ГЛАВА 1
МОДЕЛЮВАННЯ ФІНАНСОВИХ ПРОЦЕСІВ

1.1. Impact of shocks on stock markets: comparative analysis for alternative investment asset classes

Shocks in stock markets

Shocks in financial markets (the "Black Swan" in Taleb's terminology [2] already have a certain history and demonstrate different types of appearances. There are shocks in some segments of financial markets, in selected markets and at the global level. Despite the existing history of the financial shocks appearance, the scientific direction of their research is quite new in economic science. One of the reasons for this is the relatively long-time intervals between shocks occurrence. In the periods between shocks, financial markets are developed, new segments are raised, new financial instruments emerge and, quite often, the structure of the stock market can be essentially developed.

In addition, during periods "from shock to shock" the capabilities and tools of financial market regulators change. These changes undoubtedly affect to the shock investigation. On one hand, the existing genesis of shocks allows to use analog scientific methods. But the use of the analog method generates the question about correctness grounded. Another factor that characterizes the "novelty" in the direction of research of financial shocks is the growth of databases, data mining, tools of mathematical and statistical modeling. Indeed, if we compare the possibilities of economic analysis of American stock market shock in 1933 and the latest financial shocks, the use of data and quantitative methods is incomparable.

Shocks in stock markets represent a sharp change in the prices of assets that traded on them. Together, this causes changes in indices and other integral indicators of markets. In addition, the price change lead to changes in many other parameters, for example, trading volumes, size of spreads, yields, duration of bonds etc.

An important aspect in the investigation of financial shocks is their division into two groups. The first is a group of shocks due to economic and financial factors. These frameworks suppose that financial shock a certain consequence of the processes that occur within the financial system, or a reflection of economic reasons. Interesting, in this aspect, are the theoretical backgrounds elaborated by Hyman Minsky [1], which justify shocks by internal factors of the financial systems development. A fairly thorough analysis of financial shocks is given in the monograph [3].

The second group of shocks causes involves impacts of external, non-economic and non-financial distresses. These can be wars, natural, epidemiological, environmental and man-made disasters. The subjects of our scientific research are shocks exactly by from this group. Namely, the shock of this type was the global shock generated by the COVID-19 pandemic (March, 2020). Also, this type includes the shock of world stock markets generated by Russian aggression against Ukraine (February, 2022).

Event study analysis

The starting place of our study to shock`s research is Event study analysis. This approach, today, is a methodological component of the study of stock markets dynamic and is well outlined in the scientific literature. In particular, the main components of this analysis are presented in the book [4]. Book describes structure, logic and sequence of application Event study analysis.

The theory of market efficiency forms the conceptual basis of application this analysis to research shock in stock markets. This theory was developed by the American economist Eugene Fama in the 60s of the twentieth century. In 2013 Eugene Fama was awarded the Nobel Prize in Economics. The core of the theory is efficient-market hypothesis (EMH). According to this theory, all significant information is immediately and fully reflected in the market price value of stock assets. In this case, the forms of efficiency are divided into three types: week, semi-strong, strong. Research has shown that well-developed capital markets are semi-strong form efficient.

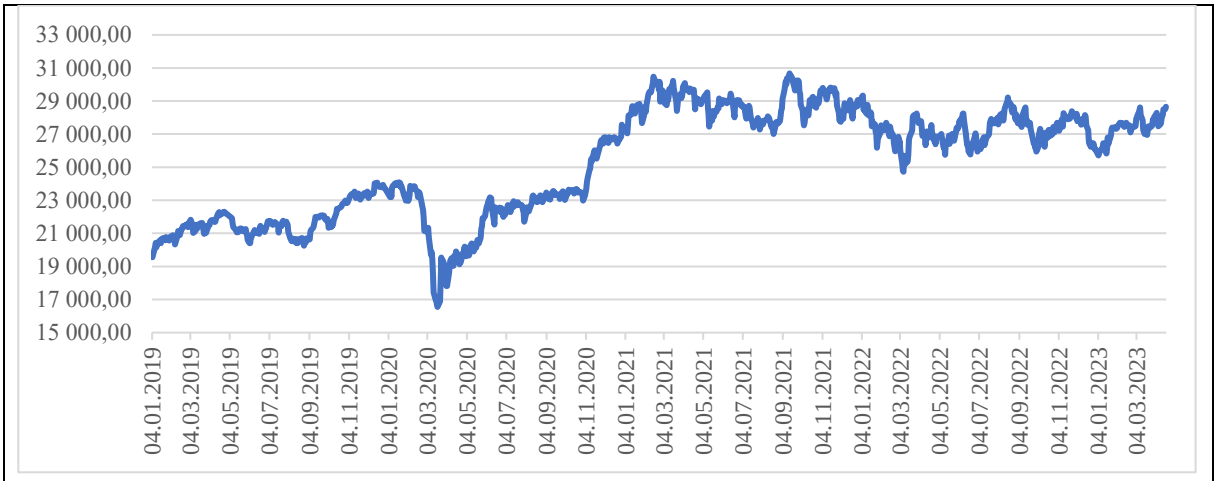
The second group of shocks is caused by external, non-economic reasons. Consired in our reseach shocks belong exactly to this group. Namely, the shock of this type was the global shock generated by the COVID-19 pandemic (March, 2020). Also, this type includes the shock of stock markets generated by Russian aggression against Ukraine (February, 2022). The application of Event study analysis involves the formation of three time intervals: before event, the event itself, after event. The analysis can be divided into two components. The first component includes the assessment of changes in market parameters (and individual market segments) directly in the implementation of the event. The second component includes the analysis of the behavior of the market before event period. One component of this analysis is to compare the values of the after event parameters with the values of the before event. The selection of intervals for analysis is a task that arises from the following questions:

- What is the time interval to use as the event itself?
- What time interval should to use for notion “before event” and for notion “after event” ?

