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Return and Volatility spillovers between Cryptocurrencies and GPU-related Stocks

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Abstract

This paper explores the complex relationship between the cryptocurrency market, represented by five major cryptocurrencies and one crypto index, and the stocks of eleven leading graphics card companies. By employing a VAR - GARCH framework and Granger causality tests over the period 2012 to 2025, this paper documents significant return and volatility spillovers across these markets. The findings underscore the importance of cryptocurrencies in financial markets and show that movements in the crypto market can shape the performance of companies that supply the hardware and infrastructure supporting crypto mining. These links highlight broader connections between digital asset dynamics and traditional equity performance.

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JEL Classification: C22, C32, G11, G32

1. Introduction

The rise of cryptocurrencies since their inception in 2009 has been one of the most disruptive forces in the financial and technology sectors. Initially regarded as a niche financial curiosity, cryptocurrencies have rapidly gained mainstream recognition, with a market capitalization surpassing $3 trillion USD by July 2025, of which Bitcoin alone accounts for more than $2 trillion USD. Central to this ecosystem is the graphics card, a vital device used in cryptocurrency mining. Mining activities require immense computational resources, directly linking the performance of graphics card manufacturers to the cryptocurrency market. This relationship has become especially prominent as mining difficulty and energy demands have surged, creating significant opportunities and risks for technology firms.

The interesting relationship of cryptocurrency markets and graphics card manufacturers reflects broader trends of interconnectedness between financial markets and technology sectors. Recent research reveals that cryptocurrencies exhibit notable spillover effects with traditional financial and commodity markets, including clean energy, precious metals, and global equities (Annamalaisamy & Jayaraman, 2023; Mo et al., 2022; Fasanya et al., 2022). Conlon et al. (2024) highlight that while Bitcoin forks maintain strong linkages with their parent blockchain, other financial and currency factors can exert occasional influence on their returns. Similarly, Iyer and Popescu (2023) emphasize the growing integration of crypto and financial markets, particularly during turbulent economic periods, suggesting that cryptocurrencies serve as channels through which systemic risk can spread between different asset classes. Recent work by Aharon et al. (2024) show that metaverse stocks are mainly driven by shocks and spillovers from metaverse tokens and major cryptocurrencies, like Bitcoin and Ethereum, with weaker effects in the opposite direction. This evidence reinforces the notion that digital asset markets exert a leading influence on technology-related equities, particularly those tied to emerging blockchain-based ecosystems.

These spillovers have been shown to intensify during periods of market volatility, such as the COVID-19 pandemic, when cryptocurrencies acted as both transmitters and receivers of risk across asset classes (Arfaoui et al., 2023). Despite the high volatility inherent in cryptocurrencies, their diversification potential has been explored extensively, with mixed results. Studies suggest that cryptocurrencies can serve as effective hedging instruments under specific market conditions, but their high co-movement with traditional assets during crises limits their utility as safe havens (Ren & Lucey, 2022; Kyriazis et al., 2023).

Graphics card manufacturers, whose revenues are closely tied to cryptocurrency mining, face unique challenges and opportunities within this framework. Mining demand surges during cryptocurrency bull markets, as higher prices incentivize miners to invest in expensive graphics cards to enhance computational efficiency. However, bear markets often lead to reduced mining activity, adversely affecting the financial performance of graphics card manufacturers. Corbet et al. (2021) and Arfaoui et al. (2023) emphasize that this dynamic is further influenced by the energy-intensive nature of cryptocurrency mining, which has raised significant environmental and regulatory concerns. The high energy consumption of mining activities has led to increased scrutiny from policymakers and has shaped discussions on the sustainability of cryptocurrency markets.

While these interconnections are widely recognized, empirical research examining the direct relationships between cryptocurrencies and graphics card manufacturers remains scarce. Most existing studies tend to analyze broad market indices rather than the detailed interactions at the individual company level, obscuring the granular mechanisms underlying these interactions (Umar et al., 2021). Furthermore, behavioral factors, such as investor sentiment, have been shown to mediate the spillover effects between cryptocurrencies and related industries, adding another layer of complexity to these relationships (He et al., 2023; Kalyvas et al., 2021).

This paper seeks to address this gap by examining return and volatility spillovers among five major cryptocurrencies, including Bitcoin, Ethereum, Ripple, Binance Coin, Litecoin and the Nasdaq Cryptocurrency Index, with the stock performance of eleven leading graphics card manufacturers. Using a VAR - GARCH framework, I analyze the transmission of returns and volatility between these distinct financial markets. In contrast to prior research that typically aggregates data at the sector level, this paper offers a granular perspective by focusing on individual graphics card manufacturers, providing deeper insights into the financial and technological interdependencies driving these markets.

The results provide clear evidence of significant return and volatility spillovers from cryptocurrencies to the stock prices of companies involved in manufacturing graphics cards. Although the reverse effect, from graphics card firms' equities to cryptocurrencies, is also observed, it is notably weaker, especially in terms of return spillovers. These findings highlight meaningful and asymmetric financial linkages between digital asset markets and specific segments of the technology industry. They further underscore the growing interdependence between emerging blockchain related markets and traditional technology firms.

This paper contributes to the growing literature on cryptocurrency economics, particularly in the areas of returns, volatility, and market interdependencies (Balcilar et al., 2017; Katsiampa, 2017). It aligns with research examining the hedge and diversification properties of cryptocurrencies (Dyhrberg, 2016; Kalyvas et al., 2020) and their linkages with other financial assets (Corbet et al., 2018; Bouri et al., 2018). Building on the work of Symitsi and Chalvatzis (2018), which explored the connectedness between Bitcoin with energy and technology indices, this paper provides new empirical evidence on the integration of cryptocurrencies with technology firms. It complements existing studies on spillovers between digital assets and other markets such as energy, equities, and various asset classes (Corbet et al., 2021; Mo et al., 2022; Conlon et al., 2024), while also highlighting the complex risk-return

dynamics between cryptocurrency markets and graphics card manufacturers. These dynamics illustrate how cryptocurrencies serve both as speculative instruments and as drivers of hardware demand. Finally, it contributes to broader discussions about the sustainability of cryptocurrency mining, the associated regulatory challenges, and the potential impact on overall market stability.

