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The emergence of Algorithmic Pricing enhanced by Hyper-Personalization in the era of Artificial Intelligence

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ظهور التسعير الخوارزمي المعزز بالتخصيص الفائق في عصر الذكاء الاصطناعي

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Abstract:
This study aims to shed light on a significant phenomenon, which is the birth of Algorithmic Pricing (AP) considering the spread of talk about improving Customer Experiences (CXs) strengthened and optimized by Hyper-Personalization instead of Mass Customization. Amid awesome scientific developments and tremendous technical advances, in the electronic fields of Information & Communication Technologies (ICT), Cyber-Physical Systems (CPS), Digital Innovations, Internet Networks, intranets & Extranets, and Satellites. And many other inventions and discoveries in the farmland of Computer Sciences. All the above has resulted in the emergence of the fifth wave of successive industrial revolutions, which led to the emanation of Artificial Intelligence (AI)-enhanced Industry 5.0. The latter carries with it transformative tools that have brought about fundamental and radical changes in the Marketing Mix (MM) landscape and dynamic pricing decisions, which have become more based on Automation and Collaborative Robots (Cobot) than ever before. Examples include Machine Learning (ML), Deep Learning (DL), Reinforcement Learning (RL), Generative AI, Big Data Analytics (BDA), Natural Language Processing (NLP), Large Language Model (LLM), ChatGPT (OpenAI), Virtual Assistants (VAs), Internet of Things (IoT), Blockchain (BC), Cloud Services, Quantum Computing, Augmented Reality (AR), Virtual Reality (VR) and Web 4.0, ...etc. It is expanding at record exponential paces, and at unprecedented, accelerated growth rhythms. The research papers concluded that smart technology, embodied in AI solutions and materialized in ML software, is steadily contributing to the dynamic management of product prices and strongly supports upgrading brands pricing policies and strategies, from the perspective of efficiency and effectiveness.

Keywords: Industry 5.0, Cyber-Physical Systems, Artificial Intelligence, Algorithmic Pricing, Hyper-Personalization

الملخص
تهدف هذه الدراسة إلى تسليط الضوء على ظاهرة تحتل مكانة مهمة للغاية، وهي ولادة التسعير الخوارزمي (*AP*) مع انتشار الحديث عن تحسين تجارب العملاء (*CXs*) وتعزيزها من خلال التخصيص الفائق بدلا من التخصيص الشامل. وسط تطورات علمية هائلة وتقدم تقني ضخم، في المجالات الإلكترونية لتقنية المعلومات والاتصالات (*ICT*)، والأنظمة المادية السيبرانية (*CPS*)، والابتكارات الرقمية، وشبكات الإنترنت، والإنترانت والإكسترانت، والأقمار الصناعية. والعديد من الاختراعات والاكتشافات الأخرى في مجال علوم الحاسب الآلي. كل ما سبق أدى إلى ظهور الموجة الخامسة من الثورات الصناعية المتعاقبة، مما أدى إلى ميلاد الصناعة 5.0 المعززة بالذكاء الاصطناعي (*AI*). يحمل هذا الأخير في طياته أدوات تحويلية أحدثت تغييرات أساسية وجذرية في مشهد المزيج التسويقي (*MM*)، وقرار التسعير الديناميكي، والتي أصبحت أكثر اعتمادًا على الأتمتة والروبوتات التعاونية (*Cobot*) أكثر من أي وقت مضى. تشمل الأمثلة: التعلم الآلي (*ML*)، التعلم العميق (*DL*)، التعلم المعزز (*RL*)، الذكاء الاصطناعي التوليدي، وتحليل البيانات الكبيرة (*BDA*)،

معالجة اللغات الطبيعية (*NLP*)، نموذج اللغات الكبيرة (*LLM*)، الـ *ChatGPT*، المساعدون الرقميون (*VAs*)، إنترنت الأشياء (*IoT*)، سلسلة الكتل (*BC*)، الحوسبة السحابية، الحوسبة الكمومية، الواقع المعزز (*AR*)، الواقع الافتراضي (*VR*)، الويب 4.0، ... إلخ. فهي تتوسع بوتيرة أسية قياسية، وبإيقاعات نمو متسارعة وغير مسبوقة. وخلصت الأوراق البحثية إلى أن التقنيات الذكية مجسدة في حلول الذكاء الاصطناعي وبرمجيات الآلة المتعلمة تسهم بشكل مطرد في الإدارة الديناميكية لأسعار المنتجات، وتشارك بقوة في رفع مستوى سياسات واستراتيجيات تسعير العلامات التجارية، من منظور الكفاءة والفعالية.
الكلمات المفتاحية: الصناعة 5.0، الأنظمة الفيزيائية السيبرانية، الذكاء الاصطناعي، التسعير الخوارزمي، التخصيص الفائق.

Introduction

Research Issue

Machine Intelligence, or what is called Artificial Intelligence (AI), is a term emerging from the sciences derived from computers. In its conceptual content, AI is considered an integrated and coordinated electronic and cloud system of various digital and cyber technologies in a virtual computing environment, which work in harmony to enable Machine Learning (ML), Deep Learning (DL) & Reinforcement Learning (RL) to sense, think, understand and act like levels of biological intelligence and simulate the processes and capabilities of the human mind to interpret, comprehend, adaptation and self-correction.

The importance and the significance of AI applications in the difficult environments of: Economics, Investment, Trade and Business, and in making complex decisions: Administrative, Organizational, Production, Financial, Accounting, Logistics and Marketing. Their tools contain within them the ability to achieve the goals and aspirations of companies with great accuracy and precision. Such as generating additional sales, maximizing profits, increasing return on marketing investment (ROI), growing market share and improving customer service, or reducing costs and saving time and efforts, which based on activating the components of tactical marketing (4Ps), which are: New Product Development (NPD), Smart Pricing, Distribution Channel Management (DCM), Integrated Marketing Communication (IMC). And other elements that have become part of the AI scene and agenda, resulting from the terrible scientific development and progress in the field of Information Technologies (IT), Telecommunications and the Internet.

Today, Automation supported by CPS & ICT is the cornerstone and fundamental pillar in transforming the amount of huge data into useful information, and elevating it to knowledge that plays a very prominent role in acquiring a Sustainable Competitive Advantage (SCA), which is reflected in the form of: Performance, Resilience, Agility, Quality, Speed, Reputation, ...etc. In a related context, the importance of AI is increasing in all aspects and levels of life. This, of course, has affected, is affecting, and will affect current and future marketing trends and tendencies in light of a highly competitive virtual environment. After academic studies and applied experiences have proven the benefits and repercussions of using marketing analysis tools supported by AI and enhanced by ML, the expected scenario in the coming timeline is increased adoption and embrace of modern digital innovations in business practices. This study aims to clear up on harnessing different and varied AI software solutions as a tributary to improving the outputs of the marketing industry and bettering the outcomes of the sales system amid the global cyber and computer transformation.

Price is truly the key to success, and it is certainly an effective means and efficient tool for growing the company's wealth in today's world of finance and business, and it is a strong reason for staying ahead of the competition. There are many circumstances, determinants and factors to consider when pricing brands. However, in the end, the price will depend on the product, market and competition. Setting the price of goods and services incorrectly can negatively affect financial and accounting results and may lead to accumulated inventories. Pricing is the most important factor in influencing total profits, and therefore requires full attention. The pricing decision needs to be rational, and to avoid haste, randomness, and improvisation. Pricing is also very sensitive, difficult and complex, as it is the only revenue within the elements of tactical marketing. Among these crucial determinants in the price function of goods and services, we find technical and computer development, the latter of which is based on the fact that fast-paced change is the only constant principle in the era of digital intelligence and science fiction, and this will inevitably affect the methods and patterns of setting prices in light of the cloud and cyber revolution.

In order to achieve victory and price superiority in the contemporary competitive business environment surroundings, there are many schemes, approaches and models, whether complex or

simplified, from which a sound and optimal pricing decision emerges. This in itself is a challenge for managing marketing activity and sales effort. The marketing and sales executive is forced to make comparisons in order to choose the most appropriate method from these methods: 1- Pricing based on covering the cost and achieving target profit margins. 2- Pricing based on gaining competitive advantage and confronting competitors in a flexible and agile manner. 3- Pricing based on changing markets Status, demand conditions and consumer psychology. Because companies compete in volatile environments and dynamic sectors, they need the ability to anticipate and respond to rapid changes, and to pivot and modify their pricing strategy whenever necessary.

There is no doubt that there is an urgent need to benefit from the gains of E-commerce and the opportunities of the digital economy, and there is an urgent situation that does not allow for postponement and delay in adopting new technologies in all components of the marketing mix in general and pricing in particular. One of these technologies is pricing enhanced by AI algorithms & ML solutions. The latter has had a significant impact on pricing decisions, given that technical development is a decisive factor determining the final price of the product, and price determinants in the virtual environment differ from the physical environment, especially in light of the growing trend of using modern payment systems such as bank credit cards, the great spread of online shopping and purchasing, and the expansion of the phenomenon of digital currencies or Cryptocurrencies, in addition to buyers' reliance on reviews and comments written on social media. Hence, these considerations will have major impacts on how products are priced, as digitization creates new methodologies and transforms existing methodologies, including pricing philosophy.

