

## ANALYSIS OF HIGH-TECHNOLOGY PRODUCT DEVELOPMENT MODELS

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**Summary.** The power and development indicators of high-technology products stimulate the search for new opportunities and strategies for their successful development and realization. To achieve this, the concept of high-technology product development, relations between high technologies and innovations, factors of high-technology environment uncertainty, and business area- and product-specific features are specified. High-technology development models presented in literature are proposed and their comparison is given.

**JEL classification:** D 800, O310.

**Keywords:** high-technology products, innovations, market uncertainty, technological uncertainty, competitive volatility, product development models, product introduction to market strategy models.

**Reikšminiai žodžiai:** aukštųjų technologijų produktai, inovacijos, rinkos neapibrėžtumas, technologinis neapibrėžtumas, konkurencinis nepastovumas, produktų vystymo modeliai, produktų įvedimo į rinką strategijų modeliai.

### 1. Introduction

The high-technology (high tech) development process, influenced by the innovative process, brings products an exceptional value which stimulates product market demand. Innovation provides products the specific basis for which world economies compete with each other on the global market. Able to find new solutions, innovations generate significant changes in existing markets, destroy them, or create new markets (Hauser et al. 2006). The development of new products using high tech enables small businesses to prosper by conquering their major competitors both in sales volume and company's financial indicators.

Despite the advantages and power of high-tech products on market, the development of these products is problematic. Christensen and Raynor (2003) have stated that over 60% of all new high-tech product development efforts are stopped before

they are commercialized, and 40% of the remaining products are withdrawn from the market (Allen 2003). Failure rate by Christensen and Raynor is high but quite optimistic compared to research by Corporate Strategy Board. According to that board, failure rate of new business ventures is over 90% and could be as high as 99% (Sharma et al. 2008). Although the results of both researches slightly differ, similar failure rates for high-tech products could be expected. A variety of surveys were conducted to determine the reasons of high-tech product development failures. Traditionally, marketing experts have argued that high-tech product failures are due not only to managerial mistakes but also due to environmental constraints (Hauser et al. 2006). Anderson has argued that timidity and incentive problems at large firms restrict their research and commercialization efforts (Sharma et al. 2008). However, Hopkins (1980) has summarized Cooper and other authors' researches and suggested the following reasons of new high-tech products' failures: 55% of surveyed companies have stated that problems are related to marketing, 16% have mentioned product defects, 10%—too high new products development costs, 6% - production problems, and 13%—other reasons (Allen 2003).

The aim of the article is to analyse models which influence high-tech product development.

The objectives of the article are to clarify high-tech development concept, observe models influencing high-tech product development, proposed by scientists, and carry out the comparison of these models.

## **2. High-Tech Product Development Concept**

In order to formulate high-tech product development concept, it is necessary to provide the definition of high-tech products. Mohr et al. (2010) argues that there are two reasons why it is important to clarify and specify high tech: (1) due to the impact of technologies on the economy, attempts are made to classify economic production and incomes; (2) due to the impact of high tech on the environment, standard marketing strategies are being modified and adapted, therefore, it is necessary to know the products to focus on.

Scientific literature uses different terms to define the products related to scientific and technological application. Table 1 presents the comparison of these terms.

The comparison of the terms used in the scientific literature has revealed that it is highly important to define relations between high tech and innovation. Hauser et al. (2006) have stated that the main goal of innovation is to maximise the profitability by creating new products and modifying existing ones. According to the Organisation for Economic Co-operation and Development (OECD) classification, which is widely used in economic analyses for innovation development, high-tech products are product innovations which can be classified into technologically-new and technologically-advanced products (Hatzichronoglou 1997).