The remainder of this paper is structured as follows: Section 2 develops and states the hypotheses. Section 3 outlines the data while Section 4 discusses methodology. Section 5 presents the empirical findings, and Section 6 concludes with key takeaways, and directions for future research.

2. Hypothesis Development

2.1. Cryptocurrency Returns and Technology Sector Dynamics

The evolution of cryptocurrencies has introduced a shifting landscape in financial and technology markets, prompting researchers to investigate their evolving relationships with other asset classes. Cryptocurrencies are characterized by high volatility and speculative activity, which contribute to their complex interactions with traditional markets (Kalyvas et al., 2021; Kyriazis et al., 2023). Recent studies have explored these interdependencies across a range of contexts, including their integration with global equities, clean energy indices, and commodity markets (Annamalaisamy & Jayaraman, 2023; Ren & Lucey, 2022).

A recurring theme in the literature is the dual role of cryptocurrencies as speculative investments and diversification tools. While cryptocurrencies can act as effective hedging instruments under certain conditions, their high correlation with traditional assets during periods of market distress often limits their utility as safe havens (Li & Miu, 2023). Furthermore, behavioral factors such as investor sentiment have been shown to mediate the spillover effects between cryptocurrencies and related industries, amplifying these dynamics during periods of heightened market activity (He et al., 2023; Kalyvas et al., 2021).

These spillover effects are particularly relevant to the technology sector, where cryptocurrency-driven demand for graphics cards exemplifies the interconnections between financial and the real economy. Mo et al. (2022) demonstrate that cryptocurrencies serve as major transmitters of risk across asset classes, with these effects varying in intensity over time. Such findings highlight the importance of understanding how cryptocurrency returns influence related sectors, like graphics card manufacturers, whose revenues are tied to mining activity.

2.2. Graphics Card Manufacturers' Stock Performance and Cryptocurrency Mining

Graphics card manufacturers occupy a unique position within the cryptocurrency ecosystem, as their products are essential for mining activities. Rising cryptocurrency prices often incentivize miners to upgrade their hardware, driving increased demand for graphics cards and boosting manufacturers' revenues. Conversely, bearish crypto market conditions can reduce mining activity, adversely affecting graphics cards manufacturers' financial performance. These dynamics have been explored in the literature, with Corbet et al. (2021) and Fasanya et al. (2022) emphasizing the bidirectional relationships between cryptocurrency markets and sectors such as clean energy and precious metals.

Environmental concerns add another layer of complexity to this relationship. The energy-intensive nature of cryptocurrency mining has raised questions about its sustainability and has attracted regulatory scrutiny (Arfaoui et al., 2023). These issues indirectly affect graphics card manufacturers by influencing the regulatory environment and shaping market perceptions of mining-related industries. Despite the significance of these factors, empirical studies on the spillover effects between cryptocurrencies and graphics card manufacturers remain limited.

2.3. Hypotheses

Building on the theoretical and empirical insights discussed so far, this study proposes the following hypotheses to examine the return and volatility spillovers between cryptocurrencies and graphics card manufacturers:

Hypothesis 1 (H1): *The returns of cryptocurrencies will spillover, to positively influence the returns of graphics card manufacturers.*

The first hypothesis posits that increased demand for graphics cards in cryptocurrency mining activities positively influences the financial performance of the manufacturers supplying these essential components. Conversely, adverse market conditions for cryptocurrencies may negatively impact the returns of graphics card manufacturers.

Hypothesis 2 (H2): *The volatility of cryptocurrencies will spillover, to influence the volatility of graphics card manufacturers.*

The second hypothesis anticipates that fluctuations in cryptocurrency market volatility will have an impact on the volatility of graphics card manufacturers, reflecting the interconnected nature of these distinct financial markets.

By formulating and empirically testing these hypotheses, this study aims to deepen the understanding of the complex relationship between cryptocurrencies and graphics card manufacturers. The findings provide important insights for academic research and offer practical guidance for investors navigating these interconnected markets.

3. Data and Sample Selection

I source cryptocurrency data from Investing.com. I consider the prices of five major cryptocurrencies, namely Bitcoin, Ethereum, Ripple, Binance Coin, Litecoin and the Nasdaq Crypto Index. For each asset, price data are considered from its respective inception date, while the end date is fixed for all cryptos and is the 31st of March 2025.[1] The rates of returns (returns)

[1] While Bitcoin was available prior to January 1, 2012, this study considers that date as its starting point. At the beginning of 2012, Bitcoin was priced around $5, having traded at even lower levels before that time. By the end of 2012, its price had more than doubled to approximately $13, and by the end of 2013, it had surged to over $800, even briefly surpassing the $1,000 mark earlier in the year.

are computed as the ratio of the first difference in price over the lagged price ($r_t = \frac{P_t - P_{t-1}}{P_{t-1}}$). Summary information for the five cryptocurrencies and the index is presented in Table 1 below.

[Insert Table 1 here]

I obtain equity data from LSEG Datastream, specifically the return index (RI) of graphics card manufacturers.[2] The sample includes all major publicly listed graphics card manufacturers from the United States and Asia, for which equity data is available. In total, eleven leading manufacturers are included, as detailed in Table 2.[3]

[Insert Table 2 here]

I consider equity data over the period starting on the 1st of January 2013 until the 31st of March 2025, to fully cover the history of the cryptocurrency data (described in Table 1). The rates of returns are computed as the ratio of the first difference in RI over the lagged RI ($r_t = \frac{RI_t - RI_{t-1}}{RI_{t-1}}$).

