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Davydov Vasilii Denisovich

DEVELOPMENT OF INVESTMENT METHODS TO DIGITAL INTELLECTUAL ASSETS

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Scientific adviser:
Doctor of Economics, Associate Professor,
Voronov Viktor Stepanovich

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INTRODUCTION

Relevance of the research topic. The problems of investment in a market economy are constantly in the focus of attention, both in scientific communities and among practitioners. Aspects of investment have gained particular value in new, emerging industries such as the creative economy and related media and entertainment industries. A characteristic feature of the creative economy is its inextricable link between creative activity and the creation of new technologies and goods. The industries and activities that form the creative economy demonstrate sustainable development and are important factors influencing sustainable growth, including the Russian economy.

The sphere of media business and entertainment is one of the most dynamically developing areas of the creative economy, in which intellectual property is the most important factor in the competitiveness of companies. The types of activity related to the creative industry are very diverse, but this study focuses on investment opportunities using copyright digital intellectual assets. The economic turnover of such assets is successfully formed by network electronic intermediaries of a new generation, which include aggregators of intellectual assets - the so-called photo stocks, audio stocks, and copyright aggregators. These intermediaries work with digital images, sound, video and text works in digital form.

In Russia, theoretical and practical research in the field of investment in such assets is not given sufficient attention, so the study of investment opportunities using digital intellectual assets is relevant.

The digitalization of economic activity has a significant impact on financial markets. However, specialized studies on the use of digital assets in investment practice, taking into account the special investment characteristics of such assets, trends in the development of relations in financial markets, as well as the use of new financial technologies, are extremely insufficient.

Based on the foregoing, the relevance of the study is due to:

- The need to develop theoretical and methodological provisions in the field of investment methods in digital intellectual assets, taking into account the specifics of their investment characteristics;
- The growth of digitalization of the investment process and the emergence of modern technologies that can be used to solve problems in the field of investment in digital intellectual assets.

The degree of development of the research topic. Investment activity in general and its problems are discussed in the works of many economists, such as Russian financiers I.T. Balabanov, V.V. Bocharov, V.V. Ivanov, O.N. Korableva, V.N. Livshits, I.Ya. Lukasevich, A.M. Margolin, M.V. Romanovsky, B.I. Sokolov, T.V. Teplova and others.

Abroad, research in the field of investment was carried out by: R. Braley, L. Krushwitz, S. Myers, G. Markowitz, S. Ross, W. Sharp and others.

The problems of the economics of intellectual property, including copyright, are reflected in the works of Russian scientists: L.P. Goncharenko, A.N. Eliseeva, A.N. Kozyreva, Yu.P. Konova, I.E. Shulgi and others. Abroad, such scientists as H. Varian, V. Lands, R. Posner, R. Touse, D. Throsby, R. Watt, and others were engaged in the economics of copyright.

The following works are devoted to the research of digital intellectual assets: V.S Voronova, I.A. Darushina, V.V. Ivanova, A.V. Kazansky.

However, insufficient attention is paid to investment methods using digital intellectual assets.

The purpose of the study: theoretical substantiation of methods for investing in digital intellectual assets of copyright, taking into account the peculiarities of the investment characteristics of such assets, and developing approaches to building an investor's financial decision support system.

Research objectives. To achieve this goal, the following tasks were set:

1. Explore the investment characteristics of copyright digital intellectual assets and identify their features compared to traditional financial assets.

2. Analyze the possibilities of forming investment portfolios, including digital intellectual assets of copyright.

3. Formulate approaches to the analysis of strategies for investing and managing a portfolio of copyright digital intellectual assets, taking into account the peculiarities of their investment characteristics.

4. Develop a structural model for an investment portfolio of copyright digital intellectual assets.

5. Develop theoretical approaches to building an investor's decision support system.

The object of the study is investment activity using portfolios of digital copyright intellectual assets.

Subject of research: a set of methods and technologies used to form and manage investment portfolios, including new classes of digital intellectual assets.

Field of study. The content of the dissertation corresponds to the Passport of the scientific specialty 5.2.4 - Finance; areas of research: clause 7. Valuation of financial assets. Financial asset portfolio management. Investment decisions in the financial sector; paragraph 34. New technologies in the financial sector, their impact on the state of financial services markets. Digital financial technologies (fintech). Digital financial assets.

Methodology and research methods. The theoretical basis of the research is the works of Russian and foreign scientists in the field of economic theory, theory of finance, theory of investment and financial management. In the course of the study, general scientific methods of cognition, analysis and synthesis were applied, as well as methods of machine learning, probability theory and statistical analysis. To perform calculations and visualize the results of the study, MS Office and Netica (Norsys) software packages were used.

The information base of the study includes reports of network companies in the media industry, scientific and methodological publications in periodicals, materials of scientific and scientific-practical conferences, Internet resources, analytical materials and expert assessments affecting the financial activities of companies aggregating copyright intellectual assets (photo stocks , audio stocks, copyright aggregators).

To obtain empirical data, the information databases of the companies "Lori", "Shutterstock", "Stock.Adobe" were used.

The scientific novelty of the research lies in the development of the theory and methodology for investing in copyright digital intellectual assets, as well as in the development of practical recommendations for the design of investor decision support systems based on machine learning methods.

The theoretical significance of the study lies in the development of methods for portfolio investment in copyright intellectual assets, taking into account their characteristics in the digital economy.

The practical significance of the study lies in the development of scientific and methodological proposals and practical recommendations for the development of investment methods using portfolios of digital intellectual assets.

Degree of reliability, approbation and implementation of the results of the study. The key results of the scientific research were published and tested in the prescribed manner, reported and approved at various scientific conferences, including: 4th International Interuniversity Scientific and Practical Conference "Technological Perspective: New Markets and Points of Economic Growth" (St. -December 15, 2018); The 32nd International Business Information Management Association Conference "Vision 2020: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage" (Seville, Spain, 15-16 November, 2018); Scientific conference of postgraduate students of St. Petersburg State Economic University "Problems of economics, science and education in the context of the implementation of a multidisciplinary approach" (St. Petersburg, April 19, 2019); X Anniversary International Scientific and Practical Conference "Architecture of Finance:

Fast and Furious Development of the Economy in the Conditions of External Shocks and Internal Contradictions" (St. Petersburg, April 11-13, 2019); 5th International Interuniversity Scientific and Practical Conference "Technological Perspective within the Eurasian Space: New Markets and Points of Economic Growth" (St. Petersburg, November 7-8, 2019); The 35th International Business Information Management Association Conference (Seville, Spain, 1-2 April, 2020); XI International Scientific and Practical Conference "Architecture of Finance: Challenges of the New Reality" (St. Petersburg, March 22–26, 2021); The 37th International Business Information Management Association Conference (Cordoba, Spain, 30-31 May, 2021); VII St. Petersburg Economic Congress (SPEK-2022): a new industrial society of the second generation (NIO.2): problems, factors and development prospects in the modern geo-economic reality (St. Petersburg, 31.03-01.04.2022).

The results of the study were used in the implementation of a research project under the Contract 6/15 dated 15.03.2018 between St. Petersburg State Economic University and PJSC CB "Ural Bank for Reconstruction and Development" on the topic "Development of the concept of an expert decision support system for managing the profitability and risk of portfolios of digital intellectual Assets” in terms of the analysis of scientific literature in the subject area of the DSS, and the analysis of the patent base for the relevant sections of the IPC.

The results obtained in the dissertation research are used by the Department of Finance of St. Petersburg State Economic University for teaching the academic disciplines "Intellectual Property in the Investment Process", "Financial Design" to undergraduates studying in the direction of preparation 38.04.08 "Finance and Credit", the focus of the program "Corporate Finance"; discipline "Financial engineering" for undergraduates in the direction 38.04.02 "Management", focus "Financial management of the organization".

Publications. The main provisions of the dissertation research were published in 20 printed works with a total volume of 13.2 pp. (author's volume 8.2 p.p.), including 9 works with a total volume of 10.5 p.p. (author's volume 6.8 pp) - in peer-reviewed scientific publications recommended by the Higher Attestation Commission under the Ministry of Education and Science of Russia, 2 articles with a total volume of 1.3 pp. (author's volume 0.6 pp) - in publications indexed in the international scientific citation database Web of Science.

Personal contribution of the author. All main results were obtained personally by the author or as a result of joint work with other researchers. In preparing the dissertation, the author took part in collecting and processing primary statistical information, building a model of a portfolio of digital intellectual assets, training the model, as well as conducting experiments with the model.

The volume and structure of the dissertation research. The purpose and objectives determined the structure of the dissertation research, which consists of an introduction, three chapters, a conclusion, a list of references (155 sources) and applications. The text of the work includes 18 tables and 52 figures.

Main scientific results:

1. The main features of the investment characteristics of copyright digital intellectual assets are identified, both in comparison with traditional financial assets and with patents. It is shown that these features are explained, among other things, by a fundamentally different mechanism for the market sale of assets. The determining factor in income volatility in this mechanism is not the floating market price quotation, but the number of asset sales. Also, the most important feature of this mechanism is that the same asset can be sold multiple times. These features must be taken into account when forming investment portfolios, which will ensure their effective management. (Davydov V.D. Conceptual approaches to investment analysis of portfolios of digital intellectual assets / V.D. Davydov // Financial Economics. - 2020. - No. 2. - P. 25-29. Print vol: 0.58; author vol. 0.58; Davydov V.D. Problems and paradoxes of digital investments / V.S. Voronov, N.Y. Puzynya, V.D. Davydov // Proceedings of the St. Petersburg State University of Economics. - 2020. - No. 5 (125). - P. 19-25. Print vol: 0.81; author vol. 0.37).

2. An approach to portfolio analysis of copyright digital assets based on the principles of inertial investment is proposed. The proposed approach is justified by the fact that in the course of the study, for the first time, the property of inertia was revealed for assets of this class. The paper shows that the investment analysis of the portfolio, taking into account the effect of inertia, makes it possible to single out groups of assets according to the degree of risk and evaluate their impact on the achieved indicators of the portfolio's return as a whole. The presence of the effect of inertia is fixed according to the data of more than ten years of observations. (Davydov V. The Nature of Momentum Effect in Digital Copyright Assets Portfolio / V. Voronov, A. Kazansky, V. Davydov // Proceedings of the 35th International Business Information Management Association (IBIMA). 1-2 April 2020. – Seville, Spain. – P. 3777-3783. Print vol: 0.81; author vol. 0.37; Davydov V.D. Digital intellectual assets in the paradigm of inertial investment / V.S. Voronov, V.D. Davydov // Issues of innovative economics. - 2022. - Volume 12. - No. 1. - P. 141-154. Print vol: 1.62; author vol. 1.12).

3. Approaches to the analysis of investment strategies and portfolio management are formulated. These approaches take into account both the peculiarities of the market mechanism for the sale of assets of the class under study and the revealed effect of inertia. In particular, it is shown that at the initial moment of time, the owner (manager) of the portfolio, unlike traditional portfolios of financial assets, does not have the frequency-probabilistic characteristics of sales or profitability necessary for risk analysis. Nevertheless, based on the analysis of the results of observations, we can confidently state that the property of inertia allows us to significantly minimize the negative consequences of errors in portfolio management, choosing (changing) an investment strategy or replenishing a portfolio with new assets. (Davydov V.D. Digital intellectual assets of copyright as investment objects / V.S. Voronov, V.D. Davydov // Problems of modern economics. - 2020. - No. 3. - P. 132-136. Print vol: 0.58; author vol. 0.40).

4. A structural model of the investment portfolio of copyright digital intellectual assets has been developed. The proposed logical-probabilistic model takes

into account not only the significant heterogeneity of the investment characteristics of intellectual assets, but also causal relationships between groups of assets identified by the demand parameter. Based on the analysis of the results of observations, it is shown that between such groups there is a continuous flow of assets in the direction of the maximum income group, during which the risk parameters are simultaneously corrected. (V. Davydov Building the Bayesian Network Model of Digital Images Portfolio / V. Voronov, A. Kazansky, V. Davydov // Proceedings of the 32nd International Business Information Management Association (IBIMA). 15-16 November 2018. – Seville, Spain, 2018. – P. 4279-4284. Print vol: 0.69; author vol. 0.32; Davydov V.D. Justification of the structure of the Bayesian network model of a portfolio of intellectual assets / V.S. Voronov, V.D. Davydov // Management of economic systems: electronic scientific journal. - 2018. - No. 12. - P. 30. Print vol: 2.31; author vol. 1.61).

5. Theoretical approaches to building an investor's decision support system have been developed. The system is implemented as a hybrid Bayesian network model of an investment portfolio and is built in the Netica software environment. The use of machine learning methods allows you to continuously improve the system, replenishing its knowledge base with the results of monitoring the activities of investors. In particular, in the course of training the developed model, it was possible to obtain an adequate response of the system to the impact of factors simulating the effect of portfolio inertia. (Davydov V.D. Hybrid Bayesian model of an inertial portfolio of intellectual assets / V.S. Voronov, V.D. Davydov // News of the St. Petersburg State Economic University. - 2019. - No. 5-2. - pp. 86-91. Print vol: 0.69; author vol. 0.48).

Provisions for defense:

1. One of the key features of digital intellectual assets is the specificity of their economic turnover. The assets under study are characterized by a fundamentally different mechanism for the market sale of assets, both compared to traditional financial assets and patents. The same asset can be sold multiple times, with each sale bringing a

fixed amount of income. The determining factor for income volatility in this mechanism is not the floating market price quote, but the number of sales of the asset.

2. The study revealed for the first time the inertia property of copyright digital assets. An approach to portfolio analysis of copyright digital assets is proposed, taking into account the identified property of inertia, which makes it possible to identify groups of assets by risk level and assess their impact on the achieved profitability of the portfolio as a whole.

3. Approaches to the analysis of investment strategies and management of a portfolio of digital intellectual assets are formulated, taking into account the characteristics of the market turnover of assets and the effect of inertia. At the initial moment of time, the owner of the portfolio of the class under study does not have the frequency-probabilistic characteristics of profitability necessary for risk assessment. This uncertainty accompanies a portfolio of intellectual assets as long as there are assets in it that have not been sold at least once. These assets form a separate group in the portfolio structure (waiting group), which responds to the impact of market demand with first sale events. The presence of such a group in the portfolio structure is one of the factors explaining the property of inertia. In turn, the property of inertia largely determines the uniqueness of investment strategies and portfolio management. However, having observed the sales process for a long time, we can confidently say that a quantitative increase in the waiting group always has a positive effect on the profitability of such portfolios, and the property of inertia allows us to significantly reduce the negative impact of errors in portfolio management, choice (change) of an investment strategy or replenishment of the portfolio with new assets. Moreover, a portfolio brought to a certain level of income, due to inertia, can continue to generate it for a long time with virtually no control influences.

4. A structural model of the investment portfolio of digital intellectual assets of copyright has been developed. The proposed logical and probabilistic model takes into account not only the significant heterogeneity of the investment characteristics of intellectual assets, but also the cause-and-effect relationships between groups of assets

identified by the demand parameter. The previously mentioned “waiting group” is the element of the model that responds to the impact of market demand with the events of the first sale of an asset. In accordance with the logic of the model, after the first sale of any asset, repeated and subsequent sales may occur. In this case, the asset is conditionally moved to the next sales groups, and with each transition the quantitative degree of confidence increases, and uncertainty, accordingly, decreases.

5. Theoretical approaches to building a system to support investor decision-making have been developed. The system is implemented in the form of a hybrid Bayesian network model of an investment portfolio and built in the Netica software environment.

1. INVESTMENT CHARACTERISTICS OF DIGITAL INTELLECTUAL ASSETS

In the framework of this work, digital intellectual assets mean works, mainly images in digital form, protected by copyright. In a general sense, digital intellectual assets may also include musical works and other sound recordings, video works, literary works and educational content assets, and other similar intellectual assets.

This chapter discusses the main characteristics of portfolios of digital intellectual assets and formulates the framework for analyzing portfolios of such assets, as well as:

- The key features of the investment characteristics of copyright digital intellectual assets are identified, both in comparison with traditional financial assets and with patents.
- The Howey test was tested for assets of this class, which showed that digital intellectual assets can be considered as objects of investment activity.
- Approaches to the analysis of investment strategies and portfolio management are formulated.

1.1. Key features of digital intellectual assets

One of the key features of digital intellectual assets is the specifics of their economic turnover. First of all, we note that the economic turnover of digital intellectual assets is carried out on the platforms of aggregator companies and has a fundamental difference compared to the mechanism for the circulation of securities.

The peculiarity of the turnover lies in the fact that the same digital intellectual asset (more precisely, a license to use it) can be sold many times, with each sale bringing a fixed amount of income.

To date, several international standards for the sale of licenses for the use of finished photographic images have been formed and used in practice: RM (Right

Managed - with image rights management) and RF (Royalty Free - without royalty deductions).

The volatility of the portfolio return under this sale mechanism depends on the number of asset sale events, and not on the changing market quotation of the asset price as with standard securities. The income from a digital intellectual asset, like that of standard securities, depends on demand, but unlike securities, demand is not reflected in the market price of the asset, but in the number of asset sales events.

Another feature of the studied asset class is the quantitative volume of assets in the portfolio. Namely, the number of assets in digital intellectual asset portfolios is significantly greater than the number of assets in patent portfolios (traditional intellectual asset portfolios) of technology companies or patent intermediaries. The size of the portfolio is determined by the business model of new generation intermediary companies (aggregators of intellectual assets) that organize the market turnover of such assets. The portfolios of the asset class under study are operated by new institutional groups of financial intermediaries that emerged in specific, clearly defined segments of e-commerce in the 2000s, when a kind of investment breakthrough occurred in the intellectual property market, the consequences of which are still not fully appreciated by economists.

The number of assets in the portfolios of intellectual asset aggregators significantly exceeds the number of assets in patent portfolios. For comparison, we note that the leading intermediary company - Shutterstock Ink. the number of assets at the 2023 exceeded 475 million units, while the largest portfolios of technology companies and patent intermediaries (patent aggregators) usually consist of several tens of thousands of patents for inventions and other industrial property assets.

Structurally, the portfolio of an intermediary (company-aggregator) consists of many author's portfolios. This structure is determined by the business model used, according to which the authors provide their digital intellectual assets to the aggregator company on a paid basis and retain copyright. Aggregator companies, in turn, organize the market turnover of digital intellectual assets on their network platforms and undertake to pay the authors a certain part of the income from the sale of the assets owned by the authors. Another part of the income from the sale of copyright assets is retained by the aggregator company as a reward for the services provided to them in organizing the market turnover, maintaining the network platform, etc.

In accordance with the business model of the aggregator company, the income from the total portfolio is not "boiler" income, i.e. the author receives income only from the sale of his assets and only if there have been events of the sale of assets belonging to him. This fact confirms the view that the risks and uncertainty of future income of both digital and other intellectual assets are among the highest. This provision reduces the potentially significant interest of investors, complicates the economic turnover and the launch of such assets on the market.

Thus, the most significant differences in the investment characteristics of the studied asset class are:

First, the specifics of the economic turnover of assets, expressed in a special mechanism for the market sale of assets: the same digital intellectual asset (more precisely, a license to use it) can be sold many times, with each sale bringing a fixed amount of income.

Secondly, the factor that most affects the volatility of income for a portfolio of digital intellectual assets is the number of asset sales events, and not the changing market price quotation (as with traditional assets).

1.2. Approbation of Howie's investment test

In the first half of the 20th century, the Howey test was developed to determine whether a particular transaction, security or asset is an investment activity[1]. As part of this study, the Howey test was tested in relation to digital intellectual assets, and

[1] Gabaldon T.A. A Sense of Security: an Empirical Study // Journal of Corporation Law. – 2000. – Volume 25. – № 2. – P. 307-347; Telpner J.S., Ahmadifar T.M. ICOs, the DAO, and the Investment Company Act of 1940 // The Investment Lawyer. – 2017. – Volume 24. – № 11. – P. 16-33.

showed that the test conditions are also met for this asset class. Thus, digital intellectual assets can be considered as objects of investment activity.

The premise is at first glance very trivial - the test is considered positive (i.e., a transaction or instrument is recognized as the subject of investment activity) when the following four conditions are met:

1. There is a fact of investing funds;
2. The invested funds are invested in a joint venture;
3. Investments involve the expectation of making a profit;
4. Investment income is directly related to the activities of a third party (promoter).

Next, we consider the applicability of all necessary conditions to the class of assets under study - digital intellectual assets.

<u>The first condition is that there is a fact of investing funds.</u> This condition is now being considered in a broader sense. In a number of regulatory documents as well as in scientific works, a broader interpretation of both options for possible forms of investment (non-cash and cash forms) and types of investment objects (various classes of assets, including intangible, tangible assets).

The digital intellectual assets studied in this paper are one of the varieties of intellectual property, which is copyright in digital form, which, like any other property that has a material value in monetary form, certainly refers to assets. Digital intellectual assets represent digital media files (containing images, text, sound, video, including assets containing a combination of several of the above elements) prepared in a special way. The value of the studied assets positively correlates with the quality of the preparation of the asset, carried out by the author (or investor) to enter the market: the better the quality of the preparation, the higher the value of the asset. It is the preparation of an asset for launch on the market that transforms an ordinary media file into an intellectual asset that has a monetary value. The issues of transforming "private" files into full-fledged assets were discussed in the scientific literature until the mid-2010s. The most significant of the questions concerned whether a "private" media file can be considered an asset, and at what point does the transformation of a "private" file into an asset take place[2].

By now, we can confidently indicate the stages of the author's (investor's) sequential actions to transform ordinary "private" files into full-fledged intellectual assets. The first stage of such a transformation is the introduction of property attributes (including an indication of the owner) into the documentary (information) structure of the file. To do this, the file should be structured in a certain way - for example, in accordance with the standards of the electronic document[3]. Such standards allow you to include in the file structure both content and descriptive sections with information (metadata), that is, a document made in accordance with such a standard, in addition to the content itself (pictorial, literary or musical data), includes sections of metadata, which, in addition number contain an indication of the attributes of the property.

Some of the metadata of an electronic document file can be created automatically thanks to modern technologies, and some of them must be entered manually. There is also a “semi-automatic” mode, when metadata is entered manually for a large number of files (for example, digital image files) with the same properties at once, or the entry of this data is programmed. Such information can be, for example, information about the owner of the file.

In practice, when creating any image with a digital camera, the latter automatically generates a large number of so-called metadata, recorded in standard commonly used formats[4]. In particular, today, when documenting an Exchangeable Image File Format (EXIF) file, a digital camera contributes metadata about both its own parameters (Camera data 1) and image parameters (Camera data 2). When documenting a file in the International Press Telecommunication Council (IPTC) format, the camera

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[2] Averyanov M., Evtushenko S., Kochetova E. Digital Economy: New Assets. - [Electronic resource]. – Access mode: https://www.itweek.ru/gover/article/detail.php?ID=190477 (date of access: 07/30/2022)

[3] See, for example: GOST 2.051-2013 Unified system for design documentation. Electronic documents. General provisions.

[4] Sokolov B.I., Voronov V.S. Institutional foundations of information and financial design // Problems of modern economics. - 2017. - No. 2 (62). - p. 146-151.

generates (but does not fill in information) sections with additional information about the image itself (including keywords) and copyright data (see Table 1).

Table 1.1 - The structure of digital image metadata in EXIF and IPTC formats

EXIF format		IPTC format
Camera data 1	Camera data 2	Description
Make: Canon **Model:** Canon EOS 1200D **Date:** 2021-10-20T09:07:07+04:00 **Exposure time:** 1/60 sec **Max Aperture Value:** f/3.5 **F-Stop:** f/5.0 **ISO Speed Rating:** 200 **Lens focal length:** 41.0 mm	**Pixel Dimension X:** 6600 **Y:** 8400 **Orientation:** Normal **Resolution Unit:** Cm **Resolution X:** 300 **Y:** 381 **Compressed Bits per Pixel:** 5.0 **File Source:** DSC **Light Source:** Other **Color Space:** Adobe RGB	**Author:** Davydov V.D. **Document Title:** Landscape **Description:** Sunset over the Gulf of Finland in autumn, panorama. **Description Writer:** Davydov V.D. **Keywords:** nature, sunset, Gulf of Finland, sea, autumn, pond. **Copyright info URL: -** **Copyright Notice: -** **Copyright status:** fixed

Source: compiled by the author.

Of course, it should be noted that any created (formed), but not yet properly prepared media files can be of some value and have a cost. The value of a file, in particular, largely depends on its purpose and possibilities for further use. For example, we can indirectly judge that an image created with an amateur camera, or a mobile phone camera, may be of less value than an image taken with a professional camera, due to the smaller volume and lower image quality.

To introduce the created file into commercial circulation and maximize its value, you need to add additional metadata attributes and record information about the author (owner) of the file. These additional attributes are added to the descriptive part of the file (see the column "IPTC format" "Description" in Table 1), the most significant of the added attributes are the following:

1. Information about copyright;
2. Information about the author/owner;
3. Keywords;
4. Name;
5. Image plot.

At the moment, the technique is not able to automatically fill in the full list of the above data. However, scientists and practitioners are actively developing software for the automatic completion of metadata. In particular, computers are already capable of recognizing the scenes of digital images and assigning them a set of keywords. To create such software, a significant amount of already labeled data is required, on the basis of which the computer will classify. Organizations have already appeared that provide data markup services immediately for large arrays of files, for example, the Russian company TAGME.

Legal recognition of the asset and its sale become possible only after the completion of the stage of entering metadata. In addition, after the end of this stage, it becomes possible to search for an asset in a large array of similar assets, thanks to the introduction of keywords and other attributes that allow you to search among authors stored in portfolios (databases) and in databases of market aggregates (intermediaries) that organize market turnover and investment process of such assets. Ahead of events, we note that this ends only the first stage of preparation for the market turnover of a digital intellectual asset.

<u>The second condition of the Howey test is that the invested funds are invested in a joint venture.</u>

The basic variant of fulfilling this condition implies the pooling of their funds (assets) by investors into a single pool and further distribution by investors of the profits received in accordance with their share of participation. The investment process of digital intellectual assets has its own specifics, therefore, in order to check the test condition, it is necessary to clarify who invests in the asset class under study, and how does the investment process take place?

In the investment process using digital intellectual assets, investors could be:

- Creators of assets are their authors.
- A person who, in accordance with the law, has acquired from the owner the right of ownership (or who has acquired the right to possess or dispose of) an asset.
- Organizations specializing in the industrial (streaming) creation of assets of this class. Such organizations have on their balance sheet professional equipment for creating photo, video and sound assets.
- Organizations acquiring rights to assets from owners (authors). Note that some copyrights may legally remain with the authors for life, despite the sale of ownership of the asset.

The process of investing digital intellectual assets is divided into a number of stages. The very first stage of the process is the direct receipt (creation or acquisition) of the original digital file and its initial preparation, which consists in filling in information in the metadata sections of the asset. As noted earlier, it is after passing through this stage that a digital intellectual asset acquires its full-fledged investment characteristics, therefore this stage is a component of the investment process.

The next stage of the investment process is the conclusion of an agreement for the organization of the market turnover of a digital intellectual asset with a network financial intermediary. Network financial intermediaries in contracts for the organization of market turnover put forward a number of obligations to authors / investors, the key of which is the requirement for the quality of preparation, content and subject matter of digital intellectual assets. The quality of the preparation of an asset means not only its physical characteristics (for example, optical resolution), but also the quality of the preparation of metadata. In addition, contracts often include requirements for interaction with tax authorities and payment services.

Under the terms of the contract for the organization of market turnover, the owner of the rights to the asset has the right to transfer his digital intellectual asset to an intermediary. The transfer of an asset to an intermediary, just like the first stage, begins with filling in the metadata. The procedure for transferring an asset to a portfolio in practice is to upload a digital file to an intermediary's portfolio on its website. The process is organized in such a way that it is impossible to complete the file upload without filling in the metadata section. This step populates the external metadata section, which is stored on the network financial intermediary's server. The metadata filled in at this stage contains information about the thematic categories in which the file will be exhibited; about pricing categories for license types to use the file; about the physical characteristics offered for sale (file size, file format). The step is required, but the number of metadata that is required to be filled out depends on the specific intermediary.

The third condition of the Howey test is that investments imply the expectation of making a profit.

After transferring a digital intellectual asset to an intermediary, the latter brings it to the market, i.e., organizes its market turnover. It is after the completion of this stage that the author/investor has the right to expect to receive investment income. The receipt of income occurs in practice if there is a demand for the assets of the author / investor. As a result, the third condition of the Howey test is also satisfied. However, the investment process using digital intellectual assets has its own individual features due to a number of features inherent in such assets.

First of all, we note that each digital intellectual asset is individual, unlike traditional financial assets: securities, currency instruments, derivative financial instruments, which are characterized by their standardization. This is due to the fact that each digital intellectual asset is an author's work. Each creator (author) of an asset has its own individual author's style, individual genre preferences, and creative level. All these factors determine the individuality of digital intellectual assets. In addition, respect for the individuality of the asset is one of the conditions of the intermediary. Thus, in principle, the same aggregator company cannot have several absolutely identical assets in the portfolio. Based on the individuality of digital intellectual assets, it can be argued that the pool of assets managed by an intermediary is not impersonal, unlike portfolios consisting of any particular currency or securities of a particular issue.

Another important feature concerns the ability of the author/investor to manage their portfolio of digital intellectual assets. After the agreement with the intermediary is concluded, the author/investor gets access to a personal account on the intermediary's website, through which the author/investor can manage his assets: he can replenish the portfolio with new assets, remove existing assets from the portfolio, or may be inactive. After loading the first asset into the portfolio, the intermediary begins to perform its part of the work - it carries out the market exposure of the asset on the site and its promotion. The intermediary performs this work in relation to all assets at its disposal using modern network technologies. As a result of these actions of the author / investor and intermediary, a market supply and demand for digital intellectual assets is formed.

Licenses for the use of digital intellectual assets are sold on intermediary sites, since the ownership of digital intellectual assets in this case, in the general case (there are exceptions), remains with their owners (authors/investors). The mechanism for selling licenses to use implies that licenses to use an asset can be sold multiple times. The terms of the agreement between the intermediary and the investor fix the obligation of the aggregator company to pay to the authors/investors a part of the income received by the aggregator from the sale of licenses for the assets owned by the investor (minus commission and other expenses stipulated in the agreement). The investor receives income only if the sale of assets belonging to him took place.

As noted earlier, this fact confirms the view that the risks and uncertainties of future income of both digital and other intellectual assets are among the highest in the economy. In our opinion, this circumstance also confirms that investing in digital intellectual assets belongs to investment activities in terms of the risk of receiving the expected investment income from a joint venture. Moreover, the risk is inherent in both the activities of the investor and the activities of the intermediary. We also note that the presence of risk and uncertainty in the results of the activities of the promoter (intermediary) or a third party, according to a number of researchers, confirms the fulfillment of the fourth condition of the Howie test[5].

The fourth condition of the Howey test is that the receipt of income from investments is associated with the activities of a promoter (intermediary) or a third party.

In addition to the high risks inherent in the activity of an intermediary, the fourth condition is justified by the concept that the portfolio of an intermediary consists of a set of portfolios of individual authors/investors. Under this view, the intermediary portfolio represents the total intellectual capital of investors in digital form, generating profit. In order to increase its competitiveness, the intermediary assumes the obligation to promote the total portfolio in the market, he makes efforts that affect the success of the entire enterprise and the total portfolio. Authors/investors who are participants (owners of shares) in the total portfolio of the intermediary reasonably expect that the result of the intermediary's actions will be the promotion of their personal portfolio and the receipt of their personal profit.

Despite the existing common goal of increasing the profit of both the intermediary (the profit of the total asset portfolio of all authors/investors) and the profit of the individual author/investor, there are also contradictions. One of these contradictions is the involvement of new participants by the intermediary. An intermediary to increase the income of the total portfolio is interested in increasing the portfolio, and one of the ways to achieve this goal is to attract new authors / investors. Increasing the total portfolio improves the competitiveness of the intermediary, as consumers (those who purchase image licenses) have more choice.

