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COMBINED INVESTMENTS IN INTERDEPENDENT SECTORS: A STRATEGIC APPROACH TO ENHANCING INVESTMENT EFFECTIVENESS UNDER HIGH MARKET VOLATILITY

ABSTRACT

This study investigates the theoretical underpinnings and empirically validated effectiveness of combined investments in interdependent sectors – namely energy, digital technologies, and cryptoassets – within the context of heightened financial market volatility and structural transformations in the global economy. The principal objective is to substantiate the hypothesis that cross-sectoral investment strategies generate a multiplicative effect on return generation and risk mitigation, outperforming conventional portfolio models.

The analysis confirms the existence of significant intersectoral linkages among the energy, IT, and crypto markets, as evidenced by synchronized index movements, correlated capital flows, and underlying technological complementarities. Empirical results demonstrate both short- and long-term causal and correlational relationships among these sectors, indicating the presence of a compensatory-multiplicative mechanism that enhances structural diversification and contributes to overall portfolio stability. A conceptual framework, denoted the "Investment Energy Asset" (IEA), is introduced as a synthetic construct integrating sector-specific strengths. Backtesting reveals the superior performance of portfolios containing IEAs: the crypto-energy combination yields an Investment Value Index (IVI) of 3.19x and a Value Retention Index (VRI) of 1.042x, surpassing traditional benchmarks such as the S&P 500. The IEA exhibits a balanced performance profile, with an IVI of 2.55x and a VRI of 1.027x. Regression analysis confirms the presence of a stable intersectoral transmission channel, with β coefficients of 1.05 for cryptoassets and 1.03 for the IEA.

Combined investments in interdependent sectors are shown to provide strategic advantages through sectoral synergy, embedded structural flexibility, and effective risk compensation. The IEA framework enables investors to construct adaptive, high-performing portfolios capable of maintaining resilience in the face of extreme volatility, technological shifts, and macroeconomic disruptions.

Keywords: combined investments, interdependent sectors, digital technologies, cryptoassets, portfolio strategy, investment energy asset, financial synergy, market volatility

JEL Classification: G11, O16, Q43, E44

INTRODUCTION

The challenge of enhancing investment efficiency for enterprises and institutional investors has acquired renewed significance amid the acceleration of digital transformation, heightened market volatility, and ongoing structural shifts within the global economy. Traditional portfolio management approaches often fail to adequately incorporate deep technological and financial interdependencies across economic sectors, while also neglecting advanced tools for the flexible allocation of capital. Consequently, the synergistic potential of cross-sectoral integration to improve portfolio performance remains largely underutilized.

Contemporary investment practices increasingly involve capital allocations into adjacent or economically interdependent sectors – particularly energy, information technology, and cryptoassets. However, these allocations frequently emerge as incidental outcomes of conventional portfolio management principles (e.g., diversification, asset allocation, hedging), rather than as components of an integrated strategic framework. At the intersection of these practices, a novel and still insufficiently conceptualized phenomenon has emerged – referred to in this study as «combined investments»: strategic allocations to mutually dependent sectors capable of generating multiplicative effects on returns, risk exposure, and overall portfolio valuation.

It is argued that the scholarly investigation of combined investments is of critical importance, as they represent a forward-looking instrument of strategic investment management. Such investments integrate sectoral synergies with enhanced adaptability to exogenous shocks. A rigorous examination of their conceptual foundations, functional mechanisms, empirical outcomes, and potential advantages is essential from both theoretical and applied perspectives.

The absence of a unified methodological framework and standardized performance evaluation criteria continues to impede the wider implementation of such strategies within institutional investment portfolios. Therefore, analytical focus should be directed toward the interrelations among the energy, IT, and cryptoasset sectors, as these may serve as the basis for developing a new investment model capable of effectively navigating the complex and dynamic conditions of the global economic landscape.

LITERATURE REVIEW

The efficiency of investment activity and the construction of optimal portfolios for institutional investors and enterprises remain subjects of sustained academic interest in both domestic and international scholarship. Current research is primarily divided into two principal domains: the first focuses on evaluating investment performance amid volatile market conditions; the second addresses diversification strategies and the formation of blended portfolio structures.

Evaluation of Investment Efficiency

In international academic literature, the efficiency of institutional and corporate investment activities is typically assessed through the interplay of macroeconomic conditions, regulatory frameworks, and internal governance mechanisms. N. Apergis (2011), for instance, examines the influence of financial openness and monetary policy regimes on investment behavior in developing economies. A. Damodaran (2012) proposes a comprehensive framework for asset valuation and investment risk analysis, which has been widely adopted by portfolio managers.

Additional contributions by F. Hays& A. Gilbert (2009) as well as E. Brack and R. Gimborean (2010) and Vakhovych et al. (2021) explore the primary determinants of investment performance, including information asymmetry, macroeconomic shocks, and managerial decision quality. Notably, the study by Hays, De Lurgio, and Grant (2009) presents a multifactor financial analysis model that incorporates regulatory resilience, liquidity management, human capital policies, and other critical variables influencing institutional investment outcomes.

E. Brack and R. Jimborean employ Data Envelopment Analysis (DEA) to assess long-term cost efficiency, illustrating that institutional performance is shaped not only by internal characteristics but also by external conditions such as macroeconomic stability, the quality of regulatory infrastructure, and the maturity of financial systems.

Within Ukrainian academic discourse, considerable advancements in investment management theory have been contributed by V. Andriichuk (2002), A. Krykliy (2011), L. Moroz (2011), O. Bezrodna (2012), B. Lutsiv (2013), and H. Klyoba (2016). Their research emphasizes the development of methodological frameworks for assessing investment efficiency under unstable market conditions. These frameworks integrate risk-sensitive decision-making processes and adaptive portfolio management strategies, with an emphasis on return- and payback-based metrics, as well as financial hedging techniques to mitigate investment risks.

Asset Diversification and Combined Investment Strategies

Portfolio diversification and effective asset allocation continue to serve as core principles of modern investment theory. Studies by H. Markowitz (1971), S. Page (2020), W. Kinlaw (2021), L. Swedroe (2005), and Y. Choueifaty (2008) affirm that diversification across low-correlation assets enhances returns while reducing risk exposure. These insights are grounded in the efficient portfolio hypothesis, which advocates for the strategic allocation of capital to optimize risk-adjusted performance.

Particular attention has been devoted to assets with varying sensitivities to market fluctuations, especially those with low beta coefficients, which are critical for hedging strategies and lowering portfolio volatility. Institutional investors increasingly apply blended investment strategies that integrate traditional, sector-specific, and alternative asset classes. These integrative approaches not only reduce portfolio risk but also generate multiplicative return effects by leveraging synergies among asset categories with diverse market behaviors.