Since cryptocurrencies are traded on a 7-day a week basis while equities are traded on a 5-day a week basis (i.e. every day, excluding weekends), I aggregate the returns of cryptocurrencies for Saturday, Sunday and Monday and set the sum to be the return for Monday. In this manner the cryptocurrency returns are adjusted to the same 5-day week basis as the equity returns and subsequently the two datasets are merged.[4]

It should be noted that all returns are winsorised at the 1% and 99% levels to remove outliers while all the time series are also tested for stationarity.[5]

[2] Unlike the Price Index (PI), the Datastream's Return Index (RI) accounts for dividend payments and stock splits.
[3] The first three firms in the table are manufacturers of GPU chips, the core of graphics cards. The other eight are board partners, who buy GPU chips and other components in bulk to design, assemble, and sell the final product.
[4] I apply this transformation to reduce the discrepancy of the return of Monday between cryptocurrencies and equities. That is because for cryptocurrencies the return of Monday would be based on information released in the market on Monday, whereas for the equities the same return would be based on information released in the market over the weekend and Monday.
[5] Stationarity is tested via the Augmented Dickey Fuller (ADF) test and all-time series were found stationary. The ADF test results are not tabulated but can be provided upon request.

3.1. Descriptive Statistics

Table 3 presents the summary statistics of daily returns for both cryptocurrencies (Panel A) and graphics card firms' stocks (Panel B). Among all the return series, cryptocurrencies exhibit notably higher mean returns, with values ranging from 0.0020 (Ripple) to 0.0042 (Binance Coin), reflecting a generally positive performance on average. In contrast, the returns of the graphics card firms' stocks are lower, with mean values ranging from 0.0004 (Intel) to 0.0019 (nVidia), indicating more modest gains. When it comes to volatility, cryptocurrencies show significantly higher standard deviations compared to graphics card firms. For instance, the standard deviation of Ripple (0.0679) and Ethereum (0.0549) reflects much larger daily fluctuations than those seen in stocks like Intel (0.0182) and AMD (0.0317), pointing to greater price variability in the cryptocurrency market. This suggests that, while cryptocurrencies offer higher potential returns, they also come with greater risk and volatility compared to the more stable stock returns, which is in-line with expectations.

[Insert Table 3 here]

4. Methodology

4.1. VAR-GARCH Model Specification

I employ a VAR - GARCH framework to estimate the return and conditional volatilities of cryptocurrencies and graphics card manufacturers, using historical information. More specifically, I estimate a Vector Autoregressive (VAR) process of order one, given by the equation below.[6]

$$R_t = B_0 + B_1 R_{t-1} + \varepsilon_t \qquad (1)$$

Where, R_t is a vector of asset returns, B_0 is a vector of constant terms, B_1 is a matrix of autoregressive coefficients and ε_t is a vector of errors.

[6] The process of order $p = 1$ was selected by referring to several information criteria like the AIC and BIC.

Conditional variances are modelled separately for each asset using a GARCH (1,1) specification as described by the set of equations provided below:

$$r_t = \mu + \varepsilon_t \tag{2}$$

Where, r_t is the rate of return at time t (given in Section 3) and μ is the mean return. The error term is given by $\varepsilon_t = z_t\sigma_t$, with $z_t \sim N(0,1)$.

$$\sigma_{i,t}^2 = \omega + a_\iota \varepsilon_{i,t-1}^2 + \beta_\iota \sigma_{i,t-1}^2 \tag{3}$$

$\sigma_{i,t}^2$ is the conditional variance of asset i, $\varepsilon_{i,t-1}^2$ is the lagged squared innovation of asset i while a_ι and β_ι represent the short- and long-term persistence of volatility of asset i.

4.2. Granger Volatility Spillovers

While a VAR model can capture return spillovers between assets, a standard (non-multivariate) GARCH model cannot directly account for cross-asset volatility spillovers. Therefore, additional analysis is proposed below to address this limitation.

The Granger causality test is a statistical method used to determine whether past values of one time series contain predictive information about another. In this context, I use the Granger causality test within a bivariate vector autoregressive (VAR) framework to examine the presence and direction of volatility spillovers between assets. This method assesses whether the volatility of one asset helps predict that of another, thereby indicating potential transmission of market uncertainty. Detailed discussion of the model is provided below.

Let $z_{i,t}$ and $z_{j,t}$ denote volatility proxies for assets i and j respectively. Then, the following VAR model is estimated:

$$\begin{bmatrix} z_{i,t} \\ z_{j,t} \end{bmatrix} = \sum_{k=1}^{p} \begin{bmatrix} \varphi_{11,k} & \varphi_{12,k} \\ \varphi_{21,k} & \varphi_{22,k} \end{bmatrix} \begin{bmatrix} z_{i,t-k} \\ z_{j,t-k} \end{bmatrix} + \begin{bmatrix} \varepsilon_{i,t} \\ \varepsilon_{j,t} \end{bmatrix} \tag{4}$$

Here, p denotes the lag order of the system, based on standard lag selection criteria like Akaike and Bayesian information criteria.[7] The Granger causality test focuses on the null hypothesis that lagged values of volatility from asset i do not help predict the volatility of asset j, formally expressed as:

$$H_0: \varphi_{21,1} = \varphi_{21,2} = \cdots = \varphi_{21,p} = 0$$

Rejection of H_0 indicates that past volatility from asset i significantly contributes to the prediction of asset $j's$ volatility, providing evidence of volatility spillover from i to j.

5. Empirical Results

5.1. Early Evidence

Table 4 presents the Pearson correlation matrix, providing insights into the relationships between the returns of cryptocurrencies and the stocks of graphics card manufacturers. The evidence suggests that the returns of all cryptocurrencies are significantly and positively correlated with one another, as expected, indicating a high degree of co-movement within the crypto market. Furthermore, we observe strong positive correlations among the GPU chip manufacturers group (NVIDIA, AMD, and Intel), suggesting strong interconnections between these companies. The remaining graphics card firms also exhibit significantly positive correlations, although these are smaller in magnitude compared to those of cryptocurrencies and GPU chip manufacturers. These correlation results suggest that, overall, graphics card stocks tend to move in the same direction. Finally, the cross-group correlations (between cryptocurrencies and graphics card manufacturers) are sometimes positive and significant and sometimes insignificant. This pattern provides an early indication of the return dynamics and spillover effects, which are discussed in Sections 5.2 and 5.3, respectively.