**Table 1.** Comparison of the Concepts Used for Identification of Science and Technology Products (prepared by authors)

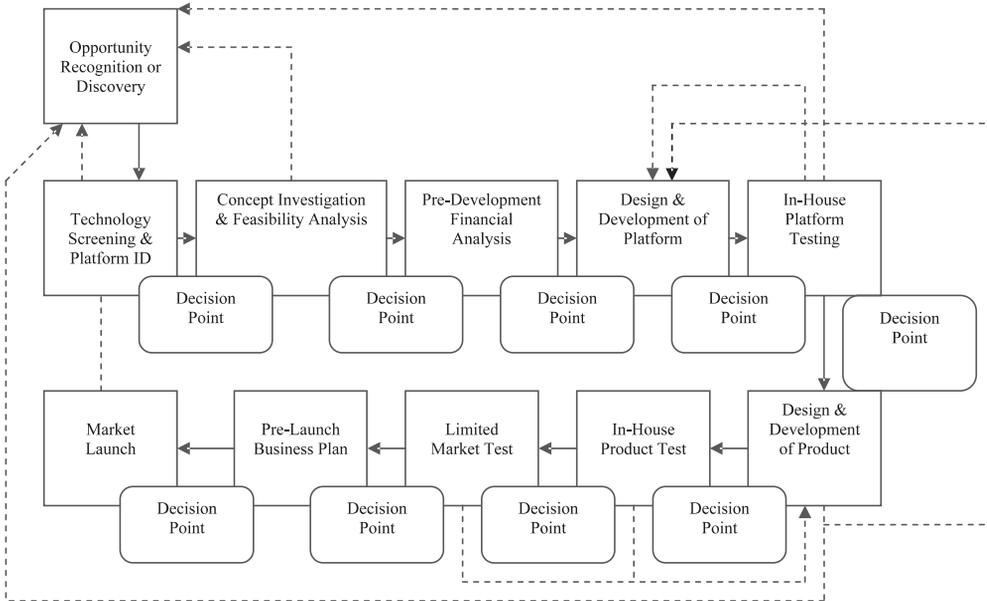
Concepts Used	Author (Year)
Product innovation and technology	R. G. Cooper, S. J. Edgett (2010)
High-tech products and innovations	J. Mohr, S. Sengupta, S. Slater (2010)
Product innovation	K. Tollin (2008)
	J. Zhang, C.A. Di Benedetto, S. Hoenig (2009)
Technology innovation products	V. Zurylo, N. Iazvinsk (2007)
High-technology products	K. R. Allen (2003)
	J. Strebel, T. Erdem, J. Swait (2004)
	A. Sharma, G. Iyer, H. Evanschitzky (2008)
	C. Easingwood, S. Moxey, H. Capleton (2006)

American Scientific Literature suggests the concept of high-tech company. U.S. Bureau of Labor Statistics defines high-tech firms as those that, compared with traditional manufacturing companies, employ twice as many technical personnel and devote twice as many resources to scientific research and development (Moriarty & Kosnik 1989). According to Hecker (2005), high-tech companies are engaged in the development and introduction of new products and/or innovative manufacturing processes through the systematic application of scientific and technical knowledge. On the basis of the above high-tech company concepts, it could be assumed that the products created and produced at such companies are high-tech products. OECD describes high-tech products as products with high research and development intensity (Hatzichronoglou 1997). However, George et al. (1999) suggests that high-technology markets are, at the same time, blessed and condemned due to revolutionary improvements that result in technological discontinuities.

It could be concluded now that high-tech products are complex, advanced, requiring specific technical knowledge, which is technologically discontinued, and being produced at the companies which have twice as many technical personnel and invest twice as many in scientific research and development than other companies. Moreover, these products are time-sensitive as scientists are continuously searching for new approaches for invention of more-advanced technologies which make all preceding ones lower-ranking.

Allen (2003) has proposed a framework which illustrates high-tech product development process from the conception to the bringing of the product to the market. The framework was prepared and modified according to Cooper's (1994) research conception of the transition to the next stage of the development and Miller and Moris' (1994) project development platform. The graph divides the process into phases, tasks and objectives with the reversible action chain, which means that the process is mainly repeated. All phases are characterized by intermediate stages. Activities, divided into distinct phases, provide information sufficient for moving the project into the next

step. Outcome is similar to Cooper's transition to the next stage of the development, where the results are foreseeable to evaluate the criteria which help to decide whether the project should be returned back or continued. The essence of this decision represents informal networks within the company and project teams, which are often supplemented from aside (Figure 1).