Unresolved Issues and Directions for Future Research

Despite significant progress in the literature, several unresolved issues persist. Chief among these is the inadequate understanding of cross-sectoral capital flow dynamics, especially within multisectoral portfolio structures. Standard performance evaluation metrics – such as the Sharpe ratio, Treynor ratio, and Value-at-Risk – do not sufficiently account for the unique characteristics of combined investment strategies, including synergistic or compensatory effects.

Moreover, a lack of standardized methodologies for constructing optimal asset mixes that account for sectoral specificity and behavioral patterns among investors continues to present a challenge. This gap impedes institutional investors' ability to engage in long-term strategic planning aimed at maximizing returns, ensuring portfolio stability, and enhancing resilience to macroeconomic shocks.

In this regard, further research should be directed toward the development of a conceptual model for combined investment. Such a model should be based on principles of adaptive diversification, cross-sectoral integration, and formalized methods of performance evaluation under conditions of market volatility.

AIMS AND OBJECTIVES

The primary objective of this study is to develop a theoretical foundation and conduct an empirical assessment of the effectiveness of combined investments across interrelated sectors – specifically, energy, digital technologies, and crypto-assets. The analysis focuses on their capacity to generate multiplicative effects on both portfolio returns and risk exposure under conditions of heightened financial market volatility. To achieve this objective, the following research tasks have been defined:

1. To identify the structural interconnections among the energy, information technology, and cryptocurrency sectors through the analysis of market indicator synchronization and capital flow patterns.
2. To examine causal and correlational dependencies among these sectors over both short- and long-term horizons.
3. To assess the performance outcomes of combined investment strategies in comparison with conventional investment approaches.
4. To develop a conceptual framework for the "investment energy asset" (iea), conceived as a financial instrument aimed at mitigating risk while preserving profitability.
5. To empirically test a set of hypotheses that underscore the benefits of combined investment strategies, including the existence of an inherent level of diversification, the compensatory nature of cross-sectoral interactions, and the synergistic potential to enhance portfolio performance. It is expected that empirical validation of these hypotheses will demonstrate the superior investment efficiency of IEAS relative to traditional investment vehicles, including standard benchmarks such as the S&P 500.

METHODS

To accomplish the stated objective and fulfill the research tasks, a comprehensive set of general scientific and domain-specific methods was employed, thereby ensuring the methodological coherence and analytical depth of the study. Methods of analysis and synthesis, along with inductive and deductive reasoning, were applied to elaborate the theoretical and methodological framework of investment efficiency. Statistical and comparative analyses were conducted to assess the performance of both energy-based and combined investment strategies. Factor analysis was used to identify the principal variables influencing the effectiveness of combined investments. Moreover, econometric modeling was employed to determine the optimal structural composition of the Investment Energy Asset (IEA).

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RESULTS

The imperative to enhance investment performance has become increasingly pressing for institutional investors and corporations amid intensified financial market volatility, ongoing structural changes in the global economy, and the growing dynamism of investment conditions worldwide. Conventional portfolio management methodologies frequently fail to incorporate the complex interdependencies among economic sectors and often overlook emerging tools for diversification and adaptive capital allocation. As a result, investors may encounter limitations in responding to market fluctuations and face challenges in achieving targeted returns within an acceptable risk framework.

In this context, the academic articulation of a combined investment approach assumes particular importance. Although the practical application of this approach is evident in the strategies of leading global firms, it remains insufficiently conceptualized within academic literature. In current investment practice, such strategies often emerge as incidental outcomes of asset diversification, capital allocation, or risk mitigation, rather than as elements of a deliberate and systematically designed methodology. The convergence of these techniques gives rise to a distinct investment domain – combined investments – defined as capital allocations into economically interconnected sectors that collectively generate a multiplicative effect on performance. Accordingly, the formulation of a theoretical framework for combined investments represents a timely and relevant direction for scholarly inquiry, particularly as an innovative tool for strategic investment management.

This study introduces an original conceptualization of combined investments as a forward-looking strategy for capital deployment under increasing intersectoral integration. The proposed framework is grounded in the author's analytical investigation of systemic linkages among three key sectors of the modern economy: energy, information technology, and crypto-assets. These sectors are not only technologically and resource-interdependent but also possess the capacity to create additional investment value often overlooked by conventional models.

The analysis has identified three primary forms of intersectoral interdependence:

1. *Unidirectional*, in which the development of one sector serves as a catalyst for another.
2. *Bidirectional*, where mutual reinforcement among sectors creates a self-sustaining cycle of growth.
3. *Mixed*, which combines both shared and sector-specific growth drivers, resulting in hybrid dynamics.

These interdependencies provide the theoretical foundation for achieving the combined investment effect – namely, the simultaneous enhancement of portfolio returns and resilience through functional complementarities across sectors.

Based on these findings, the study offers a theoretical justification for the intentional integration of investments across interconnected industries. This strategic approach facilitates the realization of synergetic benefits – increasing overall returns without a proportional rise in risk – while also enabling structural diversification. Unlike traditional models focused on capital allocation, diversification, or hedging, the combined investment framework prioritizes the inclusion of sectors exhibiting synchronous or compensatory market behavior, thereby supporting a coordinated response to external shocks.

Thus, combined investments are positioned as an innovative strategic instrument that leverages intersectoral synergies and the multiplicative outcomes derived from investments in sectors with complementary dynamics.

Given the established interrelations among the energy sector, crypto-assets, and the information technology industry, this research introduces the "Investment Energy Model" (IEM) as a methodological basis for portfolio construction at the intersection of energy infrastructure, digital technologies, and blockchain-based assets. At the core of this model lies the "Investment Energy Asset" (IEA) – a synthetic financial instrument comprising three interrelated components: the energy sector (encompassing both conventional and renewable generation), the digital sector (including data centers, cloud computing, and artificial intelligence), and the crypto sector (blockchain infrastructure and decentralized finance).

A distinctive advantage of the model is its integration of operational interdependencies between the energy sector and crypto-oriented data centers. These operations exhibit significant energy dependence, creating a bidirectional feedback loop: rising cryptocurrency prices incentivize mining and energy demand; improved IT infrastructure enhances mining efficiency; lower energy costs increase data center margins; and operational flexibility supports real-time energy resource allocation, including grid-balancing participation.

Consequently, the IEM offers fundamental diversification, technological adaptability, and resilience to macroeconomic shocks. Portfolios constructed according to this model enable institutional investors to respond dynamically to market cycles, liquidity fluctuations, and evolving demand patterns – ultimately delivering superior performance compared to traditional investment strategies, including broad-market indices such as the S&P 500.

To validate the proposed concept of combined investments, the next stage of the research entails an empirical analysis aimed at quantitatively confirming intersectoral linkages and assessing the effectiveness of the new investment model. Building upon the established theoretical framework, a statistical investigation is planned to analytically substantiate the feasibility of implementing combined investment strategies under conditions of elevated global market volatility.

