device for interferometric determination of the refractive index of crystalline materials in the optical range, depending on changes in its technical characteristics

Price, thousand USD	Price per step change x_5	Price per step change x_7	Price for stepwise simultaneous change of x_5 and x_7
[3.6 – 6.46)	5.01	5.01	5.201
[6.46 – 9.36)	7.976	8.035	8.101
[9.36 – 12.26)	10.81	10.935	11.001
[12.26 – 15.16)	13.71	13.71	13.901
[15.16 – 18.06)	16.61	16.735	16.801
[18.06 – 21.0]	19.51	19.635	19.701

Table 5. The results of the price perception survey for a device for interferometric determination of the refractive index of crystalline materials in the optical range (according to the PSM analysis)

Price (m), thousand USD	"If it's too cheap, we'll refuse"			"Good purchase"			"It's expensive, but the purchase will happen"			"It's too expensive – we'll refuse"		
	The number of votes	Structure, %	Cumulative share, %	The number of votes	Structure, %	Cumulative share, %	The number of votes	Structure, %	Cumulative share, %	The number of votes	Structure, %	Cumulative share, %
5.010	101	78	100				5	4	4	3	2	2
8.035	15	12	22	28	22	100	8	6	10	3	2	4
10.935	8	6	10	62	48	78	10	8	18	0	0	4
13.710	5	4	4	29	22	30	44	34	52	3	2	6
16.735				10	8	8	60	46	98	10	8	14
19.635							3	2	100	110	86	100
Sum	129	100		130	100		130	100		129	100	

- The total number of votes for each price in a given characteristic.
- The structure of votes as a percentage of the total (in our case).
- The structure calculates the cumulative share by adding the value from the previous row to the sum.
- Unconventionally, for the blocks "Too cheap – refuse" and "Successful purchase," the calculation of cumulative shares is made in the reverse order (starting from 100%), subtracting each subsequent stage.

The results shown in Table 5 are based on the study of the opinions of 130 business entities – potential consumers of the device for interferometric determination of the refractive index of crystalline materials in the optical range (the sample was formed based on (Research institutions in Ukraine, 2024). For the first and last blocks, we received 129 responses, which is a relatively high number and quite representative of the results. In practice, for some experts or decision-makers, there may not be a price that is too cheap or too expensive.

The results are graphically illustrated in Figure 4.

As you can see from it, the four curves have several intersection points, but we are interested in only four of them, which interpret the results of the study in this way:

4. The point of intersection of the curves "Too cheap – refuse" and "Expensive, but the purchase will take place" reflects the point of mar-

Source: According to the authors' investigation.

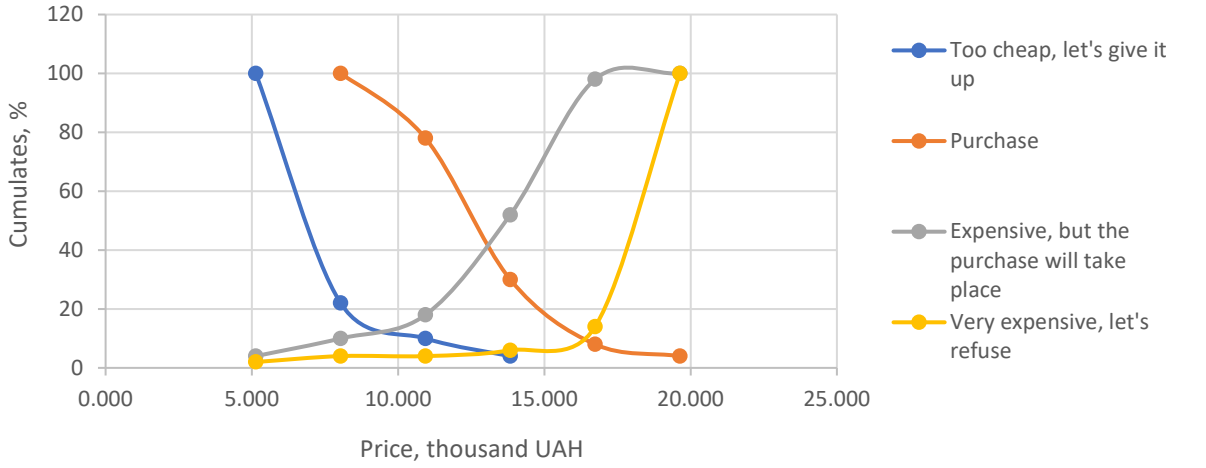

Figure 4. The graph of the PSM-analysis curves of the device for interferometric determination of the refractive index of crystalline materials in the optical range

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ginal cheapness of the product (PMC – Point of Marginal Cheapness). This point represents the lower price threshold, as the number of buyers (experts) who doubt the quality of the innovative product will increase if the price drops below this level, and they will therefore refuse to buy.