**Figure 1.** High-tech Product Development Process according to Cooper (1994), Miller & Moris (1999), Allen (2003)

Product introduction into the market usually requires higher time, money and managerial activities costs (Hultink, Hart 1998). It is defined as the stage of new product development process, when the particular product is brought to the market in order to initiate sales (Hart 2005). An important aspect of product introduction is to gain maximum benefit and expand target market size (Guiltnan 1999; Hultink & Langerak 2002) and the tactical level of market entry (Hart, Tzokas 2000). Dund and Krentler have defined market entry strategy as an integral part of marketing decisions which are necessary for bringing the product to the target market and starting generating incomes from new product's sales (Hultink et al. 1997; Garrido-Rubio & Polo-Redondo 2005; Sepp et al. 2009).

High-tech product development is exceptionally difficult due to the sector-specific technological and market uncertainty and competitive volatility. Market uncertainty refers to ambiguity about the type and extent of customer needs that can be satisfied by a particular technology (Fermeri 2003) and arises from the following sources: (1) consumer fear, uncertainty, and doubts about what need or problems the new technology will address, as well as how well it will meet those needs. It also remains unclear how

consumers will adopt the particular technology. It means that customers may delay adopting new high-tech products, and, in order to mitigate the prolonged uncertainty, require a high degree of education and information about the product, and need post-purchase reassurance; (2) customer needs, in high-tech environments, are characterized by sudden changes related to unpredictable fashion; (3) the consumers concern about how to preserve new product's competitive technological standards is completely incompatible with technological uncertainty; (4) the prevalence rate of the products of these particular sector, which is influenced by the above mentioned reasons, is much slower than of traditional products. In many cases, high-tech product markets are being materialized slower than they are expected; (5) the uncertainty of the speed of consumer ability to adopt new products stems from the inability for manufacturers to estimate the size of the market.

Technological uncertainty refers to not knowing whether the technology can deliver on its promise to meet specific needs (Moriarty & Kosnik 1989). Mohr et al. (2010) have determined five factors giving rise to technological uncertainty: (1) uncertainty related to the question whether the new product will function as promised; (2) uncertainty related to the timetable for development of the new product. In high-tech industries, the time required for product development is difficult to predict as, commonly, it takes longer than expected; (3) uncertainty related to the supplier's ability to provide prompt, effective service; (4) uncertainty related to unanticipated consequences or side effects of the product; (5) uncertainty about the product life cycle related to competitive volatility.

Competitive volatility depends on the degree of intensity of changes in competitive environment, as well as on the uncertainty about the competitors and their strategies. It has three dimensions: (1) uncertainty related to the question who the competitors are; (2) uncertainty related to competitors' market strategies; (3) uncertainty related to competitors' product offerings (Mohr et al. 2010).

Other scientists define characteristic features of high-tech industry. It is argued that: (1) high-tech market is global market, i.e. it can not be technologically only locally "high," it is characterised by worldwide uniqueness, and affects not only one national market, but the whole sector globally. Moreover, single-country market is usually too small to develop new technological solutions; (2) high tech is characterised by quick changeability, i.e. their life cycle is short. It is impossible to define one specific scope of technologies as high tech as those technologies which were yesterday regarded as high tech, today may already become common widespread technologies; (3) high-tech business is risky as it is difficult to estimate the long-term value of the developing technology, product or service; (4) high-tech business is especially susceptible to financial investments both in the case when new technology or product production requires investments into the costly researches, and in the case when new service is provided, which requires investments in the necessary technologies and products (How to Start... 2010).

Still other scientists believe that the risk in high-tech product development industry is related to specific high-tech product and their development features. Davidow,

McInnis, Helslop and Goldman (1995) suggest that short life cycle and close relations with technology and science are very important high tech features (Riggs 2000), whereas McIntyre (2004), Sahadev and Jayachandran (2004) refer to close connection between high tech and the existing infrastructure (Petrauskaitė 2009). Generally, the customer does not perceive the new technology; therefore, it is difficult to explain the customer product's functioning criteria (Abernathy, Utterback). Meldrum (1995) argues that the emergence of the new product in the market signals for the absence of the solutions for some particular problem solving resulting in the necessity of the invention of the new product. According to Gardner et al. (2000), high-tech market is especially risky, and high-tech business is particularly investment-intensive due to the dependence on the rapidly changing technological environment and short product life cycle. Some other others believe that high-tech business could be risky due to the following reasons: (1) it is difficult to estimate in advance the long-term value of the developing technology, product, or service from its introduction to the market till it reaches its maximum consumption level; (2) due to highly innovative and sophisticated technologies, it is difficult to perceive the service, its value and benefit, and start to use it (Petrauskaitė, 2009).