[Insert Table 4 here]

[7] AIC and BIC choose the order to be p = 1.

Figure 1 illustrates the price trends of the five cryptocurrencies and the Nasdaq Crypto Index. We observe that most cryptocurrencies experienced significant gains during 2020 and 2021, driven by increased investor interest and growing engagement from institutional investors. This was followed by a sharp correction in 2022, influenced by regulatory pressures and market instability. Since early 2023, however, prices have generally been on a steady upward trajectory, continuing through to the present day (31/03/2025).

[Insert Figure 1 here]

Figure 2 presents the stock price trends of the eleven graphics card firms. Most companies show an overall upward trajectory in their stock prices, with the exception of Biostar, ECS and Intel which exhibit flat or declining trends. Overall, the magnitude of stock price increases among the graphics card firms is considerably smaller than the substantial gains observed in the cryptocurrency market.

[Insert Figure 2 here]

5.2. VAR-GARCH Estimation Results

The estimation results of the VAR model (Equation (1)) are summarized in Table 5.[8]

[Insert Table 5 here]

Table 5 provides evidence of return spillovers from cryptocurrencies to several graphics card manufacturers, mostly board partners. This result suggests that past returns of the crypto market are frequently followed by positive returns in the graphics card market. This pattern supports the notion that cryptocurrency markets influence the stock performance of companies involved in supplying mining-related hardware. Overall, the transmission of returns appears to flow primarily from the cryptocurrency market to the graphics cards market, suggesting that

[8] Detailed estimation results provided in Appendix A.

developments in digital asset prices serve as a leading indicator for the returns of related technology firms.

In order to provide some context, graphics card companies like MSI, Leadtek, Biostar, Gigabyte, Asrock and PC Partner show frequent and broad-based return spillovers from all the cryptocurrencies, indicating a relatively high level of sensitivity to conditions in the crypto market. These results can be understood by considering the mechanics of cryptocurrency mining. Graphics cards are a critical input in the mining process, and miners continuously invest in high-performance hardware to maximize their returns. As cryptocurrency prices rise, mining becomes more attractive, driving up demand for graphics cards. This increased demand leads to higher graphics card prices and greater revenues for firms manufacturing and selling these devices. Consequently, when cryptocurrency markets perform well, the stock prices of firms supplying mining-related technology tend to benefit.

In contrast, the returns of GPU chip manufacturers such as Nvidia, AMD, and Intel do not appear significantly influenced by cryptocurrency market movements. However, their own returns appear to spill over to the board partners group. This pattern can be explained by their position as upstream suppliers of GPU chips rather than producers of complete graphics cards. Since these firms primarily provide GPU cores to board partners, rather than directly manufacturing and selling graphics cards themselves, their stock returns are less directly exposed to fluctuations in cryptocurrency-related demand. At the same time, because board partners depend on these manufacturers for critical components, changes in the financial performance or market valuation of upstream suppliers can affect downstream firms through cost, supply expectations, and investor sentiment.

Overall, the direction of the return spillovers indicates that cryptocurrencies function as the initiating market in the return transmission process. Graphics card manufacturers do not exert a significant return influence on cryptocurrency markets, and this finding holds for both GPU

chip manufacturers and the board partners group. This asymmetry aligns with the broader speculative and information-driven nature of digital assets, where market dynamics tend to originate within the cryptocurrency space rather than in related hardware sectors.

In conclusion, the findings support Hypothesis 1, which proposes that cryptocurrency returns positively influence the returns of graphics card manufacturers. The observed return spillovers confirm the economic linkage between these two markets and underscore the importance of considering cryptocurrency trends when assessing the performance and risk profile of firms involved in the production and sale of graphics cards.

5.3. Volatility and Shock Spillovers Results

In order to derive long- and short-term volatilities, the following steps must be followed. First, the parameters of the GARCH model, namely the constant term ω, the ARCH coefficient α, and the GARCH coefficient β in Equation (3), are estimated by maximizing the log-likelihood function based on the observed return data. These parameters capture the baseline volatility level, short-term volatility stemming from recent shocks, and long-term volatility persistence, respectively.

Second, the return residual at time t is computed using Equation (2) from the observed return r_t and the (assumed constant) mean return μ:

$$\varepsilon_t = r_t - \mu,$$

Finally, using the lagged squared residual ε_{t-1}^2, which represents the volatility shock from the previous period, the conditional variance σ_t^2 is computed from Equation (3):

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2,$$

Next, to examine the direction of the volatility spillovers, I conduct Granger causality tests. These tests evaluate whether past volatility of one asset contains statistically significant information about the future volatility of another. The analysis distinguishes between two types of causality: (a) long-term volatility spillovers and (b) short-term shock spillovers. Results are

summarized in Table 6, with Panel A presenting spillovers based on long-term volatility and Panel B based on short-term shocks.[9]

[Insert Table 6 here]

In the context of long-term volatility spillovers (Panel A), we observe that many spillovers occur within the crypto group. For example, Bitcoin exhibits a notable number of outgoing spillovers, affecting other cryptocurrencies such as Ethereum and Binance Coin, while Ethereum affects Binance Coin and Litecoin. Volatility from the Nasdaq Crypto Index spills over to Bitcoin, Ethereum and Binance Coin. Regarding cross-group spillovers Bitcoin's volatility spills over to influence the volatilities of graphics card manufacturers including AMD, Intel and MSI. Volatility from Ethereum spills over to AMD and Biostar while volatility from the Nasdaq Crypto Index spills over to Leadtek, Biostar, and ECS. These results, and more, suggest that cryptocurrencies play an important role in transmitting longer-term volatility, both within the digital asset market and across to the graphics card market. Within the group of graphics card manufacturers there are several occasions of spillovers (e.g., from AMD and Intel to nVidia and from MSI to AMD and Leadtek) reflecting operational linkages or shared exposure to market conditions. Finally, there are several cases where the volatility in the graphics card market spills over to the crypto market (e.g., from MSI to all cryptos), indicating the bidirectional nature of volatility spillovers between these two markets.