The analysis will first examine the nature of intersectoral interactions among the energy sector, the information technology industry, and the cryptocurrency market. The primary objective is to verify the existence of stable correlational and causal relationships that form the basis for constructing an effective combined investment strategy. Emphasis will be placed on evaluating the impact of global macroeconomic and geopolitical events on these sectors, especially in relation to the synchronization of price dynamics, capital flows, and investment expectations.

Subsequently, the performance of combined investments will be assessed using the Investment Energy Asset (IEA) as a target instrument that facilitates capital allocation across adjacent sectors. A comparative analysis of returns, volatility, and portfolio stability will be conducted for portfolios based on the IEA, the S&P 500 index, and individual investments in either cryptocurrencies or energy assets. This will provide empirical evidence of the IEA's potential to deliver superior investment performance while maintaining an acceptable risk profile.

The study also aims to empirically test several key hypotheses that support the conceptual model of combined investments:

1. The hypothesis of a multiplicative effect of intersectoral interdependence: This hypothesis posits that investing in interconnected sectors (energy, cryptocurrencies, and IT) generates a reinforcement effect, wherein growth in one sector stimulates expansion in others, resulting in aggregate returns that exceed those from isolated investments.
2. The hypothesis of a compensatory mechanism within sectoral interaction: It is assumed that during sector-specific downturns, related sectors may partially offset losses due to inverse market dynamics, thereby enhancing portfolio stability under turbulent market conditions.
3. The hypothesis of initial diversification: This hypothesis asserts that combined investments inherently yield a balanced portfolio structure, thereby reducing the need for broad diversification. Such an approach allows investors to minimize portfolio formation costs and avoid excessive dispersion of assets.
4. The hypothesis of the IEA's superiority over the S&P 500: It is suggested that the IEA, by focusing on sectors characterized by accelerated economic growth and high innovation potential, achieves greater efficiency while maintaining risk control. Unlike the S&P 500, which reflects the average performance of a wide range of sectors, the IEA is more flexible and responsive to market fluctuations.

Accordingly, the planned research seeks to develop a new scientific and practical paradigm of combined investing as an innovative tool for strategic capital management, capable of ensuring enhanced returns and portfolio resilience amid increasing intersectoral interdependencies and global market volatility.

To substantiate the existence of intersectoral linkages in the economy, a systematic analysis of key sector pairs will be conducted, focusing on the types of interdependencies, the mechanisms by which they are formed, and the resulting investment effects. This approach enables the empirical validation of the effectiveness of combined investments by identifying robust cross-sector interactions that create conditions for the multiplicative growth of portfolio value:

1. **Energy ↔ Cryptocurrency sector**: Cryptocurrency mining is an energy-intensive process, with profitability highly dependent on electricity costs. The expansion of the crypto market stimulates demand for low-cost, sustainable energy, while the modernization of energy infrastructure reduces mining expenditures. Investment effect: combined investments balance the stable profitability of the energy sector with the high growth potential of crypto assets, enable hedging of energy costs, and create synergies through shared infrastructure such as data centers.
2. **Energy ↔ IT (data centers)**: The acceleration of digitalization increases the demand for high-capacity data centers, which are significant energy consumers. Improvements in the energy efficiency of IT infrastructure concurrently reduce pressure on power grids. Investment effect: exposure to both sectors enables portfolio optimization through synchronized revenue growth, mitigated infrastructure risk, and the stimulation of energy grid modernization.
3. **Agriculture → Food industry**: Agricultural commodities constitute the primary input for food manufacturing, and their market fluctuations directly influence production costs and output volumes. Investment effect: vertical integration through agricultural funds and food industry equities enables investors to oversee the full production chain, redistribute profit margins, and improve portfolio stability and efficiency.

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4. **Machinery ↔ Metallurgy**: Metallurgy supplies essential raw materials, with demand driven by the machinery sector. The implementation of advanced technologies (e.g., lightweight alloys) generates shared innovation incentives for both sectors. Investment effect: R&D synergy enhances portfolio innovativeness, while temporal variation in sectoral returns reduces overall cyclicality, allowing for income generation at different economic phases.
5. **Agriculture ↔ Oil industry**: The agricultural sector is a heavy consumer of petroleum products, while agro-based commodities such as biofuels compete partially with oil. Investment effect: the combination of agricultural and oil assets provides a natural hedge against commodity price volatility, as losses in one sector can be offset by gains in the other. Investment in bioenergy fosters closed-loop systems with high internal rates of return and reduced exposure to external shocks.

In conclusion, the findings of this study indicate that investing in interdependent sectors enables institutional investors to effectively implement diversification, synergy, and hedging strategies, while also unlocking new sources of capital growth. Recognition of technological, vertical, and infrastructural linkages across industries allows for flexible risk-return allocation, enhances portfolio resilience to exogenous shocks, and improves resource distribution. Consequently, the combined investment strategy is positioned as an effective tool for structural capital management in a complex and evolving macroeconomic environment.

To enable a detailed analysis of intersectoral dynamics, it is essential to examine the resilience of cross-sectoral linkages in the face of global macroeconomic and geopolitical shocks. A central question involves whether these sectors respond synchronously to systemic events, and through which mechanisms such reactions are transmitted. Such analysis allows for the evaluation of the effectiveness of combined investment strategies and the identification of transmission channels – technological, resource-based, or behavioral in nature.

This study tests the hypothesis that stable correlational and causal linkages exist among the energy sector, the IT sphere, and the cryptocurrency market. The objective is to confirm the synchronization of price dynamics, capital flows, and investment expectations as a foundation for integrated investment strategies. The analysis covers the period from 2019 to 2025, during which the Web3, high-performance computing (HPC), energy, and digital infrastructure markets exhibited heightened sensitivity to external shocks. A persistent pattern of intersectoral interdependence was observed, shaped by both technological connections and a shared resource base.

Pandemics, monetary shifts, military conflicts, regulatory changes, and technological breakthroughs trigger cascading market responses. These dynamics unfold through a multistage mechanism: a global event (economic, political, or technological) → an initial market reaction (shifts in prices, inflation expectations, and capital cost) → behavioral adaptation by market participants (reallocation of investments, adjustments to hedging strategies, and reassessment of risks) → cascading changes in adjacent sectors through demand spillovers, resource cost variations, or shifts in transaction expenses. These effects manifest both in the short term (e.g., liquidity shocks) and the long term (e.g., structural shifts, infrastructure modernization, or transformation of market interactions). What follows is a chronology of key events that have reshaped investment flows and altered the distribution of sectoral influence (Bitcoin price, 2025; Energy Select Sector SPDR Fund price, 2025; NVIDIA stock price, 2025):