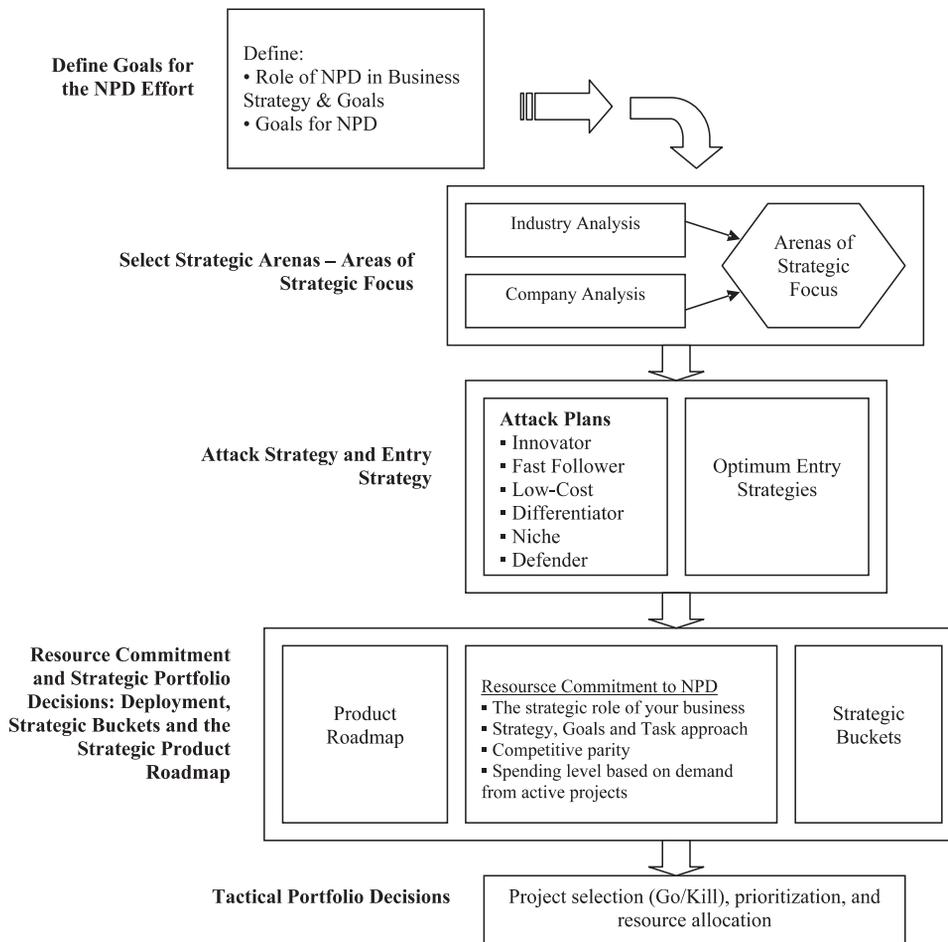
**Table 2.** High-tech Product Specific Features

High-tech Product Features	Goldmann, 1982	Riggs, 1983	Shanklin, Ryans, 1984	Von Hippel, 1986	McIntyre, Grunenwart, Rosenau, Vernor, 1988	Nystrom, MacInnis, Helslop 1990;	Allen, 1992	Meldrum, 1995;	Hecker, 1999;	Sahadev, Jayachandran, 2004
Short product life cycle	+	+	+		+	+				
Closely related to technological development		+	+				+	+	+	+
Closely related to science		+	+				+	+	+	
Closely connected with existing infrastructure					+			+		+
Difficult to use and explain functioning criteria				+				+		
Lack external infrastructure								+		
Unrecognised as appropriate to address issues they have for								+		

The above presented arguments ground the uniqueness of high-tech products and the necessity of required solutions related to their development. In order to find solutions for high-tech product introduction to the market problems, the process of the product development and introduction must be analysed integrally as, according to Hart (2005), the introduction of new product is simply the stage of new product development, when the product is brought to the market in order to initiate sales. However, Sepp et al. (2009) define new product introduction strategy as an integral part of marketing solutions which are necessary for bringing the product to the target market and starting generating incomes from new product's sales.