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[5] Telpner J.S., Ahmadifar T.M., ibid.

This reseller strategy is supported by evidence: Shutterstock Ink alone. The number of registered authors exceeds 2.3 million (see Table 1.3 below) and continues to grow. However, an increase in the total portfolio of an intermediary leads to a dilution of the shares of individual authors/investors, which is a contradiction in their activities, despite the common goals. A similar contradiction arises in ordinary joint-stock companies when the shares of individual participants are diluted. In order to mitigate the dilution effect of an individual portfolio within the aggregate portfolio, authors/investors have to increase their own individual portfolios. Despite the obviousness of this method of maintaining the previously achieved level of profitability of an individual portfolio, an increase in individual portfolios in proportion to an increase in the total portfolio does not guarantee the preservation of profitability for authors / investors, since, as noted earlier, the field of digital intellectual assets is subject to other market factors.

Note that the activity of the intermediary is not limited only to the increase in the total portfolio. Other significant aspects of its activities include:

Firstly, the creation, development, maintenance and improvement of a network platform on which digital intellectual assets are exhibited and deals are made to sell them (sale of rights to use them, licenses). The authors/investors expect the intermediary to perform these duties properly, as these are fundamentally necessary actions to attract and retain customers.

Secondly, intermediaries as such create and develop the market for digital intellectual assets. It is intermediaries who are engaged in the formation of market prices for assets (prices are identical for groups of similar assets). In addition, intermediaries establish quality requirements and rules for the trading turnover of digital intellectual assets on each platform. And also it is the intermediary who conducts transactions related to the market turnover of digital intellectual assets. As a result, the multifaceted activity of the intermediary ensures the trade turnover and liquidity of digital intellectual assets.

Authors/investors, by virtue of paying a commission from each sale of a license to use their digital intellectual asset, expect that the intermediary will use these funds to promote the network platform, its expansion and modernization, which will ultimately increase the sales of each author/investor. The intermediary, in addition to performing these basic functions, takes responsibility for ensuring the smooth functioning of the entire network, incl. for protection against external cyber threats, and in addition, it performs the functions of protecting copyrights (intellectual property rights of owners of digital intellectual assets).

Returning to the presentation of the algorithm for the investment process of digital intellectual assets, stopped on the fact that the authors / investors have the right to expect to receive a part of the income fixed in the agreement with the intermediary, but only if it takes place, i.e. there have been events of sale of rights to use the assets. The moment of the sale of the asset is significant in that after it the third section of the metadata of the digital intellectual asset begins to form. This section is filled in automatically and is external (i.e. located in the reseller's storage) and includes the following data:

- Keywords by which buyers found the file and an indication of which of the keywords were in the (primary) metadata section previously entered by the author;
- Frequency of asset sales;
- The amount of proceeds received from each sale event (the amount depends on a combination of many factors and, as a result, may vary);
- Format of the sold asset, etc.

Due to the formation of this section of metadata, after the sale of a digital intellectual asset, the value of this asset increases significantly. This happens because there are specific sales data that symbolize the transition of the asset to the next higher probabilistic category of demand. With each subsequent sale of an asset, the likelihood of future income increases, and the uncertainty about investment attractiveness decreases. This so-called administrative metadata section is constantly updated by the intermediary. The first two sections of metadata (internal and external), as already mentioned, are filled in before the release of the digital intellectual asset to the intermediary site, this is a prerequisite for all intermediaries, since without these sections the assets are difficult to identify. The third (administrative) section of metadata, unlike the first two, is filled in automatically by an intermediary and contains information that significantly increases the investment attractiveness and, as a result, the profitability of an asset.

The process of formation and subsequent improvement of the three sections (internal, external and administrative) of the metadata of a digital intellectual asset can be called the process of "increasing the information quality" of the asset (Information Enhancement) by analogy with the financial term "improving credit quality" (Credit Enhancement). An improvement in the information quality of an asset, as well as a change in credit quality, can be both internal and external.

Thus, we argue that digital intellectual assets of copyright can be considered as objects of investment activity, since all the conditions of the Howey test are met in relation to them. Consideration of the applicability of the test conditions to the asset class under study showed the following:

1. The digital intellectual assets studied in this paper are one of the types of intellectual property, which is copyright in digital form[6]. Like any other property that has a material value in cash, they certainly relate to assets. In the process of formation of digital intellectual assets of copyright and preparation for their market turnover, the introduction of metadata is required, incl. containing property attributes into their information structure.

2. A joint venture in which the funds of participants in the investment process are invested is a specialized market intermediary - an aggregator of digital intellectual assets. Structurally, the aggregator's portfolio consists of the aggregate of all assets owned by individual authors/investors. The duties of the aggregator include ensuring an uninterrupted investment process, the end result and purpose of which is to make a

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[6] Voronov V.S. Problems and paradoxes of digital investments / V.S. Voronov, N.Y. Puzynya, V.D. Davydov // Proceedings of the St. Petersburg State University of Economics. - 2020. - No. 5 (125). - P. 19-25.

profit for both individual authors / investors and the aggregator. The terms of the agreement between the intermediary and the investor fix the obligation of the aggregator company to pay to the authors/investors a part of the income received by the aggregator from the sale of licenses for the assets owned by the investor (minus the commission and other expenses stipulated in the agreement). The investor receives income only if the sale of assets belonging to him took place.

3. Each digital intellectual asset is a property that has its own individual features, and therefore, it is not an impersonal property, unlike ordinary financial assets. This is one of the reasons why the risk of investing in digital intellectual assets is characterized by greater uncertainty compared to traditional financial instruments.

1.3. Approaches to investment analysis of portfolios of digital intellectual assets

Conclusions about the similarity of the economic functions of copyright and patents in economic theory were made in the early 2000s[7]. These conclusions were based on earlier studies of the economic properties of copyright, or, in the terminology of those years, "cultural intellectual property"[8]. However, theoretical approaches to the analysis of patent portfolios are more developed, since patents for inventions as intellectual assets are of great interest to large technology companies[9].

Classical ideas about the investment parameters of portfolios of digital assets of this class do not yet exist for quite natural reasons. Nevertheless, in the early works devoted to the study of patent portfolios, theoretical concepts were formed that make it possible to analyze portfolios of intellectual assets of various nature. Due to the similarity of the economic parameters of patent assets and copyright assets noted earlier,

[7] Watt R. Copyright and Economic Theory. – Edward Elgar, 2000.

[8] Landes W.M., Posner R.A. An Economic Analysis of Copyright Law // Journal of Legal Studies, University of Chicago. – 1989. – June. – Vol. XVIII. – P. 326.

[9] Parchomovsky G., Wagner R. Patent Portfolios // University of Pennsylvania Law Review. – 2005. – Vol. 154 (1). – P. 1-77.

we will now consider some of these concepts and use them to analyze portfolios of digital images.

We single out the following concepts as the main approaches that can be used to analyze portfolios of digital images:

1. Theory of patent signals;
2. Theory of internal metrics;
3. Lottery theory;
4. Defense theory;
5. Information theory;
6. Theory of inertia.

Theory of patent signals. In the so-called "signaling theory", the patents in the portfolio formed by the company perform the function of transmitting information signals to the market[10]. These signals, according to the author of the theory, convey to the market, firstly, information about the inventions registered by the company, and secondly, about the company itself and the current state of its intellectual capital. As is known, the total cost of R&D and obtaining patent protection for a large corporate portfolio of inventions can be quite high. Based on this, the authors and supporters of the signal theory argue that a high-quality signal for investors requires such costs that are beyond the power of weak companies that do not have serious intellectual resources.

The concept of information signals turned out to be very ambiguous and caused a lot of theoretical disputes that have not subsided to date, but the very principle of signal perception and market response is confirmed by practice. In this case, the reaction may have a different character. For example, one recent paper shows that it is not uncommon for young companies to build large portfolios of patents and patent applications in anticipation of going public for an IPO[11]. This allows them to significantly improve their market reputation, as well as overcome a number of mandatory requirements of

[10] Long C. Patent Signals // The University of Chicago Law Review. – 2002. – Vol. 69 (2). – P. 625-679.

[11] Basir N. Reputation Enhancing Through Patent Portfolios: An Exploration of Lapsed Patents and IPOs // Corporate Reputation Review. – 2019. – July. doi:10.1057/s41299-019-00074-0

venture capitalists for the technological novelty of the intended product. However, after a successful IPO, the work on applications for inventions and the maintenance of already obtained patents in many cases ceases, which is also confirmed by statistics.

Another response to patent signals is the mass imitation of new products by competitors, minor improvements or "sequential innovation" under the guise of new technological developments by companies that do not have their own expensive R&D base[12].

As our studies have shown, in portfolios of copyright assets, the signaling function, apparently, is performed not by all assets in the portfolio, but only by those that demonstrate the highest level of sales, i.e. bring in the highest income. In accordance with the nature of the distribution of sales, found empirically, we conventionally call groups of such assets groups of champions[13]. Trading on many digital platforms is organized by intermediaries so that buyers can see which assets (such as images) have the highest selling rank. This leads to the fact that record-breaking assets become a kind of sales activators, as they unwittingly attract the attention of designers and other buyers to the portfolio of a particular author / investor as a whole. In turn, this increased attention can potentially increase the sales of other works by this author. According to our version, such a mechanism is most likely to manifest the effect of a positive correlation of demand for assets of this class in the portfolio[14].

However, it should be noted that the signals of record holders are seen not only by buyers, but also by other authors/investors who are competitors in the respective market. In particular, according to the theory of copyright[15], creative works are not only the result (output) of the creative process, but also its “raw material” (input). Thus, the

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[12] Bessen J., Maskin E. Sequential innovation, patents, and imitation // Rand Journal of Economics. – 2009. – Vol. 40 (4). – P. 611–635.

[13] Voronov V.S., Davydov V.D. Hybrid Bayesian model of the inertial portfolio of intellectual assets // Proceedings of the St. Petersburg State University of Economics. - 2019. - No. 5-2. - p. 86-91.

[14] Voronov V.S., Darushin I.A. Financial risk of a portfolio of intellectual assets from the standpoint of the VaR (EaR) methodology // Problems of risk analysis. - 2017. - Volume 14. - No. 3. - P. 54-63.

[15] Varian H. Copying and copyright // Journal of Economic Perspectives. – 2005. – Vol. 19 (2). – P. 121-138.

growth in the number of successful creative works stimulates the emergence of other creative works, some of which are inevitably imitations, repetitions, minor modifications, in full accordance with the trend identified for patents.

Theory of internal metrics. The author of the theory of internal metrics back in the 80s. of the last century, proposed using patent activity indicators to quantify the productivity of technology companies' R&D personnel. He substantiated his proposal by the fact that it is really very difficult to find direct indicators of the evaluation of scientific (creative) work[16]. At the same time, indicators of patent activity are quite well known and are being improved every year.

Within the framework of this concept, in our model of a portfolio of digital images, one of the probabilistic parameters is the author's creative productivity, which affects the quantitative composition of the portfolio as a whole. This factor is internal and depends on time. Aspects related to the creative performance of the author / investor are very important, because they directly affect the filling of the portfolio with assets. This process is not stable and has its own uncertainties, depending on the portfolio replenishment strategy chosen by the author/investor.

In addition, in practice, for example, statistical metrics of digital image portfolios are used to analyze the financial results of microstock companies, individual authors, collections of images within portfolios, and even individual images[17]. Such metrics can be used as direct assessments of the investment attractiveness of the portfolio:

RPI (Revenue Per Image) is the average revenue per image. It is calculated as the ratio of total income for the period to the total number of assets in the portfolio or in the collection, respectively. Sometimes this figure is given with a breakdown by months.

RPD (Revenue Per Download) is the average revenue per sale. It is calculated as the ratio of total revenue to the number of sales for the period. This metric is more

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[16] Levin R.C. A New Look at the Patent System // American Economic Review. – 1986. – Vol. 76 (2). – P. 199-202.

[17] Alvarez L. Understanding Microstock Metrics. - [Electronic resource]. - May 10, 2012. - Access mode: https://www.stockperformer.com/blog/understanding-microstock-metrics/ (Accessed: 07/25/2022).

interesting when applied to a specific asset, but is also used to evaluate portfolios as a whole and collections.

STR (Sell Through Rate) - the level of through sales. The term is borrowed from traditional wholesale trade, and in this case is used to refer to the proportion, or percentage of images in the portfolio, sold at least once. This indicator is very interesting for the analysis of the internal structure of portfolios of intellectual assets, and its analogues are also used by us further in the logical-probabilistic model. They also use a more complex "probabilistic" version of this indicator - **STRB** (Sell Through Rate Breakdown). It shows how much time passes before the first sale of assets. The STRB histogram usually displays what percentage of assets are sold within one week, two weeks, a month, two months, six months, one year, more than a year, and what percentage is not sold at all. The latter parameter is also used in our model to characterize a specific "waiting group". In general, it should be noted that in order to build the STRB histogram, it is necessary to fix the loading date and the date of the first sale of each asset in the portfolio, which is quite laborious and, with a large number of assets, is feasible only with the use of special software products.

Lottery theory. According to the "innovation lottery theory", the winnings of the patent holder can be so large that this becomes the main incentive for inventing and patenting inventions[18]. In fact, as noted in another study, the process of implementing inventions is far from being a lottery, since the latter implies the classical notion of a random event[19]. At the same time, any real invention contains a knowledge base about technologies, and probabilistic estimates here are always associated with specific technologies and financial decisions of investors.

In terms of copyright assets, the selection of a buyer in an aggregator's portfolio is somewhat random, and the likelihood of each individual image being sold is indeed very low. However, it should be noted that on the demand side, the process of finding

[18] Scherer F.M. The Innovation Lottery. In: Dreyfuss C. et al., eds.: Expanding the Boundaries of intellectual Property. – Oxford University Press, 2001. – P. 3-21.

[19] Parchomovsky G., Wagner R. Patent Portfolios // University of Pennsylvania Law Review. – 2005. – Vol. 154 (1). – P. 1-77.

the right images in a huge portfolio by the buyer is not unsystematic, he can use thematic categories, keywords, and form complex queries for the aggregator's search engine.

However, the analogy with the lottery is strengthened by the extremely high risks and uncertainties associated with the economic turnover of intellectual assets, incl. and in digital form. In particular, the peculiarity of investment portfolios of intellectual assets of the class under study is that neither the author/investor (or analyst) nor the microstock intermediary knows in advance:

- Which asset will be sold;
- At what point in time the sale event will take place;
- What income in monetary terms will be received in this case.

All these parameters can only be approximately estimated with a certain degree of probability until the moment of the sale event, which is of a random nature. Only after the event has occurred, the name of the asset, date and amount of income will add to the historical series of observations.

In order to make it clear what is at stake, Table 1.2 compares some probabilistic variables characterizing conventional financial instruments and intellectual assets, including digital ones. Recall that when working with an ordinary portfolio of securities, the manager or owner is guided by their market quotes and always knows exactly the current value of the portfolio as a whole. He himself determines which securities are required to be sold, at what point in time, in what quantity, and he sends orders for the execution of the corresponding operations. Moreover, in most cases, he knows exactly what income will be received as a result of the execution of his orders. All these parameters in the case of a portfolio of digital intellectual assets are probabilistic.

Table 1.2 - Comparison of securities and intellectual assets by degree of uncertainty

№	Variable	Securities portfolio	Portfolio of intellectual assets
	(1)	(2)	(3)
1	Name of the asset (i.e. which asset will be sold)	Known	Unknown
2	Date and time of sale	Defined	Not defined
3	Sales income	Known	Known lower limit
4	Portfolio present value	Known	Unknown
5	Sales history	Known	Known
6	Asset characteristics	Standard, assets are sold on different exchanges	Unique, but assets (rights) can be sold on different stocks

Source: compiled by the author

Among other things, in our opinion, the analogy with the lottery is also strengthened by the above-mentioned opportunity for the public to see the ratings of the most successful assets – sales record holders, which also form the illusion of a random win (note that even the very presence of such assets in a portfolio is always favorable for its profitability). However, it should not be forgotten that a record-breaking asset is not a ball taken out of a lottery drum at random, but (as in the case of patents) an author's work that reflects the author's individual (including genre) preferences, creative level and productivity.

defensive theory. In defensive theory, the creation of a large patent portfolio is seen as a kind of risk insurance. It is no coincidence that the collection of closely intersecting technological patents accumulated by competitors is called “Patent Thickets” in the theory of industry markets. Within the framework of this concept, competing firms use patent portfolios as counterweights in the most difficult negotiation processes and litigations, which can end with the payment (reception) of monetary compensation by the parties, the conclusion of cross-licensing transactions, and the combination of standard-forming portfolios into investment pools[20].

Competition is also high in the copyright market. In this area, for any kind of assets, the size of the portfolio and its quality are equally important. In particular, in order to stimulate the continuous quantitative growth of their portfolios, digital asset aggregators provide, firstly, simple and very convenient mechanisms for interaction and mutual settlements, both with authors/investors and buyers of works, and secondly, favorable sales price parameters. The aggregator business is now completely focused on electronic platforms with carefully designed interfaces and payment services. From this point of view, aggregators of all kinds are already full-fledged representatives of the digital economy today.

In addition, from year to year, almost all intermediary companies of this type report an increase in the number of registered authors / investors of various categories: from students and advanced amateurs to professional photo artists, videographers and copywriters. For example, in Table 1.3 you can see the results of the two largest photostock companies in strengthening their competitive positions.

Table 1.3 - Indicators of leading microphotostock companies according to official websites (as of early 2024).

Microphotostock	Portfolio volume, million units assets	contingent of authors, thousand people
Shutterstock	475	2300
Dreamstime	217	1100

Source: compiled by the author based on microphotostocks.

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[20] Hall B.H., Ziedonis R.H. The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995 // Rand Journal of Economics. – 2001. – Vol. 32. – P. 101-128.

Information theory. As part of the information approach, research is being conducted in which patents for inventions are considered as textual information units, subjected to deep semantic analysis, and their textual elements are studied as part of ontological models[21].

Copyright digital assets (in particular, digital images) are also structured information units that have content and attribute parts (for example, in accordance with GOST 2.051-2013). As shown above, the composition of the metadata of such information units is quite clearly defined and has a clear hierarchical structure[22].

Theory of inertia. Economic inertia can be defined as the property of maintaining stable functioning and long-term reproduction of achieved indicators, such as, for example, the return on financial assets[23]. Our research has shown that portfolios of digital images have the property of inertia. In particular, this property is manifested in the fact that a portfolio put up for sale for the first time, after market adaptation, can generate income, regardless of whether it continues to be replenished with new assets or not[24]. At the same time, in relation to patent portfolios, there are no reports of persistence effects in the economic literature, which can be explained by certain differences in the mechanisms of sales of the studied asset classes.

Signs of compliance of the parameters of the studied varieties of portfolios with the considered concepts are summarized in Table 1.4. Our analysis confirmed earlier hypotheses about analogies between the economic parameters of patent and copyright.

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[21] Giereth M., Stäbler A., Brűgmann S., Rotard M., Ertl T. Application of Semantic Technologies for Representing Patent Metadata // Lecture Notes in Informatics (LNI), Proceedings-Series of the Gesellschaft fur Informatik (GI). – 2006. – Vol. P-94. – P. 297–304.

[22] Sokolov B.I., Voronov V.S. Institutional foundations of information and financial design // Problems of modern economics. - 2017. - No. 2 (62). - p. 146-151.

[23] Ayupov A.A. Design and implementation of innovative financial instruments. Moscow: Nota Bene, 2007; Sidnina V.L. The inertia of the economic system // Society and Economics. - 2002. - No. 2. - p. 114-130.

[24] Voronov V.S., Davydov V.D. Hybrid Bayesian model of the inertial portfolio of intellectual assets // Proceedings of the St. Petersburg State University of Economics. - 2019. - No. 5-2. - p. 86-91.

The same analogies were found for patent portfolios and portfolios of digital intellectual assets, in addition, the analysis revealed new signs of correspondence[25].

Table 1.4 - Signs of compliance of portfolio parameters with existing theoretical concepts

Concept	Patent portfolios	Portfolios of digital intellectual assets
Theory of patent signals [66]	Yes. The emergence of new (radical) inventions causes mass copying [12].	Yes. The appearance of assets - sales record holders causes mass copying (for example, the plot of images) [134].
Theory of internal metrics [64]	Yes. Indicators of patent (innovative) activity of firms	Yes. Contributor Creative Performance and Portfolio Returns [2], [136].
Theory of innovation lottery [87]	Not fully [80].	Not fully [136].
Defensive theory [47]	Yes. Quantitative increase in the volume of competitors' portfolios [47].	Yes. Quantitative increase in the volume of portfolios and contingent of authors.
Information theory [40]	Yes. The patent is considered as an information unit and is the object of semantic analysis [40].	Yes. Digital assets as information units. Asset and portfolio metadata set defined [98].
Theory of inertia	No information.	Yes. Analogy with the theory of inertial investment [136].

Source: compiled by the author

[25] Davydov V.D. Conceptual approaches to investment analysis of portfolios of digital intellectual assets / V.D. Davydov // Financial Economics. - 2020. - No. 2. - P. 25-29

Interesting "food for thought" is provided by the analogies identified in the framework of information theory, but there is still very little research in this direction. Within the framework of the dissertation research, the theory of inertia is of the greatest scientific interest, since the property of inertia was first revealed by us in the class of assets under study and has a significant effect on portfolios of digital intellectual assets. As will be shown below, the effect of inertia is closest to the effect of the so-called inertial investment.

2. THE NATURE OF THE INTELLECTUAL ASSETS TIME LASTING EFFECT

2.1. Qualitative representations within the structural model of a portfolio of digital images

The effect of inertia, or the momentum effect of financial assets, has been discovered and described in the economic literature for a long time. In particular, many scientific works are devoted to the momentum effect and investment strategies with its use in stocks and stock portfolios[26], in government[27] and corporate bonds[28], in foreign currencies[29]. A separate and rather extensive literature is devoted to the inertia of derivative financial instruments, for example, such as index and commodity futures[30]. Interesting studies were devoted to revealing the informational connection between the inertia of stock options and the shares themselves[31]. Finally, in recent years, a wave of reports about research into the inertial properties of cryptocurrency assets[32] has begun, which was quite predictable. However, until recently there were no reports on intellectual assets.

This is probably because the focus of the intellectual property literature is usually on the types of patent assets, as it is patents for inventions, patent licenses that are of greatest interest to large technology companies. At the same time, experts are well aware that the economic turnover of such assets does not imply a large number of

[26] Moskowitz T.J., Pedersen L.H. Value and Momentum Everywhere // The Journal of Finance. – 2013. – Vol. 68 (3). – P. 929-985.

[27] Van Luu B., Yu P. Momentum in government-bond markets // Journal of Fixed Income. – 2012. – Vol. 22. – P. 72-79.

[28] Li L., Galvani V. Informed Trading and Momentum in the Corporate Bond Market // Review of Finance. – 2021. – Vol. 25 (6). – P. 1773-1816.

[29] Menkhoff L., Sarno L., Schmeling M., Schrimpf, A. Currency momentum strategies // Journal of Financial Economics. –2012. – Vol. 106. – P. 660-684.

[30] Miffre J., Rallis G. Momentum Strategies in Commodity Futures Markets // Journal of Banking & Finance. – 2007. – Vol. 31 (6). – P. 1863-1886.

[31] Liu M.-Y., Chuang W.-I., Lo C.-l. Options-implied Information and the Momentum Cicle // Journal of Financial Markets. – 2021. – Vol. 53. – 100565.

[32] Tzouvanas P., Kizys R., Tsend-Ayush B. Momentum trading in cryptocurrencies: Short-term returns and diversification benefits // Economics Letters. – 2020. – Vol. 191. – 108728.

trading events: patents, patent portfolios are rarely sold (assigned, licensed) more than once. The exact details of patent transactions, especially large ones, are usually classified as they are trade secrets. As a result, there are no long time series of observations of price movements, quotes or other historical data for specific patent assets, and it is impossible to infer their persistence.

However, intellectual assets are quite diverse, and such information is available for other asset classes. For example, digital assets of copyright have been circulating on the trading floors of investment intermediaries-aggregators for about twenty years. This applies in particular to digital images (photos), video, audio and literary works. As already noted, here the trading mechanism allows the sale of the same asset (or rather, a license to use it) hundreds, thousands, and sometimes tens of thousands of times. This is what allowed us to identify the presence of the effect of inertia in assets of this class[33].

Over a decade of observation of portfolios of digital images in general and of individual record-breaking assets allowed us, first of all, to demonstrate a convincing sales dynamic of digital assets of this type. The obtained experimental data were further used by us, firstly, to develop a generalized structural model of a portfolio of digital copyright assets; secondly, to substantiate the concept of the impulse structure of the cash flow generated both by individual digital assets and portfolios of digital assets as a whole[34]; thirdly, to study financial risks using Bayesian network models[35].

As already noted, digital images are traded on electronic microphoto stock platforms, which in their essence are full-fledged investment intermediaries between authors / investors and the intellectual property market. One of the essential features of the trade turnover in this area is that in fact such assets are not sold in the usual sense, and continue to remain the property of the author/investor (there are exceptions). In fact,

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[33] Voronov V., Kazansky A., Davydov V. The Nature of Momentum Effect in Digital Copyright Assets Portfolio / Proceedings of the 35th International Business Information Management Association (IBIMA), 1-2 April 2020. – Seville, Spain, 2020. – P. 3777-3783.

[34] Voronov V.S., Davydov V.D. Digital intellectual assets in the paradigm of inertial investment // Issues of innovative economics. - 2022. - Volume 12. - No. 1. - P. 141-154. doi:10.18334/vinec.12.1.114119

[35] Voronov V.S., Davydov V.D. Hybrid Bayesian model of the inertial portfolio of intellectual assets // Proceedings of the St. Petersburg State University of Economics. - 2019. - No. 5-2. – p. 86-91.

consumers are only sold licenses to use assets at fixed prices, and at the time of purchase of a license, consumers are allowed to copy the digital file of the asset itself. At the same time, different licenses can be sold for the same asset, the cost of which depends on, for example, what kind of license the buyer needs - standard or extended, what size (in megapixels), what graphic electronic format, etc.

This mechanism allows you to conditionally “sell” each image multiple times, while each sale necessarily brings income to the photo stock, part of which is then redistributed to the author/investor. In this sense, unlike traditional portfolios of securities, there can be no loss on a portfolio of intellectual assets. However, the amount of income from the sale in each case depends on a combination of several factors that are random in nature and introduce significant uncertainty into the final financial result. Let's look at the reasons for this uncertainty by looking at the current options and rates offered to consumers by Shutterstock.

First of all, we note that all digital images are offered to photostock users in 3 versions of physical size (Table 2.1). For example, if a regular (i.e., not for editorial use) raster image posted by an author/investor has an original size of 3006 x 2012 pixels (line 1, table 2.1), then the company automatically supplements it with two more versions, sized accordingly, three times less, i.e., 1000 x 669 pixels (line 2, table 2.1), and six times smaller, i.e., 500 x 335 pixels (line 3, table 2.1). For each image, the consumer sees a table similar to table 2.1. Thus, if the consumer does not need an image of the maximum size, then he can immediately buy a smaller version, and not convert it later on himself, which is an additional convenience.

Table 2.1 - Image formats offered to users

№	Physical size, pixel	Resolution, DPI	Graphic Format
1	3006 x 2012	300	JPG
2	1000 x 669	300	JPG
3	500 x 335	300	JPG

Source: Compiled by the author based on Shutterstock data

Next, the user must choose for himself - in which particular price category of sales he will buy the image:

- By subscription (Subscription);
- On request (On Demand);
- Standard or extended license (Enhanced License);
- Single and other sales (Single and Other).

This choice has a very significant impact on the value of each asset to the end user. The most profitable category is the annual subscription purchase. It should be noted that this option is currently implemented on all photo stocks without exception, and in the economic literature, many authors attribute it to one of the significant financial innovations. It consists in the fact that, having paid a certain fixed amount in advance, the user gets the opportunity to buy from 10 to 750 any images to choose from (the selection limits for the number of different companies differ) per month, depending on the size of the advance (Table 2.2). For example, with an annual subscription to Shutterstock, paying a monthly advance of $169, the consumer gets the opportunity to copy 350 of any images of their choice within a month. Naturally, such a subscription is very beneficial for those who constantly need a large number of new images of various subjects - these are graphic and web designers, publishers, advertising agencies, etc.

Table 2.2 - Tariffs for an annual subscription with a monthly advance

№	Number of downloads per month, pcs.	Price, USD
1	10	29
2	50	99
3	350	169
4	750	199

Source: Compiled by the author based on Shutterstock data

If the buyer does not have a constant need for such large quantities of images, then he can take advantage of the tariffs and options for buying “on demand” (table 2.3). There are compromise conditions for rarer purchases. For example, Shutterstock's $229 standard license allows you to copy 25 images throughout the year to choose from. And with a license with extended rights to use the asset, for 25 images per year, you will already have to pay $ 1,699 upfront. This is due to the wider use of such images in the publishing and advertising business, in particular, the higher circulation of products that will use purchased images. Note that contributors/investors also earn a higher income from selling their images in the on-demand category than from subscription sales.

Table 2.3 - Tariffs for the purchase of an image "on demand"

№	Number of downloads per year, pcs.	Price, USD	Type of license
1	5	49	Standard
2	25	229	Standard
3	2	199	Extended
4	5	449	Extended
5	25	1699	Extended

Source: Compiled by the author based on Shutterstock data

Thus, the possibility for users to independently choose any options according to tables 2.1-2.3 results in a variety of combinations of amounts received by the photostock for each download (sale). In addition, if the consumer is not a regular subscriber, then separate, higher tariffs are set for him in the category of "single and other" sales (Single and Other). There are also pricing features for news and other editorial images (Editorial type license), and for vector images. As a result, it is the wide choice of options and tariffs that explains the disproportions between the number of sales of specific assets and the corresponding income received by both the photo stock and the author/investor.

In particular, in the diagram in Fig. Figure 2.1 shows the sales results for a particular bitmap S, which has shown a distinct inertial trend since November 2011, when it was first uploaded to the Shutterstock collection. It can be noted on the diagram, first of all, that in 2011 there were only five events for the sale of this image.

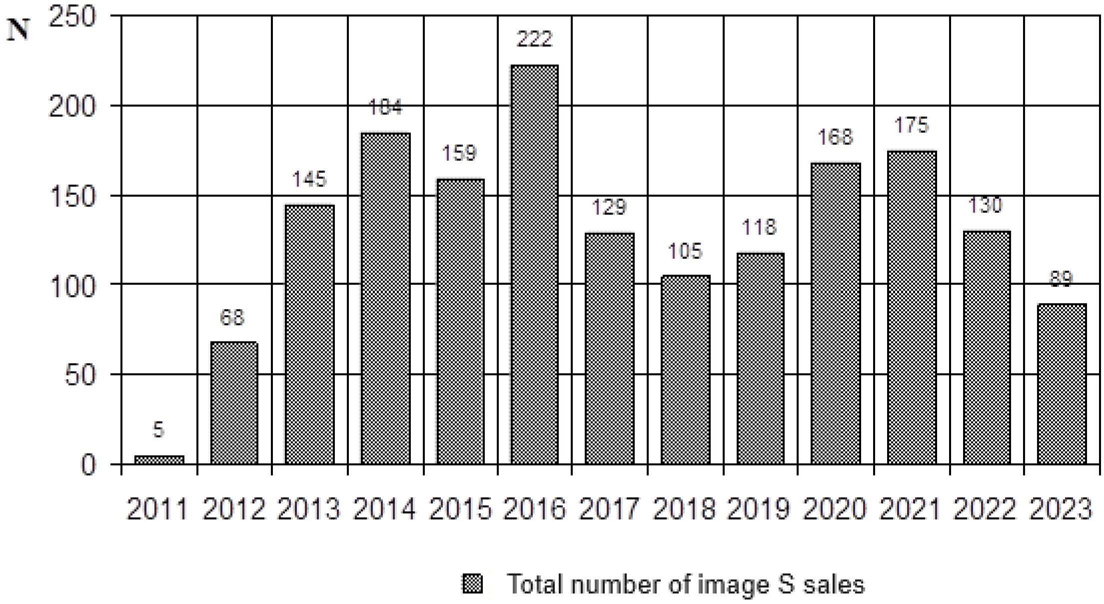

Fig. 2.1 - Total number of image S sales, including subscription, on-demand, one-off and other sales for 2011-2021. (Compiled by the author)

Further, it can be seen that it took about two years for the process to reach some higher level of sales. These observations are quite consistent with the opinion of industry experts that the adaptation ("promotion") of an individual digital asset on the microstock marketplace takes about two years on average. That is, approximately two years of exposure is required on average for an asset to attract the attention of the market and begin to generate a stable income.