Considering the commencements of the industrial revolution in its fifth generation or IR5.0, and with the increasing reliance on CPS software in production and manufacturing, and on the basis that modernization and refurbishment in the areas of marketing and the domains pricing are broad. And from here, the technical partnership between AI and probability theory on the one hand, and directed price management psychological determinants, environmental factors, and demographic characteristics on the other hand resulted in the birth of a new methodology in determining the price of products based on the rule of Hyper-Personalization.

Harnessing AP leads to Sustainable Competitive Advantage in the age of the Society 5.0 (Society 5.0, also known as the Super Smart Society). This method uses computer algorithms to determine market prices, and this modern method involves benefits and returns for expansion and profit. At the same time, it includes many technical taboos and regulatory prohibitions and legal restrictions and legislative caveats, which should be taken into account before they occur, and this requires in-depth and specialized studies.

Research Originality

During the terrible scientific development, and within the tremendous technical progress in the domain of information, communications, transportation, networks, systems, internet and automation. AI is considered one of the most critical characteristics of the electronic economy, sustainable development and quality of life, and a prominent feature in the modern digital and cyber age, and a cumulative result of computer science and its applications. This is smart, useful technology, and a valuable algorithmic tool in this computing and cloud environment with its efficient and effective software solutions, it has resulted in a huge revolution that is exponential expansion and steady growth in all aspects of contemporary life. Its importance lies in making companies, governments and societies perform their daily tasks in easier and faster ways, with top quality and extreme accuracy. It is programmed automatically to reduce human efforts and manual operations as much as possible. In addition to its ability to predictive analytics of big data.

In a related context, many discoveries of added value have emerged because of the merger between marketing and pricing sciences on the one hand, and computer and IT sciences on the other hand. Therefore, the technical and computer impact in the field of pricing policies is very clear. Considering the digital economy, the cyber environment, and market trends, the marketing activity department strives to embrace and adapt the resources of Artificial Intelligence, Machine Learning, Deep Learning, Reinforcement Learning and Predictive Analysis of Big Data. In order to make the most appropriate price decision, and to improve the optimal pricing strategy, where this led to the development of a new philosophy in pricing, called the term: Algorithmic Pricing (AP). It is the practice of setting the required and desired price in a dynamic, automatic, and customized manner, which ultimately results in achieving the organization's qualitative and quantitative objectives: customer satisfaction and profit generation.

The researcher seeks to shed light on this topic based on illuminations around ML&DL-Powered Dynamic Price (The Birth of AP in the Age of AI enhanced by CPSs and IR5). The research paper was divided into the following axes:

1- Artificial Intelligence in Light of Cyber-Physical Systems and The Fifth Industrial Revolution

1-1- Industry 5.0 & The Super Smart Society in The Age of Metaverse (Two Sides of The Same Coin)

1-2- Cyber-Physical Systems & Digital Innovations (Change is the only constant)

1-3- Artificial Intelligence and its aftermaths … Blessing or Curse

2- Algorithmic Pricing (AP) driven by Hyper-Personalization as a vital tool for achieving Sustainable Competitive Advantage (SCA)

2-1- Moving from mass to Hyper-Personalization (Searching for excellence boosted by the most accurate Customization)

2-2- Pricing Optimization based on AI (Price melting into Marketing Technology)

2-3- Birth of Algorithmic Pricing (AP) or Real-Time Pricing (Smart Dynamic Pricing)

Results and discussion

1- Artificial Intelligence in Light of Cyber-Physical Systems and The Fifth Industrial Revolution

1-1- Industry 5.0 & The Super Smart Society in The Age of Metaverse (Two Sides of The Same Coin)

Human curiosity helped transform science fiction (Metaverse) into real and tangible physical reality. The first three industrial revolutions were respectively driven by mechanization, electrification, and automation, which gradually transformed the agricultural economy into a manufacturing-based economy. While Industry 4.0 was about linking automation and digitization without human intervention, Industry 5.0 allows cooperation between humans and machines, as the fifth wave is about connecting humans and robots and making them work together, or more precisely, activating the principle of human-centeredness through coexistence and convergence between cyber-physical systems. The fifth generation of industrial revolutions (IR5), which is the product and outcome of innovative updates of the transformative, generative and changeable revolutions emerging across the timeline, in which each revolution prepares the scenario for the next revolution. Regarding Industry 5.0, it is different from its predecessors in terms of deepening and expanding the collaborative and cooperative relationship between human intelligence and artificial intelligence. That is, between humans and learned and cognitively adapted computers, and strengthening the interaction, connection and communication between humans and robotic systems in a harmonious and synergistic manner (For further digression, see: Madhavan, M., et al. 2024; Ahmad, A. Y. B., et al. 2023; Verma, A., et al. 2022; Singh, V., & Kumar, R. 2024).

In the same context, a new global anthropological variable has surfaced, which scientists have called Society 5.0 or the fifth-generation society. In essence, Super Smart Society is a highly intelligent and knowledge-intensive future society, as it has a hyperlink and interactive relationships with the Fourth and Fifth Industrial Revolutions. So that the new digital technologies have a prominent role in upgrading society. They are integrated technologies supported by AI with the central axis of humans, while automated machines are supportive and helpful, and robots are cooperative. The balanced integration and exchange of data between the areas of cyber and electronic spaces, and the materialistic and physical environments. As well as the activation of AI along with other Information & Communication Technologies (ICT), digital innovations, and computers as enabling tools lead to be achieving the three-dimensional of Sustainable Development Goals (SDGs) (For further digression, see: Shiroishi, Y., et al. 2018; Gurjanov, A. V., et al. 2020; Holroyd, C. 2022; Pereira, A. G., et al. 2020):

- Economic development and growth (Profit).
- Social development and community prosperity (Well-being).
- Confronting environmental challenges and climate change (Planet).

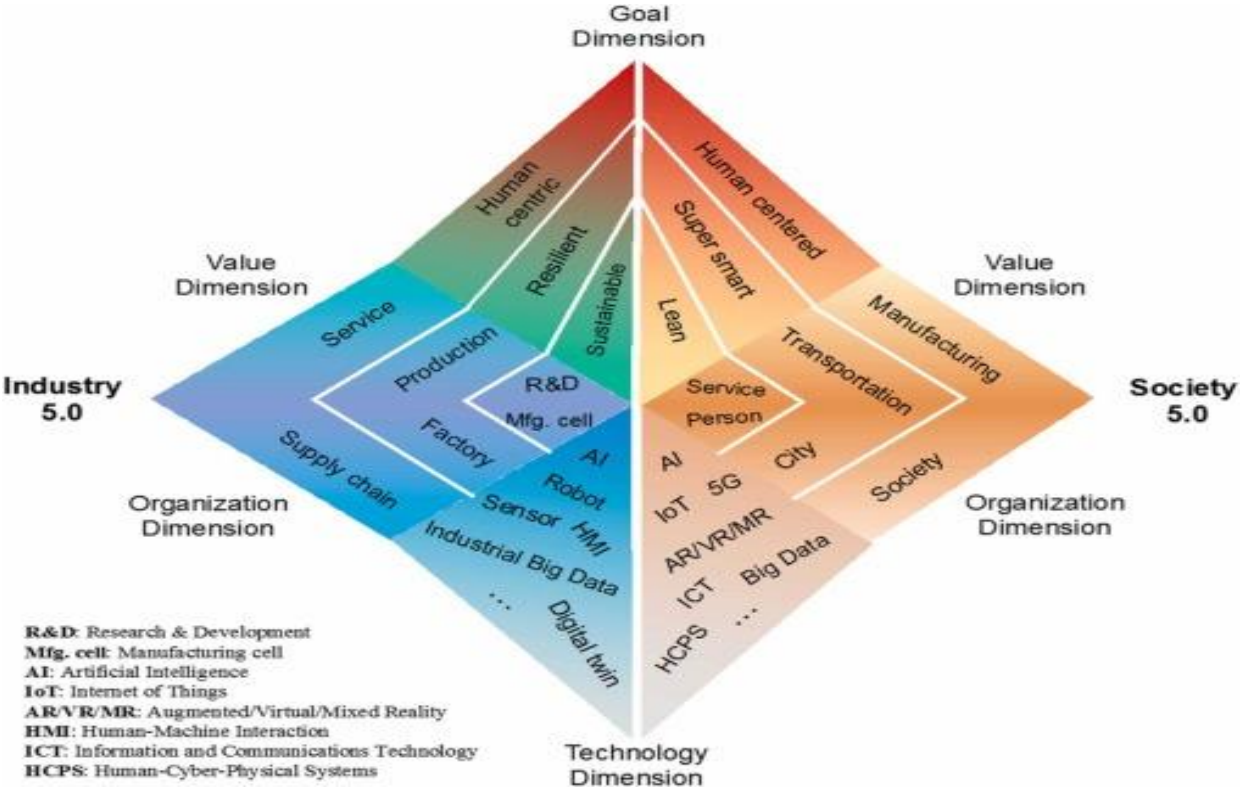

Figure (1): Industry 5.0 and Society 5.0—Comparison, complementation and co-evolution
Source: Huang, S., et al. 2022

1-2- Cyber-Physical Systems & Digital Innovations (Change is the only constant)