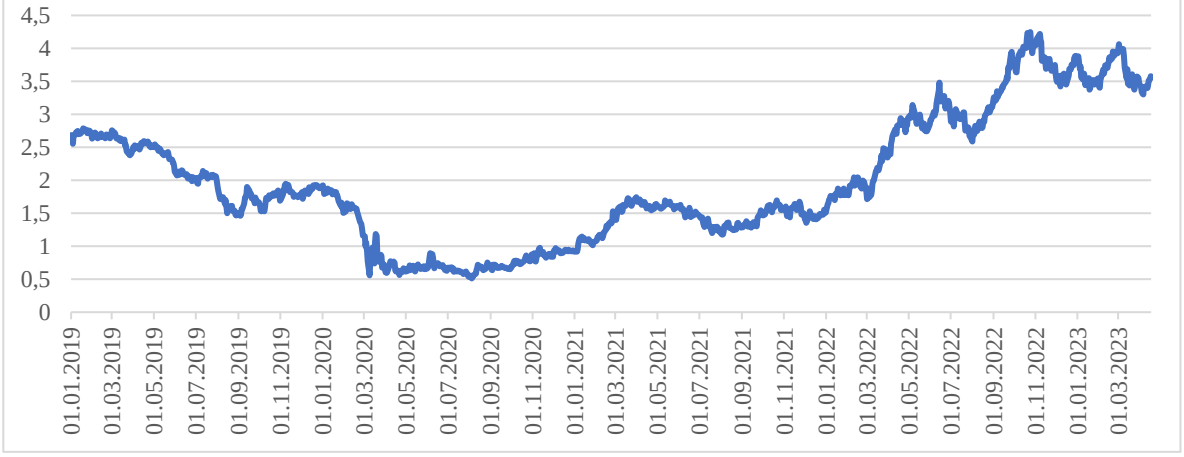
When searching for the answer to the first question, the study faces difficulties in identifying the right end of the time interval. Indeed, the onset of shock corresponds to a sharp change (a drop or increase) of parameters. In fact, this corresponds to the definition of shock. At the same time, the transition from "the event itself" to "after shock" requires some validity.

In our view, to identify a transition point from "the event itself" to "after shock" there may be a start to move the parameters backwards.

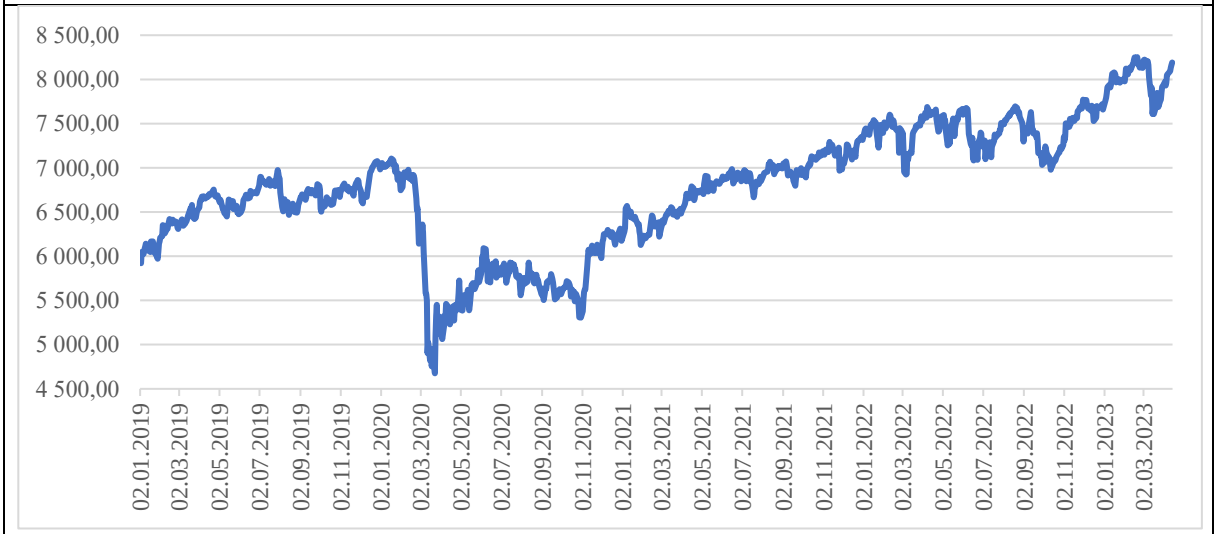
One approach to determining this may be an approach based on an analysis of the shape of the curve. In particular, the authors use the classification U, V, L, W-types [5]. Examples are given in Fig.1.