1. **COVID-19 pandemic as the initial trigger of cascading dynamics (March 2020):** The global crisis induced by COVID-19 resulted in a synchronized market collapse. Bitcoin declined by −28.5% (to USD 6,438), while the XLE energy index plummeted by −50.8% (to USD 29.13). Disruptions in supply chains and reduced activity in the Web3 space and data centers led to decreased electricity consumption. This adversely affected the revenues of energy companies operating near the break-even point. *Cascade:* The initial decline in crypto-related investments led to reduced computational loads, decreasing energy demand, and negatively impacting the profitability of energy firms. The fall in the XLE index reflected this reverse transmission.
2. **Quantitative easing and a new wave of multisectoral synchronization (2020–2021):** The Federal Reserve launched a large-scale quantitative easing (QE) program, lowering the policy rate to 0–0.25% and injecting over USD 4 trillion into the financial system. This liquidity surplus triggered a sharp rise in risk asset valuations: Bitcoin surged to USD 64,400 (+900%), and XLE rose to USD 54.49 (+87%). Simultaneously, investment in digital infrastructure – particularly data centers – increased, driving up electricity consumption. *Cascade:* Monetary expansion → increased investment in crypto and infrastructure assets → expansion of data centers → higher electricity demand → improved financial performance of energy companies → XLE growth.
3. **Bitcoin halving and the energy load (May 2020):** The halving of mining rewards doubled the price of Bitcoin within seven months, reaching USD 28,949 (+238%). Mining firms scaled operations significantly, leading to increased electricity consumption in several regions. The surge in energy demand, especially in areas with low

generation costs, bolstered the profitability of local energy producers and gradually pushed the XLE index upward. *Cascade:* Rising Bitcoin prices incentivized energy-intensive mining, which drove energy demand and improved generator revenues – with a delayed effect on XLE.

4. **Energy crisis: From COVID-19 to the war in Ukraine (2021–2022):** In the post-pandemic period, the recovery in energy demand coincided with rising consumption from miners and data centers, leading to regional power shortages. The full-scale war in Ukraine exacerbated energy tensions: WTI crude reached USD 123 per barrel, while XLE rose to USD 79.54 (+39.9%). *Cascade:* Economic recovery → ↑ digital activity and mining → ↑ energy demand → ↑ energy prices. Russia's invasion of Ukraine triggered a global energy shock, amplifying pressure on generation capacities and energy indices. High tariffs pushed inefficient miners out of the market, exemplifying a bidirectional cascade between crypto and energy sectors.
5. **AI revolution and the energy impulse from IT infrastructure (2023–2024):** With the release of GPT-4, Claude, and Gemini, investment in AI infrastructure surged. Firms such as NVIDIA and Equinix, along with investment funds including BlackRock and KKR, channeled capital into next-generation data centers. The resulting GPU demand led to electricity shortages in major tech hubs. Between 2023 and 2024, data center electricity consumption in the U.S. increased by over 28%. *Cascade:* Rapid AI advancement → large-scale data center construction → steep rise in energy use → higher generation profits → increased energy indices, including XLE (to USD 92.33, +11.3%).
6. **Bitcoin halving (April 2024):** The reduction of block rewards to 3.125 BTC constrained supply, driving Bitcoin's price to USD 66,000 (+127%). Miners re-entered the market, this time investing in green energy generation. The return of ETF funds further strained infrastructure. *Cascade:* Supply constraint → price appreciation → increased mining activity → rising energy demand → improved generation profitability → further growth in XLE.

The analysis of events spanning 2020 to 2025 supports the hypothesis of intersectoral cascading linkages among cryptocurrencies, IT infrastructure, and energy. It was found that each shock or investment impulse in one sector initiates a chain of adjustments in adjacent sectors, primarily via energy consumption and infrastructural dependencies. Consequently, the energy sector functions as an intermediary in transmitting multi-sectoral effects. This interplay provides a foundation for constructing integrated investment strategies that leverage the synergy among sectors with highly correlated dynamics – namely, crypto markets, data centers, and energy generation. Such strategies not only enhance returns but also improve risk hedging, owing to the structural interconnection of these assets.

To empirically test the hypothesis regarding the interdependence of economic sectors, a statistical analysis of the dynamic relationships among the cryptocurrency sector, the energy sector, and the IT industry is proposed. This analysis incorporates both conventional indicators (such as the regression coefficient β and the correlation coefficient) and proprietary analytical tools – namely, the Investment Value Index (IVI) and the Value Retention Index (VRI).

The IVI reflects the average market valuation of investments over the study period relative to the initial investment amount, accounting for the cumulative appreciation in asset values. This index enables the identification of the multiplicative effect of investing in interdependent sectors, particularly under conditions of asymmetric asset price fluctuations. In this study, the IVI is employed to assess combined investment strategies in the energy and cryptocurrency sectors. A recommended benchmark is a value exceeding the S&P 500 index, which would indicate the effectiveness of cross-sectoral investment and its ability to offset losses in one sector through gains in another.

The VRI captures changes in the value of combined investments at the cross-sectoral level by identifying monthly compensatory effects – losses in one sector being offset by gains in another. A key advantage of this index lies in its relative independence from the initial investment amount, thereby allowing accurate identification of periods marked by a decline in market value. VRI values above 1.0x indicate the presence of a balancing effect, which supports the hypothesis of a functioning intersectoral compensatory mechanism.

The β coefficient is used to quantitatively assess the level of dependence between economic sectors, based on asset price volatility and the degree of correlation. A β value of approximately 1.0x suggests synchronized sectoral movements, whereas values above or below this threshold imply a dominant influence of one sector or a weak/non-significant interrelationship, respectively.

This methodological framework enables a more refined identification of structural linkages among sectors, reveals portfolio diversification effects, and allows for a quantitative evaluation of the synergistic potential of combined investments in interrelated industries. A detailed assessment of sectoral interdependencies is presented in the accompanying Table 1.

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Table 1. Analysis of Economic Sector Interdependence and Combined Investments. *(Source: calculated by the author based on the following data (Bitcoin price, 2025; Energy Select Sector SPDR Fund price, 2025; NVIDIA stock price, 2025; SP500 price, 2025; Vakhovych et al., 2023))*

Assessment metrics	SP 500 Energy	SP 500 TR	BTC (Passive holding)	Energy asset+BTC	IEA
1.1 Average value of invested capital, USD	4.422	2.862	8.332	6.377	5.102
1.2 Investment value index:					
— Index_Min:	0.82	1.05	1.11	1.00	0.96
— Index_Max:	3.09	2.01	10.24	6.56	3.94
— Index_AVG:	2.21	1.43	4.17	3.19	2.55
1.3 Value retention index:					
— Index_Min:	0.88	0.92	0.88	0.84	0.93
— Index_Max:	1.33	1.06	1.33	1.42	1.15
— Index_AVG:	1.040	1.014	1.040	1.042	1.027
1.4 Sectoral interdependence ratio:					
— Beta:	-	-	1.054	1.027	1.086
— Correlation	-	-	35.8%	59.9%	94.5%

We analyzed the Value Retention Index for both the combined asset (Energy+BTC) and its individual components (Energy vs. BTC). The results were nearly identical. Therefore, graphical analysis is provided only for the combined Energy+BTC asset (Figure 1):