In a nutshell, Cyber-physical systems, called CPS, have steadily increased in importance, and the need for them has increased, because of the massive digital transformation adopted by the most industrialized countries in the technologically advanced, scientifically and research-advanced world. Typically, Cyber-Physical Systems (CPS) involve various interconnected systems, which can monitor and manipulate real objects and processes. These automated algorithmic systems are an intelligent integration of physical processes with electronic and network processes, or in other words, an interactive integration of physical elements with software components, where the behavior of mechanical work is tracked, inspected, monitored and directed, and controlled automatically, that is, remotely, by computers based on algorithms. So, the CPS takes improvement measures to make the real environment work properly and better. There are many examples of uses and applications of CPS, including: Self-driving or Autonomous Cars, Robotics Systems in Medical Care, Industrial Control Systems, Automated Avionics, Supply Chain Operating Systems, etc. The impact of CPS includes several important sectors, for example: Manufacturing, Renewable Energies, Logistics & Transportation, Health Care, Scientific Research, Infrastructure, Construction, Contracting, Agriculture, E-commerce, Space, Civil Service, Entertainment, etc. Now the discussion has moved on to a new revolution called the human-cyber-physical systems (HCPS). (For further digression, see: Yaacoub, J. P. A., et al. 2020; Liang, Q., et al. 2024; Tyagi, A. K., & Sreenath, N. 2021; Napoleone, A., et al. 2020; Wang, B., et al. 2022).

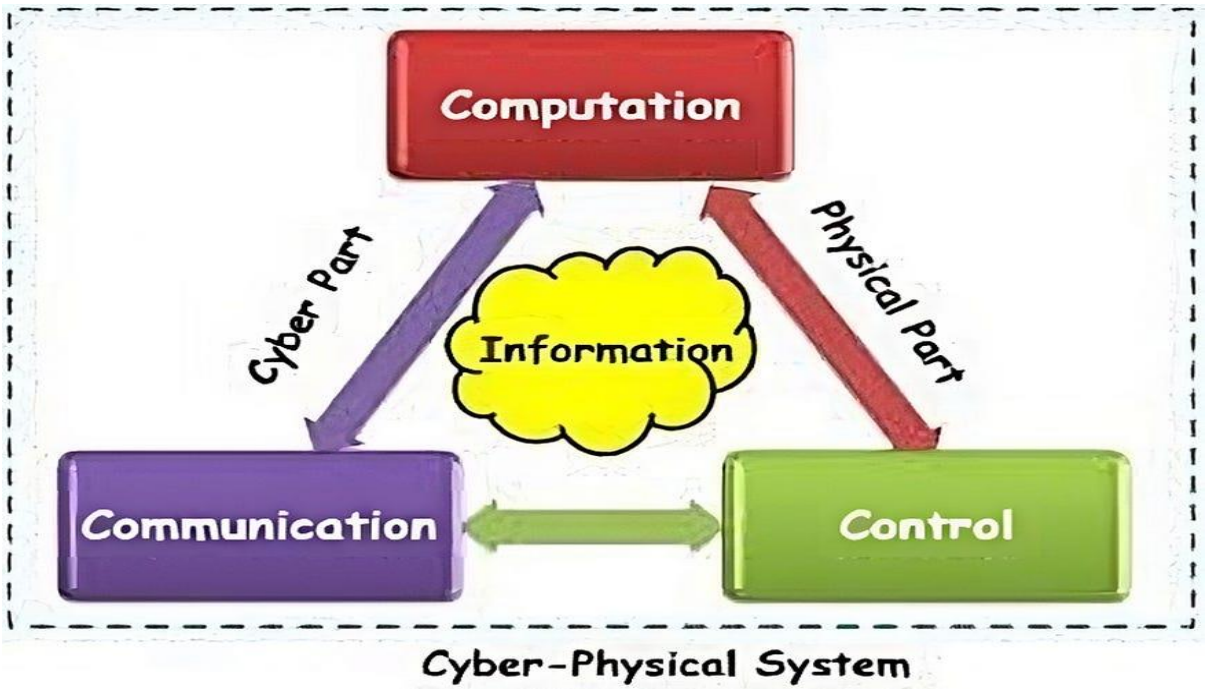

Figure (2): Fundamentals of Control Strategies in Cyber-Physical Systems (CPS): Achieving Efficiency and Reliability
Source: Dsouza, J. 2023

Digital Innovations serve as the basic building blocks for finding meaningful solutions to problems and dilemmas, whether at the level of individuals, institutions or governments. It includes all tools, applications and platforms supported by Information Technologies and Wired and Wireless Communication. It is a cumulative result of the Transformative revolutions that affected smart business models, radically changed management methods, created a boom in the fields of manufacturing, and left nothing in all aspects of life without its penetration. Digital Transformation, which is the change associated with the application of enabling technologies, has led to the development of amazing treatments for many of the issues and crises facing humanity, including (For further digression, see: Akter, S., et al. 2022; Wiesböck, F., & Hess, T. 2020; Ciarli, T., et al. 2021; Usai, A., et al. 2021):

- Generative AI.
- Big Data Analytics (BDA).
- Natural Language Processing (NLP).
- Large Language Model (LLM).
- ChatGPT (OpenAI).
- Virtual Assistants (VAs).
- Internet of Things (IoT).
- Blockchain (BC).
- Cloud Computing.
- Quantum Computing.
- Augmented Reality (AR).
- Virtual Reality (VR).
- Nanotechnology.
- Biotechnology.
- 3D printing
- Web 4.0.

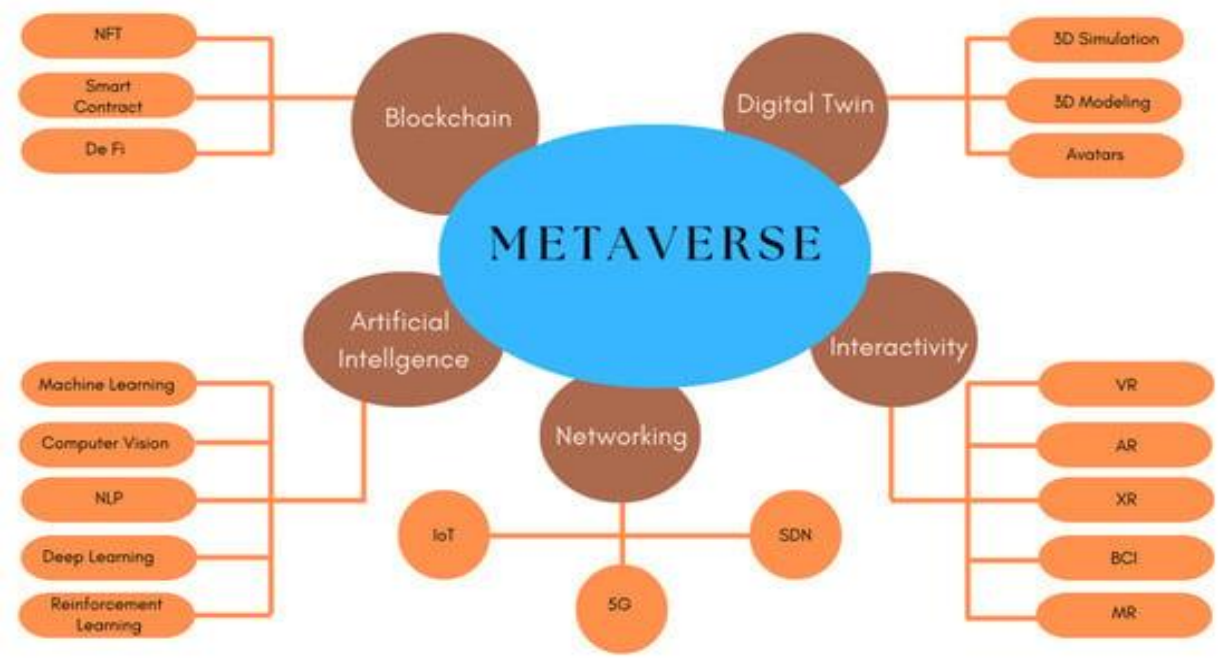

Figure (3): Digital Innovations Automation and its immense impact on society and economy. Source: Ali, S., et al. 2023

1-3- Artificial Intelligence and its aftermaths … Blessing or Curse

In a nutshell, AI depends on modeling, simulating and imitating the intelligence processes of the human mind in terms of perception, thinking, logic, analysis, understanding, deduction, assimilation, prediction and other mental and brain activities of human, through robots. AI requires a package of knowledge and expertise in mathematics, statistics, probability, artificial neural networks, computer science, psychology, linguistics, philosophy and many other fields. AI is a multidisciplinary science with multiple approaches. AI are a vital branch derived and emerging from advanced computer science and evolving CPS. Accordingly, AI have become an increasingly integral part of our daily lives. They are digital and electronic technologies and cyber and cloud innovations that have caused a global stir and a massive transformative revolution in many sectors, fields and markets, such as Manufacturing, Marketing, Finance, Stock Exchanges, Agriculture, Transportation, Travel, Traffic, Health, Academic Research, Security, Judiciary, Defense, and countless. In the same regard, AI is based on their highly capable algorithmic solutions on big data analysis. In fact, these exceptional discoveries have helped to modeling and solving difficult and complex problems and contributed to improving decision-making to be decisive in all areas of human civilization. (For further digression, see: IBM Team. 2024; Britannica Team. 2024; Burns, E., et al. 2023; HVPM Scientific Research Team. 2015; Bini, S. A. 2018; Ongsulee, P. 2017; Dimiduk, D. M., et al. 2018; Sejnowski, T. J. 2020).