Examining shock spillovers (Panel B), the results reveal that volatility shocks propagate differently compared to persistent volatility. While crypto-to-crypto spillovers are relatively less pronounced, equity-to-equity spillovers appear more concentrated than those involving long-term volatility. Furthermore, Bitcoin, Binance Coin, and Litecoin stand out as key transmitters of shocks, affecting both other cryptocurrencies and several graphics card

[9] Detailed estimation of Granger Causality results is provided in Appendix B.

manufacturers. Additionally, graphics card manufacturers such as Gigabyte, Asrock, and Biostar function as both transmitters and receivers of shocks, influencing and being influenced by both cryptocurrency and graphics card markets.

These findings suggest that volatility events originating in the cryptocurrency market can influence graphics card manufacturers' stocks, with the opposite effect also being true. Overall, the evidence presented in this section supports Hypothesis 2.

6. Conclusions

This paper examines the transmission of returns and volatility between five major cryptocurrencies, one crypto index, and eleven publicly listed graphics card firms. Employing a VAR–GARCH framework combined with Granger causality tests reveals significant interdependencies between these two markets and demonstrates how fluctuations in the crypto market can spillover and affect graphics card firms' stocks, and vice versa.

The results offer strong support for Hypothesis 1, revealing significant return spillovers from cryptocurrencies to graphics card manufacturers. Firms such as MSI, Leadtek, Biostar, Gigabyte, Asrock and PC Partner exhibit consistent positive return spillovers from Bitcoin, Ethereum, and other major coins, suggesting that cryptocurrency price dynamics directly impact the equity returns of companies more exposed to mining demand. In contrast, large early-stage manufacturing firms such as Nvidia, AMD, and Intel exhibit limited sensitivity, likely due to their diversified business models and less direct exposure to retail mining markets.

The results further support Hypothesis 2. Volatility analysis reveals distinct patterns of risk transmission across markets. Long-term spillovers are prominent within the cryptocurrency sector, reflecting strong interconnectedness among digital assets, and also occur bilaterally between cryptocurrencies and graphics card firms. In contrast, short-term spillovers are more concentrated within graphics card firms but also propagate from cryptocurrencies, highlighting cross-market short-term interactions. Overall, these findings show that long-term and short-

term volatility operate through different channels while confirming that volatility in cryptocurrencies spills over to graphics card firms and vice versa.

The findings of this study carry several important implications for investors and policymakers alike. Given the spillover of positive cryptocurrency returns to graphics card firms, investors can time their entry and exit in the graphics card market to align with bullish and bearish crypto cycles. For regulators and policymakers, the finding that cryptocurrency and graphics card markets are linked through volatility underscores the need for enhanced monitoring of cross-market exposures to anticipate potential risks to financial stability. It also points to the importance of incorporating these interdependencies into regulatory frameworks concerning market oversight, capital allocation, and supply chain resilience, particularly for hardware components like graphics cards, which saw significant shortages during the cryptocurrency boom of 2021–2022. Moreover, regulators might consider advising investors to reduce or exit positions in both markets during periods of heightened volatility to help them safeguard their investments.

Future research could benefit from examining the time-varying dynamics of spillovers, particularly during periods of market turmoil or significant technological transitions, such as Ethereum's switch to a proof-of-stake. Additionally, further work might investigate whether manufacturers of other types of crypto-mining-related hardware, such as application-specific integrated circuit (ASIC) miners or power supply and cooling system manufacturers, exhibit similar patterns of interconnectedness with cryptocurrency markets like graphics card firms do. Finally, given that graphics cards are the most commonly used hardware for training and running large AI models, future research could examine the interconnectedness between AI companies and graphics card firms, shedding light on potential risk transmission and other interdependencies between these two markets.

Conflicts of Interest
The author declares no conflicts of interest.

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Data Availability Statement
The data that support the findings of this study are available from the corresponding author upon request.

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Tables and Figures

Table 1: Five major Cryptocurrencies and One Index

Crypto	Symbol	Start Date	End Date
Bitcoin	BTC	02/01/2012	31/03/2025
Ethereum	ETH	11/03/2016	31/03/2025
Ripple	XPR	23/01/2015	31/03/2025
Binance Coin	BNB	10/11/2017	31/03/2025
Litecoin	LTC	25/08/2016	31/03/2025
Nasdaq Crypto Index	NCI	19/04/2021	31/03/2025

Table 2: Eleven publicly traded graphics cards makers

Company	Stock Market	Symbol
nVidia	NASDAQ	NVDA
Advanced Micro Devices	NASDAQ	AMD
Intel Corporation	NASDAQ	INTC
PC Partner	Hong Kong Stock Exchange	PCPA
AsusTek	Taiwan Stock Exchange	ASU
Micro-Star International	Taiwan Stock Exchange	MSI
Leadtek	Taiwan Stock Exchange	LRI
Biostar	Taiwan Stock Exchange	BSI
Elitegroup	Taiwan Stock Exchange	ECS
Asrock	Taiwan Stock Exchange	ARK
Gigabyte	Taiwan Stock Exchange	GBT

Table 3: Summary Statistics

Panel A: Cryptocurrencies

	BTC	ETH	XPR	BNB	LTC	NCI
Mean	0.0037	0.0038	0.0020	0.0042	0.0027	0.0009
Median	0.0015	0.0007	0.0000	0.0015	0.0011	-0.0008
Maximum	0.1473	0.1888	0.3214	0.1994	0.2077	0.1025
Minimum	-0.1335	-0.1557	-0.2500	-0.1556	-0.1497	-0.1248
Std. Dev.	0.0431	0.0549	0.0679	0.0527	0.0561	0.0363
Observations	3455	2362	2616	1927	2243	996