### **3. High -Tech Product Development Conceptualisation**

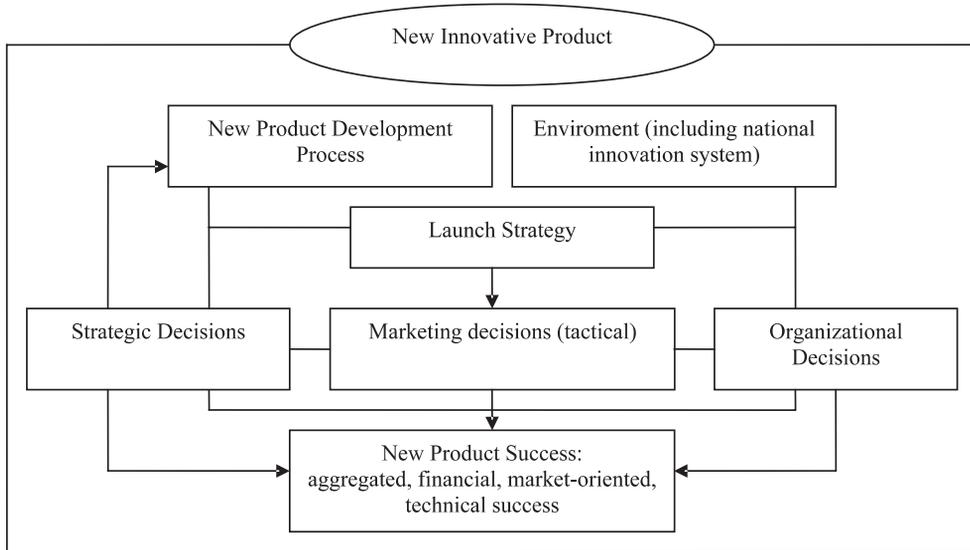
Cooper and Edgett (2010) state that high-tech firms lack explicitly formulated strategy and suggest the framework covering the process from the establishment of business goals and objectives to the allocation of resources. Authors also present the steps of new product development (NPD) strategy and describe the importance of goals and objectives of innovative products. The term "strategic arena," used by these authors, refers to the particular business-oriented market, industry, application, product type or technology; i.e. all the efforts concentrated on a new product. In order to identify "strategic arenas," Cooper and Edgett (2010) use the product-market matrix and the "strategic map." The product-market matrix helps to visualize and identify "strategic arenas." "Strategic map" is a tool used to evaluate the potential "strategic arenas" and arrange them according to their business power and attractiveness. "Strategic map" results in the assessment of the most attractive "strategic arenas." The question concerning how to attack each "strategic arena" is also a part of product innovation strategy. The strategy of product's introduction to the market might be independent referring to the product development within the company or searching for possible alliances for licensing, partnership, co-operation or open innovation as a way to enhance the opportunities of the product development in new arenas. Numerous companies use the "strategic buckets" method, in order to make decisions about the allocation of resources. "Strategic buckets" method is the basis of the conception, the method which turns the theory into practice and determines where resources will be used: either in one of the proposed plans, market, geographical segment, or in the "product arena." The "strategic map" proposed by the authors, is an effective way to consistently set out the key actions of the "attack plan" (Figure 2).