The next chart (Fig. 2.2), synchronous in time with the sales chart, allows you to see that sales and revenues change disproportionately over the years, although at first glance the charts have some similarity. This disproportionality is also confirmed by the correlation coefficient between the data arrays, respectively, for sales and revenue, equal to 0.925. The value of the coefficient less than one indicates that revenue, in addition to the number of sales, is influenced by additional factors.

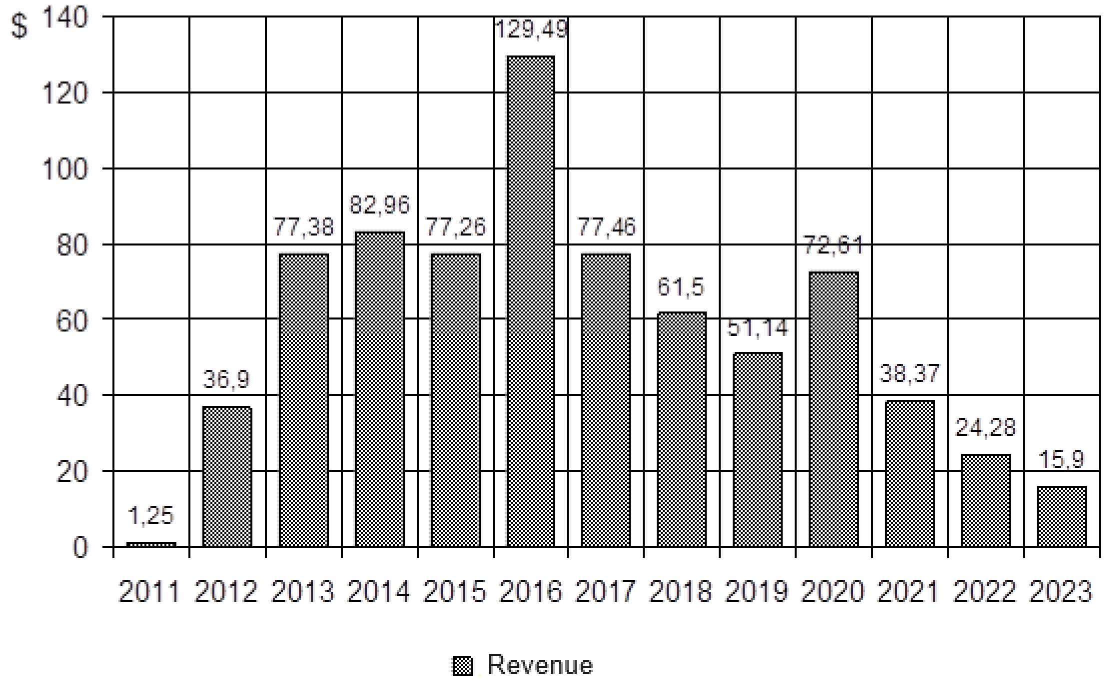

Fig. 2.2 - Cumulative revenue from the sale of image S for 2011-2021 (compiled by the author)

Two diagrams (Fig. 2.1 and 2.2) give a visual representation of the work of one asset. However, in a portfolio, all assets (there may be several thousand in one portfolio) work differently, and this is another, even more serious reason for the uncertainty of the overall financial result. The creative nature of such assets greatly influences their investment parameters, so no predictions made for conventional financial assets work in the intellectual property market.

In this regard, it is likely that the attitude to the finished photograph as an asset, albeit an intellectual one, only at first glance seems to be quite reasonable and natural in the modern world filled with commodity-money relations. Note once again that the mention of the "finished" photograph here is significant, because. our study is devoted to the economic turnover of ready-made rather than commissioned photography. Deep research into the essence of photography as a phenomenon in recent years has revealed some of its unusual aspects, which were not previously given importance, but which further increased the uncertainty of its meaning, content and value.

In particular, in a number of works, the phenomenon of photography is opposed to the rationalism of economic relations, which ensures a continuous sequential exchange of goods and money, both in direct and in reverse directions. It is understood that in this case there is always the possibility of exchanging money for goods, and goods for money. Moreover, it is shown that the same is observed in the sphere of circulation of some abstract values, where, for example, there is an equally unceasing sequential exchange of signs (forms) for their semantic content[36].

With photography, however, everything turns out to be different, namely: “It is possible to turn an object into an image subject, but reverse exchange and reverse movement are impossible”[37]. For this reason, the photograph may not comply with the principles of quantitative equivalents. The image hardly supports mathematical or structural principles. The content of a photograph is almost always conditional, it rarely comes down to a single summary. Despite its seemingly direct connection with the authentic world, photography does not correspond to the principles of the reality of the subject. Taken once, the photograph "... never operates with genuine objects"[38].

In addition, we note that an important role in photography belongs to its technical component associated with the achievements of science, including, in recent decades, in the field of information technology. This aspect of photography was noted at the beginning of the last century by W. Benjamin: "... the nature that opens up to the camera is different than that that opens up to the eye"[39]. Thus, taken together, all of the above aspects make the finished product, including the digital image, an extremely high-risk asset.

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[36] See, for example: J. Baudrillard. On the Critique of the Political Economy of the Sign. - M .: Biblion - Russian book, 2003.

[37] Vasilyeva E. Photography and non-logical form. - M .: New Literary Review, 2019. - P. 112.

[38] See ibid., p. 115.

[39] Benjamin V. Brief history of photography. – M.: Ad Marginem Press: Garage Museum of Contemporary Art, 2021. – P. 105.

In order to find approaches to solving the problems of risk and uncertainty of such intellectual assets, in this work we have built our own structural model of a portfolio of digital images. In this model, all assets in the portfolio are divided into groups of sales that show approximately the same demand, and therefore are subject to the same risk. Our study showed that portfolios of this type are characterized by the presence of a special group representing assets that have not been sold and may not be sold in the future. It turned out that this group of assets plays a special role in the portfolio, it was called the waiting group, and it was this portfolio structure that allowed us to approach the understanding of the nature and mechanism of inertia.

Let's illustrate the idea of a structural portfolio model with the help of waterfall diagrams in fig. 2.3 and 2.4, which have some similarities with the so-called "sales funnels" used in marketing. The diagrams show the distribution of assets by groups of sales of the portfolio under study in specific periods of time. In particular, in fig. Figure 2.3 shows the distribution as of November 2018. The upper bar of this chart represents the waiting group, as noted above - these are assets (226 units) that have never been sold. Below it is a bar showing the total number of all other assets that were sold at least once (280 units).

The next bar (1+) represents a group of assets that were sold more than once (179 pieces), so the difference between the values of the 2nd and 3rd bars gives 101 assets, each of which was sold only once. Then bar 10+ represents a group of assets (31 items) each sold more than 10 times, so the difference between the values of the 3rd and 4th bars gives 148 assets sold from 2 to 10 times.

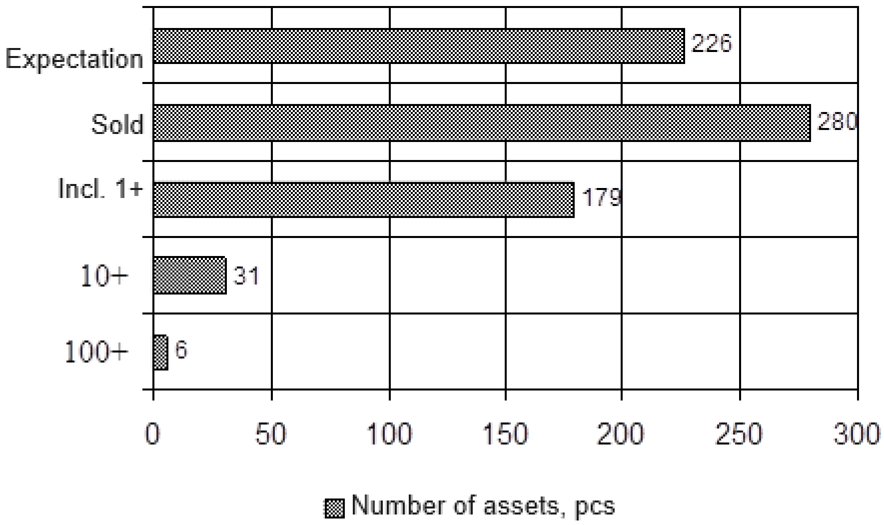

Fig. 2.3 - Number of assets in the waiting group, and assets sold at least once (Sold), including more than once (1+), more than ten times (10+), and more than a hundred times (100+) in the studied portfolio digital images, as of November 2018 (compiled by the author)

Finally, the 5th rod 100+ represents the group of champions - i.e., assets (6 pcs.), each of which was sold more than 100 times. It is easy to see that the total return on the portfolio is formed mainly by the two lower groups, which contain only 5% of the total portfolio assets. This is explained by the fact that among the record holders of these groups there are assets, each of which was sold on the indicated date, respectively, more than 200 times and more than 1100 times.

In principle, diagrams like fig. 2.3 can be built at any frequency, for example, every six months. However, the sales dynamics of the studied portfolio is such that it is more convenient to show a clearer idea of the inertia of the processes in it over a longer time interval. Therefore, in fig. 2.4 shows the same breakdown of grouped sales data for the same portfolio as of March 2021.

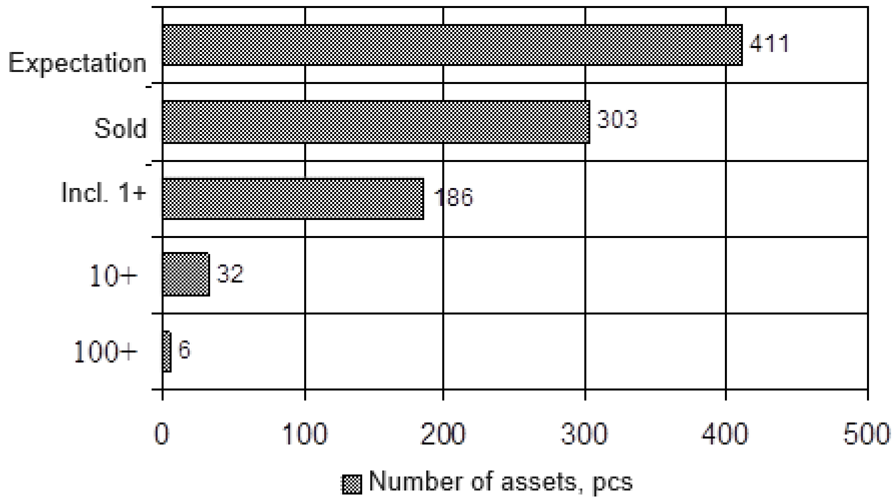

Fig 2.4 - The number of assets in the same groups as in fig. 3, in the studied portfolio as of March 2021 (compiled by the author)

Comparing the two diagrams (fig. 2.3 and 2.4), one can see that in 2.5 years the waiting group has increased to 411 members. assets; a group of all the rest sold at least once - up to 303 pieces; group sold more than once - up to 186 pcs. At the same time, the group of those sold more than ten times during this time increased by only one asset, and the group of the main record holders did not change at all.

To interpret these data, first of all, we note our observation that a simple increase in the volume of the studied and other similar portfolios does not lead to a linear increase in sales and revenue. In particular, the number of assets in the studied portfolio as a whole increased by more than 40% over the specified period. At the same time, the waiting group increased by 82%, and the group of all sold assets - by only 8%, i.e. its increase was ten times less. The 1+ and 10+ groups grew by 4% and 3%, respectively, and there were no new record-breaking revenue generators in the 100+ group during this period (see table 2.4). However, the graphs shown in fig. 2.1 and 2.2 indicate that sales are continuing successfully and the portfolio is producing an investment return.

Table 2.4 - Changes in asset sales groups

№	Sales team	2018	2021	Growth, %
1	Expectation	226	411	81,9
2	Sales	280	303	8,2
3	Incl. 1+	179	186	3,9
4	10+	31	32	3,2
5	100+	6	6	0

Source: compiled by the author

As will be shown below, the process of filling the portfolio with assets is associated with the actions of the investor, or with the creative productivity of the author, and is not necessarily stable and one-time. This process has its own uncertainties, which may depend on the strategy of the investor/author. Our research has shown that portfolios of this type have the property of inertia. In its most general form, it lies in the fact that a portfolio, brought to a certain level of income, can continue to generate it for a long time with little or no participation of the investor/author.

Here we understand inertia as a property to maintain stable functioning and long-term reproduction of achieved indicators, for example, such as the return on financial assets[40]. In addition, structural inertia implies the ability of the system to maintain the formed cause-and-effect relationships for a long time. For the subject area under study, the concept of investment inertia is close, as a property inherent in many classes of financial instruments. Thus, the property of the inertia of the portfolio of intellectual assets that we have identified is the closest to the concept of inertial investment[41].

At the initial moment of time, the owner of a portfolio of assets of this class does not know any frequency-probabilistic characteristics (sales, profitability, etc.) necessary

[40] Sidnina V.L. The inertia of the economic system // Society and Economics. - 2002. - No. 2. - P. 114-130.

[41] Ayupov A.A. Design and implementation of innovative financial instruments. – M.: Nota Bene, 2007. – P. 112.

for risk assessment. That is, he does not know the parameters that the owners (managers) of securities portfolios and similar assets habitually operate with. This uncertainty accompanies the portfolio of intellectual assets as long as there are assets in it that have not been sold at least once. In our model, this group plays the role of a kind of accumulator that responds to the impact of market demand with the events of the first sale of assets. The analogy with storage (capacity) is not accidental here, because our research has shown that the presence of a waiting group is one of the factors that give portfolios of intellectual assets a persistence property.

In the proposed structural model, each fact of the first sale is a primary perturbation, which conditionally moves the sold asset from the waiting group to the next group of the first sale in order. Then, during repeated and subsequent sales, the assets are sequentially moved to the next groups in order, but it is from the event of the first sale that the information flow begins, reflecting, on the one hand, an increase in the total income of the portfolio, and on the other hand, a decrease in uncertainty. Note that within the framework of the concept of the cost of information, this flow can be considered, among other things, from the point of view of the cost of uncertainty.

Assume that for a portfolio that is first offered for sale, the prior cost of uncertainty is proportional to the total number of asset units n. In this case, every first sale of each asset will reduce this value by an amount proportional to 1/n. For example, if on a particular date 226 of the 506 assets in the portfolio have never been sold, then the present value of the uncertainty can be estimated with a probability value of 226/506. Since, due to uncertainty, we do not know which of these assets will be sold next, when this happens, and whether it will happen in principle, it would be quite acceptable to use the found value to determine the integral probability of not receiving income for this portfolio. It is possible to construct other absolute or relative indicators of uncertainty, however, as noted above, there are aspects related to portfolio management that significantly complicate the risk assessment algorithm.

The noted aspects of management are that an investor (author, portfolio owner) can transfer the portfolio to an investment intermediary (photostock) at a time, and then take no further action, for example, not replenish it with new assets. With such a strategy, due to the already noted inertia, the uncertainty will decrease gradually. In our structural model, this process will begin with the formation of the group of the first sale, then, with repeated and subsequent sales, assets will gradually move towards the group of champions. As noted above, the process will continue until there is not a single asset left in the waiting group.

The portfolio works in a fundamentally different way when the author/investor continuously (for example, daily) replenishes it with new assets. At the same time, it is impossible to significantly reduce the uncertainty, since each new asset increases it, and the sale of this asset, due to inertia, may occur much later, or not at all in the foreseeable future. Such a strategy is typical, for example, for an investor who plans to significantly increase the investment return of the portfolio.

Finally, the author/investor, guided by their own strategic motives, can upload new assets (series of works) at large time intervals, or vice versa, continuously replenishing the portfolio, periodically taking long breaks.

All of these options suggest that the ability to choose a portfolio management strategy makes it almost useless to use simple probabilistic measures of uncertainty. However, having observed the process of selling digital images for a long time, we can confidently state that the quantitative increase in the expectation group is always positive, although it is disproportionately reflected in the return of such portfolios. In turn, the identified property of inertia makes it possible to significantly smooth out fluctuations in profitability caused, for example, by long interruptions in the process of replenishing the portfolio with new assets.

Due to the presence of the identified property of inertia, a portfolio brought to a certain level of income can continue to generate it for a long time, even if the author/investor stops replenishing it with new assets. However, in relation to the actions of specific authors (as investors), it can be noted that the creative productivity factor is not critical in terms of the risk of shortfall in income, but in terms of the quantitative volume of the portfolio, it affects the achievement of the required level of income[42].

2.2. Quantitative estimates of inertia

The previous paragraph was devoted to a qualitative understanding of the nature of the inertia effect of intellectual assets. For the analysis, we used arrays of observations on the number of sales and revenue from the sale of a specific digital image (asset S), covering more than a ten-year period. The disproportionality between the data sets on sales and revenue is shown, confirmed, among other things, by the value of the correlation coefficient. Also, taking into account our ideas about the inertia of individual assets and intellectual property portfolios, a structural model of the portfolio was presented. In this model, the role of accumulator is assigned to a special group of unsold assets, which we call the waiting group. As a result, an explanation was given of our vision of the nature of inertia and its impact on the profitability of an investment portfolio of digital intellectual assets.

The available observational results on the dynamics of sales and revenue will be further used to quantitatively estimate the value of an individual income-generating asset; the value of the portfolio as a whole; and also to quantify the effect of inertia. Since we have at our disposal accurate information about cash flows of income in the context of any observation periods, it seems possible to use the classical concept of discounted cash flows (DCF concept) for these purposes.

In particular, we note that if an asset generates an annual constant cash flow of income, then, in accordance with the DCF concept, the current (present) value of such an asset can be represented as a continuous series:

$$P = \frac{A}{1+r} + \frac{A}{(1+r)^2} + \ldots + \frac{A}{(1+r)^n}, \qquad (2.1)$$

[42] Voronov V.S. Digital intellectual assets of copyright as investment objects / V.S. Voronov, V.D. Davydov // Problems of Modern Economics. - 2020. - No. 3. - P. 132-136.

where P is the current value of the asset that generates income;

A - the amount of annual income in monetary terms;

r - is the rate of expected return;

n - is the number of whole years.

Expression (2.1) is the sum of the terms of a series of infinitely decreasing geometric progression, which can be reduced to the form:

$$P = \sum_{n=1}^{\infty} \frac{A}{(1+r)^n}, \tag{2.2}$$

or, as n tends to infinity, bring it to the form:

$$P = \frac{A}{r}. \tag{2.3}$$

To estimate the current value, we use the sales indicators of an individual asset S, shown in Fig. 2.1. For average estimates, we exclude sales for 2011-2012. due to the above reasons related to the adaptation of the asset on the trading platform, as well as sales for 2022-2023. due to a significant (3 times) officially announced decrease in the authors' income from sales in these years. Over the remaining nine years, the average number of sales is 156 per year. Therefore, if the income from one ordinary sale of an asset in the subscription category is equal to \$0.33, the average annual income for this asset in the accepted billing period could conditionally be:

$$A = 156 \cdot 0{,}33 \text{ USD} = 51{,}48 \text{ USD}$$

Using expression (2.3) at an expected rate of return of 10%, we determine the approximate value of the retrospective current value of the asset under study:

$$P = \frac{A}{r} = \frac{51.48\, USD}{0.1} = 514.8\, USD$$

Further, we note that the actual average annual income for the same period can be checked using the data from the synchronous revenue diagram shown in Fig. 2.2. The calculation shows that its value is equal to \$74.24. The discrepancy with the conditional average annual income found above can be explained by the fact that sales in other price categories (except for subscription) usually bring higher income. Thus, the resulting comparison again highlights the impact of uncertainties associated with consumers' choice of options and tariffs when purchasing assets.

Regarding the expected return used in the calculation, we note that according to long-term statistics from Ibbotson Associates[43], its rate for high-risk assets is usually at least 10-15%. Intellectual assets are, of course, high-risk assets, so choosing a rate of 10% seems quite reasonable. However, after calculating the actual average annual income, we can make some further estimates. For example, using the above limits on the spread of rates for high-risk assets, we will again estimate the approximate current value of the asset under study using expression (2.3) at rates of return values of 10%, 12% and 15%, respectively:

$$P_{10} = \frac{74.24\,USD}{0.1} = 742.4\,USD$$

$$P_{12} = \frac{74.24\,USD}{0.12} = 618.7\,USD$$

$$P_{15} = \frac{74.24\,USD}{0.15} = 494.9\,USD$$

The result shows that the approximate retrospective current value of the asset under study at an expected rate of return of 10%, naturally, also turns out to be higher. However, it should be noted that when the rate increases to 15%, this cost naturally decreases.

In order to check the resulting order of magnitude of the current value, we calculate not the average, but the exact value in a more labor-intensive way. For this

[43] Ibbotson R.G., Harrington J.P. Stocks, Bonds, Bills and Inflation (SBBI): – 2021. Summary Edition (July 26, 2021).

purpose, let's discount the cash flows from the income diagram shown in Fig. 2.2 for the accepted billing period 2013-2021. at an expected return rate of 10%.

Table 2.5 - Discounted cash flow of proceeds from the sale of asset S for 2013-2021

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
A, USD	77,38	82,96	77,26	129,49	77,46	61,5	51,14	72,61	38,37
D, share units	1,1	1,21	1,33	1,46	1,61	1,77	1,95	2,14	2,36
P, USD	70,35	68,56	58,09	88,69	48,11	34,75	26,23	33,93	16,26

Source: compiled by the author

In Table 2.5, line A shows the income values by year from the diagram in Fig. 2.2. For convenience, the line F (shares of units) presents the values of the discount factor for the corresponding years. As a result, the amount of cash flow of revenue for 2013-2021, discounted at a rate of 10% (line P in Table 2.5) is $444.97. Within the framework of the DCF concept, this amount can be interpreted as an updated retrospective current value of the asset as of 2013 d. Thus, the calculation showed that the adjusted value of the current value of the asset turned out to be lower than approximate estimates made with the same expected return and average values of annual income.

Next, let us pay attention to the fact that sales and revenue statistics also make it possible to quantify the inertia of the asset under study. Namely, based on the identified rate of decline in these indicators, we will predict the period after which the asset will theoretically stop generating cash income. Let us assume that the dependence of the decline in sales and revenue over time is linear. In this case, graphs of the linear dependence of sales and revenue on time, obtained by the linear regression method, will have to intersect the x-axis at the point of the desired year. Here and below, a standard function of the MS Excel software package was used for regression analysis.

Just as in previous estimates, data for 2011-2012 and 2022-2023 were not taken into account for regression analysis. The first regression equation was obtained for the cash flow of revenue using the data in Table 2.5 (line A, dollars):

$$A = -5{,}12 \cdot Y + 10406{,}66 \quad (2.4)$$

In Fig. Figure 2.5 shows a graph of the linear approximation of the revenue function for this asset. All necessary regression statistics metrics for this equation are presented in Appendix 1. When analyzing this equation, first of all, it should be noted that only the critical point of intersection of the linear regression graph with the x-axis (A = 0) has economic meaning. Solving the regression equation for this point gives the forecast period for revenue to decrease to zero, corresponding to 2033.

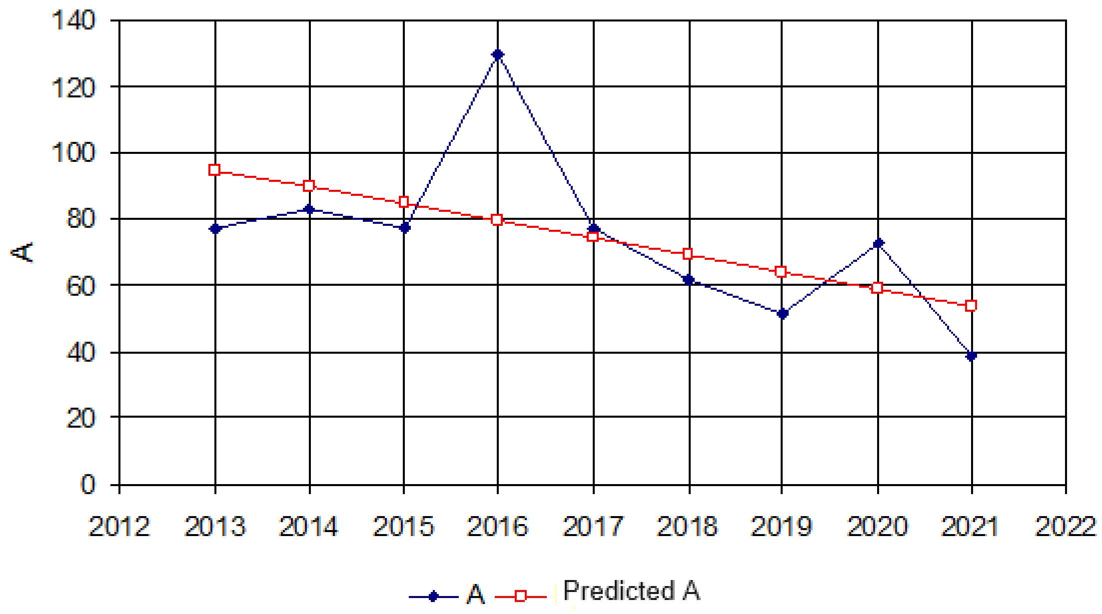

Fig. 2.5 - Graph of a linear approximation of the revenue function for an asset (compiled by the author)

Thus, as a characteristic of the inertia of the asset S, which continues to generate income at the present time, an estimate was made of the duration of the time period in years, after which the receipt of income will completely cease. Like any forecast, this estimate is approximate, however, the nature of the dependence of revenue on time, observed even visually, suggests that the flow of revenue will most likely continue for several more years.

The algorithm for assessing inertia, applied above for an individual asset, is also suitable for the portfolio as a whole. In particular, in Fig. 2.6 shows the sales results, and Fig. 2.7 – cash flow of revenue for the portfolio from which the asset (digital image) S was taken.

Note that the results are from 2009 to 2011. were also not taken into account in this regression model, because they correspond to the initial stage of “promotion” of this portfolio on the intermediary’s online trading platform (microphoto stock). As noted in the previous paragraph, the presence of such a period (2-3 years) is typical for both individual assets and portfolios as a whole. To a certain extent, this period also characterizes the inertia of the process of investing in intellectual assets of the class under study. Indicators for 2022-2023 were also excluded due to a significant official decline in sales revenue.

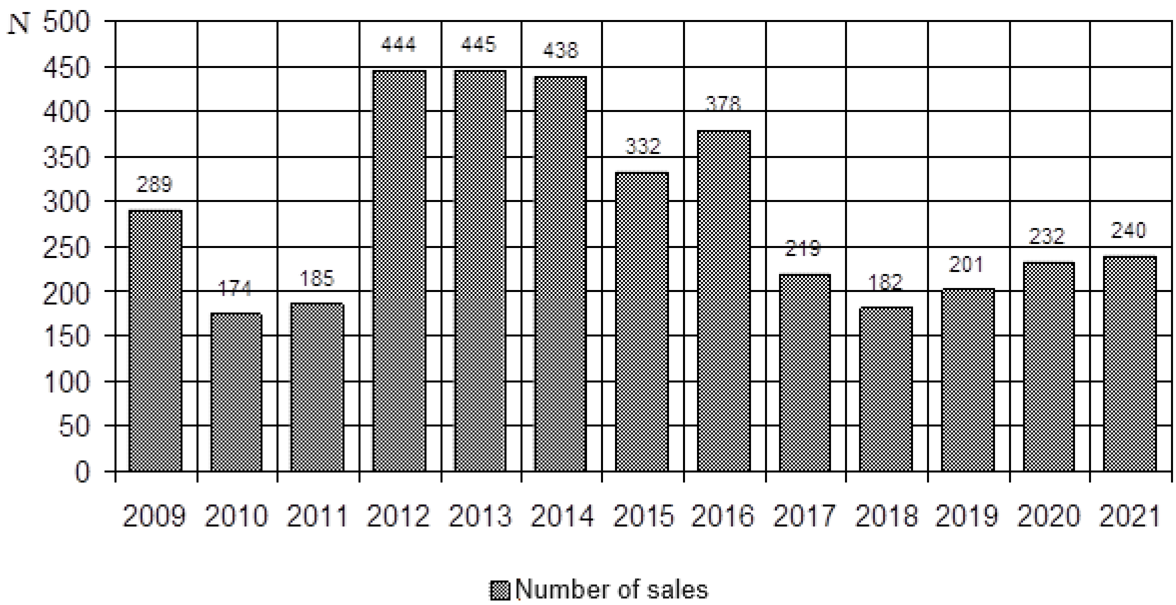

Fig. 2.6 - Sales for the portfolio as a whole (compiled by the author)

For clarity, in Fig. In Fig. 2.7, on the rods of the annual indicators of the total revenue from sales for the portfolio, the revenue from the sales of an individual image S is highlighted. This allows us to see in the combined diagram that the revenue from the sale of the image S, starting from 2012, represents a significant share of the total revenue for the portfolio. In some years, this share is 50% or more of total revenue (in particular, in 2016, 2017, 2020, 2021). This is explained by the fact that image S is the "absolute record holder" of sales in this portfolio.

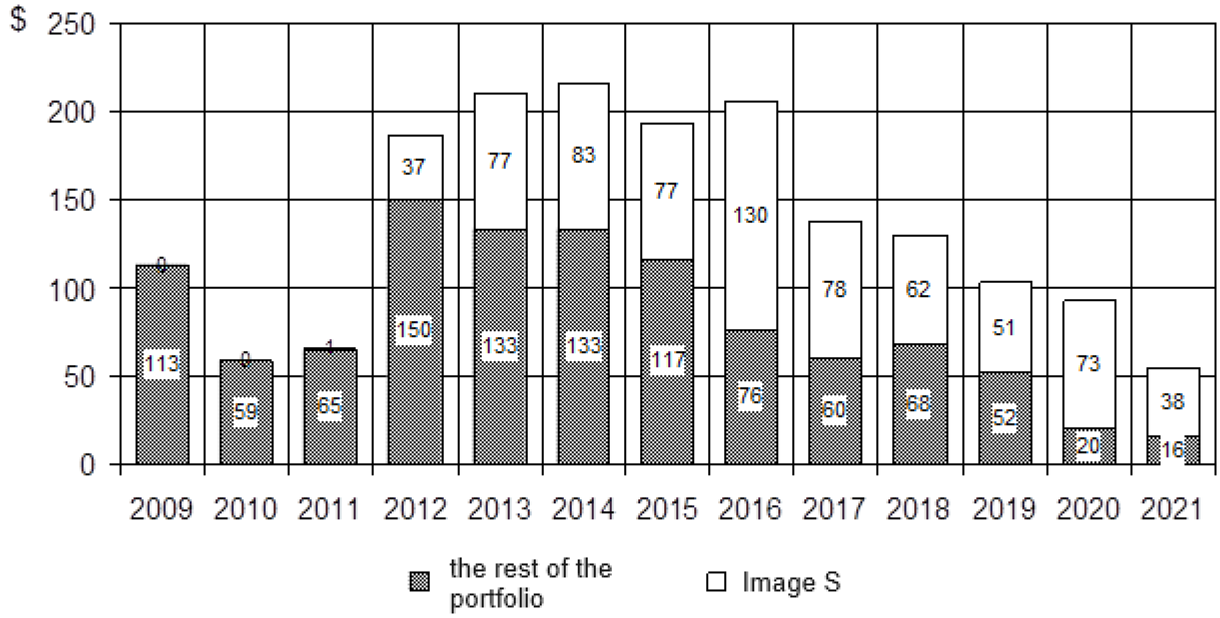

Fig. 2.7 - Portfolio Sales Proceeds with Image S (compiled by the author)

Diagram in Fig. 2.7 shows that the dynamics of total cash flow of revenue has a clear downward trend towards 2020-2021. This observation allows, using regression analysis, as in the case of an individual asset, to give a predictive estimate of the period at the end of which the investment portfolio under study would cease to generate cash income if the replenishment of it with new assets were completely stopped at the end of 2021. The initial data allows for regression analysis, both by the number of sales and by total revenue. A comparison of the assessment results is also of interest from the point of view of the uncertainties associated with the disproportions already noted above between sales and revenue indicators characteristic of the intellectual assets of the class under study.