The value of Automation and the significance of AI are increasing, especially in those detail-oriented professions, as it reduces the time of jobs full and crowded with data, as programmed machines are responsible for completing daily and routine tasks, in addition to the prominent role of AI robots and devices in improving productivity and upgrade profitability. While at the same time reducing the possibility of human error. Despite all these positive advantages of AI, there are some drawbacks and shortcomings recorded with it, such as its high cost, i.e. development costs, its requirement of in-depth technical expertise, the inability to generalize from one task to another, and the possibility of automated machines and robots replacing human jobs (For further digression, see: Schwartz, B. 2022; Koetsier, j. 2018; Boucher, P. 2020; Moshayedi, A. J., et al. 2022; Pisica, A. I., et al. 2023; Cheng, J., et al. 2021; Bhbosale, S., et al. 2020; Khanzode, K. C. A., & Sarode, R. D. 2020; Estrada Carrera, F. M. L., et al. 2022).

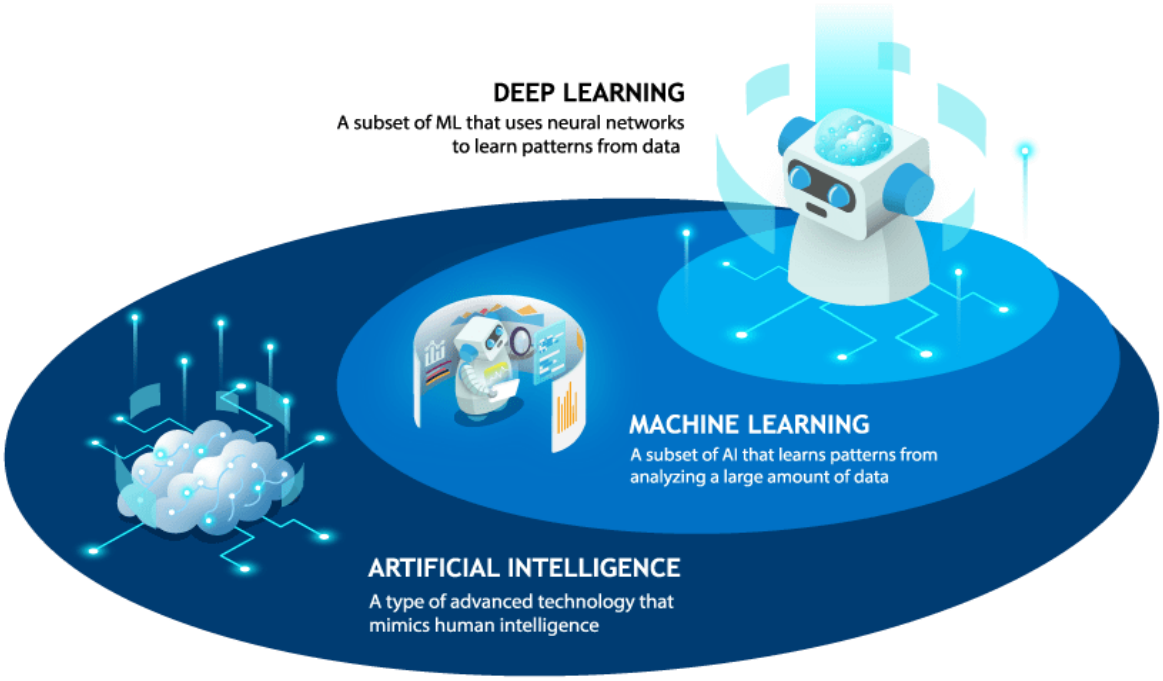

Figure (4): AI vs. Machine Learning vs. Deep Learning: Key Differences.
Source: Fager, M. 2024

The market size in the Artificial Intelligence is projected to reach US$184.00bn in 2024. The market size is expected to show an annual growth rate (CAGR 2024-2030) of 28.46%, resulting in a market volume of US$826.70bn by 2030. In global comparison, the largest market size will be in the United States (US$50.16bn in 2024). In a survey conducted by PricewaterhouseCoopers, it was found that 85% of CEOs agree that AI will significantly change the way they do business in the coming years. A 2017 PwC report also predicted that investments in AI development would lead to a 14% increase in global GDP by 2030. According to Tractica, the AI software market will reach $118.6 billion in global annual revenue by 2025 (For further digression, see: Statista Market Insights. 2024; The PwC Team. 2017; Business Wire Team. 2019; Pew Research Center Team. 2022).

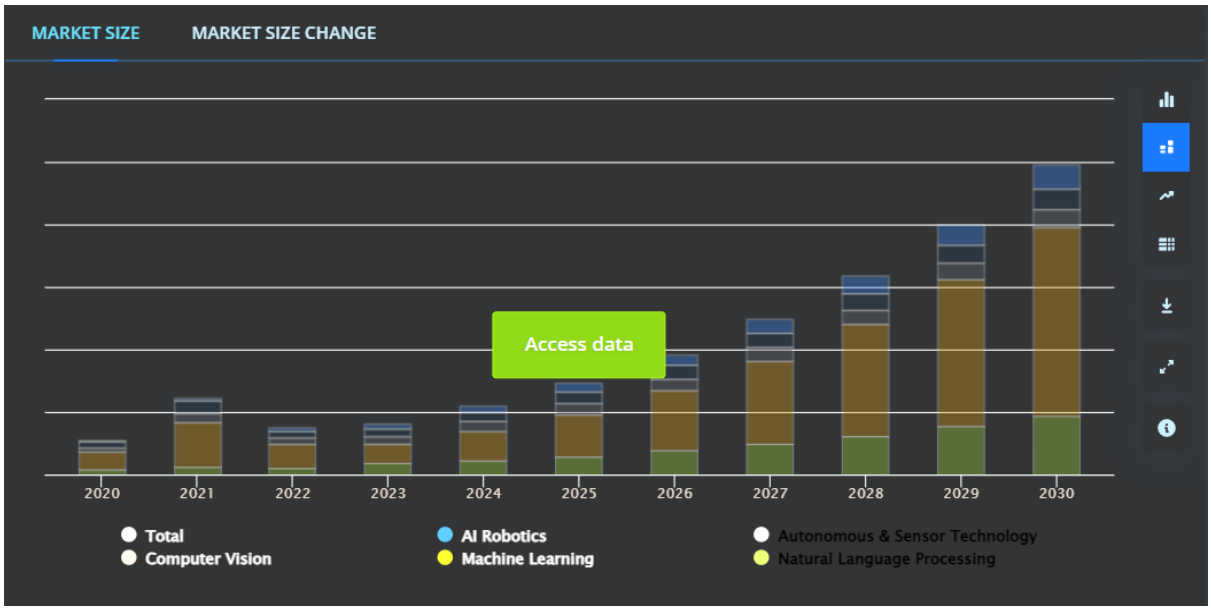

Figure (5): Artificial Intelligence - Worldwide Forecast (2020-2030).
Source: Statista Market Insights. 2024

2- Algorithmic Pricing (AP) driven by Hyper-Personalization as a vital tool for achieving Sustainable Competitive Advantage (SCA)

2-1- Moving from mass to Hyper-Personalization (Searching for excellence boosted by the most accurate Customization)

In fact, in today's dynamic and competitive business landscape Customization plays a very important and significant role from a tactical and strategic marketing perspective to outperform competitors. Its intrinsic value is due to its wonderful implications in achieving the required and desired response in terms of customer engagement and satisfying customers' preferences and interests. Additionally, make more money and keep customers happy. Accordingly, the philosophy of customization is not just hype or noise, but it is an effective methodology and an efficient tool. If it is used well in a smart and thoughtful way, it will give impressive commercial accomplishments, and amazing selling achievements will emerge from it. From extrapolating the literature written on the subject of Mass Customization and Hyper-Personalization, we will notice that the central difference between them is that the latter is an advanced and modified version, and is derived from the former, and its competitive advantage is embodied in its heavy reliance on modern digital technologies, especially AI (For further digression, see: Born Group Team. 2021; Prescouter Team. 2024; Clark, B. 2021; Prabhakar, R. 2024; Symon, N. 2024; Chandra, S., et al. 2022; Tan, C., et al. 2020; Lotker. L. 2023).