“V” shape example. Nikkei 225



“U” shape example. US 10-year bond yield



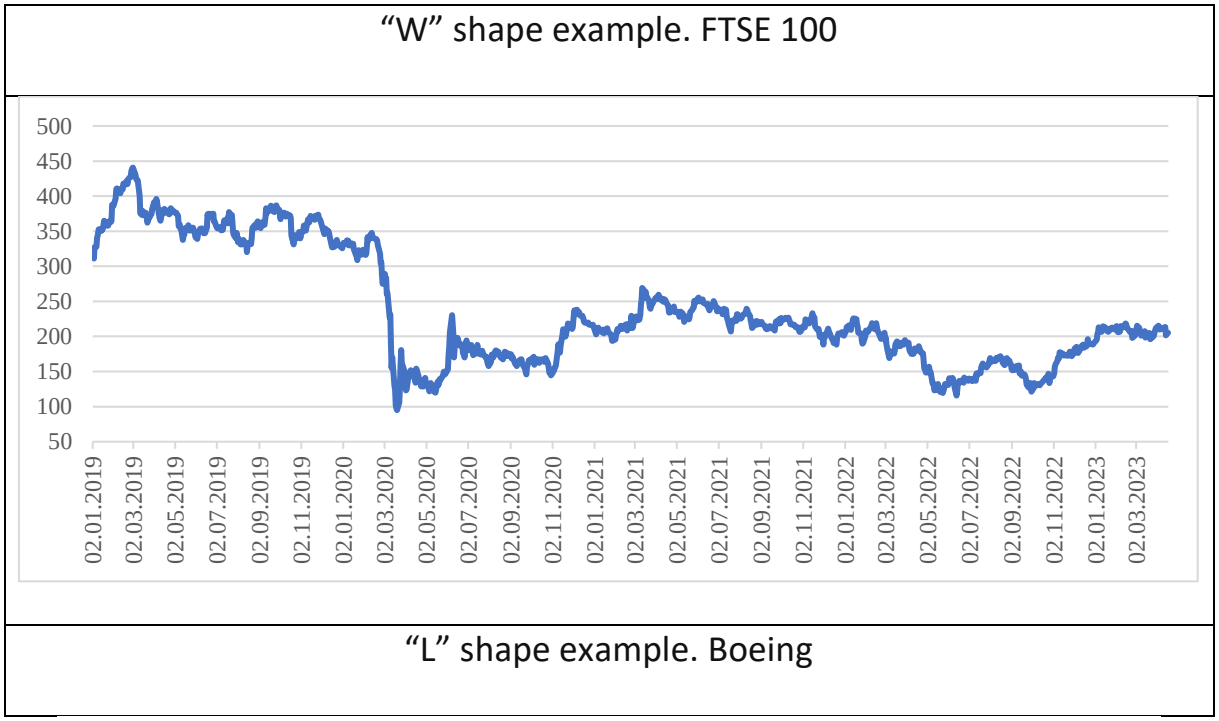


Fig. 1. Examples of curve`s shapes for transition across COVID-19 shock

However, this approach is well justified for the asset under consideration. In the case of considering a set of assets to identify generalized characteristics of shock, it is unacceptable. For some unification is needed in determining the length of the interval. In our approach, this unification is the stock index. Index of the segment to which the population belongs.

Indicators of shock

The following hypothesis was used in our research:

The appearance of shock immediately creates uncertainty for investors. This uncertainty at once affects to their behavior. Investors are beginning to actively reformat their portfolios (buy and sell stocks). The trading volumes increase.

The levels of increasing and recovering are considered as indicators of impact for different asset classes. Comparative analysis can be explored on these frameworks.

Based upon this hypothesis, we introduced into consideration two indicators. These indicators focus on changing in trading volume. They are based on

daily or weekly trading. The first indicator is "shock deepness volume" (SDV). It encompasses volume at time intervals “the event itself” and “before event”

$$SDV = \frac{Average\ \ volume\ over\ shock\ (time\ interval\ "the\ event\ itself")}{Average\ \ volume\ before\ shock\ (time\ interval\ "before\ event")} - 1.$$

The second indicator is “recovery rate of trading volumes” (RRV) which is defined as:

$$RRV = \frac{Average\ volume\ after\ shock\ (time\ interval\ "after\ event")}{Average\ volume\ before\ shock\ (time\ interval\ "before\ event")}$$

This indicator shows up how different is the volumes of trading after the shock from such volumes before it. Thus, our first assessment is a pair (SDV; RRV). These are dimensionless indicators. SDV shows the percentage increase in daily trading volume at the time of a shock. Since a shock is characterized by the abruptness of change, the higher value of SDV indicates more pronounced the shock. RRV ratio shows to what extent the average daily trading volume after the shock exceeds (or is already equal to) that before the shock. In other words, if it is well above 1, the recovery has not yet taken place. This indicator essentially reflects the long memory of shock affecting. Of course, it depends on the selected time interval.

Second our hypothesis concern high volatility of price through the day:

The appearance of shock provides rapid increasing in uncertainty regarding present momentum and future returns. This immediately leads to investors' hustle (or in slang "rush asunder"). This hustle rises from not understanding what needs to be done. Therefore, there is no classical equilibrium price. The change in price during the day can be very significant.