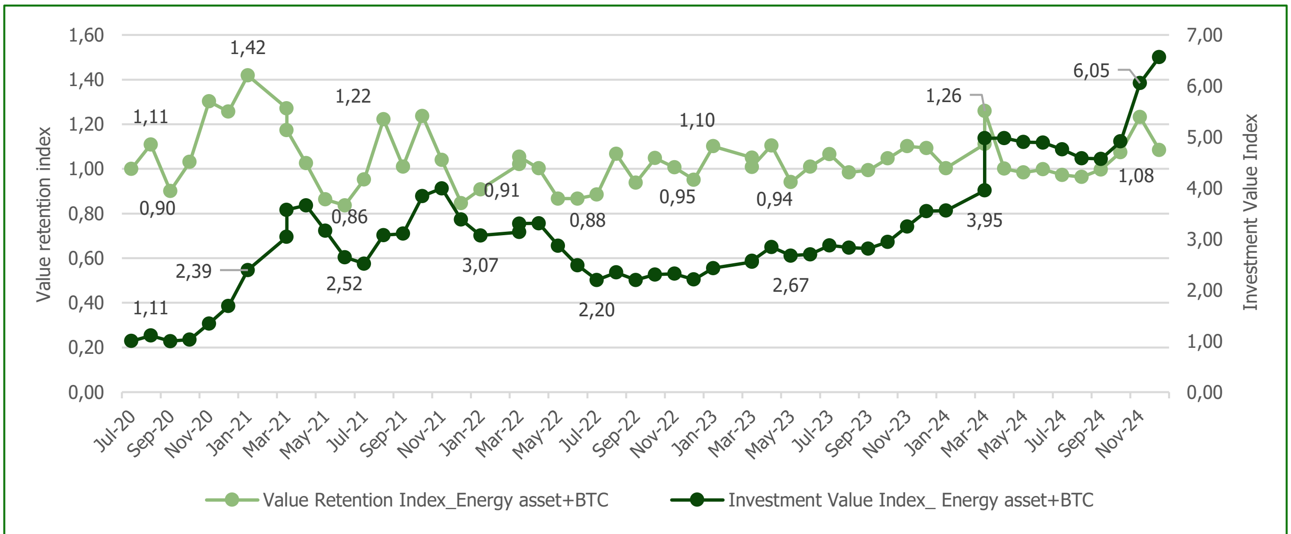

Figure 1. Analysis of the Cross-Sectoral Compensatory Mechanism for Energy and Crypto Assets. *(Source: developed by the author based on the following data (Bitcoin price, 2025; Energy Select Sector SPDR Fund price, 2025; NVIDIA stock price, 2025; SP500 price, 2025))*

The VRI analysis confirms that the combined investment in the cryptocurrency and energy sectors was effective with respect to the intersectoral compensatory mechanism. The average VRI during the observation period was 1.042x, exceeding the corresponding S&P 500 index value of 1.014x. This supports the conclusion that a portfolio integrating cryptocurrency and energy instruments demonstrates superior adaptability to market volatility due to compensatory effects.

During the observation period, VRI values fell below 1.0x in 35.2% of the recorded intervals, indicating partial drawdowns in portfolio value. The average VRI during these intervals was 0.93x, which does not pose a critical risk to overall investment performance. These drawdowns generally occurred during the spring and summer months, coinciding with seasonal reductions in electricity prices and a decline in crypto-mining profitability due to increased cooling costs. In contrast, peak VRI values ranging from 1.20x to 1.45x were recorded during Bitcoin halving events (2020 and 2024), aligning with corresponding increases in the market capitalization of cryptoassets.

The Investment Value Index additionally captures the cumulative dynamics of market value changes in the combined asset, with a one- to two-month lag, thereby facilitating the detection of disruptions in the compensatory mechanism through a gradual index decline. The average IVI was 3.19x, significantly exceeding the corresponding S&P 500 index level for the same period (1.43x). These findings indicate that the combined investment strategy yields superior returns due to the multiplicative effect of cross-sectoral interaction and the synergistic effect of simultaneous market expansion.

The overall dynamics of the Investment Value Index (IVI) indicate an inertial response of the portfolio to macroeconomic and market disturbances. Despite the restoration of the compensatory mechanism in 2022, the IVI level of 3.31x recorded in April 2022 was not reached again until the end of 2023. This delay may be attributed to the global energy crisis, which constrained the growth of the portfolio's energy components. A subsequent surge in the IVI was observed following the Bitcoin halving event in April 2024, with the index reaching 6.56x by the end of that year.

Particular attention should be given to the interdependence between the energy sector and the behavior of the cryptocurrency market, which was statistically validated through sensitivity analysis. The estimated "β" coefficients were 1.05x for crypto assets and 1.03x for the combined investment, indicating a significant direct dependence of cryptocurrencies on energy sector dynamics. In our opinion, this relationship constitutes a stable cross-sectoral transmission channel of price signals, whereby fluctuations in energy markets influence the valuation of digital assets – particularly through their impact on mining costs and the overall profitability of the crypto industry.

The Value Retention Index (VRI) for the Investment Energy Asset (IEA) exhibits a consistently positive trajectory (see Figure 2). The average VRI over the period under review was 1.027x, surpassing the corresponding figure for the S&P 500 index (1.014x). This implies the existence of an effective compensatory mechanism that preserves asset value under conditions of market volatility, even outperforming the broader market index's internal adaptability.

VRI drawdowns were observed in 29.6% of the time intervals, representing a relatively moderate occurrence. During these intervals, the average VRI was 0.97, indicating a limited depth of negative dynamics. The nature and underlying causes of these drawdowns were analogous to those recorded in the combined investment in the cryptocurrency and energy sectors – namely, seasonal declines in electricity prices and the influence of energy consumption cycles on the profitability of energy firms.