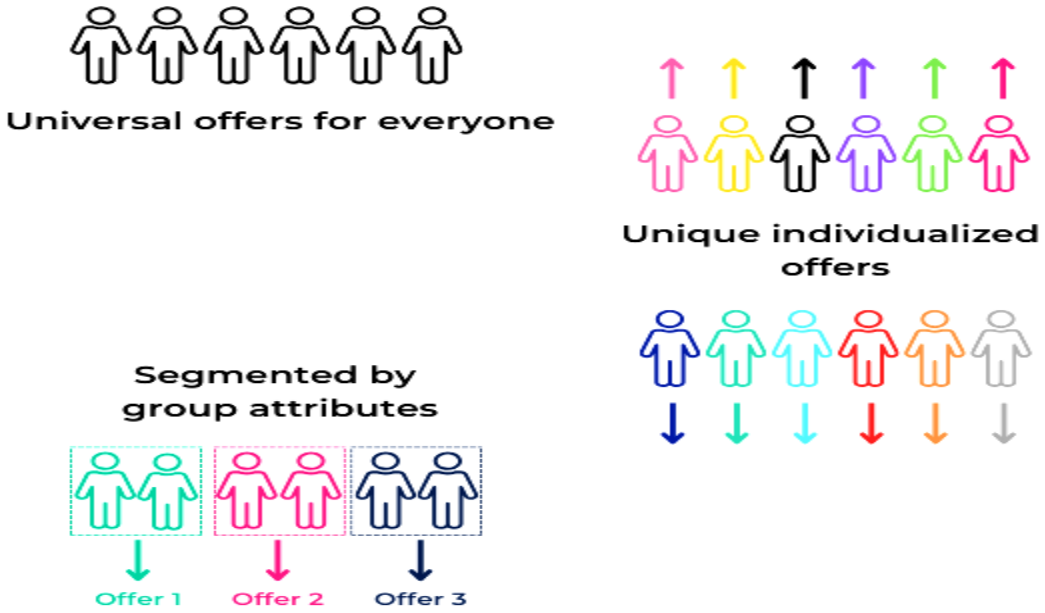

Figure (6): The evolution of Hyper-Personalization (From universal to exclusive).
Source: Lotker. L. 2023

A Hyper-Personalization strategy relies on the organization's capability to gather and transform customer data into personalized experiences. Consequently, Hyper-Personalization is a natural and logical extension of Mass Customization, but it has cyber and cloud characteristics and is full of computer and electronic specifications, which make it more flexible, stronger in response, and smarter in managing customer experiences. Indeed, it is a very precise enabling strategy that gives the marketing and sales manager great opportunities to deal with different types of customers and in the individual level, according to their moods, inclinations, needs, desires, likes, imaginations, backgrounds, perceptions, personalities, motivations, impressions, expectations, and cultures. Which inevitably varies from one customer to another, and even the same customer has different behavior and tastes from time to time (For further digression, see: Rane, N., et al. 2023; Valdez Mendia, J. M., & Flores-Cuautle, J. D. J. A. 2022; Micu, A., et al. 2022; Kumar, S., et al. 2022; Seferian, D. 2024).

Figure (7): What Is Hyper-Personalization in Marketing?
Source: Seferian, D. 2024

Therefore, it can be said from the above that Hyper-Personalization has the computational ability to adapt to the privacy of each individual customer, which is AI enhanced using predictive analytics of big data in real time. So that a goldmine of detailed and explanatory information about consumer behavior is obtained, and this It leads to a better understanding of the purchasing decision process by displaying more relevant product recommendations. And the expected marketing result will be the creation of unique, enjoyable and exceptional customer experiences. Which will inevitably lead to building audience confidence, strengthening relationships, and generating additional sales. Subsequently, Hyper-Personalization is the fusion of the marketing mix into AI algorithms driven by predictive analysis of big data. So that it creates detailed marketing programs and offers that are completely compatible with what the consumer wants and likes in real time (For further digression, see: Dollarhide, M. 2020; Piletic, P. 2023; Koenigsberg, S. 2023; Intel Style Team. 2024; Morton, F., et al. 2024; Coelho, L., & Cachola, G. 2023; Gourav Digital Club. 2023; Comarch Team. 2024).

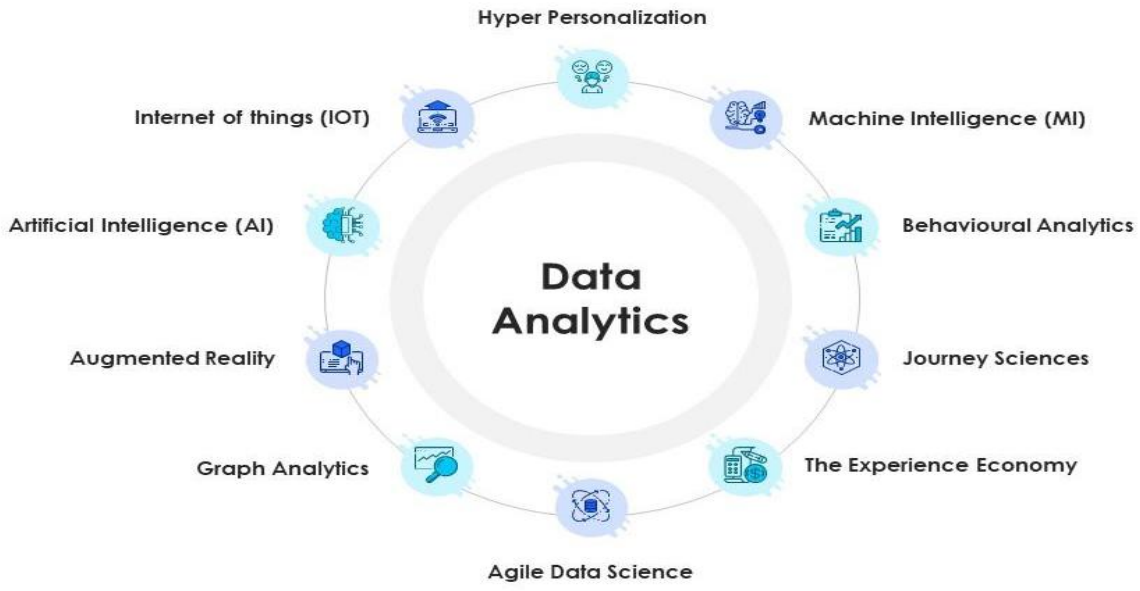

Figure (8): Data and analytics Hyper-Personalization.
Source: Slide Team Staff. 2024

2-2- Pricing Optimization based on AI (Price melting into Marketing Technology)

Marketing Technology enabled on AI offers great potential to eliminate convoluted and complex pricing problems and disturbances, or at least reduce its severity and danger. As the learning and cognitively adaptive machine receives a set of instructions to automate the pricing decision and determine the most appropriate price point for its products and services. More precisely, by being able to process massive amounts of data in real time. Computer algorithms provide the possibility of determining optimal prices at any moment considering the influences and restrictions on price fluctuations are many, such as inflation, shocks, and economic crises, in addition to the variation in the purchasing power of shoppers, the variation in the standard of living, and the differences in tendencies and preferences among consumers. Not to mention senior management's targets regarding forward-looking profit margins and comparing that to competitors in the market. Therefore, the decision maker is forced to draw a discriminating, intelligent and dynamic price roadmap (For further digression, see: Grewal, D., et al. 2020; Stone, M., et al. 2020; Ban, G. Y., & Keskin, N. B. 2021; Gan, L., et al. 2020; Tschora, L., et al. 2022; Horvath, B., et al. 2021; Venigandla, K., et al. 2023; Hertz, L. 2023).

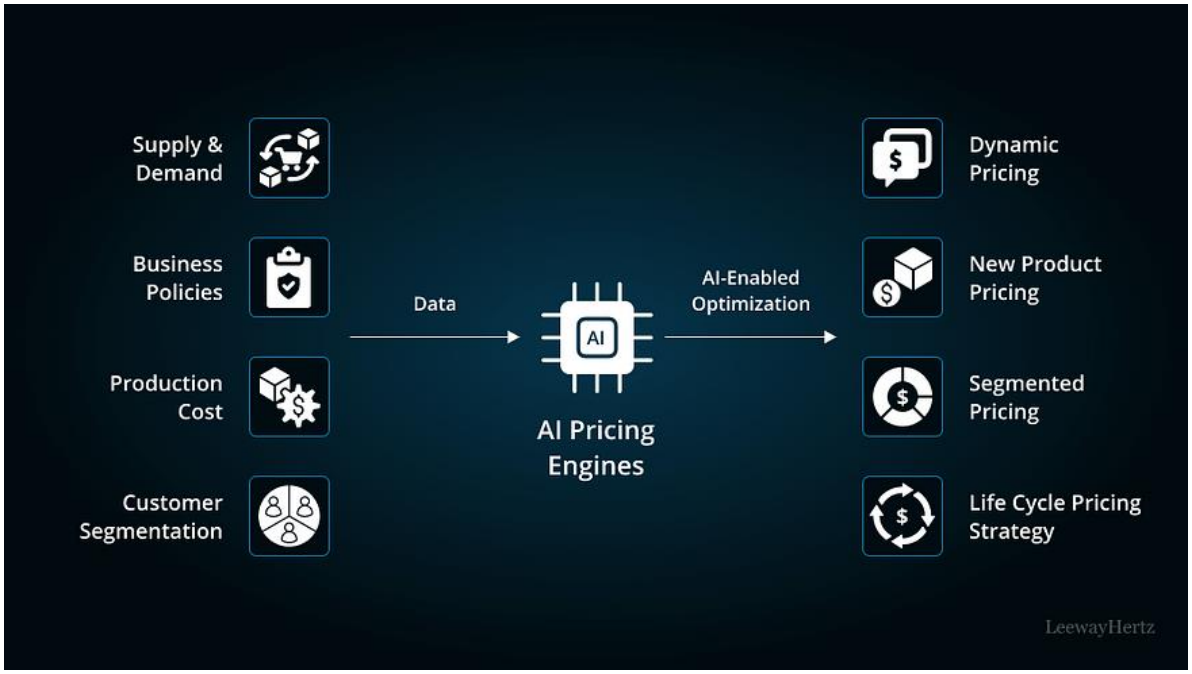

Figure (9): Smart Pricing: How AI is Transforming Pricing Engines?
Source: Hertz, L. 2023