This occurrence we formalize by imposing indicator HLDD (High Low During the Day). The HLDD is calculated for each day and then averaged out period “the shock itself”:

$$HLDD = \frac{High\ price - Low\ price}{0{,}5 * (High\ price + Low\ price)}\ (During\ the\ Day).$$

This indicator integrates two effects. The first, reflected in the numerator, shows the investor`s hustle. Large fluctuations during the day increase the values. The second effect, reflected in the denominator, can show the decreasing in the

prices and influence (increase) its values. Thus, according to our approach, the higher value of HLDD corresponds with how much the shock manifests itself.

The following hypothesis in our study was:

the hypothesis of a sharp decline in share price followed by a recovery. In our research, the fall-recovery pair characterizes adapting to the "risk-return" correspondence.

For this purpose, we used indicators methodologically consistent with SDV and RRV. Only instead of trading volume it uses price. The first indicator is "shock deepness price":

$$SDP = \frac{Average\ price\ over\ shock\ (time\ interval\ "the\ event\ itself")}{Average\ \ price\ \ before\ shock\ (time\ interval\ "before\ event")} - 1.$$

The second indicator is “recovery rate price” (RRP) which is defined as:

$$RRP = \frac{Average\ volume\ after\ shock\ (time\ interval\ "after\ event")}{Average\ volume\ before\ shock\ (time\ interval\ \text{"before event"})}$$

SDP has the nature of a classical rate of return with some specifications linked to average prices. It was supposed that such an approach nihilate price volatility before the shock to before the shocking price. The logic of using such a form of RRP is to desire an estimate comparison with the before shock period, not with the “bottom price”. It is necessary to note that indicators SDP and RRP were applied for COVID-19 shock for traditional assets in [7].

Alternative investments

Modern-day investments in academic community and practitioners are usually divided into two broad categories: investments into traditional assets and into alternative assets. Traditional assets include stocks, bonds and certificates of bank`s deposit. However, the definition of alternative assets is ambiguous due to their diversity and the constant emergence of new types of such assets. Today, the literature presents two main approaches to the definition of alternative assets: "by exclusion" and "by inclusion".

One approach [6] considers alternative investment assets as all assets that do not fall into the traditional category. This method of definition is broad and includes many types of investments, from real estate to art and wine collections.

Another approach [12] involves a clear enumeration of classes of alternative assets that belong to this category. But this approach is currently heterogeneous. Different authors use different approaches to the formation of classes. The number of classes may vary. At the same time, four large categories of alternative assets are most often distinguished: hedge funds, private capital, real assets (anything related to tangible assets, like real estate, commodities, metals, etc.) and structured products [11].

As of 2021, the total capitalization of alternative investment assets in the world market is estimated at 9.3 trillion US dollars (and taking into account hedge funds - 13.7 trillion US dollars). Moreover, the market of alternative investments is steadily growing. From 2015 to 2021, the market grew by 14.9% annually. Analytical group Preqin expects the market to grow at a slightly slower rate of 11.9% annually over the next five years. Including hedge funds, the global alternative assets market is expected to grow 70.7% to $23.3 trillion by the end of 2027. [15]

Alternative investments play a significant role in the modern investment environment. One of the important areas of using alternative investments is expanding the range of investments, in particular, diversifying risk through portfolio approach. The use of alternative investments has advantages and disadvantages from the point of view of a portfolio management. The advantages include a low or negative correlation with the return of traditional investments, which helps to reduce the risk of the portfolio due to the combination of both types of investment. In addition, alternative investments can provide typically higher returns than traditional investments because their expected returns are higher than those of traditional assets.

However, this approach has its drawbacks, such as the high potential return volatility of alternative assets compared to traditional ones, low liquidity and high investment costs associated with the entry threshold.

It is precisely because of the specific behavior of these assets that shock research is interesting for them. Because it should differ from the behavior of traditional assets during shocks. This was one of the main factors of our research. The risks of alternative investments were studied in the paper [9].

ETF-based approach

The cornerstone of our methodology is using ETFs (Exchange Trade Funds) of alternative investments. At the end of March 2020, the Global ETFs (or more widely ETPs - Exchange Trade Products) industry had 7,996 ETFs/ETPs, with 16,031 listings from 450 providers on 72 exchanges in 58 countries. ETFs/ETPs listed globally gathered net inflows of $20.44 billion during March 2020 (ETFGI, 2020).

An ETF is an investment instrument consisting of a portfolio of stocks, bonds, commodities and other assets. These assets are collected in the fund and reflected in its shares, which can be bought and sold on the stock exchange, just like stocks. ETFs allow investors to increase the diversity of their portfolio by reducing the risks associated with investing in individual stocks. In addition, ETFs often have lower fees and expenses compared to traditional mutual funds, making them attractive to a wider range of investors.

ETFs can target various markets such as stocks, bonds, commodities, currencies and others. Some ETFs track the entire market, such as the S&P 500, which tracks the 500 largest companies in the US. Other ETFs may target a specific industry, such as technology or renewable energy companies. ETFs may also involve alternative investment assets such as real estate, hedge funds, private equity, and others.

For example, there are ETFs that invest in real estate such as commercial buildings and apartment complexes. These ETFs allow investors to generate profit from real estate without directly owning it. Other ETFs may invest into hedge funds, allowing investors to access professional capital management and reduce risk.