**Figure 2.** Framework for Product Innovation and Technology Development (Cooper & Edgett 2010)

Sepp et al. (2009) suggest that new product introduction strategy and success measures are treated differently in the literature. Introduction strategy is influenced by strategic and organisational factors (Pattikawa et al. 2006; Chiu et al. 2006) and marketing changes (Chiu et al. 2006). Organisational impact means controlling the introduction process, as well as such “soft measures” as corporate culture. Marketing changes affect the whole marketing structure as tactical decisions for the product introduction. Strategic changes cover key indicators related to market and external innovative environment, particularly national innovative systems. According to Sepp et al. (2009) different measures of the new product activity are divided into four major categories: single, market-oriented, technical and financial (Chiu et al. 2006; Baker & Sinkula 2005; Lee & O’Connor 2003; Green et al. 1995). In order to evaluate to what extent Estonian national innovation system affects high-tech product introduction to the market, Sepp

et al. (2009) have proposed a conceptual framework which reflects the success of the new product on the market (Figure 3).



**Figure 3.** Framework of New High-Tech Product Entrance Success Factors (Sepp et al. 2009)

According to Mohr et al. (2010), the kind of marketing strategy depends on the type of innovation. The product's chances to succeed greatly increase if marketing strategies, tools and types of innovations are appropriately composed. Contingency theory is a class of behavioural theory that claims that there is no best way to organise a corporation, to lead a company, or to make decisions, and the optimal course of actions is contingent upon the internal and external situation. This theory states that one sequence of variables affects another sequence; i.e., marketing variables affect the new product's success. This interaction depends on a third variable, namely the type of innovation. High-tech marketing contingency theory of high-tech marketing claims that in order to successfully commercialize high-tech products, the nature of the marketing strategies must be appropriately matched to the type of innovation. In this case, two types of innovations are identified: (1) breakthrough (or radical) innovation, which is a radically new kind of innovation, unequal to any other kind of the existing innovation practice or perception; (2) incremental innovation, which is a kind of innovation, when generally minor improvements are made with existing methods, may involve extension of products already on the market, whereas, product features are typically well defined and understood by customers (Mohr et al. 2010).

The estimation of marketing objectives and strategies of technological innovations can be carried out according to the matrix of the three factors, which focuses on the innovative product market development directions, the final product, and the technology. This matrix is a detailed product/market framework proposed by I. Ansoff (1999). Table 2 presents the essence of marketing strategy, based on Ansoff's matrix.

**Table 2.** Marketing Strategies for Technologically Innovative Products by I. Ansoff (1999)  
(Zhurylo, Iazvinka, 2007)

Market	Product	Technoloohy	
		New	Existing
New	New	Architectural strategy	Family (pinch) if innovations strategy
	Existing	External modifying innovation strategy	External innovations diffusion strategy
Existing	New	Deepending innovations sstrategy	Dividing horizontal diffusion strategy
	Existing	Internal modifying innovations strategy	Developing diffusion strategy

Architectural strategy is realized in the case of development of the innovation technologies which are used by a producer for creation of new innovative commodities and accordingly, new markets. In this case an enterprise is oriented on realization of researches in a few various scientific directions the results of which can have multipurpose application and solve different problems of consumers. The final result of enterprise scientifically-technological activity is the creation of so-called architectural innovation the technological advantages of which gives the creator the opportunity to form a structure of new market, to set own rules in accordance to market policy, marketing actions and others like that.

External modifying innovations strategy directs a technological enterprise on realization of scientifically-designer works which enable to perfect the final product, that already present at the market. However application of various modifying innovations provides to creation of market niches the consumers of which show preference to the offered product due to the use of the innovative technology and unique technological properties.

Deepening innovations strategy is related to development of the innovative technology which enables to create new products that attract consumers with the row of substantial technological advantages. A new commodity satisfies the existent needs of consumers at high-quality new level. Introduction of innovative technology promotes universality of product, comfort of its use, safety. With the help of this strategy a producer penetrates deeper to the formed market and occupies leading positions.

Internal modifying innovations strategy. The innovative technological elaborations form the wide circle of possibilities in relation to creation of various modifications of commodity which is used by consumers. Innovative activity in this direction illustrates active application of growing innovations, that, in the turn, provides expansion of commodity assortment, continuation of life cycle of products, more high-quality meeting of existent market needs, fixing of enterprise at the acquainted market and increase of his competitiveness.