5. The intersection of the curves "Expensive, but the purchase will take place" and "Successful purchase" gives a point called the Indifferent Price Point (IPP). At this price point, the proportion of respondents who consider a product or technology inexpensive is equal to those who perceive it as expensive.

6. The intersection of the curves "Too cheap – refuse" and "Too expensive – refuse" gives the OPP (Optimum Price Point). At this point, people are least likely to accept an innovation because the price is too high or too low. At the same time, it allows the company to get additional profit from the transaction compared to other price options.

7. The intersection of the curves "Too expensive – refuse" and "Successful purchase" gives the point of marginal costliness (PME – Point of Marginal Expensiveness). If the company puts a price for an innovative product close to or higher than the PME, most customers will refuse the offer, considering it unacceptable.

Excel does not provide a way to determine the intersection of two lines or curves, so we must calculate it mathematically. We find the adjacent points by intersecting two segments. We find the equation of two lines passing through two points using expression (8):

$$\frac{x-x_1}{x_2-x_1}=\frac{y-y_1}{y_2-y_1}. \quad (8)$$

Equate the two equations to find "x" (the abscissa of the intersection point). You do not need to find the ordinate of the intersection.

So, to find the optimal price (OPP), you should first substitute the coordinates of the segment belonging to the Too Cheap to Pass curve into the equation of the line passing through the two points: A (x_1; y_1) and B (x_2; y_2).

A (10.935; 10) and B (13.835; 4):

$$\frac{x-10.935}{13.835-10.935}=\frac{y-10}{4-10}. \quad (9)$$

We get the first linear equation: $y = -2.07x + 32.62$. After that, we substitute the coordinates of the segment belonging to the "Too expensive – refuse" curve into the equation: C (10.935; 4.0) and D (13.835; 6.0):

$$\frac{x-10.935}{13.835-10.935}=\frac{y-4}{6-4}. \quad (10)$$

We obtain the second linear equation: y = 0.69x – 3.54.

Equating the two equations, we get:

- $-2.07x + 32.62 = 0.69x - 3.54$.
- x = USD 13.102 thousand.

We find the prices similarly: PMC = USD 6,918 thousand, IPP = USD 12,967 thousand, PME = USD 16,141 thousand. It is worth noting that the median (average market price) may sometimes be higher than the optimal price. This may indicate that one or more market leaders set high prices. However, in our case, the OPP is higher than the IPP.

The optimum price (OPP) for the device for interferometric determination of the refractive index of crystalline materials in the optical range, depending on the change of technical parameters, at the point level [6.47 – 7.36] of the seventh feature "the ability to conduct a rapid analysis of the refractive indices of optical materials" is USD 13.102 thousand. The average score of the seventh attribute is USD 13.102 thousand. Thus, we can observe a significant level of the seventh characteristic at a price slightly higher than the market average. Raising the character's level and the price will create the effect of "excessive quality."

Validating the pricing model using historical data in Table 6 enables us to compare its predictions with actual outcomes, thereby assessing its accuracy and reliability. If the model accurately predicts past performance, it is more likely to perform well in future scenarios.

Table 6. Validation of the range of prices for the industrial innovative product due to the dynamics of consumer price sensitivity to the seventh technical parameter of the innovative product

Price level according to PSM-analysis, thousand USD	The level of the technical parameter	Influence of a technical parameter on price formation	Influence of a technical parameter on price formation
6,918	PMC (Point of Marginal Cheapness)	4,69 – 5,58	Weak
12,967	IPP (Median Price)	6,47 –7,36	Crucial
13,102	OPP (Optimal Price)	6,47 –7,36	Crucial
16,141	PME (Point of Marginal Cost)	7,36 – 8,25	Strong

Thus, the model enables the precise determination of the market price range boundaries for the innovative product. Marketers can use this to generate different price options for innovative industrial products from which to choose the optimal one. In our calculation, this range is USD [12,967 – 13,102] thousand.

Price sensitivity analysis offers valuable insights into how customers perceive and respond to changes in pricing. By integrating this information with traditional pricing methods, industrial marketers can gain a deeper understanding of customer preferences and the relative importance of price compared to other factors, such as the features of industrial innovations developed in laboratories that are not adapted to the requirements of the industrial market. As a result, the authors' method enables the determination of the boundaries of the market price range for an innovation with sufficient accuracy.