Alternative investment assets can be more complex and less liquid than traditional stocks and bonds, and therefore more difficulty to buy and sell on the stock market. However, with the help of ETFs, investors can easily and affordably invest in these assets, reducing costs and risks.

Consequently, ETFs can be linked to alternative investment assets, helping investors to diversify their portfolios and reduce risk. ETFs can be a useful tool

for comparing different alternative assets, as they allow investors to easily understand and compare the risks and potential returns of each asset. An ETF is a tool that allows an investor to compare completely different alternative assets and choose the best option for their portfolio. It is also important to note that when comparing different alternative assets through ETFs, an investor can be sure that all assets meet certain standards and regulations, which reduces risks. ETFs can help investors compare different alternative assets and understand their risks and returns, allowing investors to make more informed decisions about their portfolio. Using ETFs of alternative assets gives the possibility to realize our research in a homogeneous environment which correctness comparably.

Our methodological approach is to build a representative sample of ETFs that represents alternative investments in the US stock market. US market was chosen as more developed, and therefore has a wide base of ETFs coverage of various types of alternative investments. Also, the US market has a sufficient history for the availability of statistics, which is important for a meaningful indicators assessment using different approaches. In addition, the sample assumes coverage of all major types of alternative investments.

Data mining for research

The verification of our scientific hypotheses was based on the technique of intelligent data analysis. To test these hypotheses, we formed a representative sample of ETFs of alternative investment assets. A database of marker data (prices and trading volumes) was established for them.

There are various data sources that provide information on the market performance of ETFs. One of the broad information resources is Financial Knowledge & Information Portal [15]. It includes a good classification of ETFs by segment and region. We also analyzed the information resource JustETF [16], which contains sufficiently complete and detailed information. We settled on ETF Database [14] after a comprehensive analysis of resources. This database was created in 2009. From our perspective, it is now the world's largest digital database

focused on ETFs. This database contains data on ETFs of various types, including 10 types of alternative asset classes.

The basic conditions of sample formation in our study were:

each type of alternative investment assets must be represented in the sample by at least 3 exchange trade funds;

the average daily volume with such a fund exceeds 50,000 (if this does not contradict the previous clause);

availability of weekly quotation data starting from July 30, 2018.

After applying these conditions, we obtained a database of 91 ETFs. They are divided into 10 classes of alternative assets presented in Table 1.

Table 1

Sample of alternative investments ETFs

Type of alternative investments	*Number of ETFs in sample*	*ETFs*
Agricultural commodities	6	CANE, CORN, DBA, JO, SOYB, WEAT
Commodities	15	BCD, BCI, BDRY, CMDY, COM, COMB, COMT, DBC, DJP, FAAR, FTGC, GCC, GSG, PDBC, USOI
Precious metals	18	AGQ, BAR, DBP, DBS, GLD, GLDM, GLL, GLTR, IAU, OUNZ, PALL, PPLT, SGOL, SIVR, SLV, UGL, ZSL
Hedge fund	6	ADME, FMF, FVC, MNA, PHDG, RLY
Long-Short	3	BTAL, FTLS, QAI
Metals	5	CPER, DBB, JJC, JJN, SLX
Oil and gas	10	BNO, BOIL, DBE, DBO, GAZ, KOLD, SCO, UCO, UNG, USO
Real estate	18	BBRE, DRN, DRV, FREL, ICF, IYR, KBWY, MORT, REK, REM, REZ, RWR, SCHH, SRS, SRVR, USRT, VNQ, XLRE
Private equity	4	BDCL, BIZD, PEX, PSP
Global real estate	6	HAUZ, IFGL, REET, RWO, RWX, VNQI
Total	91	

The data sample was directly formed using the finance.yahoo.com data resource. The price, yield and trading volume analysis was based on weekly data from July 30, 2018 to March 6, 2023 and covered 241 values for each ETF. This period covers all selected ETFs. Returns are calculated based on ETF prices quoted in US dollars.

As periods of economic shock, the periods of the beginning of the active phase of the global Covid-19 pandemic and the full-scale invasion of Russia into Ukraine were selected for analysis, as well as, respectively, the pre-shock periods that preceded them and the periods of recovery, which are listed in Table 2.

Table 2

Periods selected for analysis

	Before Shock Period	Shock Period	After Shock Period
Covid-19	30 Jul 2018 – 17 Feb 2020	24 Feb 2020 – 27 Apr 2020	5 May 2020 – 29 Nov 2021
RUW	1 Feb 2021 – 21 Feb 2022	28 Feb 2022 – 14 Mar 2022	21 Mar 2022 – 6 Mar 2023

Analysis of Covid-19 Shock

The assessments procedures were applied to indicators presented in the subsection "Indicators of shock". The results are shown in the Table 3. The obtained assessments are the basis for a comparative analysis of the reaction of alternative asset classes to the Covid-19 Shock.