Building an AI-powered dynamic pricing solution represents a pivotal step toward achieving greater efficiency, competitiveness, and profitability in modern business operations. By harnessing the power of AI and advanced machine learning algorithms, organizations can unlock unprecedented capabilities in pricing optimization. Harnessing the flood of data available from customer interactions allows companies to price appropriately—and reap the rewards. Indeed, the secret to increasing profit margins is to harness the data to find the best price for product. Determining prices according to the conditions of rationality and optimality is difficult to achieve due to the complexity and density of internal and external data that require accurate predictive analyses. The data is collected from multiple, diverse and renewable sources, for example (For further digression, see: Guizzardi, A., et al. 2021; Pricing Solutions Team. 2024; Baker, W., et al. 2014; Black Curve Blog Team. 2024; Gazi, M. S., et al. 2024; Takyar. A. 2024; Dowling, L. 2023):

- Historical transactions and records, or what is known as archives.
- Profit and loss analysis for previous years.
- Contextual data, such as customer reviews and trends, and what the customer says about our product on social media.
- Consumer sensitivity to price changes.
- And so on.

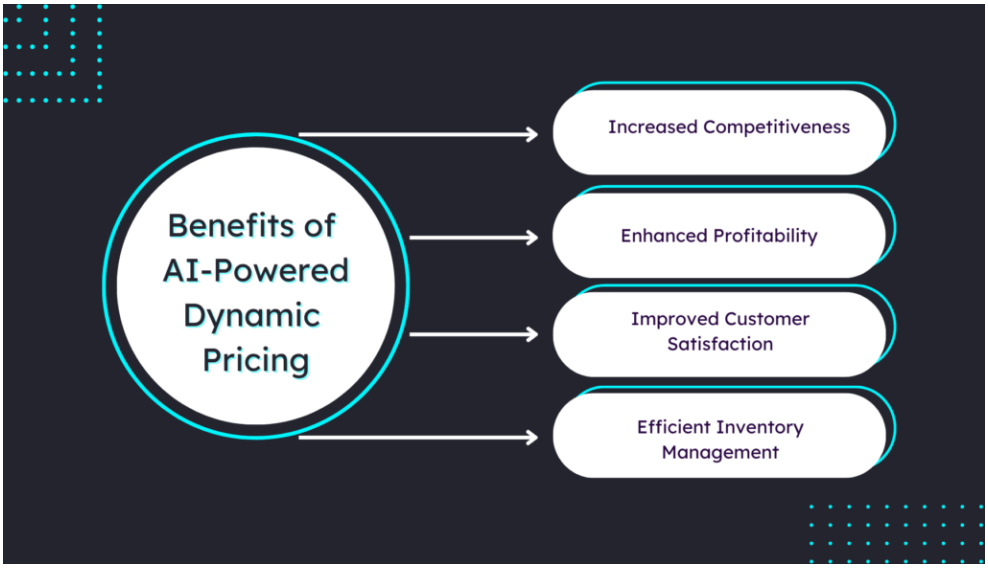

Figure (10): Benefits of AI-Powered Dynamic or Adaptive Pricing
Source: Dowling, L. 2023

Fortunately, digital technologies in the era of Cyber-Physical Systems and Industry 5.0 can help company leaders make better and faster price decisions and increase their profits and returns on marketing investment (ROI). Learning Robots can also participate and contribute to predicting customers' willingness to pay for a product and anticipating their reactions as feedback on various offers and price reductions. There are three vital areas that motivate and activate Marketing & Sales Management to make an exceptional difference and create unique distinction by using AI-enabled algorithms to upgrade price performance, raise returns, and multiply cash flows in dynamic, highly competitive markets (For further digression, see: Thota, V., et al. 2024; Akilandeeswari, S. V., et al. 2024; Cheung, W. C., et al. 2017; Takyar. A. 2024; Kumar, A. 2022):

- Real-time responses to demand and supply.
- Customize prices.
- Learning on demand.

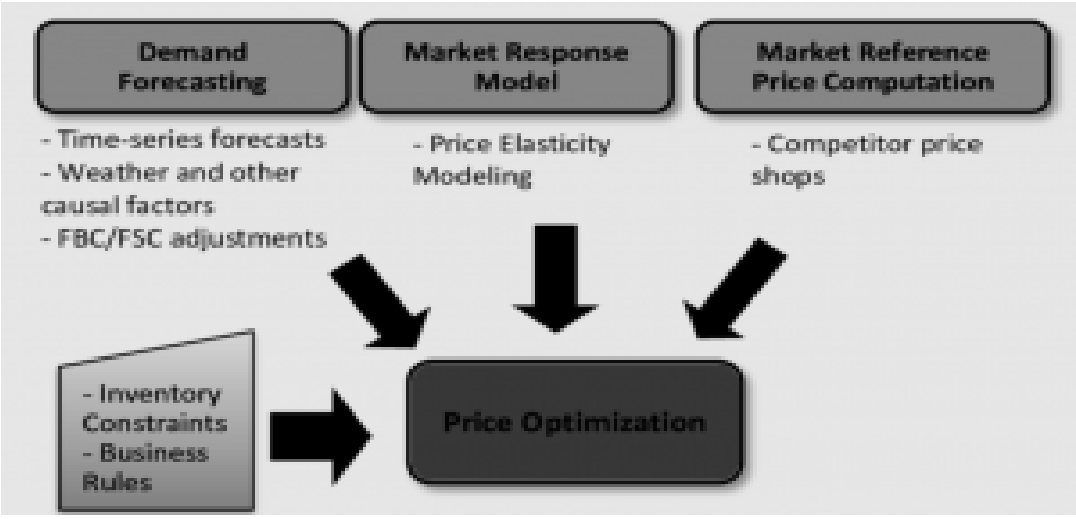

Figure (11): Pricing Optimization & AI Techniques.
Source: Kumar, A. 2022

Dynamic pricing and trending of price scenarios using AI-enabled big data predictive analytics involves adjusting prices in real-time based on cost behavior, market demand, inventory levels and many other critical factors that fall under pricing determinants. This approach ensures that the marketing

executive is always attentive, awake, cognizant, conscious and aware of market changes and can adjust prices smoothly to improve revenues, incomes and profit margins. This flexibility allows for the possibility of offering discounts and allowances according to the dynamics and sensitivity of the markets and according to the status of demand, whether it is slow, fast, low or high (For further digression, see: Zatta, D. 2024; Harazim, A. 2024; Marín, G., et al. 2024; Accenture Team. 2024; Akilandeeswari, S. V., et al. 2024; Cheung, W. C., et al. 2017).

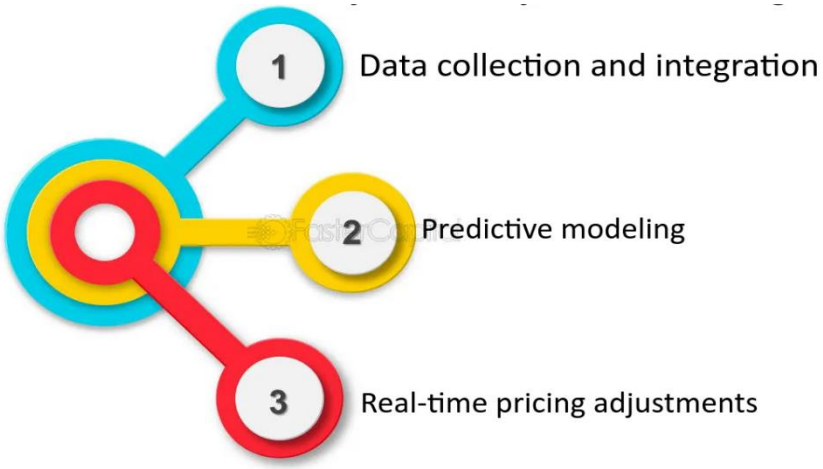

Figure (12): The Role of Data Analytics in Dynamic Pricing.
Source: Faster Capital Team. 2024

Pricing powered by Hyper-Personalization involves offering each customer unique, individual prices that match their preferences, spending habits, purchasing power, and willingness to pay. Computers enhanced with AI can help analyze customer data, their purchasing history, and consumption behavior to establish, design, build and inform each customer of a specified, exact, right, desired, targeted and appropriate price, and even provide personalized price offers on products in which they have previously shown interest. And whereupon success in implementing this approach will certainly lead to building stronger liaisons, links and ties with customers. As well as Improving their satisfaction, confidence, hope, assurance, credence, dependence and reliance in conjunction with increasing their loyalty, adherence, allegiance, devotion, fealty, fidelity, honesty, reliability, sincerity, support and trustworthiness (For further digression, see: Aparicio, D., & Misra, K. 2023; Le, C., et al. 2016; Karr, D. 2016; Clutch Team. 2023; Meyer, A. 2022; Skurniak, F. 2022; Dilmegani, C. 2023).