In Fig. Figure 2.8 shows a graph of the linear approximation of the sales volume function for the portfolio as a whole, in accordance with the data in the diagram presented in Fig. 2.6 (2012-2021). The regression equation for sales volumes for the portfolio in the accepted calculation period is as follows:

$$A = -31{,}04 \cdot Y + 62895{,}93 \quad (2.5)$$

All the necessary regression statistics metrics for it are presented in Appendix 1.

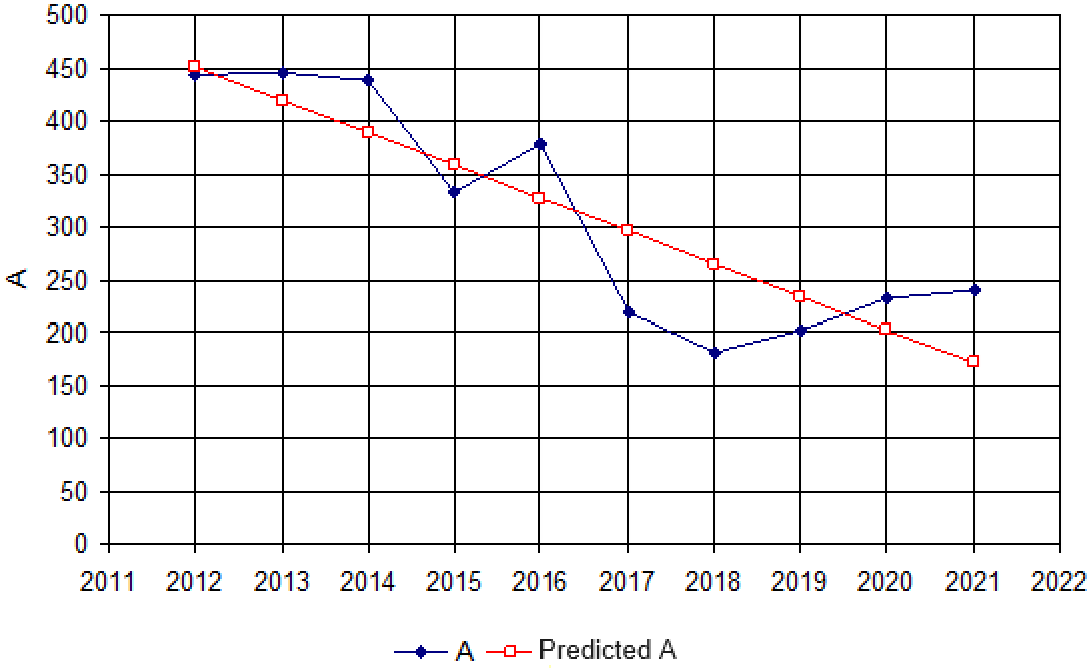

Fig. 2.8 - Graph of a linear approximation of the function of sales volumes for the portfolio as a whole. (compiled by the author)

Below in Fig. Figure 2.9 shows a graph of the linear approximation of the function of the total cash flow of proceeds from sales for the portfolio as a whole, in accordance with the data of the time-synchronous diagram in Fig. 2.7 (2012-2021). The regression equation for the portfolio sales revenue function is as follows:

$$A = -17{,}22 \cdot Y + 34873{,}56 \quad (2.6)$$

All the necessary regression statistics metrics for it are presented in Appendix 1.

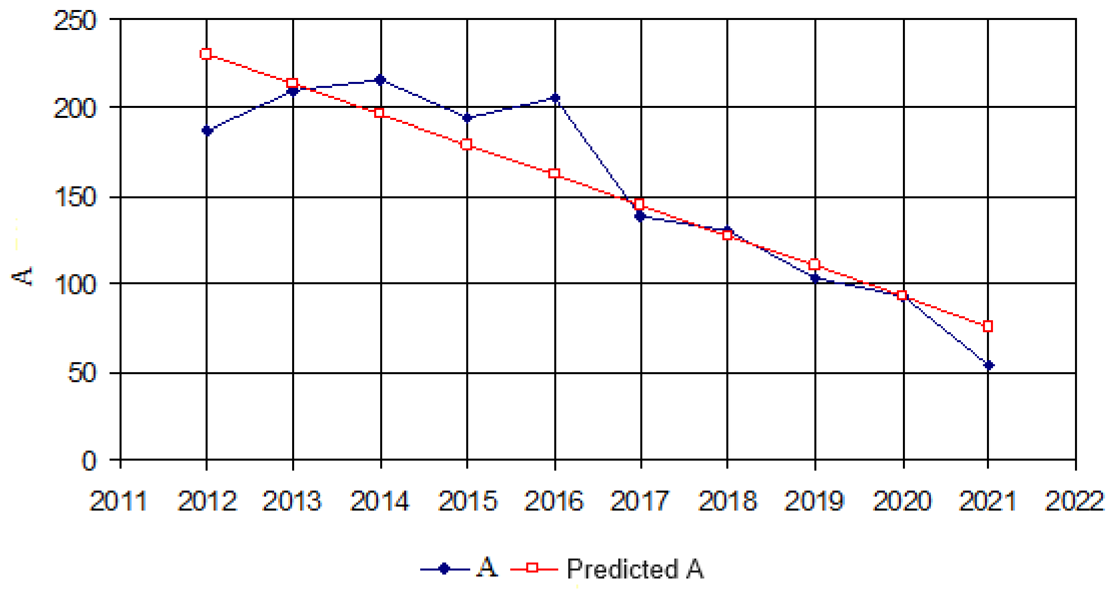

Fig. 2.9 - Graph of a linear approximation of the revenue function for the portfolio as a whole (compiled by the author)

As in the previous case of an individual asset, it should be noted that only critical points of intersection of linear regression graphs with the x-axis (A = 0) have economic meaning. Solutions of the regression equations obtained above for the portfolio as a whole for this point show that the forecast period at the end of which sales will cease is 2026, and the forecast period for the cessation of revenue receipts is 2025 (see below Fig. 2.10).

Again, we note that the spread in the terms obtained characterizes the uncertainty associated with the fact that sales of licenses for the same asset may generate income that differs depending on the category in which the sale took place (subscription, on demand, single); what physical image size is required; what license is required for the buyer (regular, extended). The ability for consumers to choose these parameters violates the proportionality of sales volumes and revenue. This disproportionality is confirmed by the correlation coefficient between data sets on sales and portfolio revenue, equal to

0.829. A value less than one indicates that revenue, in addition to the number of sales, is influenced by additional factors.

Another significant factor of uncertainty is related to the fact that, according to the rough estimate made above, the end of operation of asset S occurs in 2033, which is 6-7 years higher than the forecast for the portfolio. This strong discrepancy can be explained, firstly, by our assumption that sales and revenue depend linearly on time. In reality, the type of this dependence is unknown to us. Secondly, we do not know in which year exactly the front of the increase in sales and cash flow of revenue for the asset ended. Thus, we can only make an assumption that the portfolio's termination date will be within the range between the two estimates obtained. However, even this result does not prevent us from demonstrating clear effects of inertia, both for an individual asset and for the portfolio as a whole.

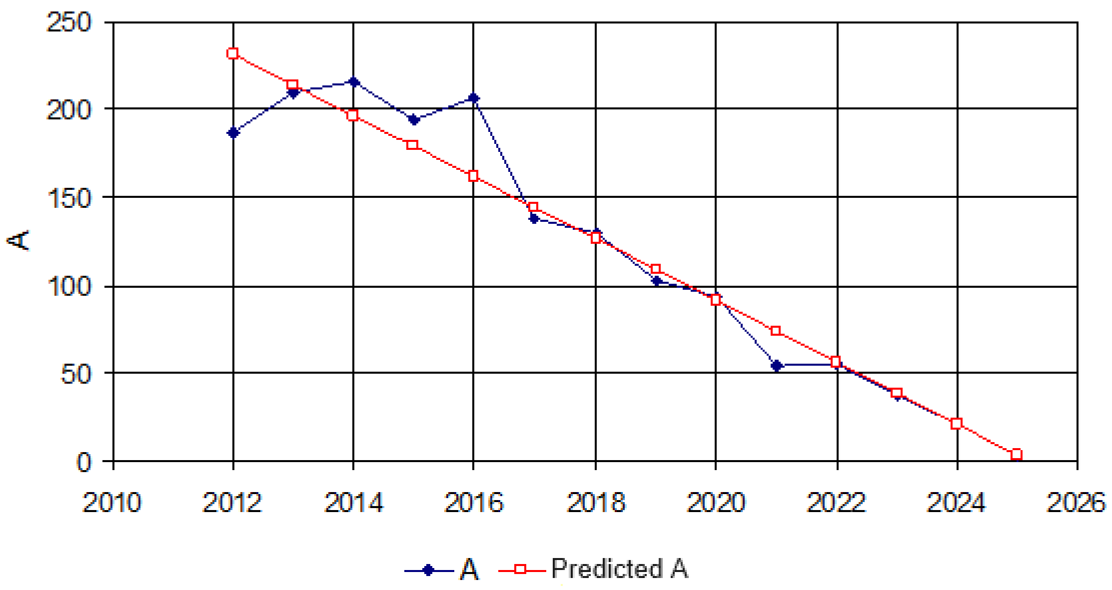

Fig. 2.10 - Graph of a linear approximation of the revenue function for estimating the present value of the portfolio (compiled by the author)

Next, we note that the resulting regression equation (2.6) also makes it possible to predict the total cash flow of revenue. In turn, this allows, again using the DCF concept, to approximately estimate the value of the portfolio as a whole at a given rate of return.

As in the case of an individual asset, we will take it equal to 10%. Table 2.6 presents the calculation of the cash flow of revenue for the portfolio, taking into account the forecast for 2024-2025. The data in table 2.6 is grouped according to the same principle as above in table 2.5 for an individual asset.

Table 2.6 - Discounted cash flow of sales revenue for the portfolio as a whole, taking into account the forecast for 2024-2025

Year	2022	2023	2024	2025
Revenue, USD	54,72	37,5	20,28	3,06
D, share units	1,1	1,21	1,33	1,46
P, USD	49,75	30,99	15,25	2,10

Source: compiled by the author

Discounting the cash flow of revenue obtained in this way, taking into account the forecast for 2024-2025. gives an approximate estimate of the residual current value of the portfolio for 2021 in the amount of $80.79 (amount in line P, dollars in Table 2.6).

Combining the obtained data (Fig. 2.10) makes it possible to analyze the full cash flow of revenue, which includes the actual flow obtained as a result of observations (see Fig. 2.7) and the forecast flow (line "Revenue" in Table 2.6). Discounting the total cash flow constructed in this way allows us to make an approximate estimate of the current (present) value of the portfolio for some other dates of its life. For example, discounting only the actual revenue received for the period from 2012 to 2023. makes it possible to approximately estimate the retrospective current value of the portfolio as a whole at the beginning of 2012 in the amount of $1,044.65.

Thus, the obtained dependencies and estimates of the current value clearly characterize the inertia of the portfolio, in this case, the ability to generate income in the forecast period.

2.3. Return impulses in an inertial investment portfolio

The previous paragraph analyzed the cash flow of total revenue for the portfolio under study as a whole. This cash flow is represented by observational data showing the economic process of selling all the assets in the portfolio. The characteristic of the process is some total value of income for all assets, which can be determined on any fixed date in each observation period.

It should be emphasized that this total flow is represented by data that reflects in dynamics the sum of the individual cash flows of proceeds from the sale of each individual asset. However, our research has shown that, unlike the total cash flow of portfolio proceeds, the cash flows of proceeds from the sale of individual assets have a distinctly individual character. The analysis of the processes of sale of several hundred individual assets, carried out in this work, revealed some new patterns.

In particular, the analysis showed that the nature of the sales charts of individual assets indicates the presence of clearly defined periods of initial growth, then continuation and further decline of the entire process of obtaining revenue over time. Based on this observation, we concluded that such processes can be quantitatively and qualitatively described using the concept of momentum, which is widely used to characterize dynamic inertial processes in various subject areas. Since the information parameters of the process under study are the number of sales and income values observed at fixed points in time, it is proposed to call the identified impulses within the framework of the proposed concept of the inertial portfolio, respectively, trading impulses and profitability (income) impulses.

In accordance with our assumption about the momentum structure of the cash flow, given the homogeneity of the random events of the sale of assets, it is permissible to represent the entire sale process as a stream of random events. In this case, it is convenient to represent the sequence of sales events for each asset in time as a stream of random events propagating in the direction of the x-axis (Fig. 2.11). One event in such a stream corresponds to one sale (i.e. a one-time sale) of an asset. In fact, such a flow consists of elementary indivisible random events (1; 2; 3, ... i), i.e. such events, further discretization of which is impossible.

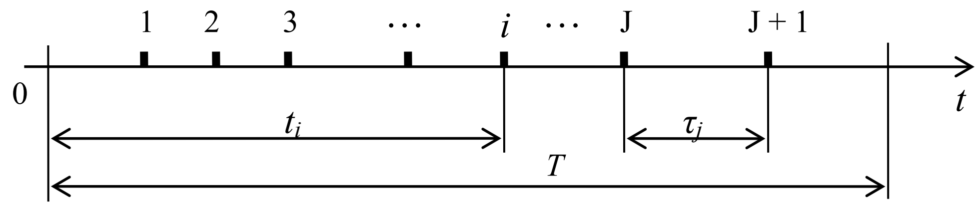

Fig. 2.11 - Random stream of elementary events of the sale of an individual asset (compiled by the author)

Let us present some characteristics of the flow of random sales events shown in Fig. eleven:

T - observation time, may vary depending on the selected study period;

t_i is the moment of the i-th random sale event;

τ_j is the interval between events, is a random variable;

λ is the intensity of the flow of events, i.e. how many events occur per unit of time on average.

The exact time moments of the next events in such a stream are unknown. If it is known how many events n occurred during the observation time, then $\lambda = n/T$.

In probability theory, it is customary to consider such flows of events within the framework of the model of the flow of infinitely short impulses, i.e. such impulses, the duration of which can be considered infinitely small[44]. In this case, the most important observable characteristics of the flow are the moments of occurrence of random

[44] See, for example: Sedyakin N.M. Elements of the theory of random impulse flows. - M .: Soviet radio, 1965.

impulses, and the intervals between them, which are also random variables. In addition, we note that the pulses in some processes may have different amplitudes.

A stream of infinitely short pulses is generally called Poisson if it satisfies the requirements of being ordinary and having no aftereffect. In addition, the flow may be stationary or non-stationary, i.e. such a flow, whose intensity, in turn, depends on time.

Since in our case the probability of the occurrence of asset sale events does not depend on the moments of previous sales, and the probability of the simultaneous sale of two or more assets can be considered close to zero, the stream of random asset sale events can be considered a Poisson stream (a stream of rare events). The amplitude of all sales event stream impulses is the same; for convenience, it can be considered equal to one.

The probability that n events will occur in a Poisson stream during the observation time is:

$$P_n = \frac{a^n \cdot e^{-a}}{n!}, \qquad (2.7)$$

where a is the Poisson parameter, which for a stationary flow is equal to the average number of events during the observation time. As is known, the mathematical expectation, as well as the standard deviation of the values of the intervals between events for such a flow, are equal to the reciprocal of the flow intensity. On the one hand, this suggests that the dispersion of event occurrence times in the stream of rare events is large and poorly predictable. On the other hand, this makes it possible to test the hypothesis about the Poisson nature of the flow under study. In particular, if the values of the expected value and the standard deviation found experimentally turn out to be close, then this can serve as empirical evidence in favor of the Poisson distribution hypothesis[45].

On fig. 2.12 shows the daily distribution of random impulses of the stream of events for the sale of the SN image in August 2013, which we obtained as a result of

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[45] Voronov V.S., Davydov V.D. Digital intellectual assets in the paradigm of inertial investment // Issues of innovative economics. - 2022. - Volume 12. - No. 1. - P. 141-154. doi:10.18334/vinec.12.1.114119

observations. This image, as well as image S, is taken from the studied portfolio, which was analyzed in the previous paragraphs. As noted above, the amplitude of all sell event impulses is the same, since one elementary impulse represents one sale event.

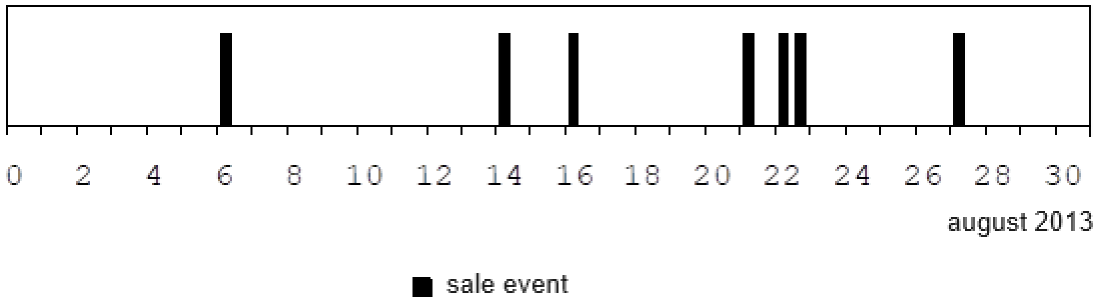

Fig. 2.12 - Distribution of random impulses of the event stream of the sale of the SN image in August 2013 (compiled by the author)

The accumulation or increase in the frequency of random sale events allows you to combine impulses into groups corresponding to daily, quarterly, annual and other observation periods. In such groups, the number of events can be considered as the total amplitudes of selling impulses. In turn, the characteristics of such impulses are already the corresponding envelope curves, which allow one to proceed to the analysis of more complex continuous random processes.

For example, a set of accumulated elementary trading events that reflect the full historical series of random events for the sale of the SN image for 2011-2020. shown in fig. 2.13. The results of our observations showed that during the specified period of time, the SN image was sold 254 times. The diagram is constructed in such a way that each of its rods displays the sum of all elementary events of the sale of a given asset for the corresponding year indicated on the abscissa axis.

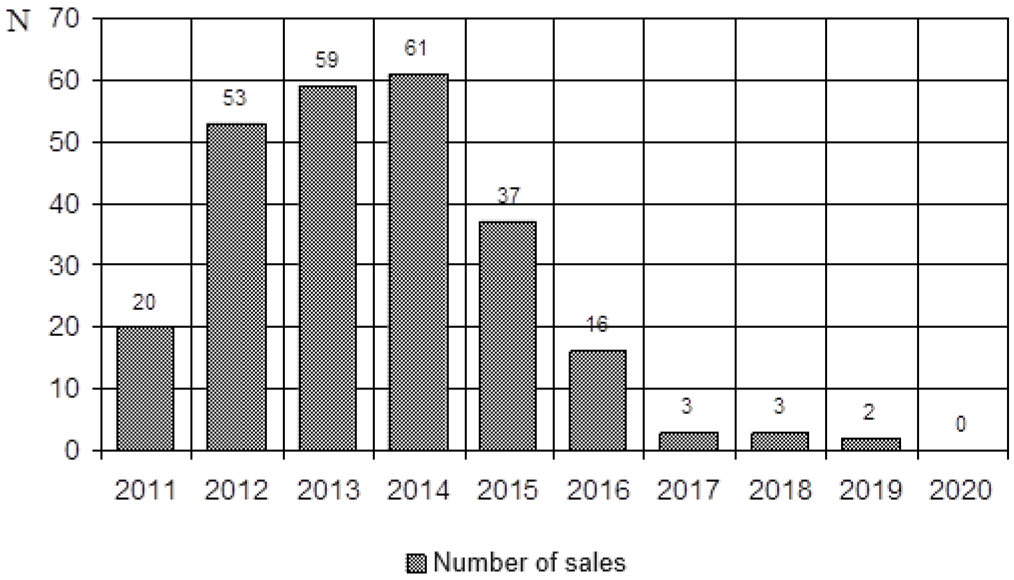

Fig. 2.13 - Number of SN image sales for 2011-2020, in all categories (compiled by the author)

In contrast to the diagram of the flow of elementary random events (Fig. 2.12), the annual diagram in Fig. 2.13 displays a more complex random process in which it becomes possible to single out the front of growth (2011-2012), then continuation (2012-2014) and decline (2014-2019) of the information parameter of the total impulse of the number of sales of this asset. In addition, a characteristic section of the diagram (2016–2019) can be distinguished, which, compared with the steady flow of 2012–2014, represents the so-called thinning (rarefied) stream of random events, the intensity of which is ten times lower. Note that the analysis of such flows is still a serious mathematical problem[46].

In general, visual analysis suggests that it is preferable to consider the flow of random events of the sale of assets as stationary only in annual periods. Accordingly, the number of sales events in each annual period can be used to estimate the flow intensity and probability parameters.

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[46] See, for example: Smagin V.A. Prediction of the next event in the thinning stream of time // Information and space. - 2011. - No. 1. - P. 36-40; Sedyakin N.M. Elements of the theory of random impulse flows. - M.: Soviet radio, 1965. - S. 82-91.

The availability of a complete set of historical data allowed us to test for the first time the hypothesis of the Poisson nature of the flow of random events of the sale of intellectual assets. For this purpose, by means of statistical analysis of the standard MS Excel package, the parameters of the expectation and standard deviation of the values of the intervals between elementary events of the sales flows of the studied assets were found. In particular, according to the SN image for the period 2013-2014. (a total of 120 sales events) received:

- expectation $\mu = 6.19$ days;
- standard deviation $\sigma = 6.06$ days.

The difference between the obtained values is less than 3%, which fully confirms our hypothesis about the Poisson distribution of random events in the studied flows. Confirmation of the Poisson nature of the flow makes it possible to make well-founded estimates of the probabilities of non-occurrence of sales events (P0) and the occurrence of at least one event ($P_{ХБ1}$). In particular, from expression (2.7) in the complete absence of observed events ($n = 0$), we obtain:

$$P_0 = e^{-a} . \tag{2.8}$$

In turn, the probability of at least one event occurring is defined as the opposite event:

$$P_{ХБ1} = 1 - P_0 = 1 - e^{-a} . \tag{2.9}$$

Expressions (2.8) and (2.9) are of great practical importance, because they make it possible to assess the risk of a complete cessation of the sale of an asset, and vice versa, to assess the probability of at least one trading event occurring under the existing (observed) parameters of a random flow of trading events for specific assets. For example, Table 2.7 shows the values of the probability of a complete cessation of the sale and the probability of at least one sale of the SN image on average per month, for which all the parameters of the stream of random events are known to us. Table 2.7 shows that, starting from 2016, the probability of a complete cessation of the sale of this image increases to 26%, then the flow of trading events thins out, and by 2020 sales stop completely. As will be shown in Chapter 3, such estimates are very important for building logical-probabilistic models to support investor decision-making.

Table 2.7 - Probabilities of termination of the sale and the occurrence of at least one sale event of the SN image on average per month

Period	2013-2014	2016	2017-2018	2019
P_0, %	0,67	26,35	77,88	84,65
$P_{ХБ1}$, %	99,33	73,65	22,12	15,35

Source: compiled by the author

As noted above, the second information parameter of this process is the income from the sale of the asset (revenue). In accordance with our assumption about the impulse structure of the cash flow, the second stream of random events of income is different in that each event of the stream has an additional characteristic - amplitude (Fig. 2.14). This is because each random, indivisible income event represents a specific amount of money received as a result of a trading event. In this case, the value of income in monetary terms is plotted on the y-axis, and the diagram represents the flow of random impulses.

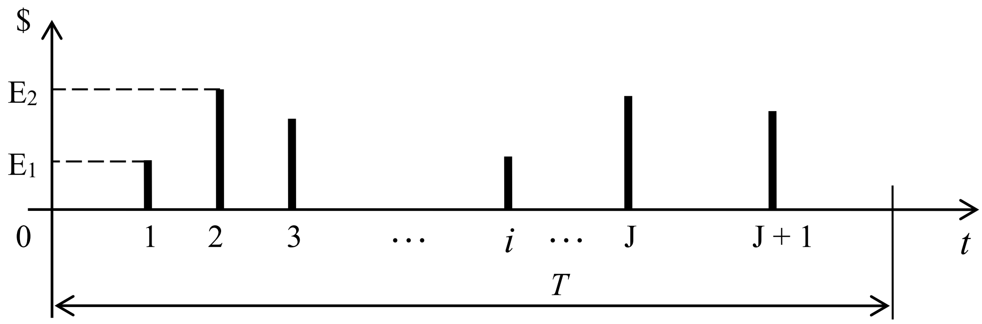

Fig. 2.14 - Random impulse stream of elementary events of receiving income from the sale of an individual asset (compiled by the author)

In particular, the diagram in fig. 2.14 is built in such a way that all elementary income impulses exactly correspond in time to the trading events of the diagram in fig. 2.11, but at the same time, the amplitudes of all income impulses are different (for example, the amplitude E2 > E1), because they display income in monetary terms.

On fig. 2.15 shows the daily distribution of random impulses of the stream of events of receiving income from the sale of the SN image in August 2013, which we obtained as a result of observations. This diagram is completely synchronous in time with the daily diagram of sales events presented above in Fig. 2.12, but all flow impulses have an amplitude displayed in monetary terms on the y-axis.

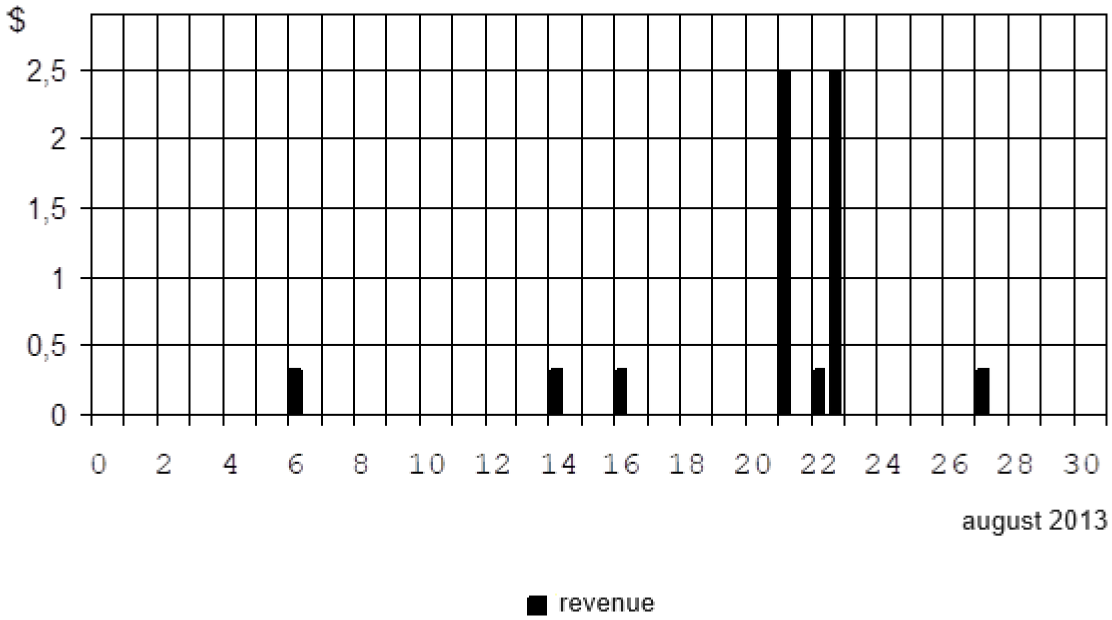

Fig. 2.15 - Distribution of random impulses of the income stream from the sale of the SN image in August 2013 (compiled by the author)

Just as in the case of elementary trading events, the accumulation or increase in the frequency of receipt of elementary impulses of income allows us to combine them into groups corresponding to daily, weekly, quarterly, annual and other periods, and thus move on to continuous random processes, the characteristic of which is the envelope curve.

For example, in fig. 16 is an annual chart showing the complete set of elementary impulses of income from the sale of the SN image for 2011-2020. Accordingly, each of its rod displays the sum of elementary impulses of income for the corresponding year, indicated on the x-axis. An analysis of this chart shows that it is not equivalent in configuration to the time-synchronous sales quantity chart shown in Figure 1. 2.13. The absence of complete equivalence between the charts is also confirmed by the value of the correlation coefficient between the sales and revenue data arrays, equal to 0.966.

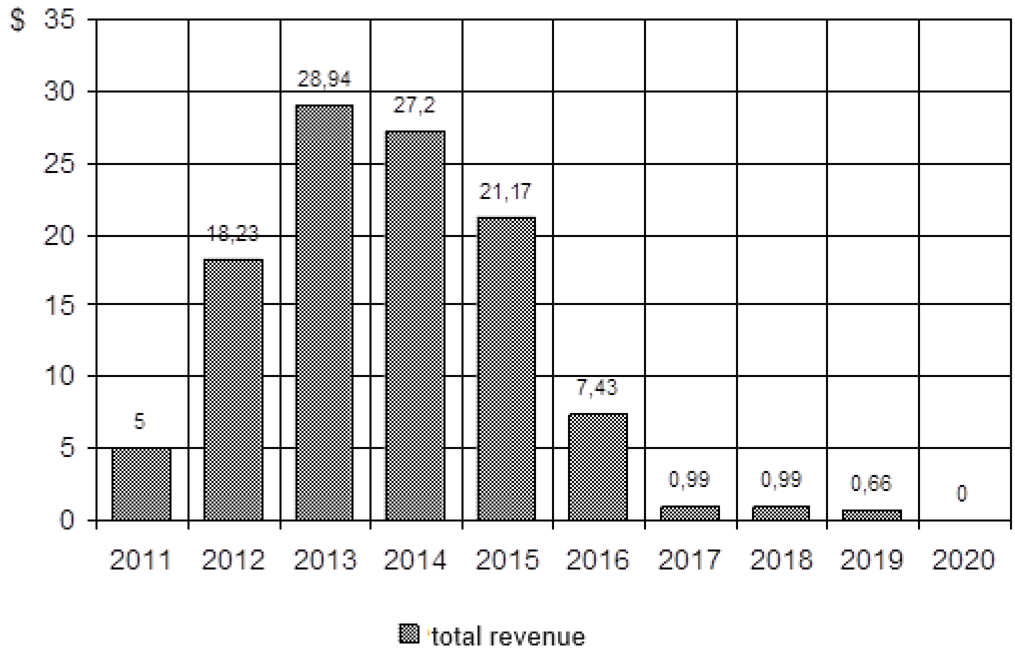

Fig. 2.16 - Total income from the sale of the SN image for 2011-2020 (compiled by the author)

Visual analysis of the diagram in fig. 2.16 shows that this income impulse has an initial front, growing for about two years (2011-2012); then - a period of stabilization near a certain maximum value (2013-2014); then - a decline until the complete cessation of income (2015-2019). For the quantitative analysis of dynamic (inertial) processes, in the general case, the following pulse parameters are analyzed:

- Amplitude - the largest value of the value of the information parameter characterizing the process, in this case - income;

- The duration of the front, characterizing the rise time of the value of the information parameter from 0.1 to 0.9 of the amplitude value;
- Pulse duration - the length of time measured according to the diagram at the level of 0.5 amplitude;
- The duration of the decline, which characterizes the time of decreasing the value of the information parameter from 0.9 to 0.1 of the amplitude value.