Table 3

Results for Covid-19 Shock

	Agro	Commodity	Global Real Estate	Hedge Funds	Long Shorts	Metals	Oils	Prec Metals	Private Equity	Real Estate
SDP	-0.11	-0.24	-0.21	-0.07	0.02	-0.19	-0.23	0.07	-0.27	-0.16
RRP	1.09	0.97	0.92	1.11	1.02	1.25	0.61	1.28	0.97	0.88
HLDD	0.06	0.08	0.11	0.08	0.05	0.07	0.23	0.10	0.18	0.20
DV	-0.01	2.21	2.89	2.98	2.09	0.56	7.86	1.65	4.39	4.60
RRV	2.49	10.35	1.25	2.70	1.12	6.08	11.51	4.73	2.40	3.01

A graphical stratification of SDP and RRP indicators for shock associated with the Covid 19 pandemic can be seen in Fig. 2 and 3.

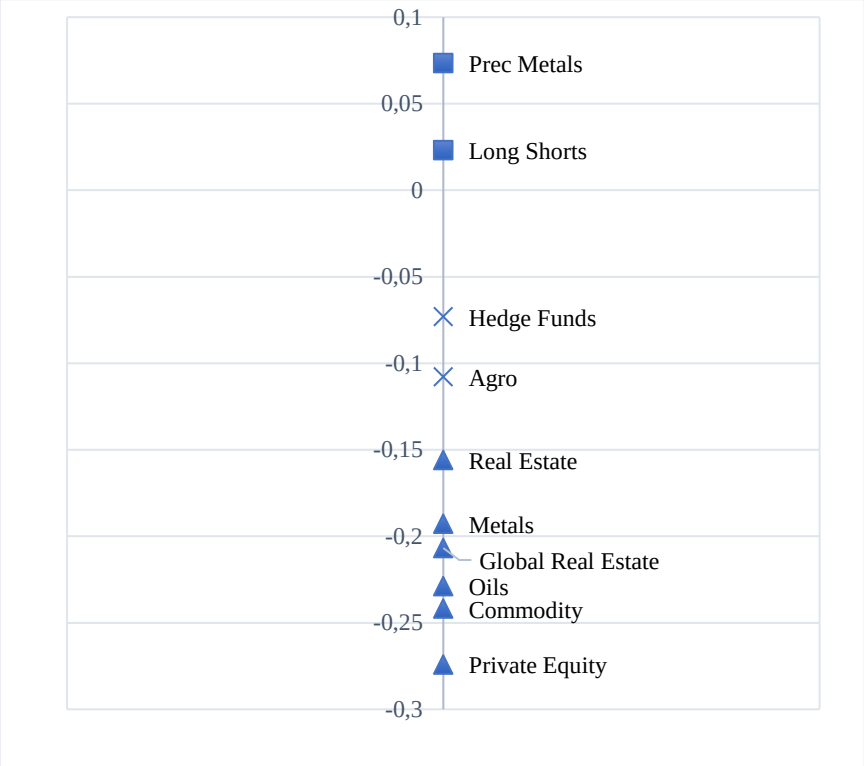


Fig. 2. Covid-19 shock. SDP stratification (vertical axis displays SDP values)

Fig. 3. Covid-19 RRP stratification (vertical axis displays RRP values)

The shock associated with the coronavirus pandemic was global in nature and affected almost all classes of alternative investment assets. ETFs related to commodities, metals, gas and oil, private equity and real estate showed the biggest price declines. Approximately the same classes were characterized by a significant increase in the ETFs volume during the shock period, which is explained by the activity of investors who tried to exclude these exchange-traded funds from their portfolios and diversify them with the help of other instruments (such as precious metals or various funds that showed much smaller price drop indicators).

Most of the classes listed above also showed quite good recovery rates, returning to the shock prices. However, several types of alternative assets have recovered significantly worse than others - primarily real estate and oil. This is due to the fact that industries closely related to them, such as transport, air transport and retail, have experienced the most significant and long-lasting effects of the consequences of the coronavirus infection. Analogous processes for private equity capital (venture investments) are associated with their high risk in any period of time, which forces investors in crisis periods to primarily refuse investments of this type.

In Fig. 4 graphically depicts the relationship between the indicators of relative growth in the number of transactions with certain classes of alternative assets during the shock period and after it.

As can be seen from Fig. 5, part of the groups of alternative investment assets did not show a significant increase in the volume of operations during the shock period and was characterized by a certain increase in this indicator during the recovery period. This class includes agricultural, metals and precious metals. The second class of alternative assets includes hedge funds, long shorts and global real estate. The volume of operations with them during the shock period increased more than 2 times, but the post-shock popularity among investors was less than that of the previous group.

The third class of alternative assets is formed from real estate and private equity. They showed approximately the same RRV as the second class, but the

volume of operations with them during the crisis was significantly higher. Commodities, which showed abnormally high popularity after the shock, and oil, the number of transactions with which increased more than 8 times during the shock period and during the recovery period, made up separate categories.