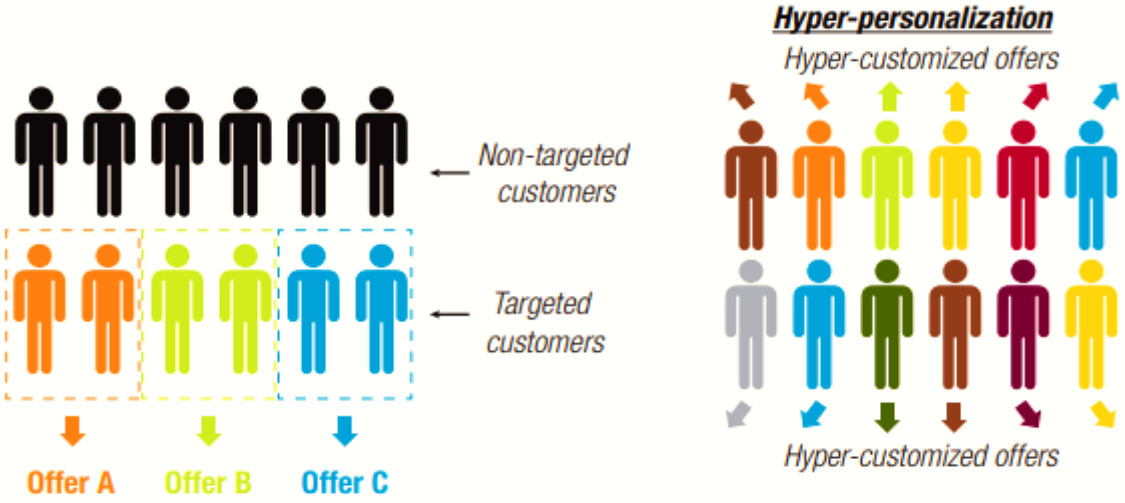

Figure (13): Hyper-Personalization with Big Data and AI
Source: Yagci, E. 2023

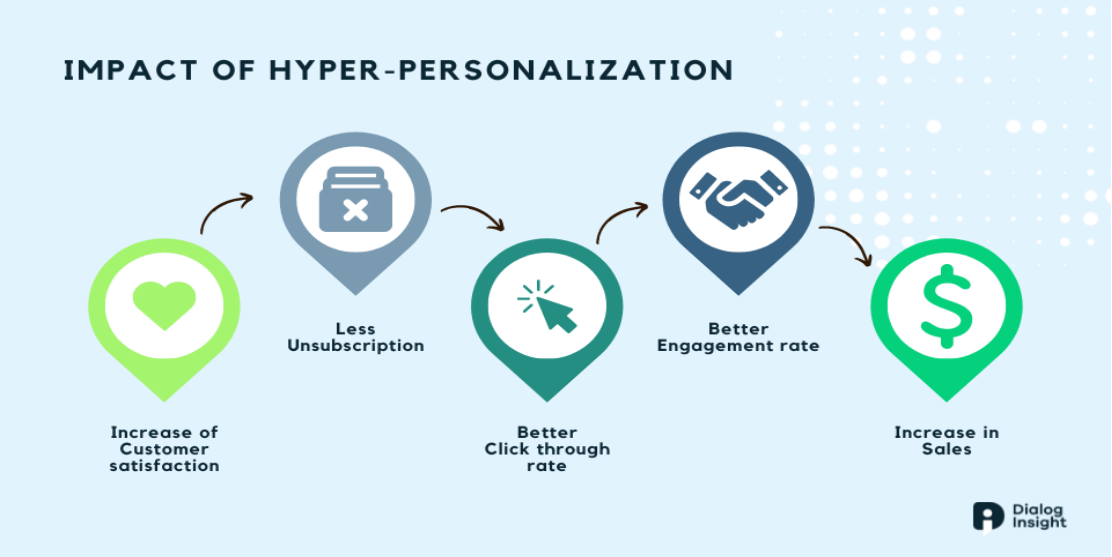

Figure (14): What are the impacts of Hyper-Personalized?
Source: Morin, M. N. 2024

2-3- Birth of Algorithmic Pricing (AP) or Real-Time Pricing (Smart Dynamic Pricing)

In short, Algorithmic Pricing (AP) driven by AI software and applications can be said to be setting dynamic prices based on Smart Automation. In a highly competitive market, companies are constantly looking for new ways and manners to escalation revenues and maintain competitive edge, and as pricing decision makers have become more aware and mature than ever to harness computer technologies and digital innovations in order to determine the customized price. Methods using AI mechanisms and tools are being used remarkably and attractively in the growth driven by making smart pricing decisions and optimizing prices based on Big Data Analysis of customers behavior, experience, and their purchasing decision and journey in real time. Survey studies show that there are many benefits that allow achieving unprecedented gains at an accelerated pace, especially Algorithmic Pricing (AP) based on Hyper-Personalization through sound, safe, appropriate, favorable, precision, accurate and correct targeting (For further digression, see: Gordon. K. 2024; Calvano, E., et al. 2020; Li, Z. 2022; Kühn, K. U., & Tadelis, S. 2018; Van Der Rest, J. P., et al. 2022; Sánchez-Cartas, J. M., & Katsamakas, E. 2022; Chapdelaine, P. 2020; Wu, Z., et al. 2022; Brown, Z. Y., & MacKay, A. 2023).

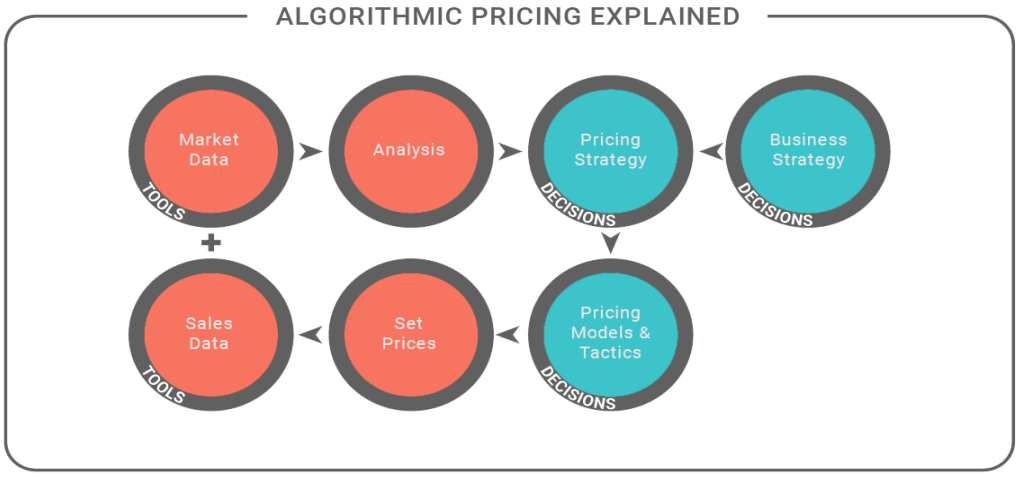

Figure (15): Explaining Algorithmic Pricing (AP)
Source: Convious Blog Team. 2024

Absolutely, cyber-physical systems in light of the fifth wave of successive industrial revolutions have caused an earthquake in marketing methodologies in general and in pricing policies and strategies specifically, as product pricing decisions have become more flexible, dynamic, agility, efficient and rational. There is no doubt that such developments require the injection of large sums of money to

invest in computing resources, and the search for specialists in determining prices with extreme accuracy. Especially since the brand pricing manager does not know with certainty how optimal the price is, the price may be low and not attract demand, or prices may be too high and do not achieve the greatest possible number of sales (For further digression, see: Gordon. K. 2024; Chawla, S., et al. 2007; Assad, S., et al. 2024; Normann, H. T., & Sternberg, M. 2023; Bertini, M., & Koenigsberg, O. 2021; Brown, Z., & MacKay, A. 2022).