Since the presented total impulse of the income of the image SN has two close maximum values in 2013 and 2014, we define its amplitude (A) as the average between them, equal to \$28.07. Then the corresponding levels for estimating the characteristics of the front, the pulse duration, and the decline will be (see table 2.8):

Table 2.8 - Calculation of the levels of the information parameter of the income impulse of the image SN

№	Information parameter levels (USD)
1	$0,1 \cdot A = 2,81$
2	$0,5 \cdot A = 14,04$
3	$0,9 \cdot A = 25,26$

Source: compiled by the author.

Therefore, in accordance with the proposed concept, marking the found levels on the diagram (Fig. 2.16), we can see that the duration of the front of the income impulse for this asset is about two years; estimated pulse duration - four years; the duration of the decline is about three years. It is visually noticeable that the impulse as a whole is asymmetric, and the duration of the decline exceeds the duration of the rise (front). The pulse shape is close to trapezoidal.

On fig. 2.17 conditionally presents the process of formation of the cash flow of the total revenue for the inertial portfolio of intellectual assets. For the sake of simplicity, the pulses in the diagram have a rectangular shape, although in practice it is often close to trapezoidal or triangular. In accordance with the proposed concept, the full cash flow of revenue, including the historical retrospective, is formed by completed and current (incomplete) income impulses of individual assets.

Thus, at any fixed point in time, the total return on a portfolio can be graphically represented as an A-A section of the flow of all random pending impulses of income from the sale of individual assets that continue to generate revenue. We emphasize once again that the amplitudes of all income impulses are also random variables.

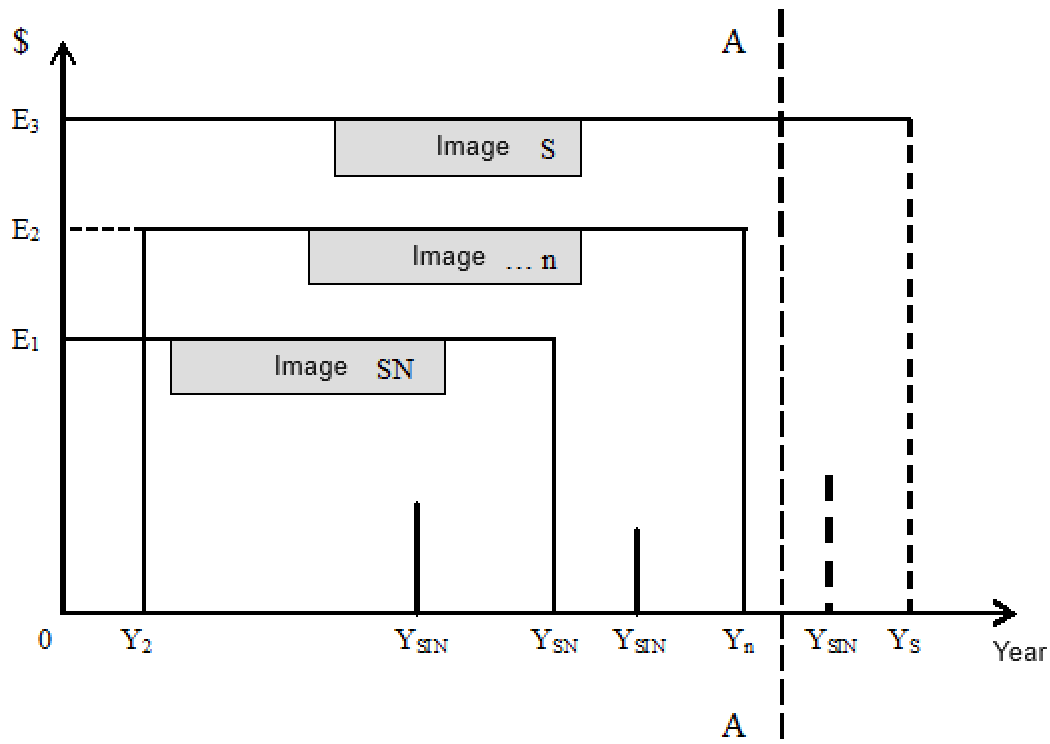

Fig. 2.17 - Completed and incomplete income impulses of individual assets in an investment portfolio (compiled by the author)

For example, the income impulse of image SN is completely completed on the YSN date, and image impulse S is currently ongoing, so its future decline is shown by a dotted line, and the completion time of YS is not determined. The income pulses of other images (n) may be randomized relative to the SN and S pulses along the time axis. In particular, some income pulse with amplitude E2 is shown, which began at time Y2 and ended (Yn) later than the image pulse SN. Note that it is the overlap in time of such impulses that creates the continuity of the cash flow generated by the inertial portfolio of digital assets.

Finally, in any portfolio there are also sporadic, or single impulses of income. On the diagram in fig. 2.17 they are represented by infinitely short rods of different amplitudes, designated as YSIN from the English Single (single). This is a kind of very rare (sparse) elementary income impulses, reflecting the facts of a single sale of specific images in long periods. As noted above, photostocks themselves usually classify them as Single and other, i.e. "single and other" sales. Most often, such purchases are made by those who rarely use microphoto stocks and make impulsive purchases associated with the creative process, or those who urgently need a rare image for their projects. Typically, these customers do not have a subscription (for example, it may not be very profitable for them) and a single purchase always costs them more than regular customers. Naturally, single sales do not form long-term impulses like those shown in Fig. 2.13 and 2.16, they refer to different images, and look like in fig. 2.17 as rare single rods.

In historical hindsight, photo stocks record data on all sales, which allows you to identify all revenue impulses, including those that have been completed. For example, the SN image generated the maximum revenue in 2013-2014, then within 3 years sales dropped to zero and now there is no regular revenue coming in, although sporadic sales may occur. Thus, the SN image contributed to the total income, but does not participate in the formation of the current cash flow of the portfolio revenue.

Due to uncertainty, we do not know which assets, assigned (in our structural model) to the waiting group, will become sources of new income impulses. However, a comparison of the parameters of new growing impulses with the parameters of completed impulses allows us to make some quantitative predictions. Such comparisons can be made, for example, comparing assets by the rate of rise of impulse fronts, and by the number of sales.

The proposed model of the inertial portfolio of digital assets is quite consistent with the well-known Long Tail economy model proposed by Anderson C. for the market of information goods and services[47], but it also has some fundamental differences.

Briefly, the essence of this model is that due to the multiple reduction in the costs of replication and distribution of digital information products, modern electronic network trading platforms have been able to place, unlike ordinary stores, hundreds of thousands of items of goods, such as books, musical works, films. Due to this, buyers-users of the Internet have received almost unlimited access to all works, including very rare (niche) ones. Studies have shown that the well-known Pareto rule is no longer valid, because. the cash flow of proceeds from the sale of electronic copies is formed not by twenty percent, but by almost the entire set of assets.

According to the author of the concept K. Anderson, this process rather obeys the rule according to which 98% of the assets are sold (copied) at least once a quarter[48]. However, the temporal structure of sales of individual assets was not studied by the specified author. For us, the main interest is his conclusion that in this type of economy, the success or failure of any information product (individual work) in principle becomes unimportant, because cumulative sales in any case make e-business profitable. In addition to this idea, we note that the digital intellectual assets we are studying, in their essence and content, are very close to the information products studied by the author of this concept.

We also recall that in our case, digital image aggregators have increased their portfolios to several hundred million individual assets. As our research has shown, even compared to the Long Tail model, the supply of digital assets of this class is even more oversaturated. In particular, this is eloquently evidenced by the fact that in the portfolio structure there is always a waiting group, the assets of which have not yet been sold, and it is possible that the sale of some of them may not take place in principle. As shown above, the majority of sales in the digital image portfolio under study are

[47] Anderson C. The Long tail // Wired Magazine. – 2004. – 12 (10). – [Электронный ресурс]. – URL: https://www.wired.com/2004/10/tail/ (дата обращения 30.07.2022)

[48] Anderson C. The Long tail: How endless choice is creating unlimited demand. – London: Random House, 2007.

generated by less than five percent of assets, which is very far from the classical Pareto model.

In our opinion, one can note the unconditional positive contribution of inertia to understanding the process of formation of the total cash flow of income in the framework of the idea of profitability impulses. Here, the analogies with physical and some economic processes are obvious, and are confirmed by our empirical data on the temporal structure of cash flow elements.

3. FORMATION OF APPROACHES TO CREATION OF THE INVESTOR DECISION SUPPORT SYSTEM

One of the objectives of the study is the formation of approaches to the design of a system to support the adoption of financial and managerial decisions of the investor. This task was solved using machine learning methods, since the subject area of the economic turnover of intellectual assets is characterized by the presence of a large number of uncertainties.

3.1. Background to the development of Bayesian models

Bayesian belief networks (BBN) are directed acyclic graphs in which nodes represent uncertain variables of any nature, and directed links between nodes indicate causal relationships between the corresponding variables. Each node of such a network is associated with a probability table that models the connection with the so-called parent nodes, taking into account all the uncertainties present in these connections. BBN theory combines elements of Bayesian probability theory and the concept (assumption) of conditional independence in representing relationships between variables[49].

Currently, the BBN tools are used to solve a wide range of tasks in various industries for the numerical assessment of risk metrics and the degree of uncertainty, which may be due to various reasons:

- Incomplete knowledge about the object of study;
- The conditions of the problem are characterized by the presence of accidents;
- Incomplete understanding of the subject area of the study;
- Various combinations of these factors.

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[49] Tulupyev A.L. Bayesian networks: logic-probabilistic approach / A.L. Tulupyev, S.I. Nikolenko, A.V. Sirotkin. - St. Petersburg: Nauka, 2006; Sukar L.E. Probabilistic graph models. Principles and applications / per. from English. – M.: DMK Press, 2021.

Models based on the principles of BBN are of fundamental importance in machine learning, since Bayesian methods allow us to measure the level of uncertainty in data and change it with new data. The processes modeled using the BBN can be both static and dynamic.

The ultimate goal of constructing a BBN is to obtain a probabilistic inference apparatus that is maximally adapted to the uncertainties and risks of a particular task or the subject area as a whole. Probabilistic inference can be carried out in any direction of the network, including: from consequences to causes, from causes to effects, and mixed inference is also possible.

In a broad sense, Bayesian networks are one of the most productive concepts for the formation of expert systems, which are a software tool that uses expert knowledge to provide effective solutions to non-formalized problems in a narrow subject area. An expert system is able to help a specialist-expert, and sometimes partially replace him in solving problems under conditions of uncertainty. An integral part of any expert system is the knowledge base (a structured body of knowledge) about the subject area, which determines the behavior model of experts in the area under study using certain inference procedures. Knowledge bases are accumulated in the process of building and operating any expert system of this type.

The advantages of using the BBN in comparison with other concepts for building expert systems include:

1. Relative ease of performing subjective probabilistic assessment of cause-and-effect relationships from a psychological point of view and an intuitive representation in the form of a directed graph.
2. Interpretability of a logical conclusion from a computational point of view, due to the presence of a theoretical axiomatic apparatus.
3. The methods underlying the mathematical apparatus of the BBN provide an efficient calculation of conditional probabilities.

As shown in previous chapters, the studied portfolios of digital intellectual assets have an asymmetric heterogeneous structure of return and risk in the context of asset groups. For this reason, in our logical-probabilistic Bayesian model, it is proposed to take into account causal relationships between the main components of the portfolio, and not just its significant heterogeneity. As a portfolio component, it is proposed to consider groups of assets grouped on the basis of the same (comparable) demand. The author's logical-probabilistic model was built based on the assumption of a continuous flow of assets in the direction from the “expectation group” to the “record holder group”, during which the portfolio risk metrics continuously change[50].

The initial assessments of the risk metrics of the portfolio of digital intellectual assets were made using the VaR (EaR) methodology based on empirically obtained data on the distribution of a random variable of total income across the portfolio[51]. However, as further studies have shown, the VaR (EaR) methodology does not allow to fully take into account the specific features of the economic turnover of digital intellectual assets, since this methodology does not take into account the structural heterogeneity of the portfolio.

To solve this problem, the tools of Bayesian belief networks were used. The results of previous studies of portfolio risk metrics using the VaR (EaR) methodology were used in our Bayesian portfolio model as input parameters[52]. The flexibility of the BBN tools is expressed in the ability to integrate input parameters given in discrete and / or continuous form, take into account the different nature of some data, and use dependencies between different types of variables.

Risk factors specific to the intellectual property market have a significant impact on digital image portfolio returns. Factors that have a significant impact on the demand for digital images include: the attitude of consumers to photo stocks, the compliance of the subject matter of assets in the author's portfolio with modern fashion in web design,

[50] Voronov V.S. Substantiation of the structure of the Bayesian network model of a portfolio of intellectual assets / V.S. Voronov, V.D. Davydov // Management of economic systems: electronic scientific journal. - 2018. - No. 12. - P. 30.

[51] See, for example: Voronov V.S. Financial risk of a portfolio of intellectual assets from the standpoint of the VaR (EaR) methodology / V.S. Voronov, I.A. Darushin // Problems of risk analysis. - 2017. - T. 14. - No. 3. - p. 54-63.

[52] Voronov V. Building the Bayesian Network Model of Digital Images Portfolio / V. Voronov, A. Kazansky, V. Davydov // Proceedings of the 32nd International Business Information Management Association (IBIMA). 15-16 November 2018. – Seville, Spain, 2018. – P. 4279-4284.

advertising, and publishing. The main consumers of the studied digital intellectual assets are designers, web developers, media, bloggers and other media industry participants who use digital intellectual assets in their professional activities.

When assessing the risk of traditional financial instruments (securities, currencies), the main risk factor is the price volatility of the instrument. In the original model, taking into account the peculiarities of the turnover of digital intellectual assets, the following were chosen as risk factors that have a greater impact on the financial result of the portfolio:

- market demand for images of the author/investor. This is an external factor that depends on the current market situation, reflecting the number of sales events of the author's assets over a fixed period of time;
- creative performance of the author. This is an internal factor that reflects the presence of events of receipt of new assets in the portfolio, on which the volume of the author's portfolio depends.

The classic ways to manage the risk of a portfolio of traditional financial instruments are diversification of the set of instruments, various hedging methods, selection of instruments with different correlations of returns, etc. However, such methods are not applicable to portfolios of digital intellectual assets, and risk minimization is possible only by changing the impact of the main risk factors for groups of portfolio assets.

We also note that there are significant amounts of historical data for traditional financial instruments for many years. A lot of works are devoted to the study of the cost and profitability parameters of individual financial instruments and portfolios of instruments, in which the normal or lognormal nature of the distribution of a random value of profitability is confirmed. In relation to intellectual assets, especially digital ones, there are significantly fewer historical data arrays, while the events occurring in the process of turnover of such assets have a more complex probabilistic nature.

In the proposed logical-probabilistic model, the impact of the main risk factors on key risk metrics is presented as a set of events that are characterized by:

- Some frequency of occurrence;
- Influence on certain elements of the portfolio;
- The presence of the level of impact (strength). In this case, the level of impact can be taken into account (weakened or strengthened) by training a logical-probabilistic model.

The initial simplified version of the logical-probabilistic model is shown in fig. 3.1. In this model, the main risk factors affecting the portfolio are traditionally represented as variables at the nodes of the Bayesian network. Each node of the model is characterized by a certain level of distribution of the probability of occurrence of events. To adapt the model to a specific author's portfolio and make calculations, it is necessary to take into account the totality of impacts for each specific portfolio, due to its information environment.

The resulting node of the model is income R (Revenue) for a portfolio consisting of digital intellectual assets. An increase in this indicator represents the portfolio's response to changes, which can be both external, achieved by reducing the impact of risk factors, and internal, by training the model. External changes are due to a decrease in the impact of risk factors and, in accordance with the logic of the model, affect income indirectly, through the parent nodes of sales S (Sales), creative productivity of the author PR (Productivity) and demand D (Demand).

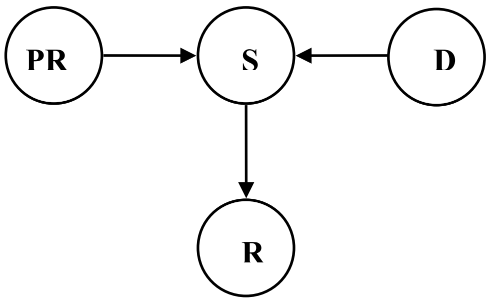

Fig. 3.1 - Simplified network structure (compiled by the author)

Node S displays the probability of asset sales events in the portfolio arranged according to the frequency principle. The frequency of sales is directly dependent on the demand for assets, since due to the special mechanism for the sale of digital intellectual assets, the price for homogeneous groups of assets is fixed and the demand for such assets, unlike conventional financial assets, is not reflected in the market price, but in the frequency of sales. Each group of assets is characterized by its own sales probability distribution function (these functions can be continuous or discrete), which is affected by certain risk factors, the impact of which can be both positive and negative.

Internal changes are the results of model training, which is due to the emergence of new data, with the use of which it is possible to refine the modeling predictions. Training of the author's model is possible, since Bayesian methods allow measuring the level of uncertainty in the data and changing it with newly received data. For example, portfolio performance results for the last period.

The sales node S is affected by risk factors from the parent nodes: the market demand D and the creative productivity of the PR author. The factor of the author's creative productivity depends on the actions (or inactions) of the author and reflects the intensity of replenishment of the portfolio with new assets. The demand factor can be either low or high, it affects the frequency of asset sales over a certain period. The sales node S, in turn, affects the income node R, which is directly dependent only on the facts of sales.

Despite the apparent, at first glance, lack of uncertainty in the factor of creative productivity due to the fact that this factor is completely dependent on the author, this factor is characterized by uncertainties that depend on the portfolio management strategy. In addition, the very process of filling the portfolio with new assets is not stable. As shown in Chapter 2 above, portfolios of digital intellectual assets have an inherent persistence property.

The key task of the model is to evaluate the resulting factor of the model - the value of income at node R. This problem is solved by forecasting (Causal Reasoning) - certain probabilities of parent nodes are set and after calculations the probability of certain values at the income node is determined. The model built using the BBN also allows for the reverse inference (diagnosing or Evidential Reasoning) - the process of determining the probabilities of parent nodes (creative productivity, demand) for a given probability value at the income node. Since each node of the logical-probabilistic model is a random variable representing a probability distribution that is in a certain dependence on the parent nodes, the second task of building the model (after building the graph architecture) is to determine the joint probability distribution of the nodes (risk factors) of the model. It is the joint distribution that fixes the dependencies between the nodes in the graph of the logical-probabilistic model, which allows both direct and reverse inference.

Dependencies between variables are given by algebraic expressions. If D is a random variable that characterizes the demand for digital intellectual assets, and PD is a discrete distribution of this probability, then $P_D(D=d)$ or $P_D(d)$ is the probability that the argument D will take some (certain) value d in a particular range of their likely values. We will do the same with the random variables PR, S, and R associated with creative productivity, sales, and income. The nature of each distribution and the ranges of its values are separate issues depending on the specific goals of the analysis, however, regardless of this, based on the architecture of the BBN, it can be written that the value of $P(PR = pr, D = d, S = s, R = r)$, which is the probability that the variables PR, D, S, and R will take values respectively equal to pr, d, s, r, factorized by the equation:

$$P(PR = pr, D = d, S = s, R = r) = \\ = P_{PR}(pr) \times P_D(d) \times P_s(s|PR = pr, D = d) \times P_R(r|S = s), \qquad (3.1)$$

where each $P_j(i|J = j)$ is the conditional probability that the variable *I* will take on the value of *i* if the variable *J* will take on the value of *j*. To solve this equation, it remains to determine the variables at all nodes of the model. The presented algebraic expressions allow us to model the processes occurring in the portfolio of the asset class under study and calculate the probability values of obtaining a certain income R of the portfolio.

As our observations have shown, the groups of champions have a greater influence on the total income and are more dependent on the demand factor for assets than on the transit mechanism of replenishment of assets. Due to the greatest influence of groups of record holders on total return, they have the maximum impact on the risk of the metric of the entire portfolio.

The creative productivity of the author is an indicator that directly depends on the decisions made by the author, his actions or inaction. Currently, the neoclassical concept of economic theory dominates, according to which economic actors always act rationally, maximizing their benefits. In practice, an economic subject (author, investor) has an individual approach to justifying decision-making, so he does not behave exclusively rationally, as the neoclassical concept prescribes, moreover, he can make erroneous and irrational decisions.

Rational human behavior implies that under conditions of uncertainty, an economic entity will make a choice in favor of the most optimal option. It is customary to use the theory of probability to assess the optimality of one or another variant of human behavior, i.e. rational behavior is considered to be such behavior of a person in which he weighs all possible solutions and determines the probability of a favorable day for his outcome with a particular decision.

From the point of view of the neoclassical concept, the most rational behavior of the author / investor is the continuous replenishment of the portfolio with new images, i.e. the probability of creative performance should be equal to 100%. But in practice it happens differently. The behavior of a decision maker depends on the way the decision is made: some make decisions by thinking and evaluating all the outcomes and their probabilities for a long time, others make decisions quickly, based on their experience and intuition.

G. Simon, within the framework of the concept of bounded rationality[53], suggested that the decision-making process of economic entities is often based not on clear mathematical calculations, but on heuristics - unconscious, and, as a result, quite

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[53] Simon H.A. Rationality as Process and as Product of Thought // American Economic Review. – 1978. – Vol. 68. – № 2. – P. 1-16.

simple to perceive mechanisms used in making operational, and from a subjective point of view vision of effective decisions, usually not based on logic and rationality. Heuristics occur because decision makers often either lack the necessary computational ability or lack the time to accurately assess the likelihood and outcomes of each possible decision.

In this study, some heuristics of behavioral economics are considered in relation to the creative productivity of the author. As part of the study, heuristics are considered as revealed deviations in the behavior of ordinary people relative to the neoclassical concept of economic theory.

From the standpoint of influence on the author's creative productivity, the group of heuristics of self-control and preferences is of greater interest. It is this group that reflects the contradictions between the postulate of an economic subject that maximizes utility and the opposite behavior of subjects encountered in life.

Authors, like the whole set of individuals, can be divided into three groups in relation to risk: risk-averse, risk-neutral, and risk-averse. Groups in relation to risk are formed based on the value function. The replenishment of the portfolio by the author, as well as the adoption of any other investment decision, is associated with both the receipt of future income and the implementation of expenses, therefore it is advisable to consider the value function taking into account the attitude of the economic entity, both to income and expenses. Such a function, for example, was proposed in the 20th century by the founders of the behavioral theory of economics - Kahneman D. and Tversky A[54].

So, the author's decision to replenish the portfolio with new assets simultaneously involves both receiving income from the asset in the future and current expenses. The latter may be associated with the independent creation of an asset, or include the cost of acquiring it from another source. Since an author's creative output normally involves portfolio replenishment costs, and the author operates under both budget and loss-taking constraints, the probability of an author's creative output may well be less than one.

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[54] Kahneman D. Prospect theory: An analysis of decision under risk / D. Kahneman, A. Tversky // Econometrica. – 1979. – № 47. – P. 263-291.

Based on the provisions of the prospect theory, we can conclude that the probability of the author's creative performance also depends on the personal experience of the author (economic entity) in managing a portfolio of digital intellectual assets, incl. from income and expenses, which form the author's attitude to their value.

The author's personal experience is manifested in the heuristic of decreasing sensitivity, according to which an economic entity perceives income (benefits) and expenses (losses) relative to a certain reporting point. For the author of a portfolio of digital intellectual assets, an additional monthly income of 25 monetary units on a typical income of 100 monetary units per month will seem higher than an additional income of the same 25 monetary units per month on a typical income of 1,000 monetary units per month. Since in the first case the additional income will seem higher to the author, the author will make more efforts to receive this income, i.e., in accordance with the concept, it can be argued that in the first case the probability of the author's creative productivity will be higher.

With the help of the Kahneman-Tversky capital value function, one can explain, among other things, the logic of the content of a significant part of the author's portfolio - the "waiting group" consisting of assets that do not have sales events. When replenishing the portfolio with new assets, the author expects that they will generate income in the future. However, due to market factors reflected in market demand, some assets are not sold at all. This fact is confirmed by real observations of portfolios of assets of the studied class.

Naturally, authors / investors have certain expectations that such an asset can bring at least some income in the future. However, the author, even with full confidence that the asset will never be sold in the future, will almost certainly continue to keep such an asset in his portfolio in order to justify his investment. This position is explained by the fact that if you remove such an asset from the portfolio, you will have to recognize the previously incurred costs as irreversible losses, which is less preferable for the average author than keeping an unsold asset in the portfolio. Thus, the author is not ready to return to the state before the introduction of the asset into the portfolio and ignore the sunk investment. It is this behavior of authors/investors that corresponds to the loss aversion heuristic.

Similar to this effect is the investment effect, according to which individuals attach more value to the assets that they own, since the owner, by virtue of owning this or that asset, begins to overestimate its real value. This overvaluation occurs because the experience of using, owning and disposing of the asset does not allow the owner to perceive the asset as separate from himself. In particular, the owner of a portfolio of digital intellectual assets, in the event of a hypothetical sale of an asset that has not been sold before, is most likely to request a price for the sale of ownership (alienation) of the asset that is higher than the price for such an asset prevailing in the market.

Further development of the theory of prospects is reflected in the studies of R. Thaler. On the basis of experimental data, he revealed the phenomenon of hyperbolic discounting[55], which consists in the fact that events that should happen in the near future are more important for an individual than those events that should happen in the distant future. The results of the experiments showed that people tend to choose a smaller reward today than a larger one tomorrow, while the curve describing income discounting has a hyperbolic shape.

This phenomenon shows that often a person's behavior in these matters deviates from the standard neoclassical theory of behavioral representation, which assumes that a person discounts utility exponentially. This can be represented by the example of the purchase by the author/investor of a new asset and adding it to the portfolio with the aim of further selling the rights to use.

Let's pretend that:

1. The author has a choice of two assets to buy in a portfolio at the same price: one of the assets will bring income from the sale of a license (rights to use the asset) today for 10 rubles, and the other tomorrow for 11 rubles.

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[55] Thaler R. Some empirical evidence on dynamic inconsistency // Economics Letters. - 1981. - No. 8 (3). – P. 201-207.

2. The author has a similar choice, but between assets, one of which will bring income from the sale of rights to use the asset in 10 days, 10 rubles, and the other in 11 days, 11 rubles.

From the standpoint of the concept of hyperbolic discounting, confirmed by experimental data, the author is more likely to choose the first option in the first case, and the second option in the second case.

R. Thaler in his works argues that the choice of one or another decision depends on the context in which decisions are made, called the architecture of choice[56].

In relation to the creative productivity of the author, such a context may be the availability of technical means and the necessary skills for the independent creation of digital intellectual assets. An author with a choice architecture that provides for the availability of technical means and skills, all other things being equal, is more likely to be creatively productive than an author with a choice architecture that only purchases assets from other sources. This is due to the fact that the costs of independent production of an asset in the general case may be lower than the acquisition of a ready-made similar asset.

Thus, the approach to the creative productivity of the author from the point of view of behavioral economics allows increasing the accuracy of estimating the probability value of the indicator:

- The probability of the author's creative productivity may well be less than one, since in a normal situation it implies the presence of expenses to replenish the portfolio, and the author operates on the basis of both budget constraints and loss acceptance.
- The probability of creative productivity will be higher for an author operating in a choice architecture that provides technical means and skills, compared to an author operating in a choice architecture that provides only the acquisition of assets from other sources, since the cost of creating an asset independently is generally lower than acquisition of a similar asset from another source.

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[56] Thaler R, Sunstake C. The Architecture of Choice: How to Improve Our Decisions about Health, Wealth, and Happiness. – M.: Mann, Ivanov and Ferber, 2018.

- The probability of creative performance depends on the personal experience of the author, since he perceives income (benefits) and expenses (losses) relative to a certain reporting point.

Reasonable expert opinions should be based on the analysis of as complete data and information as possible. But there are no sales statistics for the assets in the waiting group according to the task statement. However, copyright digital assets have a basis for analysis that other types of assets may not have. Namely, as was shown in the first chapter, due to their internal specificity, such assets are information units, in the structure of which extensive blocks of metadata are built. In particular, to refine expert assessments, sets of keywords are of interest, designed to provide a quick search for assets in huge collections of photo stocks.

Most photo stocks have mandatory requirements that require the presence of several dozen (usually up to 50) keywords in the descriptive section of the metadata of each image. In principle, sets of keywords can be as unique as the assets themselves. However, there are overlapping subsets that are interesting for analysis. Firstly, these are subsets of keywords accompanying, for example, images belonging to the same thematic category. It is quite obvious that such subsets cannot but intersect.

Secondly, subsets of image keywords that simultaneously belong to the same thematic category, but to different sales and expectation groups in the proposed model. Such subsets can not only intersect, but also coincide.

It should be noted that experts (as well as owners of portfolios of digital images) are greatly assisted by photostock - it sorts, ranks keywords and presents the results in a special section of the owner's personal account. Thanks to this, you can see exactly which keywords (кс) the buyers used to find a particular asset, and even the share of each word in their general list (see Fig. 3.2). At the same time, the more sales events occurred, the more accurate this information.

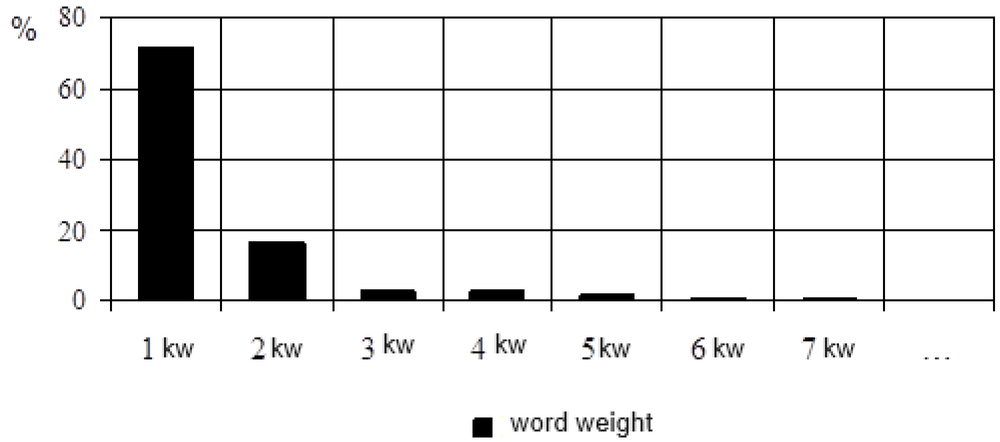

Fig. 3.2 - Actual ranking of keywords (cs) attached to a digital image S sold over 1000 times (compiled by the author)

The subset of assets in a wait group is well-defined, so experts are able to analyze assets that have keyword sets that match (or overlap) with keyword sets across all sales groups. It should be noted that in addition to sets of keywords, the descriptive sections of digital assets also contain other metadata and meta-information, the analysis of which may also be important for reasonable forecasts of experts.