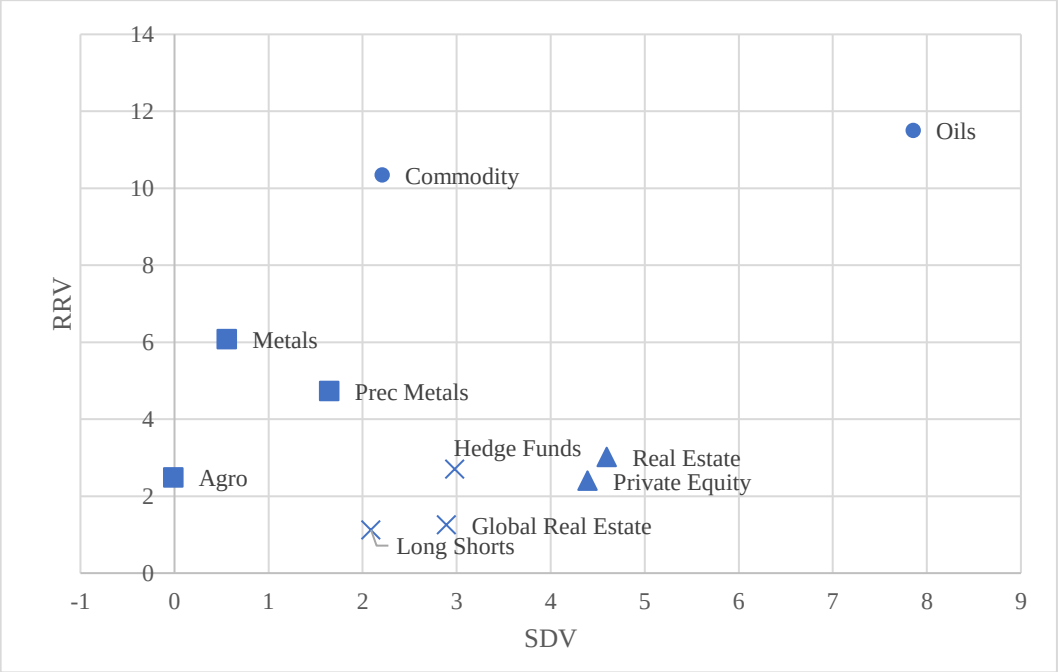


Fig. 4. SDV – RRV matrix for Covid-19 Shock

It is also worth noting that the post-crisis indicator of the k-ratio changed its sign compared to the pre-crisis value (mostly from negative values, individual categories became positive). This indicates a change in the general trend of certain groups of alternative assets – from a trend towards a decrease in profitability before the crisis to the opposite in the post-crisis period.

Shock generated by Russian invasion to Ukraine

Our approach was applied to the analysis of the shock caused by the start of the Russian-Ukrainian War (RUW). The indicators presented above were calculated and a comparative analysis was carried out between classes of alternative assets.

A graphical stratification of SDP and RRP indicators for RUW shock can be seen in Fig. 5 and 6.

Table 4

Results for RUW Shock

	Agro	Commodity	Global Real Estate	Hedge Funds	Long Shorts	Metals	Oils	Prec Metals	Private Equity	Real Estate
SDP	0.23	0.16	-0.06	0.00	0.02	0.23	0.19	0.03	-0.07	-0.02
RRP	1.19	1.07	0.82	0.97	1.03	1.04	1.27	0.92	0.82	0.89
HLDD	0.09	0.10	0.04	0.04	0.03	0.14	0.19	0.07	0.05	0.05
SDV	4.75	2.40	0.34	0.98	1.20	3.33	3.14	1.94	2.47	0.55
RRV	1.73	1.58	1.14	3.13	3.28	0.84	5.40	1.57	1.19	3.09

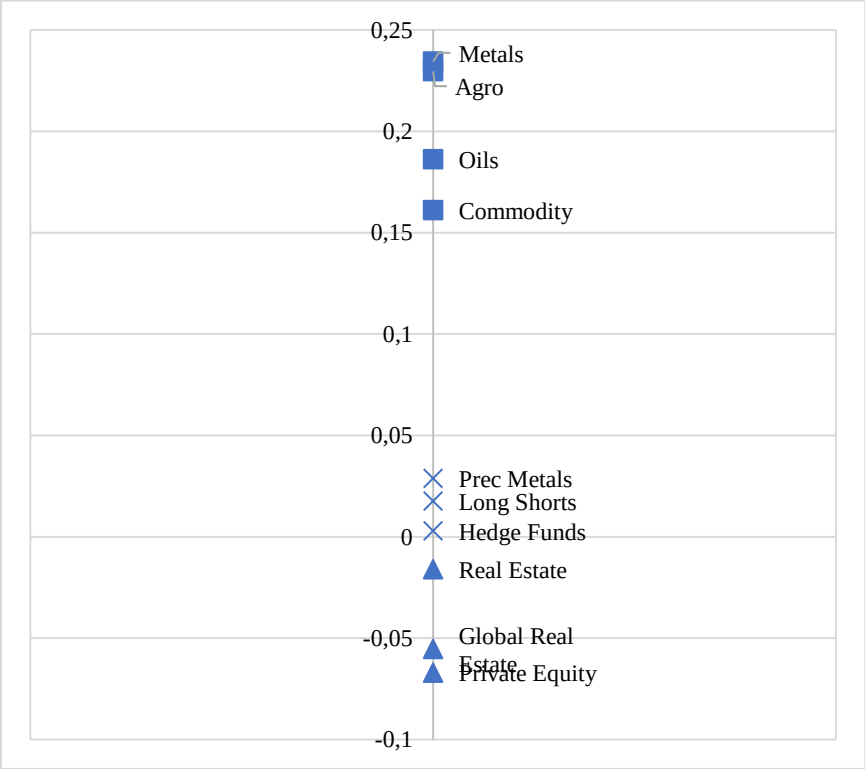


Fig. 5. RUW shock SDP stratification
(vertical axis displays displays SDP values)

During the shock period associated with the RUW, private equity and real estate lost the most in value. Hedge funds, long shorts and precious metals did not lose in value and even showed a small growth. Oil, metals, agricultural and commodities showed significant price growth rates. As for the price change in the post-shock period, it is worth noting here the continuing upward trend in all four groups of alternative assets mentioned above.