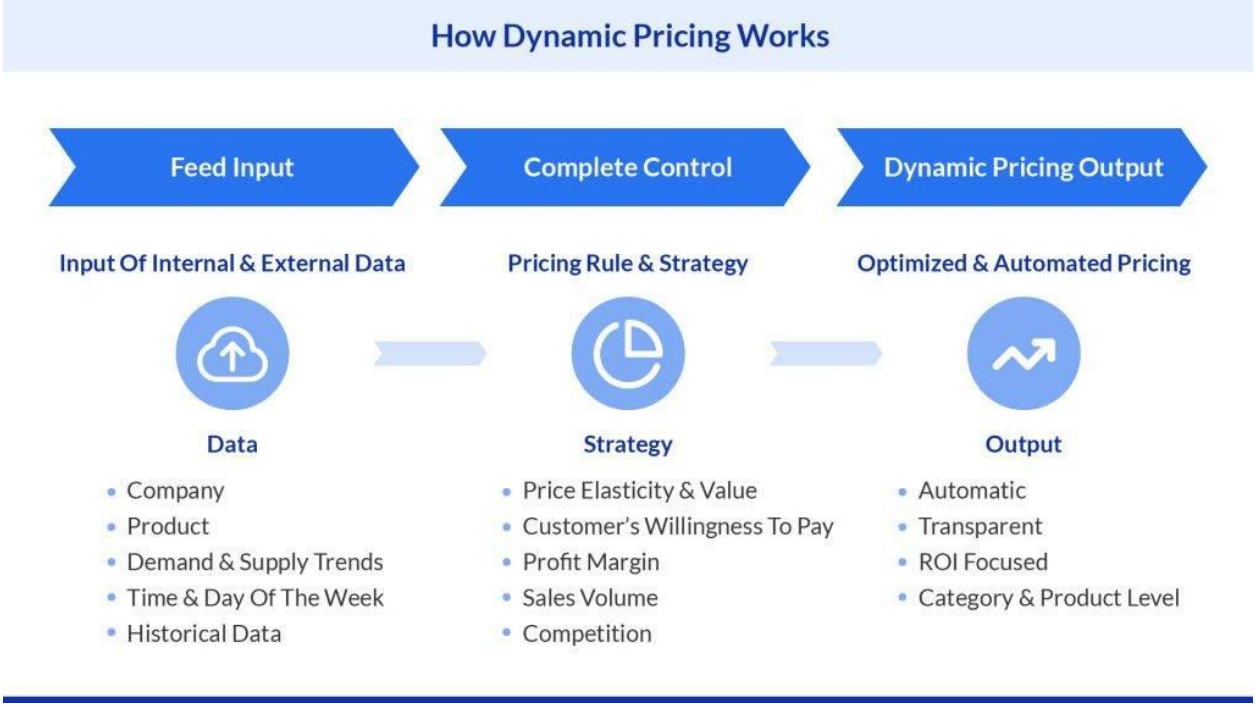

Figure (16): How dynamic pricing algorithms operate?
Source: Flipkart Commerce Cloud Team. 2023

Despite the pros, advantages and gains from a revenue management and benefit maximization perspective, AI-powered Algorithmic Pricing (AP) under the umbrella of Hyper-Personalization, as with any new technology, results in potential challenges, risks, caveats, threats and warnings that companies must be aware of to ensure effective implementation of moral and legal responsibility and overcome barriers, hurdles, obstacles and obstructions. It raises difficult questions including discrimination and bias in data and concerns about fairness, privacy and transparency. Another disadvantages, cons, flaws, shortcomings, criticisms, defects and deficiencies are that the price may be affected by climatic and weather conditions, the cultural and psychological factors prevailing within the organizational structure, or the change in the mood and priorities of the consumer in the purchasing situation, which are factors that are difficult and may not be possible to measure. Although AI algorithms can analyze vast amounts of data faster and more accurately than humans, they may lack the human intuition and creativity needed to make complex pricing decisions. Therefore, decision-making skills and human input are still necessary to ensure that the pricing strategy is consistent with the overall business strategy, and this is what advocates of the Fifth Industrial Revolution who do not support replacing humans with machines (For further digression, see: Seele, P., et al. 2021; Dowling, L. 2023; Gazi, M. S., et al. 2024; Calvano, E., et al. 2019; Musolff, L. 2022; Gordon. K. 2024; Calvano, E., et al. 2020; Li, Z. 2022; Kühn, K. U., & Tadelis, S. 2018; Van Der Rest, J. P., et al. 2022).

Figure (17): Ethical Considerations of Dynamic Pricing.
Source: Dowling, L. 2023

In addition to the drawbacks mentioned above, there is also one potential downside, which is resistance to change. Dynamic pricing strategies and frequent price changes and fluctuations may leave the customer confused, fluster, muddle, perplex and dissatisfied because if customers perceive the pricing strategy to be unfair or inconsistent it may damage the brand's reputation. However, some products and services are fully compatible with the dynamic pricing approach, such as applications for booking flights, travel, and hotels, as individuals understand price fluctuations in this case, but for instance they may become frustrated, perturb, upset and angry when the prices of a retailer's products change. The Boston Consulting Group (BCG) discussed the problem of human resources specializing in pricing fear that AI will eliminate, cancel, terminate and dispose of their roles, but concluded that excluding and get rid of pricing management staff is unlikely. Especially in long-term goals, while automation can handle daily pricing tasks. But with the tremendous technical development, and with training algorithms on a wide range of data, these problems may be overcome in the foreseeable future (For further digression, see: Garden, B. 2023; Cottenie, S., & Liedekerke, L. D. 2019; Accenture Team, 2023; Faster Capital Team. 2024; Cummings, R., et al. 2020; Ittoo, A., & Petit, N. 2017).

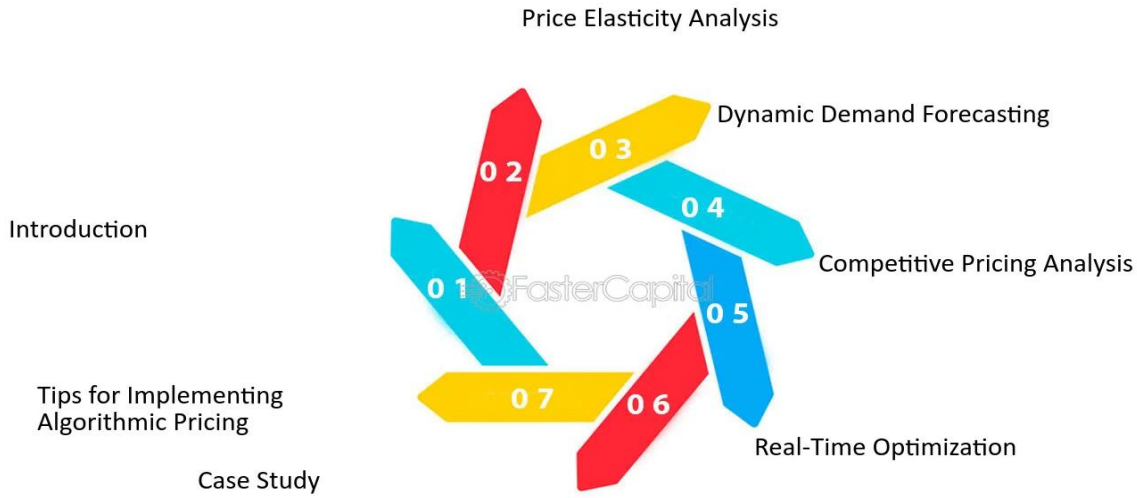

Figure (18): Maximizing Profits through Algorithmic Pricing (AP).
Source: Faster Capital Team. 2024

Conclusion

Ultimately, harnessing Artificial Intelligence in all its aspects, tributaries and branches (Generative AI, Big Data Analytics (BDA), Natural Language Processing (NLP), Large Language Model (LLM), ChatGPT (OpenAI), Virtual Assistants (VAs), Internet of Things (IoT), Blockchain (BC), Cloud

Computing, Quantum Computing, Augmented Reality (AR), Virtual Reality (VR), Nanotechnology, Biotechnology, 3D printing, Self-Driving Cars and Web 4.0), sometimes called Machine Intelligence, is smarts and cleverness exhibited by machines, as opposed to the natural intelligence and brainpower exhibited by human, such as learning and problem solving. In this context, AI technologies are developing very rapidly. This is mainly because automation processes large amounts of data instantaneously, right away, immediately and quickly, it makes predictions more accurate and customization higher quality. Therefore, many global technology companies in various industries are racing and scrambling to pump huge amounts of money to invest in Machine & Deep Learning applications, as the largest successful, distinguished, outstanding and strong business organizations today employ digital innovations to improve their exceptional performances and gain an advantage over their competitors and opponents.

In the same regard, Algorithmic Pricing (AP) is an innovative and a new paradigm methodology for a dynamic, automatic, and customized pricing process for products and services, as an alternative to cumbersome, arduous, and complex traditional pricing plans, schemes, styles and ways. This dramatic transformation and radical shift in pricing approaches, mechanisms, policies and strategies came as a logical and objective result of the efforts seeking to optimize prices and better predict the price that achieves two goals at the same time: satisfying the target market and reaping the desired profits. Smart price management based on exploiting scientific development and technical progress in the field of cyber technologies in general and participates in achieving it Artificial Intelligence with its wings Machine Learning & Deep Learning in particular. This has resulted in a real revolution in companies' approach to pricing strategies enhanced by automation and computer science, especially considering the repercussions of the Fifth Industrial Revolution and within the implications of digital innovations for cyber-physical systems.

To wrap up, the modern Algorithmic Pricing (AP) method supported by AI derives its scientific importance from the strength of estimating the best prices and acquires its practical value from the quality of accurate predictive analysis according to huge historical data, which does not take a long time. The inputs contain a significant number of facts and data about the buyer's demographic, consumer, psychological, personal, behavioral and geographic characteristics and attributes, market trends, order size, inventory quantity, competition structure, economic conditions, flexibility of laws, and others. The optimal and most appropriate price is then extracted, devised, directed, and produced in light of the aforementioned conditions, restrictions, and circumstances. This allocated price, according to Hyper-Personalization mechanisms, leads to maximizing revenues, generating additional sales, developing market shares, and increasing profitability to the maximum extent while maintaining existing customers and attracting more potential customers. Additionally, outperforming existing and prospective competitors.

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