3.2. Interpretation of logical-probabilistic conclusions on a simple structural model of a portfolio of digital images

To train the structure of the model, assess its sensitivity and interpret the logical-probabilistic conclusions, a simplified network was used, the analysis of which was made in the 1st chapter. However, the graphical analogue of the BBN, built in a real editor program, has some differences related to the individual features of the software product (Fig. 3.3). As in the original network, the portfolio node in the graph diagram is represented by the discrete variable Sales, which displays the sale of assets with a certain frequency. The first parent Demand node (on the left in the diagram) represents the impact of market demand. From the side of the second parent node Prod (in the diagram below), the activity of the author/investor affects the portfolio. Finally, the portfolio total return node is represented by the continuous variable Earn, the priors of which were obtained experimentally, so the model is essentially a hybrid one.

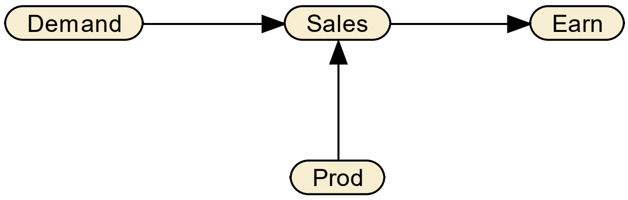

Fig. 3.3 - The initial graph of the network model (compiled by the author)

The characteristics of all variables used in the composition of the BBN are given in Table 3.1. Since Bayesian networks of this type allow the interpretation of any hypotheses, the "Comment" column indicates the initial assumptions for assigning discrete states to all variables.

Table 3.1 - Variables in the composition of the BBN

№	Node designation	Variable interpretation	Probabilistic states	Comment
	1	2	3	4
1	Demand	Market demand for assets (discrete)	{high; low}	Expert judgment
2	Prod	Author's creative output / portfolio replenishment strategy (discrete)	{high; low}	In equal parts
3	Sales	Sales (discrete)	{high; mid; low}	Expert judgment
4	Earn	Total portfolio return (continuous)	{0 to 1.32; 1.32 to 2.145; 2.145 to 2.97; 2.97 to 3.795; 3.795 to 4.62; 4.62 to 5.445; 5.445 to6.27; 6.27 to 7.092; 7.095 to 7.92}	Discretization of the empirical income distribution curve

Source: compiled by the author.

In order to bring the model into a working state (train), it is necessary to assign probabilistic levels for all states of variables, i.e. it is necessary to fill in the tables of all unconditional (marginal) and conditional probabilities. Marginal probabilities at the market demand parent node were assigned based on the realistic assumption that, in general, market demand for self-exposed intellectual property assets should rather be characterized as low. Based on this, the first table of unconditional probabilities (TUP) of the demand node was filled in (see table 3.2).

Table 3.2 - TUP for the Demand node

№	Condition	Probability, %
1	High	50
2	Low	50

Source: compiled by the author.

Completing the Conditional Probability Table (CPT) for the sales variable node (see Table 3.4) requires more attention because this variable has three states, and two parents that have two states each. Therefore, this CPT will have 12 values, since it is necessary to “enumerate” all possible probabilistic states of this variable for all variants of the states of the parent nodes.

To begin with, with both high demand and high author/investor productivity (line 1 of CPT), sales are more likely to be high, less likely to be medium, and sales stop is unlikely. Therefore, a probability of 60% is assigned to the high level, 39% to the average level, and 1% to the lowest level. Further, we proceed from the fact (2nd line of the CPT) that low demand is the most unfavorable risk factor, but at the same time there is still high productivity or investor activity, therefore, a low level is assigned a probability of 70%, an average of 20%, a high of 10%. In the next state (the 3rd line of the CPT), the factors are reversed, and this is much better, because the presence of demand is more important: a high level of sales is assigned a probability of 60%, an average of 30%, and a low of 10%, because performance is low. Finally, in a state of lack of demand and low productivity (4th line of the CPT), the probabilities of discontinuing sales are assigned 80%, the average level is 19%, and 1% for the high level.

Table 3.4 - CPT for the sales point

№	Parent node status		Probability, %		
	Prod	Demand	High	Mid	Low
1	High	High	60	39	1
2	High	Low	10	20	70
3	Low	High	60	30	10
4	Low	Low	1	19	80

Source: compiled by the author.

The conditional probabilities at the node of the total income variable are given by discretizing the real continuous distribution experimentally obtained in the course of previous studies[57]. Each of the nine intervals in the diagram of this node corresponds to one of the probabilistic states of the modeled variable. Since the sales node, the parent node of this node, has three states, the CPT for the income node will display 27 probabilistic states (see Table 3.5).

Table 3.5 - CPT for the node of total income

№	Parent node status	Probability, % (according to the numbers of levels in Table 3.1)								
		1	2	3	4	5	6	7	8	9
1	High	1	2	4	10	20	**25**	20	11	7
2	Mid	3	5	12	22	**25**	20	8	3	2
3	Low	7	11	20	**25**	20	10	4	2	1

Source: compiled by the author.

[57] Voronov V.S., Darushin I.A. Risk Assessment of a Portfolio of Intellectual Assets Based on the VaR (EaR) Methodology // Science Journal of NRU ITMO. Series "Economics and Environmental Management". - 2016. - No. 3 (26). - S. 12-23.

Data on the real distribution of the aggregate income probability density allowed us to test the expert hypothesis that, in diagnostic probabilistic inference, the movement of evidence in the income node in the direction from lower income to higher should be accompanied by an increase in probabilities in the sales node and (at least) in the demand node. By enumeration of options for shifting the maximum of the probability distributions of the total income in the states High and Low relative to the state Mid in the table of conditional probabilities of the variable of the income node, such a dependence was indeed obtained. Actually, after that, the preliminary stage of training the model was completed, and direct, inverse and mixed probabilistic conclusions using it became possible.

Before the initialization of the model in the Netica software environment, only preliminary values of equal probabilities are displayed on the bar diagrams of nodes. After filling in all the probability tables and initializing the constructed BBN, the machine produces the distribution of total probabilities (Fig. 3.4) before evidence arrives.

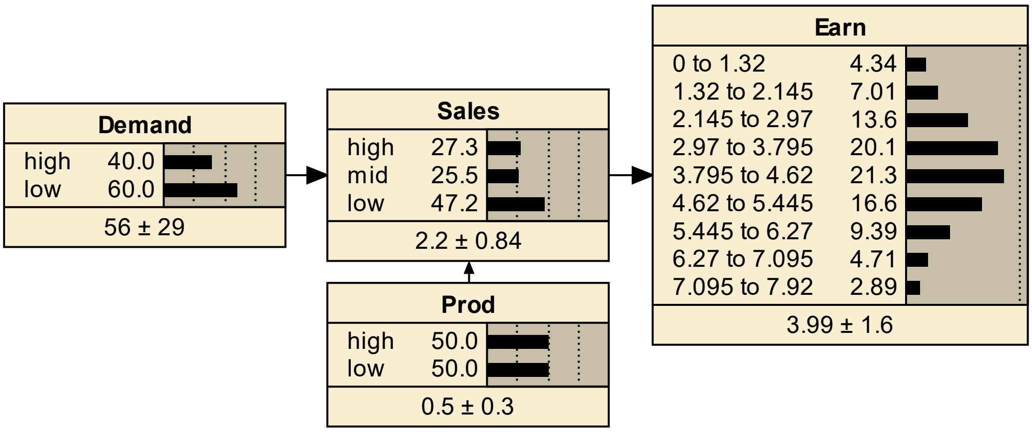

Fig. 3.4 - Initial network after model initialization (compiled by the author)

To check the prior distribution of the total probabilities in the node of the sales variable (Sales, Fig. 3.4), built by the machine before the receipt of evidence, the following calculations were performed:

$P(S_h) = P(S_h|PR_h, D_h) \cdot P(PR_h) \cdot P(D_h) + P(S_h|PR_h, D_l) \cdot P(PR_h) \cdot P(D_l) +$
$+ P(S_h|PR_l, D_h) \cdot P(PR_l) \cdot P(D_h) + P(S_h|PR_l, D_l) \cdot P(PR_l) \cdot P(D_l) =$
$= 0{,}6 \cdot 0{,}5 \cdot 0{,}4 + 0{,}1 \cdot 0{,}5 \cdot 0{,}6 + 0{,}6 \cdot 0{,}5 \cdot 0{,}4 + 0{,}01 \cdot 0{,}5 \cdot 0{,}6 =$ **0,273**

$P(S_m) = P(S_m| PR_h, D_h) \cdot P(PR_h) \cdot P(D_h) + P(S_m|PR_h, D_l) \cdot P(PR_h) \cdot P(D_l) +$
$+ P(S_m|PR_l, D_h) \cdot P(PR_l) \cdot P(D_h) + P(S_m|PR_l, D_l) \cdot P(PR_l) \cdot P(D_l) =$
$= 0{,}39 \cdot 0{,}5 \cdot 0{,}4 + 0{,}2 \cdot 0{,}5 \cdot 0{,}6 + 0{,}3 \cdot 0{,}5 \cdot 0{,}4 + 0{,}19 \cdot 0{,}5 \cdot 0{,}6 =$ **0,255**

$P(S_l) = P(S_l| PR_h, D_h) \cdot P(PR_h) \cdot P(D_h) + P(S_l|PR_h, D_l) \cdot P(PR_h) \cdot P(D_l) +$
$+ P(S_l|PR_l, D_h) \cdot P(PR_l) \cdot P(D_h) + P(S_l|PR_l, D_l) \cdot P(PR_l) \cdot P(D_l) =$
$= 0{,}01 \cdot 0{,}5 \cdot 0{,}4 + 0{,}7 \cdot 0{,}5 \cdot 0{,}6 + 0{,}1 \cdot 0{,}5 \cdot 0{,}4 + 0{,}8 \cdot 0{,}5 \cdot 0{,}6 =$ **0,472**

где:

$P(S_h)$, $P(S_m)$, $P(S_l)$ – full probabilities of sales (S) in states high, mid, low, respectively (Fig. 3.4);

$P(S_h|PR_h, D_h)$, $P(S_h|PR_h, D_l)$, $P(S_h|PR_l, D_h)$, $P(S_h|PR_l, D_l)$, $P(S_m| PR_h, D_h)$, $P(S_m|PR_h, D_l)$, $P(S_m|PR_l, D_h)$, $P(S_m|PR_l, D_l)$, $P(S_l| PR_h, D_h)$, $P(S_l|PR_h, D_l)$, $P(S_l|PR_l, D_h)$, $P(S_l|PR_l, D_l)$ – conditional probabilities of sales (S) in states high, mid, low, respectively, provided that the probabilities of productivity (PR) and demand (D) correspond to states high or low, respectively (see table 3.4);

$P(PR_h)$, $P(PR_l)$ – prior probabilities of performance levels in high and low states, respectively (see Table 3.3);

$P(D_h)$, $P(D_l)$ – prior probabilities of demand levels in states high and low, respectively (see Table 3.2).

Calculations showed that the found values of the total probabilities correspond exactly to the values output by the machine in the sales node (Sales, Fig. 3.4). Next, we checked the values of the total probabilities in the node of the portfolio total return variable. Since the calculation algorithm in the ranges is repeated, 2 values were checked selectively in the probability ranges №5 and №6, respectively:

$P(E_5) = P(S_h) \cdot P(E_{h5}|S_h) + P(S_m) \cdot P(E_{m5}|S_m) + P(S_l) \cdot P(E_{l5}|S_l) =$

$= 0{,}273 \cdot 0{,}2 + 0{,}255 \cdot 0{,}25 + 0{,}472 \cdot 0{,}2 =$ **0,21275 (21,3%)**

$P(E_6) = P(S_h) \cdot P(E_{h6}|S_h) + P(S_m) \cdot P(E_{m6}|S_m) + P(S_l) \cdot P(E_{l6}|S_l) =$

$= 0{,}273 \cdot 0{,}25 + 0{,}255 \cdot 0{,}2 + 0{,}472 \cdot 0{,}1 =$ **0,16645 (16,6%)**,

where:

$P(E_5)$, $P(E_6)$ – total probabilities of total return (E) for the portfolio in probabilistic ranges No. 5 and No. 6, respectively (Fig. 3.4);

$P(S_h)$, $P(S_m)$, $P(S_l)$ – full probabilities of sales (S) in states high, mid, low, respectively (Fig. 3.4);

$P(E_{h5}|S_h)$, $P(E_{m5}|S_m)$, $P(E_{l5}|S_l)$, $P(E_{h6}|S_h)$, $P(E_{m6}|S_m)$, $P(E_{l6}|S_l)$ – conditional probabilities of total return (E) for the portfolio in probabilistic bands №5 and №6, respectively, provided that the probabilities of sales correspond to high, mid, or low states, respectively (see table 3.5).

Calculations showed that the obtained values of the total probabilities of total income in the ranges №5 and №6 (including rounding) correspond exactly to the values output by the machine in the node of the variable total income (Earn, Fig. 3.4).

In the graphical interface of the Netica program, the conclusions and states of the model can be controlled by simply clicking on the corresponding bar of the diagram of any node. At the same time, the implementation of the corresponding event is simulated (evidence is entered), and the probabilities at the connected nodes are automatically recalculated by the machine and displayed on their bar diagrams[58]. The response of the model to the input of evidence was tested by the steps of reverse (diagnostic) inference. In particular, entering the lowest level of probability of total return included in the model (Fig. 3.5) gives the lowest values of the demand probability of 81.4%, and the probability of low author productivity (investor activity) of 52.8%. At the same time, the total probability of sales termination is 76.1%, with a probability of 17.6%, an

[58] Voronov V.S., Davydov V.D. Bayesian approach in financial engineering: constructing intelligent systems for supporting financial decisions // Issues of innovative economics. - 2021. - Volume 11. - No. 4. - S. 1509-1520.

average level of sales is possible, and with a probability of only 6.29%, a high level of sales is possible, which is fully consistent with the logic of the constructed model.

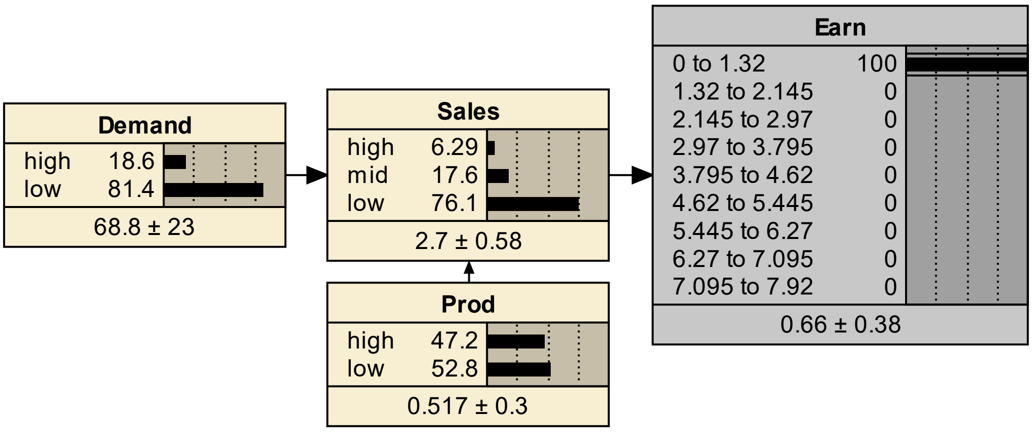

Fig. 3.5 - Diagnostic input of the lowest level of the state of the total income variable (compiled by the author)

At the next levels of the income variable, all probabilities change for the better. For example, at the third level (Fig. 3.6), the total probability of sales termination decreased to 69.5%, and the probability of the average level exceeded 20% (was 22.5%). At this level, the overall picture does not yet look optimistic, but the dynamics of changes in the states of all variables is generally encouraging.

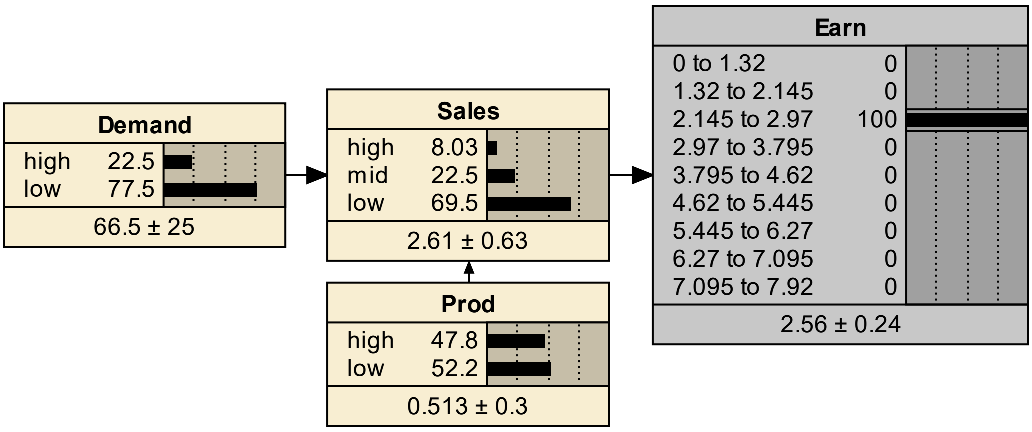

Fig. 3.6 - Diagnostic input of the 3rd level of the state variable of total income (compiled by the author)

The output of total income to the level of mathematical expectation (5th level, Fig. 3.7) further strengthens the positive trend. The probability of high demand is already 40.8% (which is very significant), and the probabilities in the performance node show an even more positive trend, since the probability of high performance of the author (investor activity) exceeded 50% (was 50.2%). The overall probability of sales being terminated decreased to 44.4%, while the average level probability reached 30%. With some degree of optimism, it can be noted that such levels of probabilities could already be of interest to experienced investors.

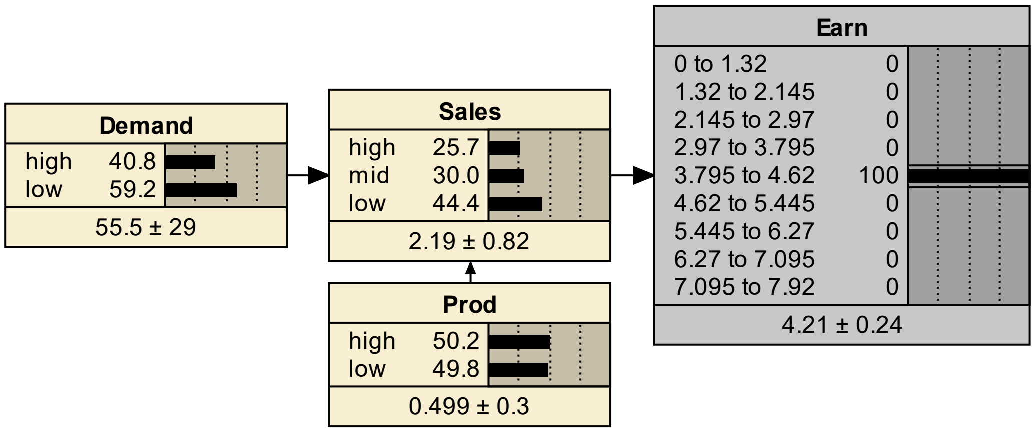

Fig. 3.7 - Diagnostic input of the 5th level of the state variable of total income (compiled by the author)

Finally, reaching a level of total income that exceeds the expected value completely changes the picture. In particular, at the 7th level (Fig. 3.8), the portfolio return can no longer cause any doubts. The probability of high demand increased to 63.8%, the probability of high performance of the author - to 52.7%, and the overall probability of continued sales came close to 60% (was 58.2%). The level of probability of stopping sales is already more than two times lower than the level of probability of continuing sales.

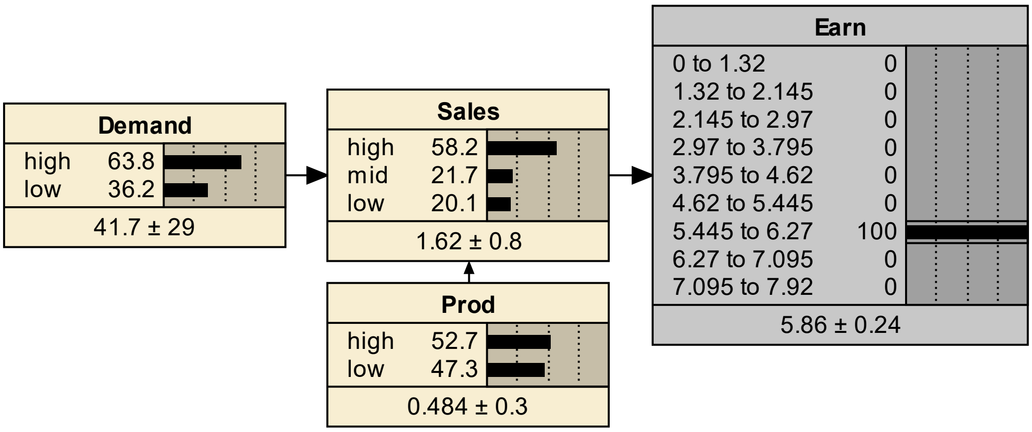

Fig. 3.8 - Diagnostic input of the 7th level of the state variable of total income (compiled by the author)

Further on fig. 3.9 the highest probable level of the cumulative return on a portfolio incorporated in model is presented. This state suggests that with such income, there is still a 31.6% chance of loss of demand (which is quite realistic for the intellectual property market). The overall probability of selling is 66.1%, which is more than four times the probability of stopping sales. This level is the most significant for any investor. Finally, the level of influence of the author's productivity (the activity of the investor replenishing the portfolio) is limited here by the probability of 53.2%.

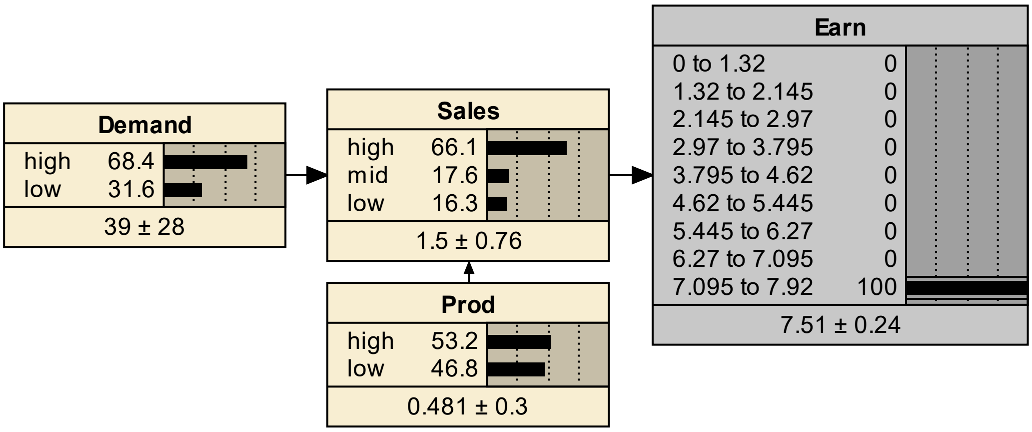

Fig. 3.9 - Diagnostic input of the last (9th) level of the state of the variable of total income (compiled by the author)

On fig. 3.10 presents empirical curves of dependence of the probability of the demand variable on the actual distribution of the probability density of the total income for the portfolio, obtained as a result of long-term observations. The x-axis of the diagram shows the numbers of distribution density levels used in the node of the total income variable. Essentially, this chart is a graph of the model's sensitivity to demand, since the figures for it are obtained by entering the appropriate evidence to support the states of the income target variable.

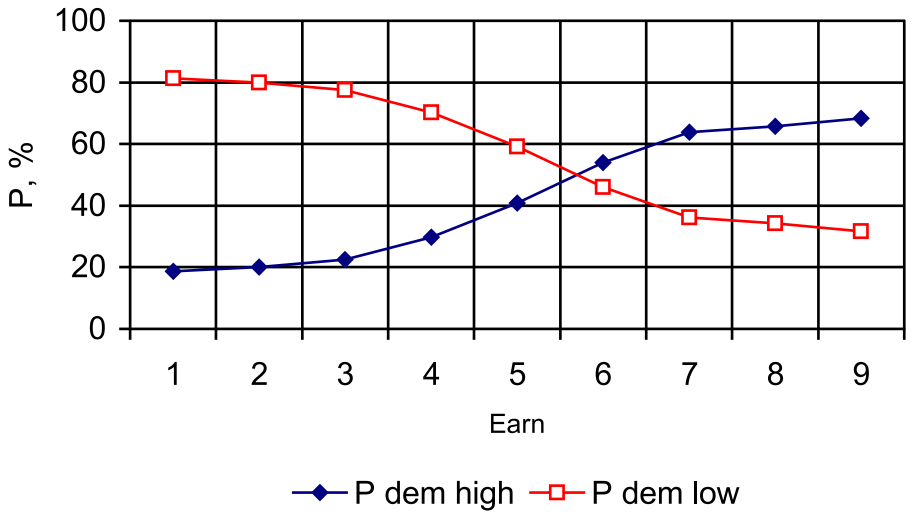

Fig. 3.10 - Curves of dependence of the probability of demand on the actual distribution of total income in the portfolio (compiled by the author)

Unlike the previous state diagrams (fig. 3.5-3.9), the diagram of fig. 3.10 displays all possible states of the model for given levels of probabilities of the variables of all parent nodes and the CPT of the sales node. The continuous curves give a more complete picture of the possible consequences of portfolio management. For example, with the given model parameters, the diagram in Fig. 3.10 tells the investor that the level of sales that ensures the total return on the portfolio in the range of expectation may be insufficient, because. the risk of falling demand is too high. Namely, in order to protect a portfolio with such parameters from risk, sales must provide a total return of at least the 7th band of the income distribution density.

In the next diagram in Fig. 3.11 curves of dependences of probability levels of sales from actual distribution of density of probabilities of the cumulative income on a portfolio are presented. This chart is built in the same way as the previous demand chart, but it plots the model's sensitivity to sales levels.

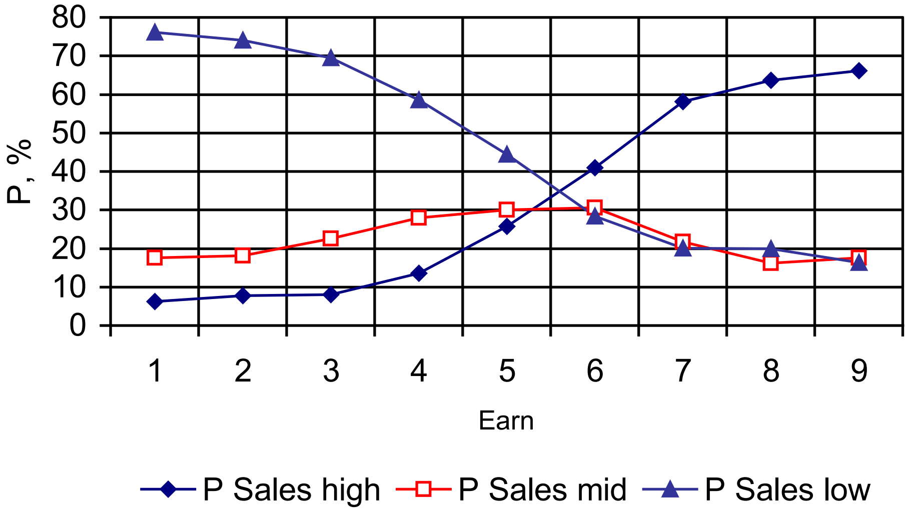

Fig. 3.11 - Curves of dependence of the probabilities of sales on the actual distribution of total income in the portfolio (compiled by the author)

Note that the diagram in Fig. 3.11 allows you to significantly refine the conclusions drawn from the analysis of the previous demand diagram. In particular, by analyzing it, the investor can see that sales may be of interest from the level that provides the total return on the portfolio, starting already from the 6th (and not from the 7th) range, since. the full probability of sales is formed by almost equal shares of probabilities of high and medium level (in aggregate they are 71.6%). At the same time, the probability of termination of sales is less than 30% (28.4%).

Finally, another auxiliary diagram (Fig. 3.12) presents curves of dependence of the probability levels of activity of the author / investor on the actual distribution of the probability density of the total return for the portfolio. This chart represents, respectively, a graph of sensitivity to the level of activity of the author / investor.

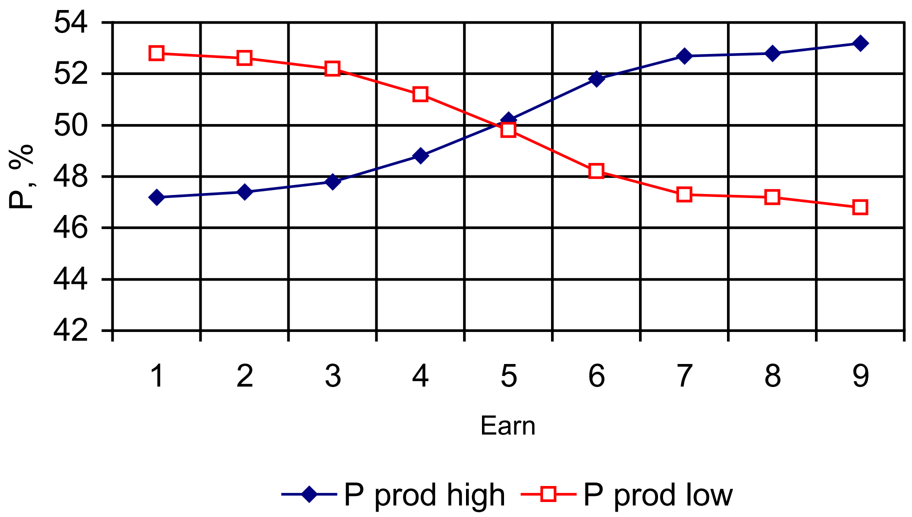

Fig. 3.12 - Curves of dependence of the probabilistic levels of activity of the author / investor on the actual distribution of total income in the portfolio (compiled by the author)

The scenario in which the node of the author's variable productivity (investor's activity) is transferred to a low probability state (low 100%) allows us to simulate the effect of inertia, which we have identified both for portfolios and for individual assets of the class under study. As noted above, in the node of variable performance, the ratio of probability levels is deliberately set as 50/50. The low probability state of this variable actually means that the node does not affect the state of the sales variable. Looking ahead a little, we note that if, with a mixed output, the demand level is transferred to a high state (high 100%), then with a level of total income equal to the expected value (5th range), the network already gives a probability of a high level of sales of 55.8% and an average 34.9%. Naturally, with further progress of the evidence in the node of the total income variable towards the maximum, the probability of a high level of sales continues to increase (up to 85.7%), which confirms the logic of the model.

Once again, we note that continuous curves, like the curves in Fig. 3.10, 3.11, and 3.12 give a more complete picture of the possible consequences of portfolio management. Therefore, diagrams of this type can be used in intelligent decision support systems to help the investor in diagnosing complex problem situations in the face of uncertainty, lack of experience, and insufficient information. Such situations are typical for the intellectual property market.

Next, consider the model from the side of parent nodes. The most obvious direct (predictive) inference is to test the probabilistic states of the model by introducing evidence into the parent nodes that determine the state of the target variable. The first evidence corresponds to the statement of high demand (Fig. 3.13) - while the total probability of high sales automatically increases from 27.3% to 60%, and the distribution of the total probability of total return across the portfolio shifts the maximum to the 6th range (22.5%), i.e. above the expectation level.