Panel B: Graphics cards makers

	NVDA	AMD	INTC	PCPA	ASU	MSI	LRI	BSI	ECS	ARK	GBT
Mean	0.0019	0.0014	0.0004	0.0014	0.0006	0.0012	0.0011	0.0007	0.0007	0.0009	0.0012
Median	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	0.0749	0.1069	0.0623	0.1495	0.0513	0.0662	0.0997	0.0991	0.0725	0.0981	0.1238
Minimum	-0.0704	-0.0922	-0.0561	-0.0964	-0.0434	-0.0523	-0.0914	-0.0736	-0.0640	-0.0633	-0.0996
Std. Dev.	0.0250	0.0317	0.0182	0.0371	0.0152	0.0199	0.0346	0.0261	0.0212	0.0242	0.0224
Observations	3456	3456	3456	3456	3456	3456	3456	3456	3456	3456	3456

Table 4: Pearson Correlations

Variable	BTC	ETH	XPR	BNB	LTC	NCI	NVDA	AMD	INTC	PCPA	ASU	MSI	LRI	BSI	ECS	ARK	GBT
BTC	1																
ETH	0.67***	1															
XPR	0.42***	0.50***	1														
BNB	0.63***	0.66***	0.51***	1													
LTC	0.69***	0.68***	0.53***	0.61***	1												
NCI	0.91***	0.85***	0.63***	0.69***	0.70***	1											
NVDA	0.15***	0.20***	0.12***	0.19***	0.19***	0.36***	1										
AMD	0.10***	0.14***	0.11***	0.16***	0.16***	0.31***	0.60***	1									
INTC	0.10***	0.14***	0.09***	0.15***	0.15***	0.24***	0.51***	0.43***	1								
PCPA	0.04**	0.06***	0.03	0.06***	0.09***	0.10***	0.09***	0.08***	0.04***	1							
ASU	-0.01	-0.02	0.01	-0.02	0.03	-0.04	0.03**	0.02	0.07***	0.06***	1						
MSI	0.00	0.02	0.00	0.01	0.01	0.05	0.09***	0.07***	0.05***	0.10***	0.26***	1					
LRI	0.05***	0.03	0.01	0.04*	0.02	0.11***	0.06***	0.04**	0.01	0.12***	0.17***	0.22***	1				
BSI	0.06***	0.04*	0.02	0.06**	0.02	0.10***	0.07***	0.07***	0.02	0.13***	0.20***	0.25***	0.44***	1			
ECS	0.00	0.04*	0.05**	0.04*	0.03	0.02	0.05***	0.03*	0.05***	0.09***	0.21***	0.24***	0.22***	0.27***	1		
ARK	0.02	0.03	0.00	0.02	0.02	0.03	0.07***	0.06***	0.07***	0.13***	0.24***	0.31***	0.27***	0.35***	0.23***	1	
GBT	0.01	0.03	0.02	0.04*	0.04*	0.05	0.10***	0.08***	0.04**	0.14***	0.25***	0.49***	0.29***	0.33***	0.25***	0.40***	1

* p-value < 0.1, ** p-value < 0.05, *** p-value < 0.01

Table 5: Summary of Return Spillovers

	BTC	ETH	XPR	LTC	BNB	NCI	NVDA	AMD	INTC	PCPA	ASU	MSI	LRI	BSI	ECS	ARK	GBT
L.BTC	P									P		P	P	P		P	P
L.ETH										P		P	P	P		P	P
L.XPR			N							P		P	P	P	P	P	P
L.LTC										P		P	P	P	P	P	P
L.BNB										P		P	P	P			P
L.NCI												P	P	P		P	P
L.NVDA							N		N	P	P	P	P	P	P	P	P
L.AMD					N				N		P	P				P	P
L.INTC								N	P		P	P					
L.PCPA	N											P					P
L.ASU			N				N	N	N		N		P	P			P
L.MSI								P		P		N					
L.LRI					N								P	N	N		
L.BSI								P						P		N	
L.ECS							P		P								
L.ARK																	
L.GBT			P						P		P	P				P	P

Table 6: Summary of Volatility & Shock Spillovers

Panel A: Volatility Spillovers																	
	BTC	ETH	XPR	BNB	LTC	NCI	NVDA	AMD	INTC	PCPA	ASU	MSI	LRI	BSI	ECS	ARK	GBT
L.BTC	NA	✓		✓				✓	✓			✓					
L.ETH		NA		✓	✓			✓						✓			
L.XPR	✓	✓	NA		✓		✓										
L.LTC		✓	✓	NA	✓									✓			
L.BNB			✓		NA						✓			✓			
L.NCI	✓	✓		✓		NA							✓	✓	✓		
L.NVDA							NA									✓	
L.AMD							✓	NA									
L.INTC							✓		NA				✓		✓		
L.PCPA				✓			✓			NA	✓					✓	
L.ASU									✓		NA				✓		
L.MSI	✓	✓	✓	✓	✓	✓		✓				NA	✓		✓	✓	
L.LRI	✓			✓						✓			NA	✓		✓	✓
L.BSI							✓		✓	✓			✓	NA	✓		
L.ECS							✓				✓		✓		NA		
L.ARK			✓		✓		✓	✓	✓				✓	✓		NA	
L.GBT							✓	✓	✓				✓	✓	✓	✓	NA

Table 6: Summary of Volatility & Shock Spillovers

Panel B: Shock Spillovers																	
	BTC	ETH	XPR	BNB	LTC	NCI	NVDA	AMD	INTC	PCPA	ASU	MSI	LRI	BSI	ECS	ARK	GBT
L.BTC	NA	✓		✓			✓	✓			✓						
L.ETH		NA		✓								✓		✓			
L.XPR			NA														
L.LTC		✓		NA					✓	✓		✓		✓			✓
L.BNB				✓	NA								✓	✓		✓	
L.NCI						NA											
L.NVDA	✓						NA		✓			✓		✓	✓	✓	✓
L.AMD								NA									
L.INTC							✓		NA		✓		✓	✓	✓	✓	✓
L.PCPA	✓	✓		✓			✓	✓	✓	NA							
L.ASU							✓	✓	✓		NA			✓	✓		
L.MSI				✓			✓	✓	✓	✓	✓	NA	✓	✓	✓	✓	✓
L.LRI	✓	✓		✓	✓				✓	✓			NA	✓	✓	✓	✓
L.BSI	✓	✓			✓		✓		✓			✓		NA		✓	✓
L.ECS							✓		✓					✓	NA		✓
L.ARK	✓	✓					✓	✓	✓	✓			✓	✓	✓	NA	✓
L.GBT							✓		✓	✓	✓		✓	✓		✓	NA