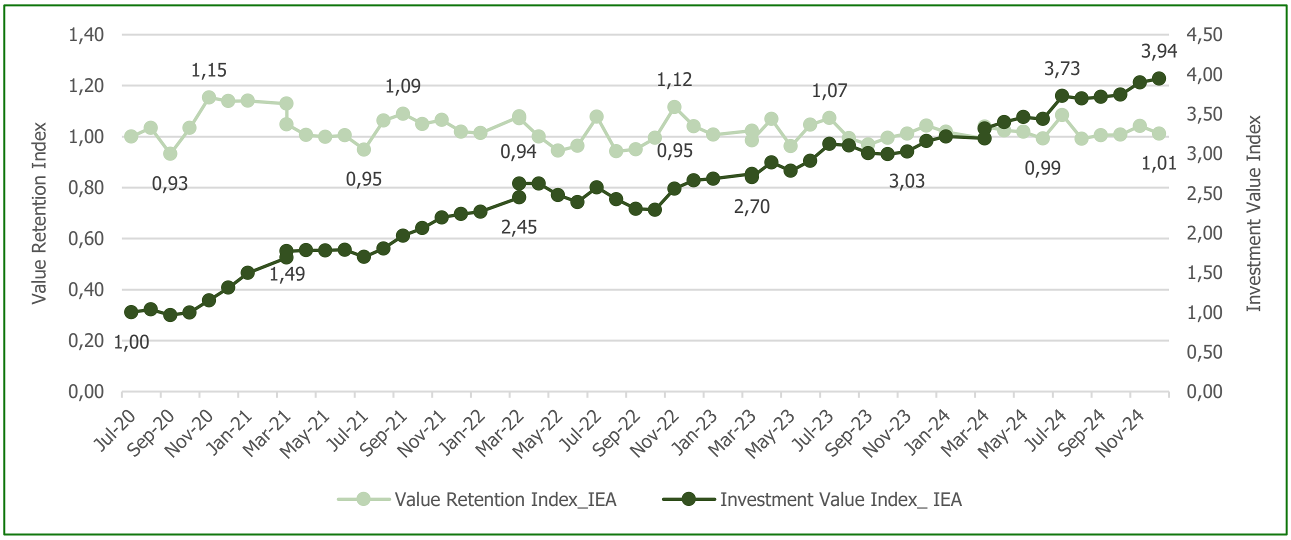

Figure 2. Analysis of the Cross-Sectoral Compensatory Mechanism for the Investment Energy Asset.

Simultaneously, the VRI for the IEA was slightly lower than that of the combined crypto-energy portfolio (1.042x), which may be explained by the inclusion of the S&P 500 index component in the IEA structure. This element serves as a volatility dampener but also marginally reduces the asset's growth potential during peak phases.

The average IVI for the IEA was 2.55x, significantly higher than that of the market index (1.43x), though below the level associated with the combined investment (3.19x). This reflects the moderate profitability of the IEA, driven by a higher degree of diversification and the inclusion of lower-risk components in the portfolio. This structural composition facilitates a more predictable and stable growth pattern while mitigating sensitivity to idiosyncratic market shocks.

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The most pronounced characteristic of the IEA is its elevated sensitivity to developments in the energy sector, as evidenced by a "β" coefficient of 1.086x. In comparison, the corresponding coefficient for the combined investment stands at 1.027x. This suggests that the IEA is the most responsive to fluctuations in the energy market, potentially enhancing profitability during expansionary phases while simultaneously increasing vulnerability during contractions.

Therefore, the IEA may be considered an effective instrument for investors oriented toward the energy sector, offering high adaptability to market conditions, moderate profitability, and a stable valuation trajectory.

As part of the ongoing research, a detailed analysis of combined investments is planned in order to assess the impact of capital allocation across interrelated sectors on the overall performance of an investment portfolio. The primary focus will be placed on evaluating key financial metrics that characterize both return and risk dimensions.

1. **Return assessment.** Investment performance will be measured using standard profitability indicators, including:
   - Internal Rate of Return (IRR);
   - Cumulative investment return (ROI)
2. **Risk assessment.** Portfolio risk analysis will combine classical methodologies with original approaches developed within the scope of this study:
   - Standard deviation will be used as the baseline indicator of volatility.
   - A proprietary diversification cost indicator, developed herein, will quantify the additional capital required to expand the portfolio and achieve the desired level of risk hedging. This diversification cost metric is based on determining the minimum number of assets that must be added to the existing portfolio to achieve a meaningful diversification effect. An analysis of the S&P 500 market index structure suggests that at least 15 distinct asset types are necessary for adequate diversification. Based on this benchmark, the additional capital required for portfolio expansion is estimated. A market risk premium of 4.5% is applied to approximate the cost of this capital. It is further assumed that, following diversification, the volatility of the portfolio will converge toward the volatility of the benchmark index.
3. **Integral efficiency ratio.** The effectiveness of combined investments is assessed as the ratio between the IRR and the risk-adjusted measure that accounts for diversification costs. Two types of efficiency indicators have been calculated:
   - Excluding diversification costs;
   - Including diversification costs.

The latter is considered to be a more objective efficiency metric, as it reflects the cross-sectoral allocation of capital and captures the advantages of integrated portfolio construction strategies. The results of the efficiency analysis are presented in Table 2 and Figure 3 below:

Table 2. Analysis of the Efficiency of Combined Investments. *(Source: calculated by the author based on the following data* (Bitcoin price, 2025; Energy Select Sector SPDR Fund price, 2025; NVIDIA stock price, 2025; SP500 price, 2025)*)*

Assessment metrics	SP 500 Energy	SP 500 TR	BTC (Passive holding)	Energy asset+BTC	IEA
Investment Efficiency Index (before diversification)	**1.06**	**1.37**	**0.96**	**1.05**	**1.74**
Investment Efficiency Ranking (before diversification)	3	2	5	4	1
Investment Efficiency Index (after diversification)	**1.33**	**1.37**	**1.57**	**1.60**	**2.00**
Investment Efficiency Ranking (after diversification)	5	4	3	2	1
I. Investment Return and Risk Criteria:					
1.1 Total ROI, %	198.6%	97.0%	863.3%	530.9%	286.2%
1.2.1 IRR_before diversification, %	24.5%	14.5%	57.3%	44.5%	31.0%
1.2.2 IRR_after diversification, %:	22.5%	14.5%	55.2%	42.6%	28.5%
– Investment amount, USD	2,000	2,000	2,000	2,000	2,000
– Net investment income, USD	3,971	1,940	17,265	10,619	5,724
– Net investment income_after diversification, USD	3,521	1,940	16,005	9,809	5,004

(continued on next page)

Table 2. Continued.

Assessment metrics	SP 500 Energy	SP 500 TR	BTC (Passive holding)	Energy asset+BTC	IEA
1.3.1 Investment risk_before diversification (Annualized STDEV), %:	23.1%	10.6%	59.7%	42.6%	17.9%
1.3.2 Investment risk_after diversification (Annualized STDEV), %:	16.9%	10.6%	35.2%	26.6%	14.2%
II. Investment diversification criteria:					
2.1 Portfolio diversification cost (fund cost), USD:	(450)	0	(1,260)	(810)	(720)
– Number of assets in investment:	10	15	1	6	7
– Number of assets in diversified portfolio_ based on SP500:	15	15	15	15	15
– Number of additional assets required for diversification:	5	0	14	9	8
– Investment amount per asset, USD:	2,000	2,000	2,000	2,000	2,000
– Required investment for diversification, USD:	10,000	0	28,000	18,000	16,000
– Cost of capital for diversification (ERP), %:	4.5%	4.5%	4.5%	4.5%	4.5%

A comparative analysis was conducted to evaluate the performance of different types of investment assets using the integral efficiency index, which simultaneously considers return, risk, and the cost of diversification.