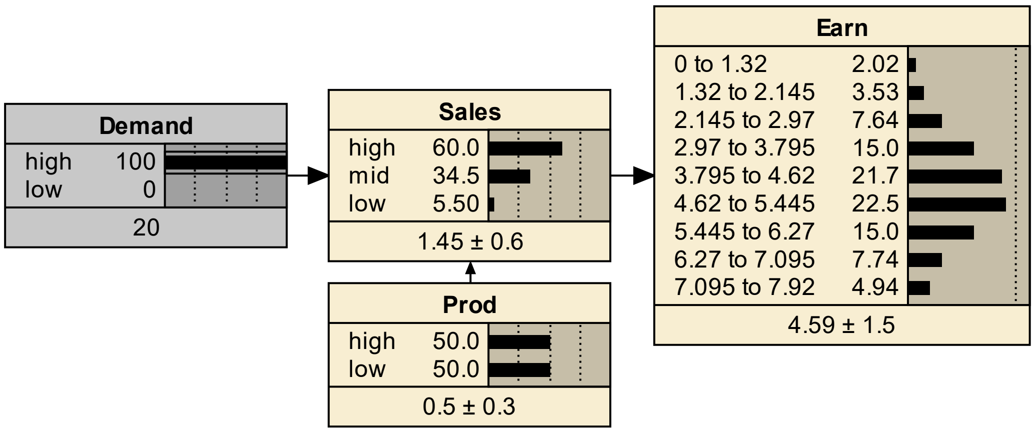

Fig. 3.13 - Response to the input of evidence of high demand (compiled by the author)

Then it can be seen that if a high level of sales probability is also confirmed in such a state (Fig. 3.14), then the total income probability distribution diagram will correspond to the limit state with a maximum in the 6th range (25%).

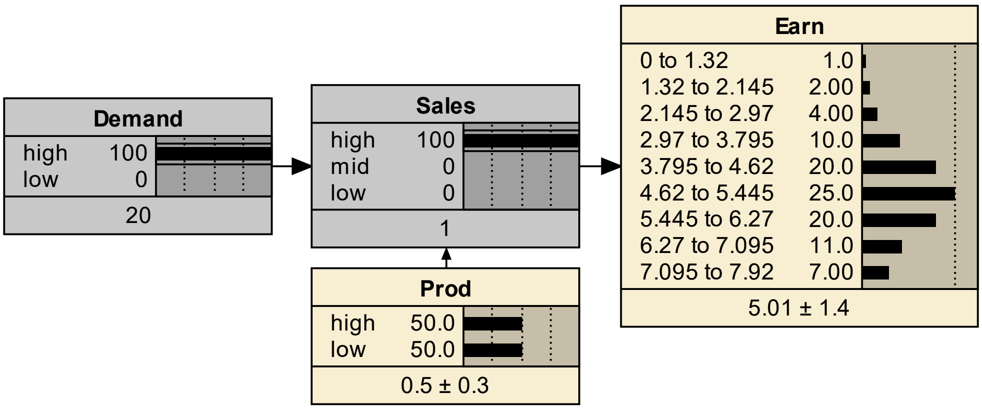

Fig. 3.14 - Reaction to confirmation of a high level of sales (compiled by the author)

Next, we will verify that if evidence is introduced at the demand node confirming low demand (Fig. 3.15), then the total probability of stopping sales increases sharply from the initial 47.2% to 75%, and the total probability of distribution of total income shifts the maximum by 4- th position (23.6%), i.e. below the expectation level.

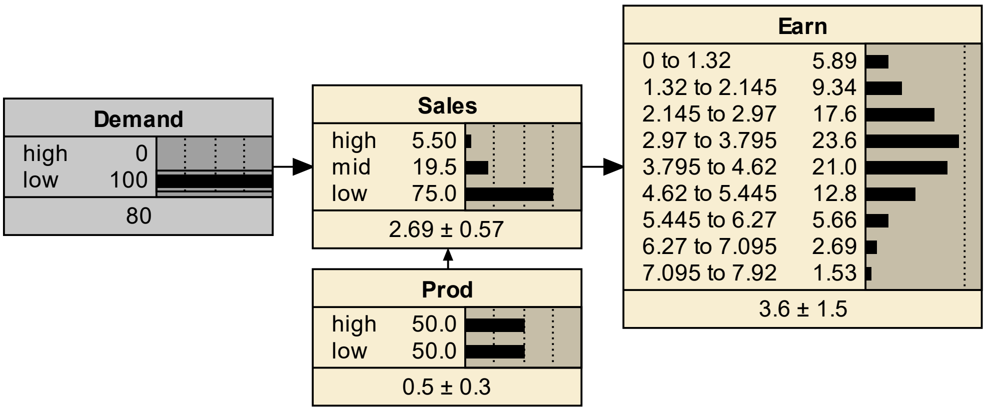

Fig. 3.15 - Reaction to the input of evidence of low demand. (compiled by the author)

If in this state the low probability of sales is also confirmed (Fig. 3.16), then the total income probability distribution diagram will correspond to the limit state with a maximum in the 4th range (25%), i.e. below the expectation level. At the same time, the probability of poor performance also increases by 3.3% (up to 53.3%), which corresponds to the logic of the model.

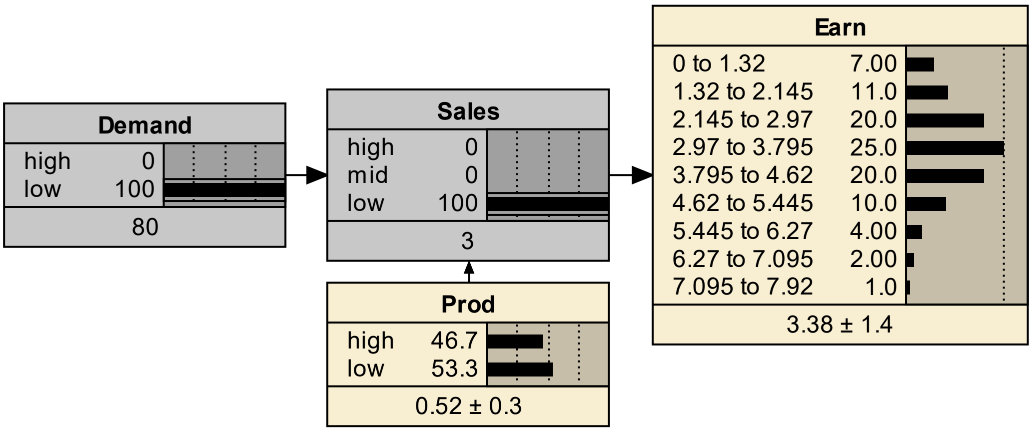

Fig. 3.16. Reaction to confirmation of low sales. (compiled by the author)

The next variant of direct inference involves joint input of evidence into the author/investor demand and productivity parent nodes (Fig. 3.17). If both confirm high levels of demand and productivity probabilities, then sales continue with the highest probability of 60%, and the distribution of the total probability of total income shifts the maximum (22.9%) to the sixth range, i.e. above expectation.

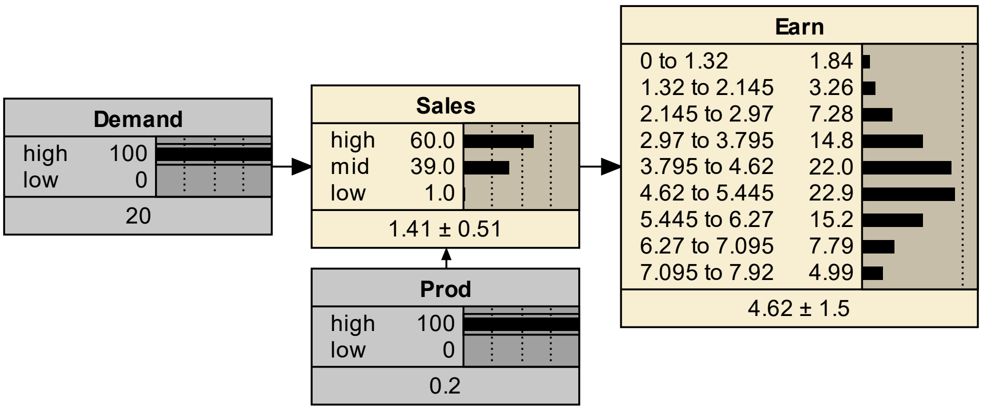

Fig. 3.17 - Response to co-injection of evidence into parent nodes (compiled by the author)

However, if the productivity factor switches to the opposite state at maximum demand (Fig. 3.18), then a redistribution occurs in the sales node in the direction of increasing the probability of stopping sales immediately by 9%. At the same time, in the distribution of the total probability of income for the portfolio in all ranges near the maximum, the probabilities decrease by approximately 1%. In fact, this state reflects the weak impact of the productivity factor on the sales process, which occurs due to inertia, because the cessation of portfolio replenishment did not reduce sales expectations, and almost did not reduce revenue if there is enough demand to continue sales.

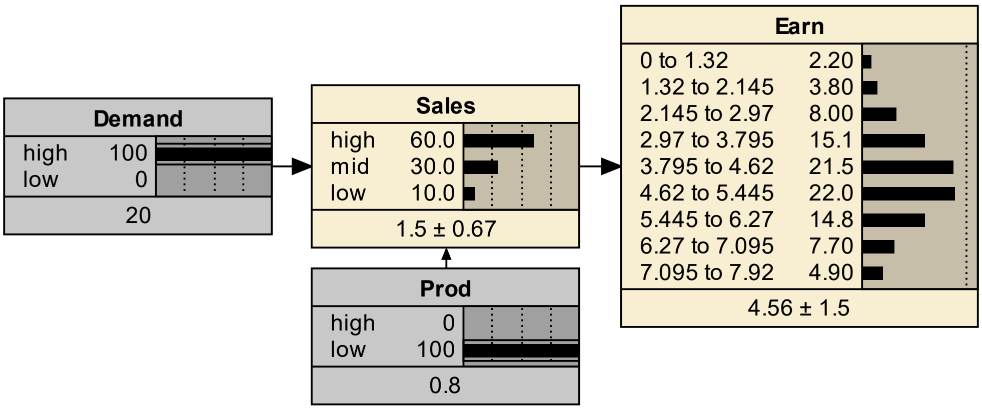

Fig. 3.18 - Reaction to the input of a certificate of termination of the portfolio replenishment (compiled by the author)

Mixed inference provides even more interesting possibilities for analyzing model states. Let's start with the most critical case, when the portfolio is in the most unfavorable state. Namely: demand is low, there is no portfolio replenishment, total income is at its lowest level (Fig. 3.19). In this case, it can be seen that there is a 90.6% chance that sales do not occur, and there is only a 9.22% chance that sales could only reach an average level.

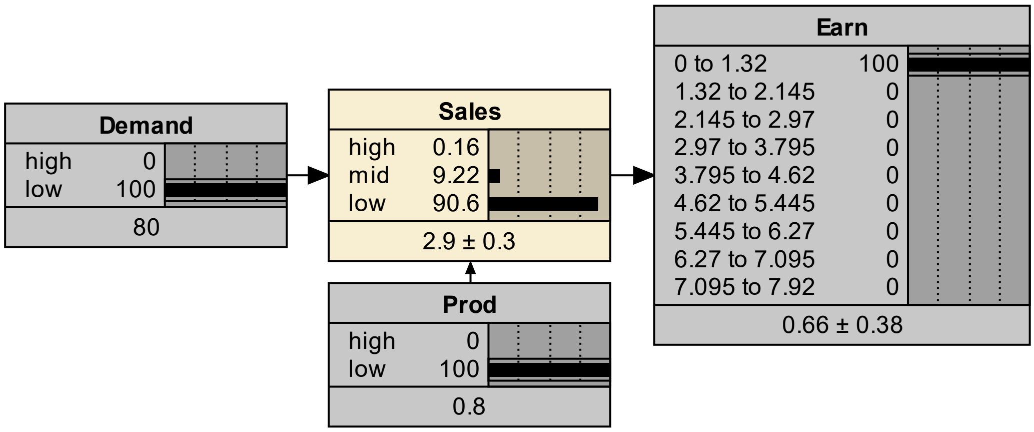

Fig. 3.19 - Worst case mixed withdrawal option (compiled by the author)

If in the same situation there is evidence that a higher total return is coming in at the expectation level (Figure 3.20), then even with the lowest demand for assets, the probability of sales at the average level already reaches 22.7%, and increases to 0, 95% chance that sales could be high.

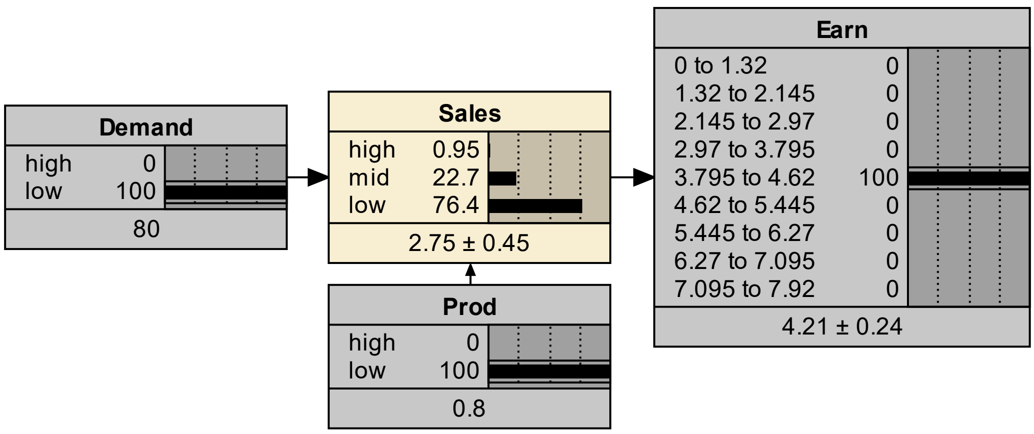

Fig. 3.20 - Response to confirmation of improvement in portfolio total return with low demand (compiled by the author)

Finally, if, under mixed output, total income falls within the highest range of the distribution (Figure 3.21), then the average probability of sales rises to 30.4%, and the probability that the level of sales could be high increases to 5.6%. It can be added that such a state corresponds to a real situation, when, due to the achieved inertia, a certain level of sales continues to be maintained in a completely "abandoned" portfolio.

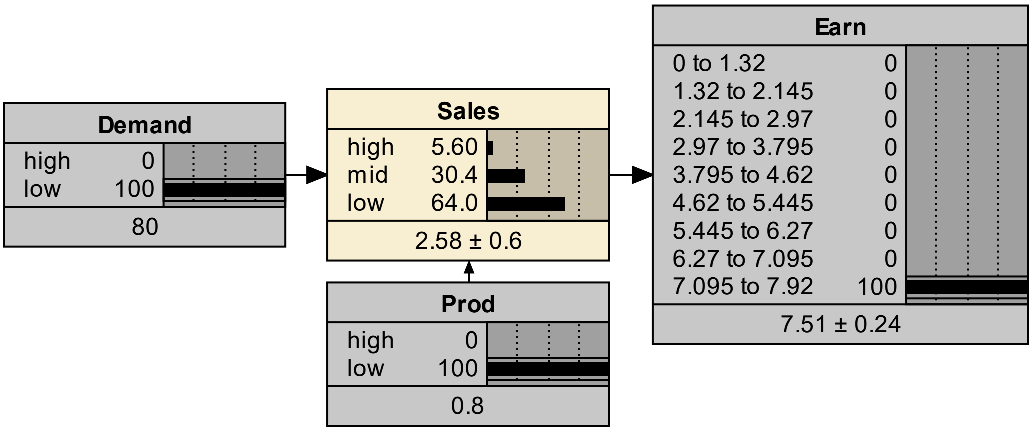

Fig. 3.21 - Reaction to confirmation of the possible return of the portfolio with low demand and low activity of the author / investor (compiled by the author)

But the situation changes radically if demand is confirmed at a high level (Fig. 3.22), for example, "champion" assets are found in the portfolio that generate stable revenue over a long period of time. In this case, even at the lowest level of total income, the distribution of probabilities across sales levels looks very different. Namely, the probability of a high level is a rather significant 27.3%, and the probability of maintaining some average level is more than 40% (equal to 40.9%), which is not bad at all in the absence of a portfolio replenishment or low investor activity.

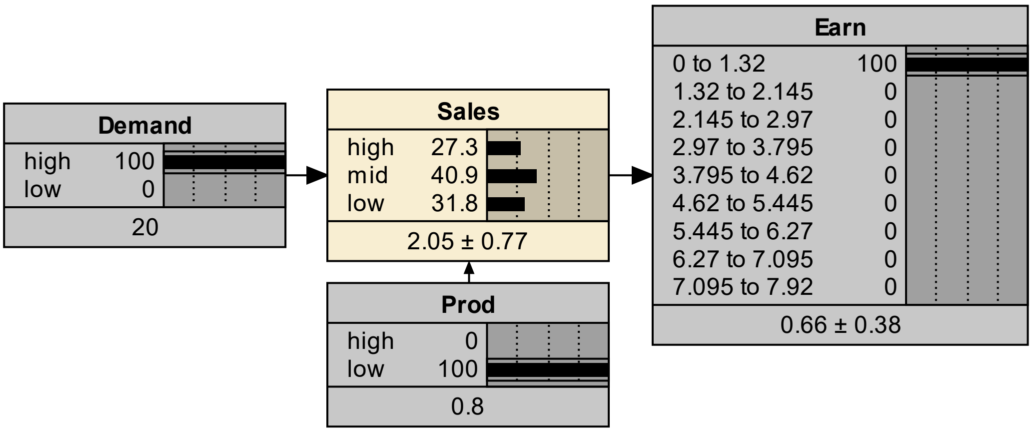

Fig. 3.22 - Reaction to the confirmation of the minimum profitability at the maximum demand (compiled by the author)

If further evidence arrives confirming that the level of total income is close to the expected value (Fig. 3.23), then the probability distribution in the sales node can already be called good, because the probability of a high level of sales is 55.8%, and the probability of their termination is less than 10% (9.3%). Such a portfolio may already be of interest to even a cautious investor.

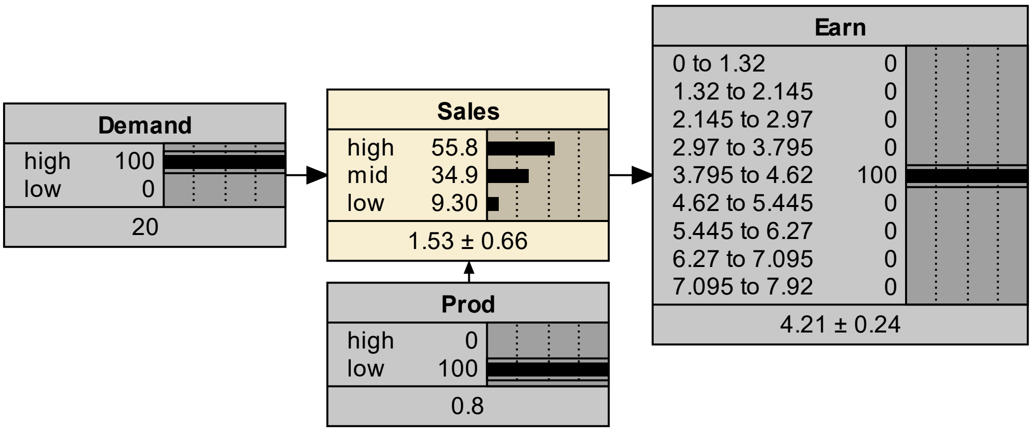

Fig. 3.23 - Response to confirmation of average returns at maximum demand (compiled by the author)

Finally, in the best condition, if we do not take into account the activity of management (Fig. 3.24), i.e. at the highest level of total portfolio income, the probability of sales becomes the highest (85.7%), and the probability of their termination decreases to 2.04%. Naturally, a portfolio that demonstrates such opportunities may already be of serious interest to any investor.

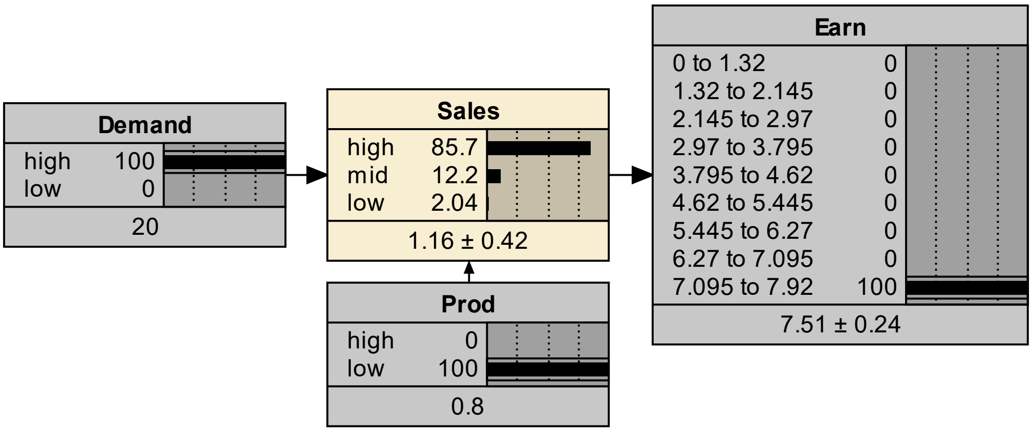

Fig. 3.24 - Response to confirmation of maximum profitability with maximum demand (compiled by the author)

In fairness, it can be noted that in this state, the positive contribution of the productivity factor (activity) may not necessarily consist in an even greater probability of sales (Fig. 3.25), but may manifest itself, for example, in reducing the probability of their termination to almost zero (0.2%), which is also significant.

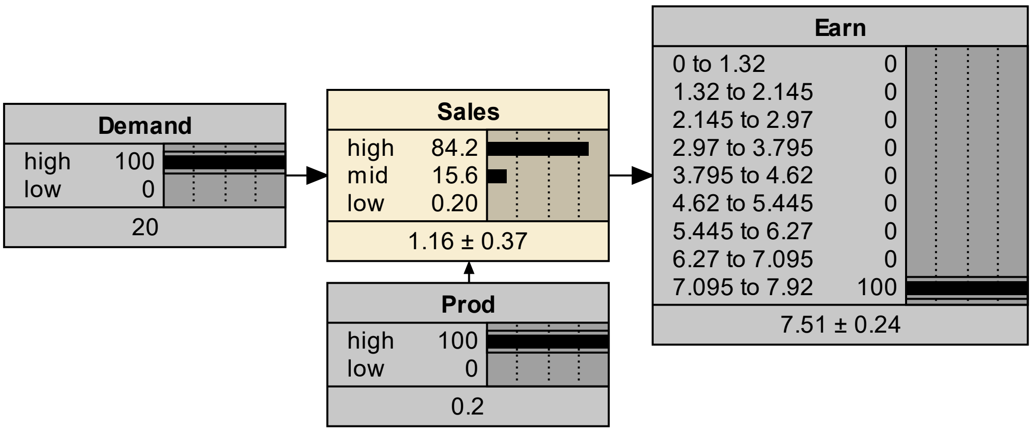

Fig. 3.25 - Reaction to confirmation of maximum profitability with maximum demand and activity of the author / investor (compiled by the author)

In order to show the possibilities of mixed inference, Fig. 3.26 presents empirical curves of dependences of the levels of probabilities of sales on the actual distribution of the probability density of total income over the portfolio at a fixed maximum demand and minimum activity of the author/investor. These curves cover the states of the model, not only those shown in Fig. 3.22-3.24, but also all possible intermediate states.

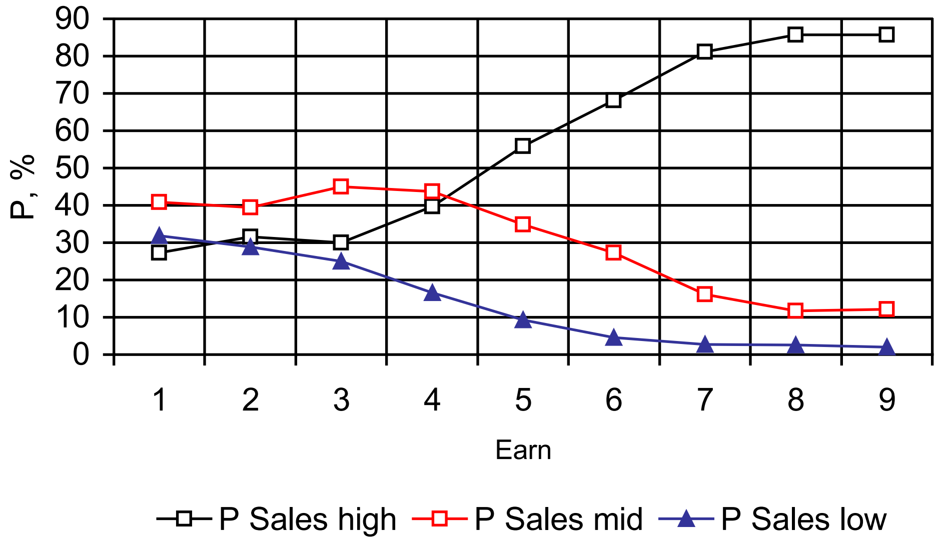

Fig. 3.26 - Curves of dependence of the probabilities of sales on the total income with a mixed output (maximum demand, minimum investor activity) (compiled by the author)

Diagram in Fig. 3.26 allows the investor to see that under favorable conditions of high demand, the inertia effect makes the portfolio attractive not only from the 6-7 range of total income, as was shown earlier, but, in fact, starting from the 2-3 range. The sensitivity plots of the sales variable strongly indicate that, under given conditions, the probabilities of high and medium sales combined may already exceed the probability of a sell-off. Thus, information about the sensitivity of the model, obtained by analyzing the discrete states of variables, makes it possible to generalize the modeling steps and more advantageously demonstrate the possibilities of supporting investor decisions.

The BBN presented above was built from the minimum required set of variable nodes, which allows demonstrating the logic of the model, its sensitivity, and the possibilities of probabilistic conclusions. However, as already noted above, the BBN mechanism makes it easy to introduce any new variables and explore possible relationships between them. Therefore, at the next stage, a more complex model is considered, taking into account additional factors.

3.3. Opportunities to improve the original portfolio model

In the previous paragraph, the minimum required configuration of the BBN was presented, in which two independent parent nodes of market demand and author/investor activity variables were used. The probabilistic states of these variables were specified by discrete states of unconditional (marginal) probabilities, which were introduced into the corresponding TUP. However, in Bayesian networks, it is more convenient to manage such variables with the help of additional parent nodes, which, in turn, display the impact of factors that affect dependent variables. Let's consider some possible variables that extend the original BBN (Table 3.6).

Table 3.6 - Additional variables in the composition of the BBN

№	Node designation	Variable interpretation	Probabilistic states	Comment
	1	2	3	4
1	Cost	Direct equipment acquisition costs	{high; low}	Expert judgment 80/20
2	M_Cost	Costs for maintaining and updating equipment	{high; mid; low}	Expert judgment
3	Skills	Prior professional experience	{high; low}	Expert judgment 70/30
4	Labor	Labor costs	{high; mid; low}	Expert judgment

Continuation of Table 3.6

№	Node designation	Variable interpretation	Probabilistic states	Comment
	1	2	3	4
5	Buyer	Number of registered buyers of digital assets	{more; less}	95/5 for a large photostock
6	Qual	Asset quality - artistic level and technical quality of execution (images)	{high; low}	Expert judgment 80/20
7	Trend	Compliance of assets with current market trends	{yes; no}	Expert judgment 90/10
8	Technol	Availability of technologies (software) for processing and preparing digital images	{yes; no}	Expert judgment

Source: compiled by the author

In order to train and test a realistic, operational BBN that is not overloaded with information, we supplement the previous model graph structure with some variables from Table 3.6. In particular, the former parent performance node (Prod) will be supplemented with variables that reflect the presence of prior professional experience (Skills) and the direct cost of acquiring the necessary equipment (Cost). The node of demand (Demand), in turn, will be supplemented with variables of asset quality (Qual) and compliance with current market trends (Trend). Finally, the sales node (Sales) will be supplemented with a new parent node (Buyer), which displays the number of registered users at the photostock (Fig. 3.27). Thus, the updated BBN contains five parent nodes.

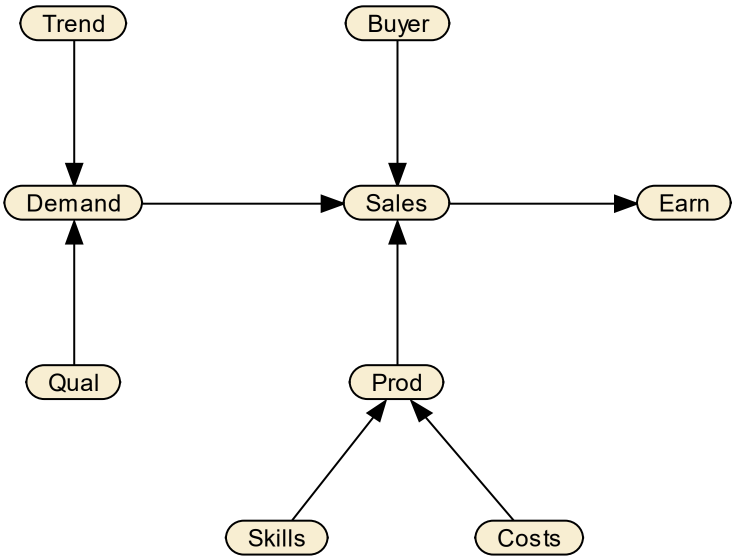

Fig. 3.27 - Initial graph of the network model (compiled by the author)

On the example of the previous version of the BBN, the logic and procedural moments of assigning the probability levels of variables by the experts to fill in the TUP and CPT were described in detail. However, for the new variables used in the model, the ratio of marginal probabilities is shown in Table 3.6. After filling in all the probability tables and initializing the network, the following distribution of unconditional and total probabilities was obtained (Fig. 3.28).

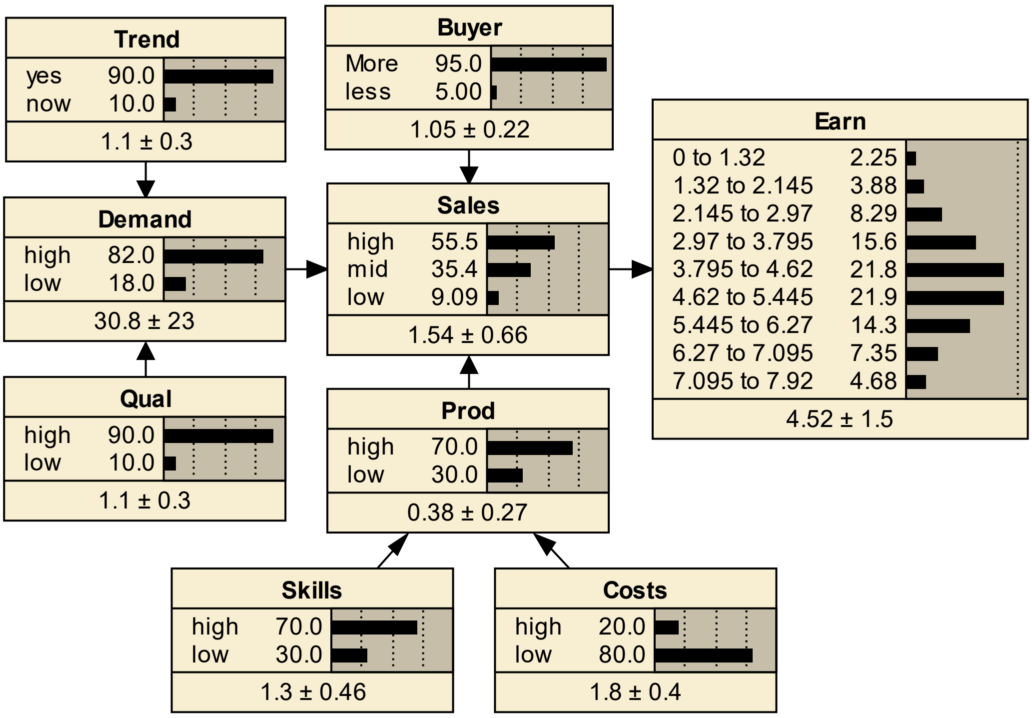

Fig. 3.28 - Improved BBN after model initialization (compiled by the author)

As you know, the more nodes of variables there are in any BBN, the more opportunities for probabilistic conclusions it gives. In particular, the updated model takes into account the fact that a novice author/investor, as a rule, is not very experienced and is not ready to immediately purchase a full set of expensive equipment (digital camera, optics, accessories, lighting, studio). More often he uses an inexpensive minimum set of equipment. Therefore, the variables in the nodes representing the experience and the possible level of equipment costs are set in this case to a low probabilistic state (low 100%).