Figure 1: Daily Prices of Cryptocurrencies (01/01/2012 – 31/03/2025)

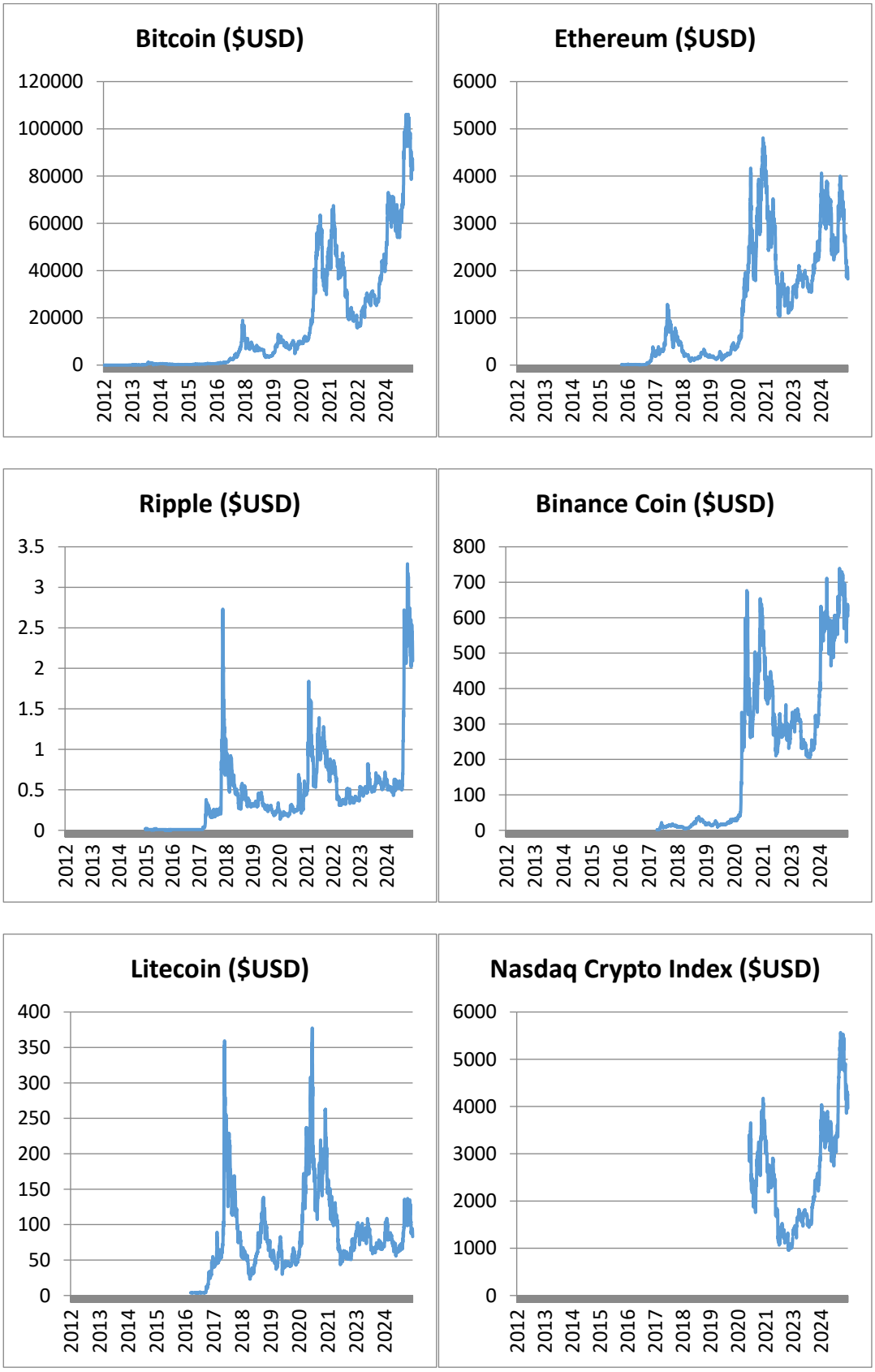
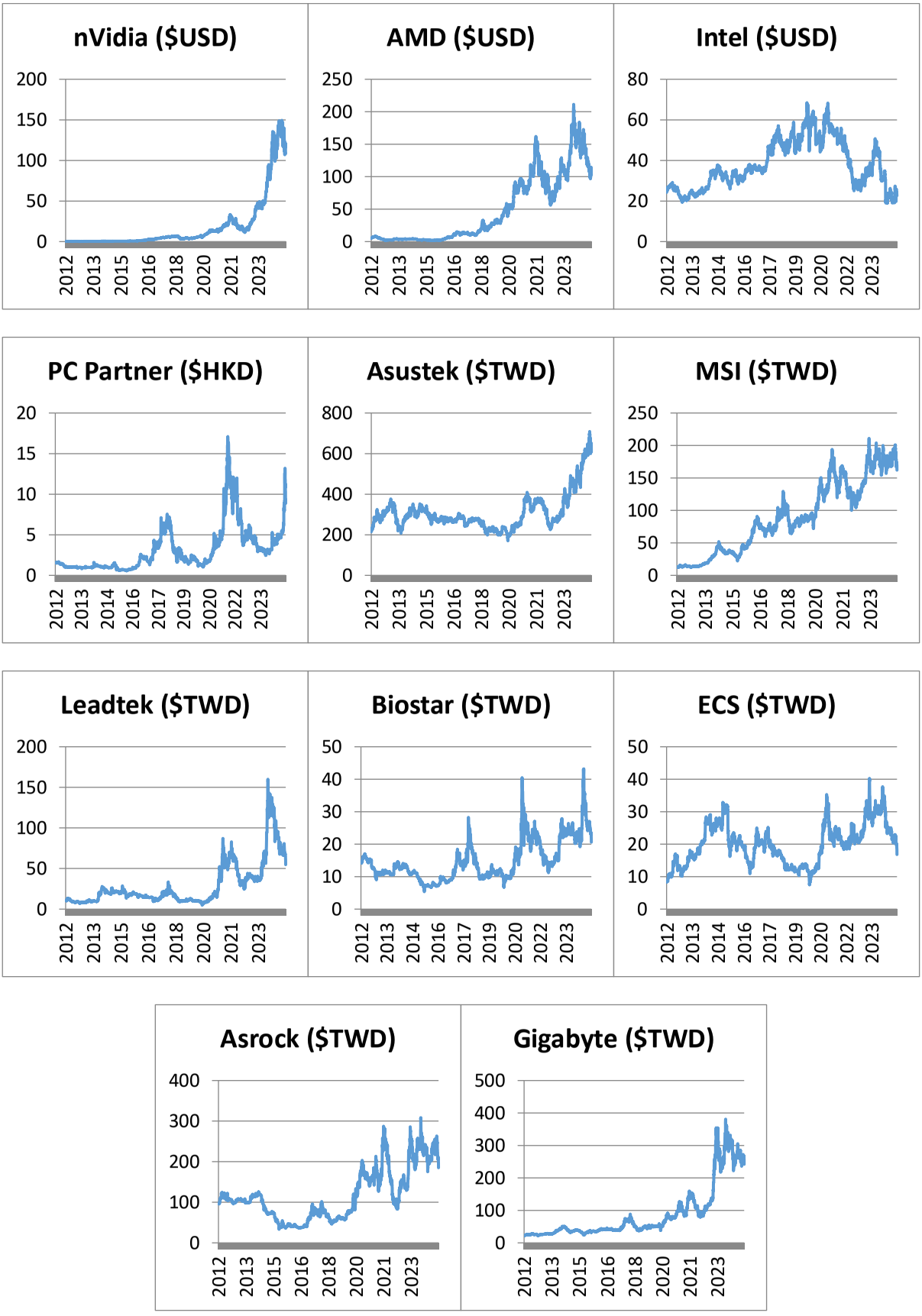