3. DISCUSSION

1. This study's results raise a discussion of several of the authors' generalizations and considerations.

2. Testing a pricing model involves evaluating its effectiveness in achieving specific objectives and ensuring it performs well under various scenarios. Testing the authors' price-determining model under various scenarios is crucial to evaluate its robustness and flexibility. This could include testing the model's performance under market conditions, competitive landscapes, and pricing strategies. Compared to previous studies that focused mainly on consumer markets or simplified industrial cost models (e.g., cost-plus pricing or competitive benchmarking), our approach highlights the importance of testing industrial innovations under diverse market scenarios, thus extending the scope of prior research.

3. Pricing on innovative industrial products can vary significantly based on several factors, such as the uniqueness of the product, the value it offers to customers, production costs, market demand, competition, and overall business strategy. The model requires further study of the price sensitivity of different categories of industrial consumers. Each such category is characterized by peculiarities that will determine different results when assessing the level of price sensitivity. Earlier research often treated industrial demand as relatively homogeneous, whereas our findings underscore the need to differentiate consumer groups by their sensitivity levels. This distinction advances beyond prior work, where the heterogeneity of industrial customers was insufficiently explored.

4. While earlier models often emphasized either technical attributes or general market benchmarks, our study shows the value of integrating price sensitivity analysis with traditional pricing methods in industrial contexts. This creates a more comprehensive framework, filling a gap left by previous research. The authors' model can be tested on consumer and industrial markets. Additional research should be conducted to identify several adjusting indicators that would enable specific market factors to be taken into account in the pricing of industrial innovations planned for the relevant market. The authors' price-determining model focuses on product attributes and features, while overlooking broader contextual factors that influence consumer preferences, such as

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brand perception, industrial market dynamics, or situational factors. Failing to consider these factors can limit the accuracy and relevance of the proposed price-determining model.

Integrating traditional pricing methods with price sensitivity analysis provides industrial marketers with a comprehensive approach to determining prices. By leveraging the strengths of both techniques, companies can make more effective pricing decisions for launching "technology-push" innovations that enhance profitability, customer value, and competitive positioning in the market. Thus, compared with prior studies, this research contributes by bridging cost-based and competitor-oriented approaches with price sensitivity analysis, offering a new framework for industrial "technology-push" innovations.

CONCLUSION

A price-determining model for industrial "technology-push" innovations offers a structured approach to evaluating the commercial viability of R&D outcomes. By integrating traditional cost-based and competitor-oriented pricing with price sensitivity analysis, the model addresses the complexity of aligning technical value with consumer willingness to pay and offers practical guidance for optimizing pricing strategies in industrial markets.

1. Traditional pricing methods focus on cost-plus and competitor-based pricing, which may not fully account for customer willingness. Price sensitivity analysis helps identify price points that maximize revenue or profit by considering customer demand elasticity and price thresholds. By integrating these insights into traditional pricing models, businesses can develop more effective pricing strategies tailored to customer preferences and market dynamics. By understanding customer price sensitivity and competitor pricing strategies, businesses can better position themselves within the market. Integrating price sensitivity analysis with traditional pricing methods allows companies to assess the potential impact of price changes on their competitive position and adjust pricing strategies accordingly. This enables businesses to maintain or enhance their competitive advantage while maximizing profitability.

A valuable scientific and practical outcome of this study is the development of a model for valuing R&D results, which enables the consideration of the consumer's price sensitivity to the technical parameters of the R&D result. This helps to balance the potential benefit of the value received by the consumer from the technical parameters of the R&D result with their ability to purchase this product. The cost assessment of R&D results, concerning the price sensitivity of consumers, justifies their cost at a significantly higher level of quality. It opens up prospects for further development of scenarios for the market's product development.

2. The above result is achieved with the help of the PSM method used in the model of R&D results valuation described by the author. This method enables the determination of the boundaries of the market price range for a product with sufficient accuracy. Marketers can use it to generate different price options for R&D results, from which to choose the optimal one. The increase or decrease in its level will depend on the manufacturer's strategy, market specifics, competitive environment, and functional and cost properties of the product itself.

By strategically combining multiple pricing approaches, we created a nuanced pricing model that maximizes value for both participants of innovation processes: an industrial inventor and an industrial customer. To reach that outcome, we should incorporate elements of competitive pricing, where pricing is based on comparing the vital technical characteristics, with cost-plus pricing, which ensures that costs are adequately covered and profitability is maintained. Balancing the competitive proposition with the cost structure will help us determine optimal pricing levels.

A promising avenue for further research is the integration of PSM analysis with advanced data analytics and machine learning methods, which would enhance the precision of estimating customer price sensitivity and provide a more robust foundation for pricing decisions in dynamic industrial markets.

The proposed price-determining model aligns with the concept of open innovation, the principles of the Fourth Industrial Revolution, and the modern transfer and commercialization of industrial "technology-push" innovations.

AUTHOR CONTRIBUTIONS

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