Due to lack of experience, it is also likely that asset quality will not be very high at this stage, so the new asset quality variable is also set to low (low 100%). However, we will take into account that the microphoto stock has long been a large international company with a high reputation and a very large number of users. For example, it is known that as of the beginning of 2022, Shutterstock had about 400 thousand registered subscribers, and in total there were more than 2 million buyers. In addition, inspectors who accept works from authors/investors make sure that the portfolio (collection) of the photostock includes mainly high-quality assets that meet current market trends[59].

If, taking into account all this, the author/investor overcame the first difficulties and the total return on his portfolio reached at least the expected level (Fig. 3.29), then the network allows you to show that with a probability of 36.5% his portfolio can provide high, and with a probability 32.8% average sales, although the level of demand is not yet very high (37.7%).

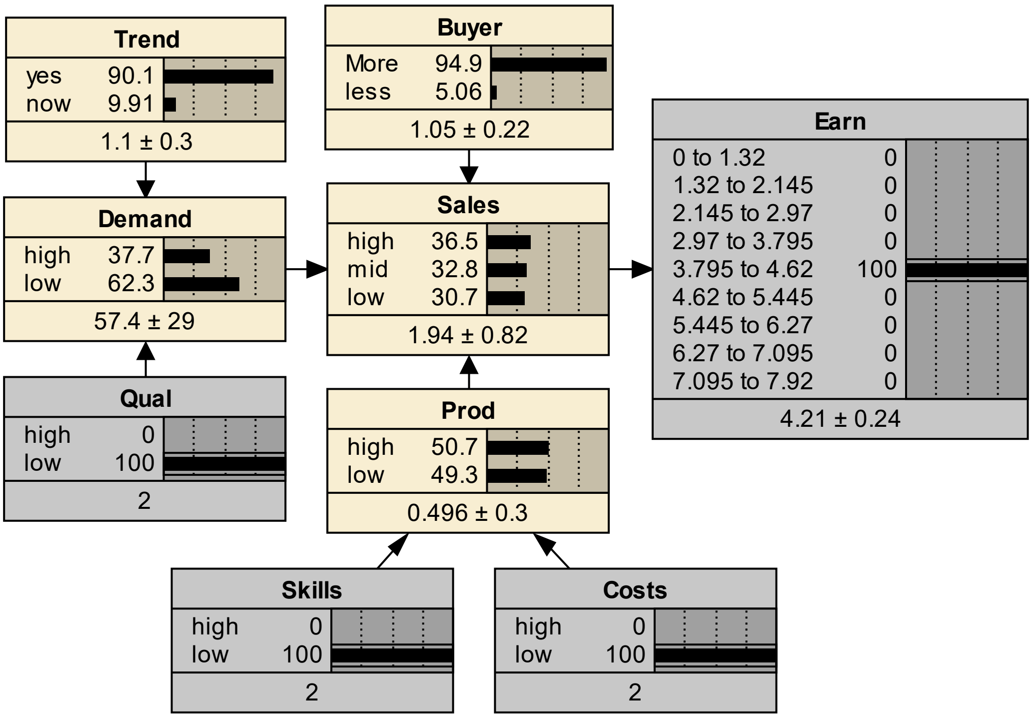

Fig. 3.29 - Probabilistic mixed inference (compiled by the author)

Continuing to work in the same mode, the author / investor can count on the fact that with the release of total income in the 6th-7th range, the probability of sales will increase to 68.7%, with a probability of high demand of 48.9% (Fig. 3.30).

[59] Voronov V.S. Investment hybrids for the digital market of intellectual property / V.S. Voronov, V.D. Davydov // Economics and entrepreneurship. - 2023. - № 7 (156). - P. 544-549

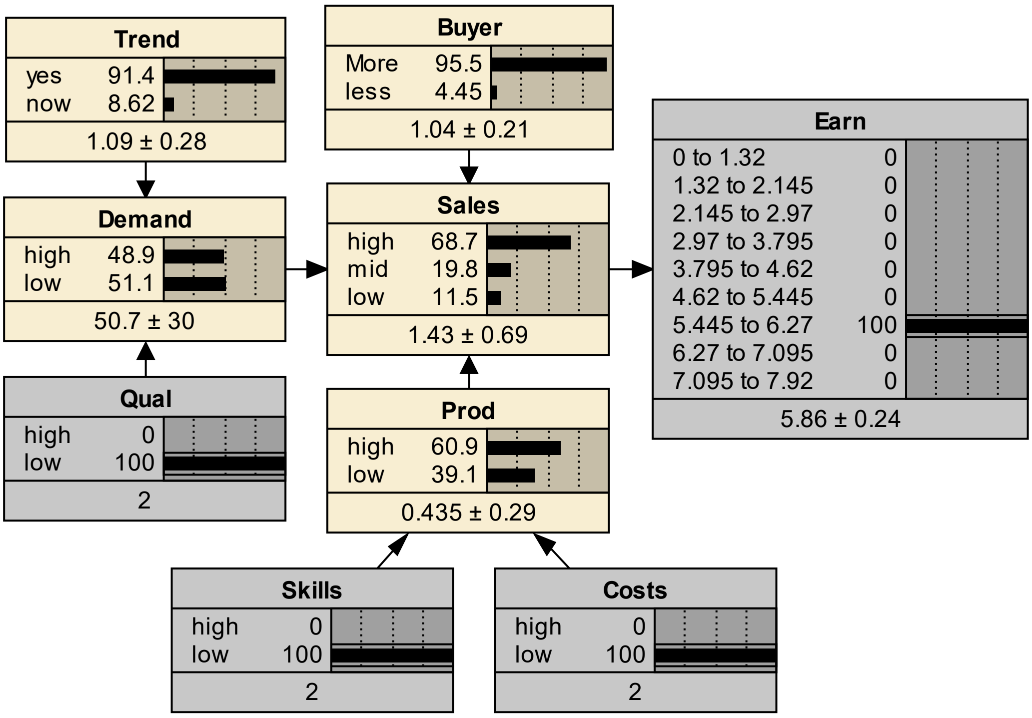

Fig. 3.30 - Results of increasing the level of total income (compiled by the author)

If, after some time, the author/investor has gained some work experience, and increased the cost of purchasing the missing equipment, then the probability levels of experience and cost variables can be tested in a high state (high 100%), although it should be noted that the increase in costs cannot be considered favorable. factor (Fig. 3.31).

However, if the author/investor managed to significantly improve asset quality due to this, then even with a lower level of total income (range 3-4), one can expect that the probability of high demand for his work will increase to 83.1% with the probability of high sales level of 35.5% and an average of 49.1%.

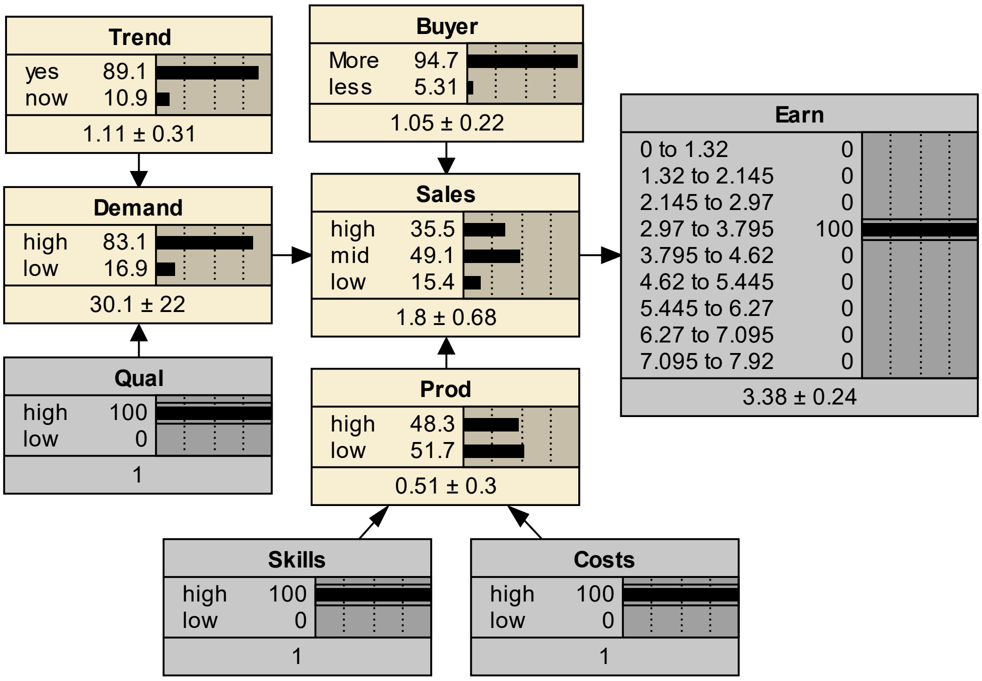

Fig. 3.31 - Response to improved asset quality (compiled by the author)

Under the same conditions, the output of the total income in the range of the expected value (Fig. 3.32) finally consolidates all the positive trends in the growth of the probability of high demand (87.4%) and sales above 50%.

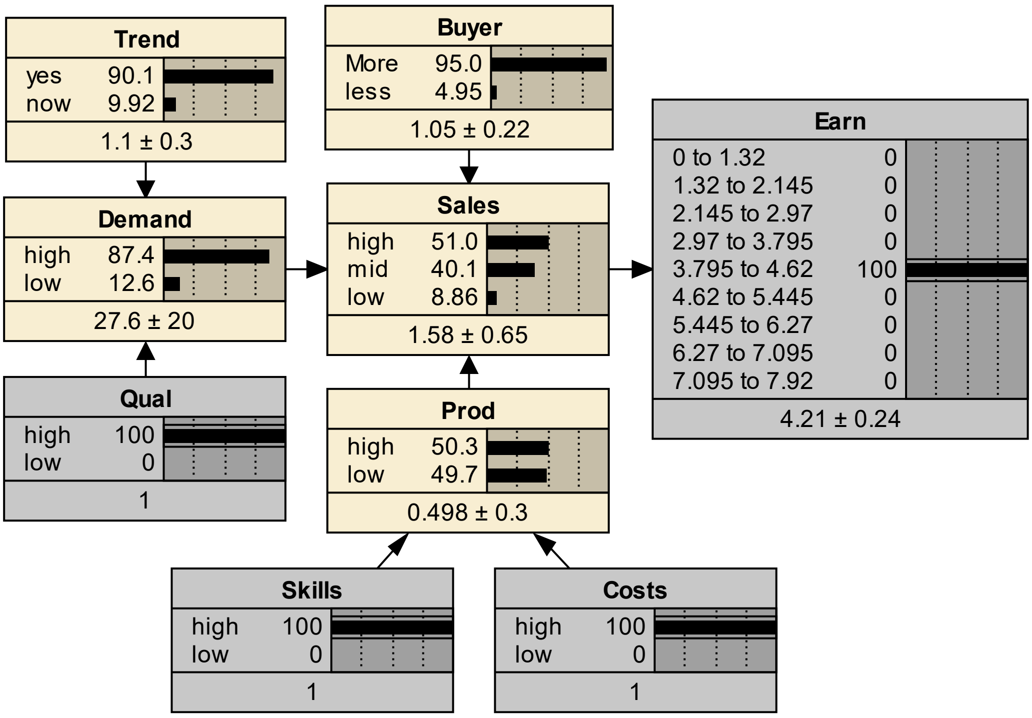

Fig. 3.32 - Consolidation of the trend of sustainable sales (compiled by the author)

Finally, the output of total income in the range of maximum return makes it possible to test the maximum levels of probabilities included in the model (Fig. 3.33). Here, the overall probability of achieving high demand is 92.1%; the probability of a high level of sales is 83%. Note that here, among other things, the network makes it possible to test the impact of variables that reflect hitting market trends and the number of users at the photo stock (not shown).

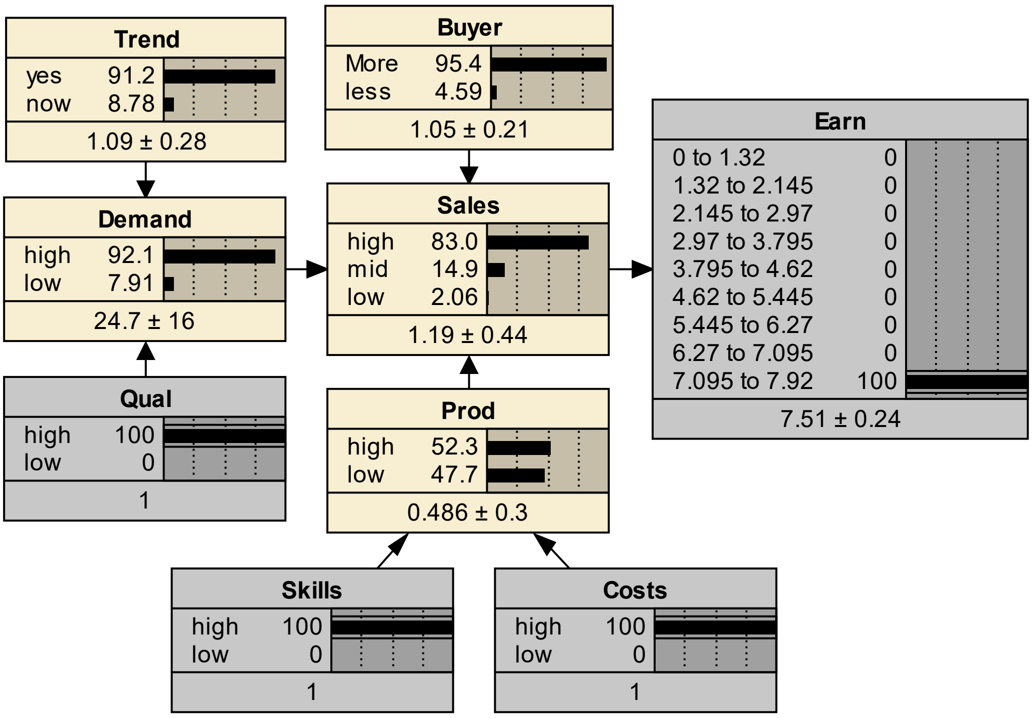

Fig. 3.33 - Portfolio marginal return status (compiled by the author)

In the process of direct probabilistic inference, entering the maximum probability levels of all parent variables (recall that in this version of the BBN there are five of them) allows us to obtain not only the probability density distribution of the target income variable, but also a very remarkable distribution of the total probabilities in the node of the author/investor activity variable. Namely, in this node there is a ratio of total probabilities of 50/50, which corresponds to the main hypothesis about the inertial properties of the portfolio (Fig. 3.34).

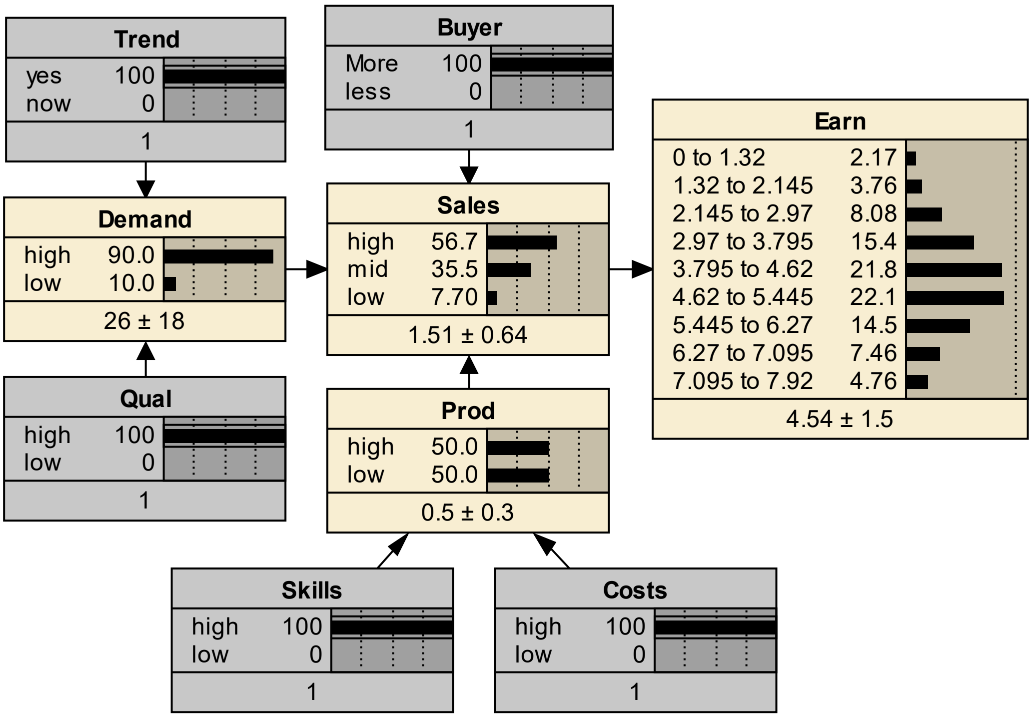

Fig. 3.34 - Direct output in the most favorable state (compiled by the author)

Since the updated BBN was supplemented with five variables, the actual number of combinations of the probabilistic states of the model increased many times over, and reached several tens, taking into account the enumeration of the probabilistic states of all variables. Continued training of such a model with the verification of expert opinions becomes a rather laborious task. Therefore, let us return to the variant of sensitivity diagrams with continuous curves of probability levels, since each of them allows us to replace nine discrete state diagrams of the BBN.

For example, in fig. 3.35 shows the empirical curves of dependencies of the levels of probabilities of sales on the actual distribution of the probability density of total income for the portfolio at a fixed maximum demand and minimum activity of the author/investor. This variant of mixed output was chosen from many others, because it again demonstrates the possibilities of inertial investment. In particular, it shows the investor that, for a given set of variables, there are probabilistic states in which the persistence effect reduces the probability of a sell-off at almost any level of total portfolio return provided in the model. This is confirmed by the fact that in all ranges of total income, the probability of sales termination may be lower than the probabilities of high and medium sales.

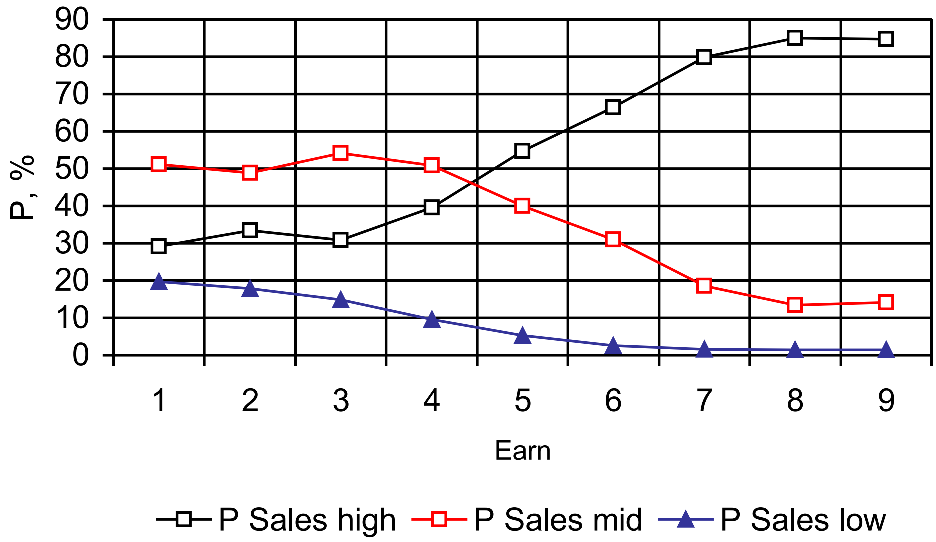

Fig. 3.35 - Curves of dependence of the probabilities of sales on the total income with a mixed output (maximum demand, minimum investor activity) (compiled by the author)

Thus, the results of the analysis of the sensitivity of the model to the incoming information, and the probabilistic conclusions make it possible to justify the decisions made by the investor under conditions of uncertainty. In particular, in order to make decisions, an investor (as well as any decision maker) needs to know:

- What alternative solutions exist;
- What is the degree of trust in the information received and expert opinions;
- What are the investor's preferences, i.e., what he would like to receive as a result of making a decision.

As shown above, the BBN consists of nodes representing variables in the subject area, which, in fact, reflect the degree of confidence of the investor. If, as a result of the analysis, the knowledge gained convinces the investor, then further it becomes the basis both for the formation of alternative solutions and for modeling preferences, i.e., for evaluating the usefulness of each alternative.

CONCLUSION

The dissertation research presents a theoretical substantiation of methods for investing in copyright digital intellectual assets, taking into account the key features of the investment characteristics of such assets, and approaches to building an investor's financial decision support system using Bayesian trust networks are developed.

The main results of the study are as follows:

1. The key features of the investment characteristics of copyright digital intellectual assets are identified, both in comparison with traditional financial assets and with patents. Portfolios of digital copyright assets today are operated by new institutional groups of financial intermediaries that appeared in some segments of e-commerce in the early 2000s. New intermediaries operate with super-large portfolios of assets. If the portfolios of large modern technology companies and patent intermediaries (aggregators) include tens of thousands of patents for inventions and other industrial property assets, then the portfolio taken for comparison is only one Shutterstock Ink. by the beginning of 2022, it has confidently exceeded the mark of 400 million units of copyright assets.

In addition, unlike standardized securities and other financial assets, intellectual property assets are unique. Each such asset is a single work and has an author and/or owner, whose rights, in fact, are the subject of economic turnover.

The sale of rights (licenses) to use digital assets of this class also has a fundamentally different market mechanism compared to securities or patents. Its most important feature is that the same asset can be sold multiple times, with each sale bringing a fixed amount of income. However, in turn, this fixed amount depends on parameters such as:

- Price category of the sold digital asset;
- Type of license required by the buyer;

- The physical size of the digital asset, for example, the file size of an image, which directly affects its quality;
- Required electronic format, fundamentally different, for example, for vector and raster images used for different purposes (also for sound, video, text assets).

The determining risk factor (income volatility) with such a sale mechanism is not the floating market price quotation, but the number of asset sales for the analyzed period, or the frequency of sales. Thus, income is determined by the market demand for specific assets, but the demand is not reflected in the market price, but in the frequency of sales.

As the study showed, the structure of such portfolios is very heterogeneous in relation to demand, which cannot but affect financial results. A significant portion of the assets may not be sold at all, and may not contribute to total return, or to a measure of risk as measured by sales results. There are also assets with very low financial returns. Together with the non-tradable group, they can occupy up to 90% of the entire portfolio. Finally, the "record holders" that generate the main income may be only 6-10% of the total number of assets, but at the same time generate more than 80% of the total income. The identified features of the investment characteristics of copyright digital assets made it possible to formulate approaches to their portfolio analysis.

2. An approach to portfolio analysis of copyright digital assets based on the principles of inertial investment is proposed. In the dissertation research, observational data on real-life portfolios of digital images were used. In order to decompose risk factors, it was proposed to consider each asset sale event as a single positive cash flow. All events (sales) for a long fixed period were sorted into five groups, ranked by the frequency of sales. With this approach, assets that fall into the same group have approximately the same demand, i.e., they are exposed to similar risk factors. Our experience has shown that such a cash flow map is suitable for analyzing any portfolio of digital assets of this class.

The process of filling the portfolio with assets may be related to the creative productivity of the author and is not necessarily stable. This process has its own uncertainties, depending on the portfolio management strategy. This study shows for the first time that portfolios of this type have the property of inertia, which significantly affects various aspects of portfolio management. The presence of the effect of inertia is confirmed by the data of more than ten years of observations.

For the area under study, the concept of inertia of investments is close, as a property inherent in some classes of financial instruments. The latter are used to implement long-term investment strategies focused on benefiting from long-term following of market trends. The concept of inertial investment is the closest to the property of inertia of portfolios of intellectual assets identified in the dissertation research.

3. Approaches to the analysis of investment strategies and portfolio management are formulated. At the initial moment of time, the owner of such a portfolio does not have any frequency-probabilistic characteristics (sales, profitability, etc.) necessary for risk assessment. This uncertainty accompanies the portfolio of intellectual assets as long as there are assets in it that have not been sold at least once. As shown in the paper, this group of assets plays the role of a kind of accumulator in the portfolio structure, which responds to the impact of market demand with the events of the first sale. The analogy with the drive is not accidental here, because. the presence of such a group (waiting group) is one of the factors explaining the property of inertia.

In turn, the property of inertia largely determines the originality of investment strategies and portfolio management. For example, the portfolio owner can transfer it to an investment intermediary, and then take no action, not replenish it with new assets. With such a strategy, due to the already noted inertia, the uncertainty of income generation will decrease gradually, in the process of forming the group of the first sale and further flow of assets towards the group of champions.

The portfolio works fundamentally differently when the owner continuously (for example, daily) replenishes it with new assets. At the same time, it is impossible to significantly reduce the uncertainty, since each new asset increases it, and sales, due to inertia, may occur much later, or not at all.

Other control strategies are known, but the possibility of choosing them makes it almost useless to use simple probabilistic indicators of uncertainty. Nevertheless, observing the sales process for a long time, we can confidently state that a quantitative increase in the expectation group always has a positive effect on the profitability of such portfolios, and the property of inertia can significantly reduce the negative impact of errors in portfolio management, choice (change) of investment strategy or replenishment of the portfolio with new assets. Moreover, a portfolio brought to a certain level of income, due to inertia, can continue to generate it for a long time with virtually no control actions.

4. A structural model of the investment portfolio of copyright digital intellectual assets has been developed. The proposed structural model takes into account not only the significant heterogeneity of the investment characteristics of intellectual assets, but also causal relationships between groups of assets ranked by the demand parameter.

The “expectation group” mentioned above is an element of the model that responds to the impact of market demand with the events of the first sale of an asset. The fact of the first sale is the initial perturbation that conditionally moves the sold asset to the next group of the first sale. In accordance with the logic of the model, after the first sale of any asset, repeated and subsequent sales may occur. At the same time, the asset conditionally moves to the next sales groups in order, and, with each transition, the quantitative degree of confidence increases, and the uncertainty, respectively, decreases. Thus, the first sale of each asset, in fact, is the beginning of an information flow (events), reflecting, on the one hand, an increase in the total income of the portfolio, and, on the other hand, a decrease in uncertainty regarding its profitability parameters.

5. Theoretical approaches to building an investor's decision support system have been developed. The system is implemented on the basis of a hybrid Bayesian network model of the investment portfolio and built in the Netica software environment. The basic version of the model includes discrete variables of the author's creative productivity (investor activity), market demand, sales, and a key continuous variable of income (Earn). Managing the performance parent node allows you to model both a

refillable portfolio and run-of-the-mill operation without replenishment. The probabilities at the income node are given by a real continuous distribution, experimentally obtained in the course of previous studies. Each interval on the diagram of this node corresponds to one of the probabilistic states of the modeled variable. This distribution allowed us to test the hypothesis that, in diagnostic probabilistic inference, the movement of evidence in the income node in the direction from lower to higher income should be accompanied by an increase in probabilities in the sales node and (at least) in the demand node.

In the course of training the model, an adequate response of the system to the impact of factors simulating the effect of portfolio inertia was obtained. Using the principles of machine learning allows you to continuously improve the system, replenishing its knowledge base with real observations of the activities of investors, which is shown in the work on the example of an extended network model.

Thus, in the course of the study, the scientific task of developing the theory and methodology of investing in digital intellectual assets of copyright was set and solved. The property of inertia in digital intellectual assets is revealed. In this regard, the principles of inertial investment are proposed to be used in the portfolio analysis of such assets.

The results of the study provide investors with access to a new promising asset class and provide a theoretical basis for creating the tools necessary to support financial decision making.

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APPENDIX

APPENDIX A

Table 1.

Linear approximation of the function of proceeds from the sale of an asset S for 2013-2021.

Regression statistics	
Multiple R	0,553255245
R-square	0,306091366
Normalized R-square	0,206961561
Standard error	22,58126712
Observations	9

Analysis of variance

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1574,502827	1574,502827	3,087783401	0,122299588
Remainder	7	3569,395373	509,9136248		
Total	8	5143,8982			

	Odds	Standard error	*t-statistic*	*P-value*	*bottom 95%*	*Top 95%*	*Lower 95.0%*	*Top 95%*
Y-intersection	10406,65867	5880,021811	1,769833344	0,120065596	-3497,383504	24310,70084	-3497,383504	24310,70084
Variable X 1	-5,122666667	2,91522905	-1,757208981	0,122299588	-12,01608797	1,770754642	-12,01608797	1,770754642

REMAINING

WITHDRAWAL

Observation	*Predicted Y*	*Remains*
1	94,73066667	-17,35066667
2	89,608	-6,648
3	84,48533333	-7,225333333
4	79,36266667	50,12733333
5	74,24	3,22
6	69,11733333	-7,617333333
7	63,99466667	-12,85466667
8	58,872	13,738
9	53,74933333	-15,38933333

APPENDIX B

Table 2.

Linear approximation of the sales volume function for the portfolio as a whole for 2012-2021.

Regression statistics	
Multiple R	0,86917799
R-square	0,755470379
Normalized R-square	0,724904176
Standard error	56,70349516
Observations	10

Analysis of variance

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	79468,60909	79468,60909	24,7158729	0,00109104
Remainder	8	25722,29091	3215,286364		
Total	9	105190,9			

	Odds	Standard error	*t-statistic*	*P-value*	*bottom 95%*	*Top 95%*	*Lower 95.0%*	*Top 95%*
Y-intersection	62895,92727	12588,71849	4,996213659	0,001057819	33866,2904	91925,56415	33866,2904	91925,56415
Variable X 1	-31,03636364	6,242849353	-4,971506099	0,00109104	-45,43240005	-16,64032722	-45,43240005	-16,64032722

REMAINING

WITHDRAWAL

Observation	*Predicted Y*	*Remains*
1	450,7636364	-6,763636364
2	419,7272727	25,27272727
3	388,6909091	49,30909091
4	357,6545455	-25,65454545
5	326,6181818	51,38181818
6	295,5818182	-76,58181818
7	264,5454545	-82,54545455
8	233,5090909	-32,50909091
9	202,4727273	29,52727273
10	171,4363636	68,56363636

APPENDIX C

Table 3.

Linear approximation of the revenue function for the portfolio as a whole for 2012-2021.

Regression statistics	
Multiple R	0,910257318
R-square	0,828568384
Normalized R-square	0,807139432
Standard error	25,15072744
Observations	10

Analysis of variance

	df	*SS*	*MS*	*F*	*Значимость F*
Regression	1	24458,42727	24458,42727	38,6658379	0,000254343
Remainder	8	5060,472727	632,5590909		
Total	9	29518,9			

	Odds	Standard error	*t-statistic*	*P-value*	*bottom 95%*	*Top 95%*	*Lower 95.0%*	*Top 95%*
Y-intersection	34873,56364	5583,702146	6,245598838	0,000246885	21997,52341	47749,60386	21997,52341	47749,60386
						-	-	-
Variable X 1	-17,21818182	2,769003958	-6,218186062	0,000254343	-23,60351639	10,83284725	23,60351639	10,83284725

REMAINING

WITHDRAWAL

Observation	*Predicted Y*	*Remains*
1	230,5818182	-43,58181818
2	213,3636364	-3,363636364
3	196,1454545	19,85454545
4	178,9272727	15,07272727
5	161,7090909	44,29090909
6	144,4909091	-6,490909091
7	127,2727273	2,727272727
8	110,0545455	-7,054545455
9	92,83636364	0,163636364
10	75,61818182	-21,61818182