Family (pinch) of innovations strategy. A technological enterprise use scientifically-technological elaborations which were made earlier, for manufacturing of new

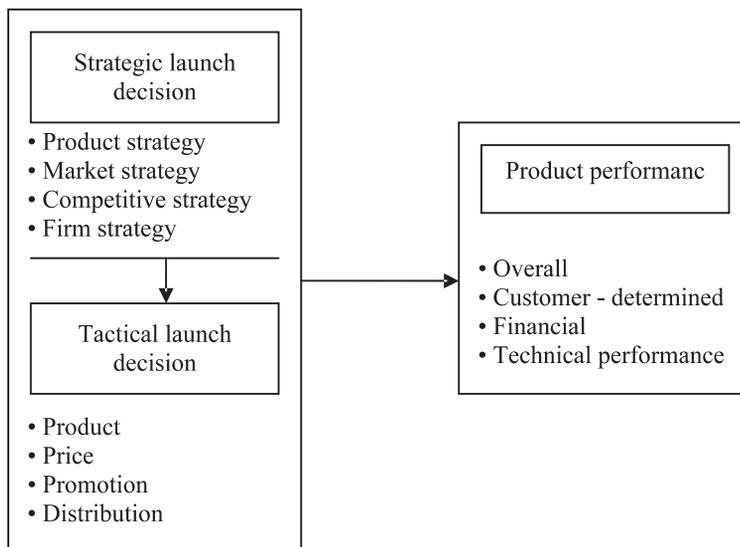
products and distributes it at new markets. In this case an enterprise forms the briefcase of multipurpose innovative technologies, which afterwards provide a basis for manufacturing of many products oriented to the different markets, and prove competitive advantages in the near future.

**External innovation diffusion strategy.** The use of the scientifically-technological elaborations made by an enterprise enables to perfect an existent product by such method, that it can be applied in different industries and, accordingly, be realized at the different markets. Not making technological efforts, a manufacturer tries to extend a sphere of product use, actively using marketing actions.

**Dividing horizontal diffusion strategy.** An enterprise directs efforts on creation of family of new products, using existent technology, and moves forward these products at the old market. Strategy is effective in the case of low saturation of market and permanent growth of demand from the side of purpose-oriented consumers.

**Developing diffusion strategy.** An enterprise in full uses existent technological potential and repeatedly perfects a product that enables it to extend the volume of active market. Application of this strategy does not foresee introduction of considerable technological changes in a product. If a producer is fully sure in market constancy, consumer advantages of the products and forecasts low technological activity of competitors, can boldly activate the activity in this direction (Zhurylo, Iazvinka, 2007).

Hultink et al. (1997) and Chiu et al. (2006) have proposed the exact framework for the elements of high-tech product introduction strategy. These strategic launch decisions determine what to introduce, where to introduce and why to introduce. Product launch decisions are based on the strategic and tactical solution-complex, and, complementing each other, they increase and influence new product performance (Figure 4).



**Figure 4.** Impact of Product Launch Decisions on Product Performance by Hultink et al. (1997) (Chiu et al. 2006)

One of the most influential models to illustrate customers' adoption of innovations is based on E. Rogers's (2003) framework for the evaluation and adoption of innovations. His model describes the critical characteristics that influence a customer's potential adoption of a new innovation as well as the various categories of adopters that adopt over time as a new innovation diffuses through a market. These categories include innovators, early adopters, early majority, late majority, and laggards. Innovators, early adopters, and the early majority adopt an innovation prior to the average time of adoption, whereas the late majority and laggards adopt after the average time of adoption. G. A. Moore has adapted the theory of adoption and diffusion of innovations for the purchase of high-tech products. His key insight about how to modify the traditional adoption and diffusion theory to account for the unique environment of high-tech products is the large gap, or "chasm" between the early market (composed of innovators and early adopters) and the mainstream market (early majority and laggards) (Mohr et al. 2010). "The chasm" refers to as the gulf between visionaries (early adopters) and pragmatists (early majority). It derives from critical differences between these two categories of customers. Visionaries treat pragmatists as pedestrian, whereas early majority think visionaries are dangerous. Visionaries will think and spend big, whereas pragmatists are prudent and want to stay within the confines of reasonable expectations and budgets. Visionaries want to be first in bringing new ideas to the market, but pragmatists want to go slow and steady. "The chasm" arises because the early market is saturated but the mainstream market is not yet ready to adopt; therefore, there is no one to sell to. The nature of a firm's marketing strategy in selling to visionaries is very different from the marketing that is required to be successful with pragmatists. Many firms do not understand this difference and are unable to make the necessary shift in strategies to be successful (Moor et al. 2002).