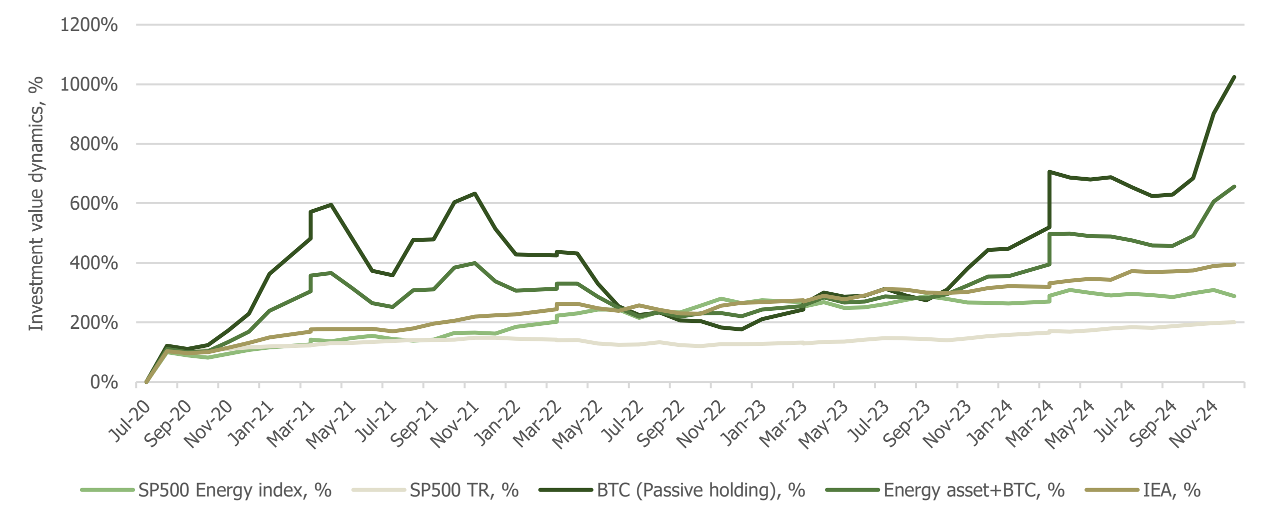

Figure 3. Investment Asset Returns During 2020-2024. *(Source: developed by the author based on the following data (Bitcoin price, 2025; Energy Select Sector SPDR Fund price, 2025; NVIDIA stock price, 2025; SP500 price, 2025))*

The highest level of investment efficiency was recorded for the Investment Energy Asset, with an efficiency index of 2.0x. This result is attributed to a combination of high IRR (31.0%), moderate risk (σ = 17.9%), and relatively satisfactory initial diversification (7 out of the 15 required asset types). After further diversification – achieved by adding 8 new assets at a cost of USD 720 – the portfolio's volatility was reduced to 14.2%, while the IRR declined to 28.5%. This balance between risk and return resulted in the highest efficiency among all the evaluated options.

The second-best performance was observed for a combined investment in an energy asset and Bitcoin, which demonstrated the highest IRR (44.5%) but was accompanied by elevated volatility (σ = 42.6%). The inclusion of six diverse assets limited the diversification cost to USD 810. The resulting efficiency index was 1.60x, supporting the rationale for combining assets with differing sensitivities to market factors.

Investment strategies focused on individual assets without cross-sector diversification proved less efficient. Investments in a crypto asset, for instance, showed relatively high returns but were associated with substantial risk and diversification expenses. A similar pattern was observed for investments in a standalone energy index. The absence of a multiplicative return effect and the constrained asset structure led to lower efficiency: the crypto asset ranked third with an index of 1.57x, and the energy index ranked fifth with 1.33x.

The S&P 500 market index occupied the fourth position (1.37x). Despite having the maximum level of diversification (15 asset types) and the lowest volatility among the instruments studied (σ = 10.6%), the relatively modest IRR (14.5%)

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resulted in lower overall efficiency. This outcome confirms that a high degree of diversification does not guarantee superior performance in the absence of enhanced returns, which can be achieved through combined cross-sectoral strategies.

Overall, the results support the effectiveness of combined investment strategies as a tool for improving portfolio performance by distributing capital across interconnected sectors, thereby achieving an optimal balance between return and risk under controlled diversification costs.

Based on the conducted analysis, the key hypotheses regarding the existence of a stable intersectoral interconnection among interdependent economic sectors – specifically, energy, crypto-assets, and the IT industry – have been confirmed. It has been identified that these sectors not only respond synchronously to external shocks but also develop intersectoral compensatory mechanisms that enhance the adaptability of investment portfolios to volatility. Combined investments constructed on these interrelationships demonstrate superior performance compared to single-sector strategies, providing both a multiplicative return effect and reduced volatility due to initial diversification.

Empirical findings, derived from calculations of the Investment Value Index and the Value Retention Index, indicate the advantages of both the combined crypto-energy portfolio and the Investment Energy Asset relative to the S&P 500 market index. Notably, the average IVI for the combined investment reached 3.19x, evidencing a synergistic growth effect, while the corresponding metric for the IEA was 2.55x. Both assets outperformed the market index not only in terms of return but also with respect to price stability. The results support the rationale for employing combined investment strategies as effective instruments for systemic capital management within a complex macroeconomic environment.

DISCUSSION

The findings of the conducted study expand the current academic discourse on the effectiveness of institutional investors' strategies by re-evaluating traditional approaches to diversification and portfolio construction. In contrast to classical models (H. Markowitz, Y. Choueifaty, L. Swedroe), which emphasize statistical independence among assets and linear risk minimization through allocation, the results support the integration of intersectoral linkages as a foundation for constructing combined portfolio strategies.

The research confirms the existence of systemic connections between the energy sector, digital technologies, and crypto-assets, characterized not only by correlation but also by causality. Unlike approaches that examine sectors in isolation (as seen in the works of N. Apergis and A. Damodaran), the proposed Investment Energy Asset model enables the identification of multiplicative effects at the level of structural capital interaction. Within this framework, the energy sector acts as a key intermediary transmitting both positive and negative investment impulses, consistent with the findings of E. Brack and R. Gimborean regarding the significance of the external environment for investment performance.

The integration of intersectoral dependencies facilitates the application of combined investment strategies as adaptive risk management mechanisms driven by compensatory effects. This constitutes a departure from conventional strategies based on index diversification (e.g., via the S&P 500) or low-beta asset allocation. Empirical evidence suggests that intersectoral linkages enhance portfolio resilience to volatility and support capital preservation under conditions of macroeconomic turbulence – unlike models relying solely on historical returns or metrics such as the Sharpe or Treynor ratios.

Particular attention should be paid to the fact that the study validates not only the effectiveness of combined strategies through hedging and synergy, but also highlights the role of informational, infrastructural, and resource linkages as channels for transmitting both risk and return. This aspect enables the extension of multifactor models developed by scholars such as F. Hays, De Lurgio, and Grant by introducing new variables that capture technological and energy-related interconnections across sectors.