Fig. 6. RUW shock RRP stratification (vertical axis displays RRP values)

So, in contrast to the Covid-19 shock, the market reaction to the beginning of the Russian-Ukrainian war was radically different. The nature of the price shock was mostly growing (which is confirmed by the k-ratio indicator for almost all categories). To a greater extent, this applies to certain asset classes (such as agricultural, metals, oils and commodities). At the same time, there was a sharp increase of volume in these categories of alternative assets. This trend is caused by investors' expectations regarding the shortage of the main components of the war participants' exports. The reaction of other classes of alternative assets to the shock either did not occur (hedge funds, precious metals, funds with long-short) or was less significant.

Regarding the ratio of trading volumes during the shock associated with the Russian-Ukrainian war and recovery, alternative investment assets can be divided into 4 categories. This is global real estate, which has hardly reacted to it.

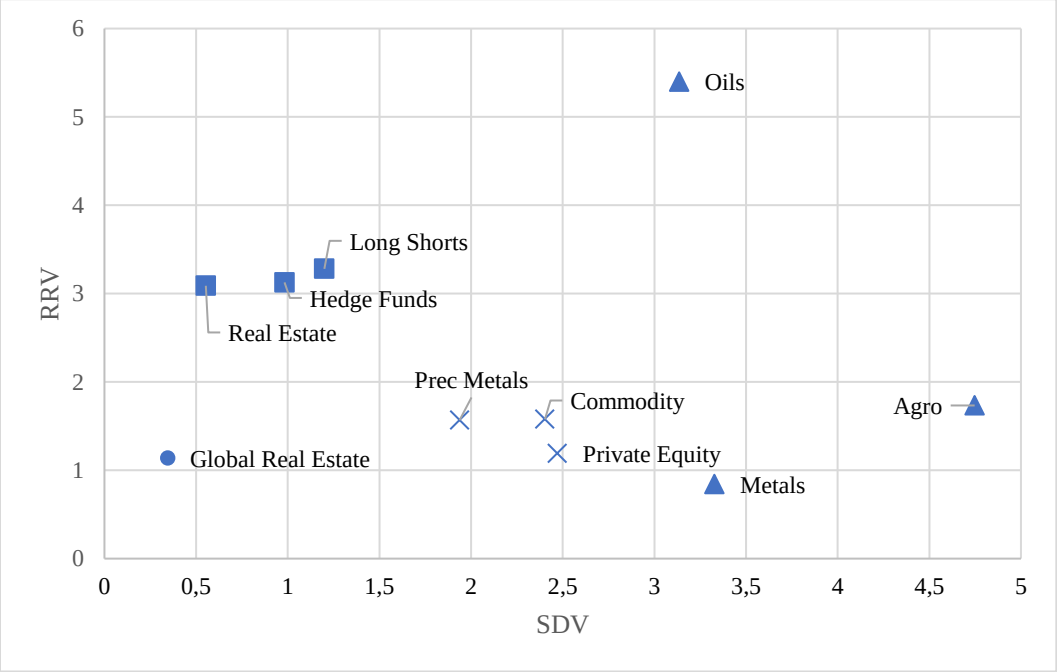


Fig. 7. SDV – RRV matrix for RUW Shock

The second class is real estate, hedge funds and long shorts, which reacted weakly to the shock in terms of trading volumes, but during the recovery period, volumes increased by more than 3 times. Volumes of trading in commodities, private equity and precious metals grew approximately equally in the shock and post-shock periods. Metals, agricultural and oil showed anomalous indicators of the growth of trading volumes during the shock period. The last group was also characterized by very significant growth during the recovery period. Most likely, this is related to the sanctions that have been applied in this industry..

Results of shock analysis

Analyzing the obtained results, several conclusions can be drawn. Alternative assets responded significantly to the studied shocks. All three our hypothesis were confirmed. The response was different across both alternative investment classes and shocks. The classes related to real estate (especially during the covid period) and various commodities, such as agricultural , metals and oil (primarily due to the shock of the war) showed the greatest reaction. The most "traditional" alternative assets – hedge funds, long shorts and precious metals - reacted the least to the shock.

The values of indicators, in particular the volumes of deals, showed that investors actively use alternative investments when forming portfolios. But shock phenomena stimulate the reformation of portfolios.

Both shocks created uncertainty for investors. But the depth of uncertainty was different. In the case of the Covid-19 shock, the uncertainty was global. In the case of the RUW shock, the uncertainty was segmental (in terms of asset classes) and geographically limited. This determined the multidirectional nature of the response to shocks. The first shock was characterized by a sharp drop in prices, and the second, on the contrary, by an increase. Because in the first case, the uncertainty of the development of the world economy dominated. And in the second – a potential shortage of commodities.

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