#### **4. Conclusions**

To sum up, it must be stated out that the proposed models are based on information management and careful selection of the alternative solutions and their time allocation. Cooper & Edget (2010) and Allen (2009) have suggested the models which offer strict and exact framework for actions designed for high-tech companies in order to develop their products and plan the realisation of these products on the market. According to the authors, the decisions, which are made before the development or during the development process, have especially strong impact on the product's success on the market. Market research and summary of information are essential for the successful realisation of choosing an appropriate solution alternative. In Chiu et al. (2006) model, decisions are based on the strategic and tactical decision-complex, which strengthen and complement each other, thus, affecting new product performance. Sepp et al. (2009), in order to evaluate how national innovation system supports innovative product introduction to the market, have suggested a conceptual framework reflecting new products' success on market. Mhor's (2010) contingency theory and Ansoff's

(1999) product/market matrix help high tech developers and producers to indicate the right action direction due to the type of innovation, product and market features. Moor (1991) has adapted exceptionally customer-centred adoption and diffusion theory for high-tech product purchases. This theory identifies the importance of strategy application according to high-tech product life cycle, customer categories and high-risk phase in high-tech product life cycle.

In their publications, authors, in order to emphasize the power of high-tech products, name the factors due to which the development of these products becomes difficult. This process is related to the specific market and technological uncertainty and the competitive volatility. The results of the researches conducted by scientists have shown that this problem requires solutions related to marketing problems.

As the result of close and careful analysis of the models affecting high-tech product development presented in this article, I suggest to divide them into the categories and apply into the following order:

- models designed for the purification of product development direction affecting the position of the product and market at the initial product development phase;
- strictly-structured models designed for the determination of the actions from the initial development stage to the product introduction to the market, or tangible results;
- models identifying the impact of the factors on the product introduction to the market;
- models that focus on the impact of customer behaviour on product life cycle.

The categorisation of these models leads to the preconditions for their application in different product development stages. Product introduction to the market and new product development process are closely related to each other because of the product introduction being the part of product development process; therefore, they must be analysed as a single process.

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## AUKŠTŲJŲ TECHNOLOGIJŲ PRODUKTŲ VYSTYMĄ ĮTAKOJANČIŲ MODELIŲ ANALIZĖ

Vaida ZEMPLICKIENĖ  
Vilniaus Gedimino technikos universitetas

**Santrauka.** Produktų, sukurtų įdiegiant aukštąsias technologijas, vertė bei galia yra tiek įmonės gerovės, tiek ir šalies ekonomikos variklis. Šių produktų vystymo nesėkmės mastas skatina išsiaiškinti šio reiškinio priežastis, stabdančias aukštųjų technologijų sektoriaus plėtrą, ir ieškoti naujų galimybių bei strategijų, sudarančių prielaidas sėkmingam šių produktų vystymui bei realizavimui. Siekiant šio tikslo apibrėžiama aukštųjų technologijų produktų vystymo samprata, išryškkinamas aukštųjų technologijų ir inovacijų santykis, įvardijami aukštųjų technologijų aplinkos neapibrėžtumo veiksniai, šiai verslo sričiai bei produktams būdingi ypatumai. Pateikiami literatūroje įvairių autorių siūlomi modeliai, susiję su produktų, sukurtų įdiegiant aukštąsias technologijas, vystymu, atliekamas jų lyginimas.

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**Vaida Zemlickienė** – Vilniaus Gedimino technikos universiteto Verslo vadybos fakulteto doktorantė. Pagrindinės mokslinių interesų kryptys: produktai, sukurti įdiegiant aukštąsias technologijas, inovacijos, produkto vystymas, produkto įvedimas į rinką, produkto tarptautinė rinkodara.