In this context, the study moves beyond traditional methods for assessing investment efficiency, as outlined in classical financial literature, by proposing a formalized approach to analyzing synergistic effectiveness. This framework involves measuring not only financial indicators (returns, volatility, asset value) but also the dynamics of intersectoral indicators such as energy consumption of IT infrastructures and blockchain hashrate volumes.

Despite the identified benefits of combined investing, the study also acknowledges the methodological challenges associated with designing such strategies. Existing approaches – particularly Value-at-Risk and the Treynor ratio – do not fully reflect the compensatory dynamics of capital flows across sectors. This underscores the need for the development of new performance metrics that incorporate scenario-based modeling, investor behavioral characteristics, and sectoral sensitivity to joint shocks.

Therefore, the results not only confirm the initial research hypotheses but also offer prospects for formalizing a multisectoral investment framework that considers the structure of the economy within the context of energy transition and digitalization. Combined strategies based on the integration of energy, IT, and crypto-assets may be regarded as a new class of investment models for institutional investors seeking long-term resilience, adaptability, and systemic efficiency.

CONCLUSIONS

The study confirmed all initial hypotheses concerning the existence of intersectoral linkages among the energy, IT, and cryptocurrency sectors, as well as the effectiveness of combined investment strategies. A stable interdependence among these sectors was identified, manifested through synchronized index dynamics, energy consumption transmission, capital flows, and technological complementarity. Both correlational and causal relationships were established, functioning over short- and long-term horizons.

A multiplicative effect of cross-sectoral interaction was empirically demonstrated, reflected in the synchronous growth of market indicators and an increase in overall portfolio returns. Simultaneously, a compensatory mechanism was observed, whereby countercyclical responses of individual sectors to external shocks contributed to risk mitigation and asset value stabilization. These findings confirm the structural effectiveness of sectoral diversification as a key component of combined investment strategies.

The proposed conceptual framework of combined investing involves the initial diversification of assets across the energy, digital, and cryptocurrency segments and is implemented through the "Investment Energy Model." The central element of this model is the "Investment Energy Asset", which consolidates multisectoral characteristics into a single financial instrument and demonstrates the ability to hedge risk without compromising returns.

Empirical results revealed the superiority of combined portfolios over traditional ones. For the crypto-energy configuration, the Investment Value Index reached 3.19x, while the Value Retention Index stood at 1.042x, both exceeding the corresponding benchmarks of the S&P 500. The IEA demonstrated balanced performance, with an IVI of 2.55x and a VRI of 1.027x. Regression analysis confirmed the presence of a stable price signal transmission channel, with a β coefficient of 1.05x for cryptocurrencies and 1.03x for the IEA.

In summary, combined investments at the intersection of energy, digital technologies, and crypto-assets create a synergy of returns and structural resilience through a compensatory-multiplicative mechanism of intersectoral interaction. The patterns identified form a foundation for the construction of adaptive institutional portfolios capable of self-balancing in conditions of high volatility and structural transformation of the global economy.

Future research perspectives: The results obtained open several avenues for further academic inquiry. First, it would be advisable to expand the set of indicators characterizing intersectoral linkages, particularly through the integration of ESG metrics, energy supply resilience indicators, levels of digitalization, and the development dynamics of blockchain infrastructure. This would enhance understanding of the underlying factors driving multisectoral correlation.

Second, the development of predictive models for assessing the performance of combined investments using machine learning and neural networks appears promising. These approaches may enhance the accuracy of evaluating the synergistic effects and compensatory capacities of the IEA under dynamic market conditions.

Third, an important research direction involves examining the impact of geopolitical and regulatory factors on the operation of the Investment Energy Model. Special emphasis should be placed on cross-border capital movements, the integration of crypto-assets into the financial system, and policies related to the green transition.

Additionally, future studies may aim to empirically validate the IEM within specific jurisdictions, stock markets, or types of institutional investors, thereby enabling the adaptation of the model to diverse economic environments and regulatory frameworks.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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КОМБІНОВАНІ ІНВЕСТИЦІЇ У ВЗАЄМОПОВ'ЯЗАНІ СЕКТОРИ: СТРАТЕГІЧНИЙ ПІДХІД ДО ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ІНВЕСТИЦІЙ ЗА УМОВ ВИСОКОЇ РИНКОВОЇ ВОЛАТИЛЬНОСТІ

У дослідженні проаналізовано теоретичні засади та емпірично підтверджено ефективність комбінованих інвестицій у взаємозалежні сектори — а саме в енергетику, цифрові технології та криптоактиви — в умовах зростання волатильності фінансових ринків і структурних трансформацій глобальної економіки. Основна мета дослідження полягає в обґрунтуванні гіпотези про те, що міжсекторальні інвестиційні стратегії генерують мультиплікативний ефект щодо прибутковості та зниження ризиків, перевершуючи за ефективністю традиційні портфельні моделі.

Аналіз підтверджує наявність суттєвих міжгалузевих зв'язків між енергетичним, IT- та крипторинками, що виявляється в синхронних рухах індексів, корельованих потоках капіталу й технологічній комплементарності. Емпіричні результати демонструють і коротко-, і довгострокові причиново-наслідкові та кореляційні зв'язки між цими секторами, що свідчить про наявність компенсаційно-мультиплікативного механізму, який посилює структурну диверсифікацію та сприяє загальній стабільності портфеля. У дослідженні запропоновано концептуальну модель «Інвестиційного енергетичного активу» (IEA) як синтетичну конструкцію, що інтегрує сильні сторони кожного сектора. Результати бектестування підтверджують переваги портфелів з IEA: комбінація криптоактивів і енергетики демонструє Індекс інвестиційної вартості (IVI) на рівні 3.19x і Індекс збереження вартості (VRI) — 1.042x, що перевищує показники традиційних бенчмарків, зокрема S&P 500. IEA демонструє збалансований профіль ефективності з IVI = 2.55x і VRI = 1.027x. Регресійний аналіз підтверджує наявність стабільного каналу міжсекторальної трансмісії, де коефіцієнт β становить 1.05 для криптоактивів і 1.03 для IEA.

Комбіновані інвестиції у взаємозалежні сектори забезпечують стратегічні переваги завдяки секторній синергії, вбудованій структурній гнучкості й ефективній компенсації ризиків. Модель IEA дає змогу інвесторам формувати адаптивні, високопродуктивні портфелі, здатні до збереження стійкості в умовах надмірної волатильності, технологічних зрушень і макроекономічних шоків.

Ключові слова: комбіновані інвестиції, взаємозалежні сектори, цифрові технології, криптоактиви, портфельна стратегія, інвестиційний енергетичний актив, фінансова синергія, ринкова волатильність

JEL Класифікація: G11, O16, Q43, E44

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