Figure 2: Daily Prices of Graphics Card Makers (01/01/2012 – 31/03/2025)



Appendix A: VECTOR AUTOREGRESSION RESULTS

	(1) BTC	(2) ETH	(3) XPR	(4) LTC	(5) BNB	(6) NCI
main						
L.BTC	0.0360**					
	(0.0172)					
L.ETH		0.0013				
		(0.0210)				
L.XPR			-0.0360*			
			(0.0201)			
L.LTC				-0.0048		
				(0.0216)		
L.BNB					0.0063	
					(0.0232)	
L.NCI						0.0147
						(0.0348)
L.nVidia	-0.0247	-0.0315	-0.0737	-0.0565	0.0121	-0.0046
	(0.0393)	(0.0581)	(0.0672)	(0.0609)	(0.0612)	(0.0564)
L.AMD	-0.0236	-0.0391	0.0157	0.0052	-0.0897*	0.0234
	(0.0293)	(0.0468)	(0.0527)	(0.0512)	(0.0537)	(0.0563)
L.Intel	-0.0129	0.0214	0.0911	0.0550	0.0664	-0.0287
	(0.0478)	(0.0673)	(0.0799)	(0.0694)	(0.0672)	(0.0603)
L.PcPartner	-0.0375*	-0.0186	-0.0198	-0.0014	0.0091	-0.0067
	(0.0202)	(0.0287)	(0.0335)	(0.0298)	(0.0301)	(0.0297)
L.Asustek	0.0281	0.0288	-0.1732*	-0.0758	0.0499	0.0100
	(0.0514)	(0.0851)	(0.0977)	(0.0892)	(0.0875)	(0.0818)
L.MSI	-0.0296	0.0104	-0.0936	-0.0265	-0.0185	-0.1197
	(0.0435)	(0.0664)	(0.0778)	(0.0711)	(0.0724)	(0.0786)
L.Leadtek	-0.0118	-0.0015	-0.0417	-0.0367	-0.0812**	-0.0271
	(0.0242)	(0.0355)	(0.0419)	(0.0367)	(0.0372)	(0.0362)
L.Biostar	-0.0116	-0.0298	-0.0422	-0.0430	0.0724	0.0132
	(0.0332)	(0.0461)	(0.0550)	(0.0482)	(0.0491)	(0.0498)
L.ECS	0.0313	-0.0180	0.0312	0.0086	0.0064	0.0689
	(0.0371)	(0.0560)	(0.0659)	(0.0582)	(0.0600)	(0.0583)
L.Asrock	-0.0078	0.0030	0.0428	0.0363	-0.0495	0.0181
	(0.0347)	(0.0483)	(0.0576)	(0.0500)	(0.0507)	(0.0481)
L.Gigabyte	0.0436	0.0418	0.1274*	0.0443	0.0128	0.0134
	(0.0405)	(0.0565)	(0.0675)	(0.0585)	(0.0575)	(0.0540)
Constant	0.0037***	0.0039***	0.0028**	0.0029**	0.0044***	0.0008

	(0.0007)	(0.0011)	(0.0013)	(0.0012)	(0.0012)	(0.0012)
nVidia						
L.BTC	0.0065					
	(0.0100)					
L.ETH		0.0067				
		(0.0106)				
L.XPR			0.0013			
			(0.0081)			
L.LTC				-0.0083		
				(0.0109)		
L.BNB					0.0119	
					(0.0128)	
L.NCI						-0.0055
						(0.0299)
L.nVidia	-0.0576**	-0.0599**	-0.0505*	-0.0558*	-0.0630*	-0.0586
	(0.0228)	(0.0293)	(0.0272)	(0.0306)	(0.0337)	(0.0485)
L.AMD	-0.0011	-0.0119	-0.0123	-0.0151	-0.0039	0.0337
	(0.0170)	(0.0236)	(0.0213)	(0.0257)	(0.0295)	(0.0484)
L.Intel	-0.0218	-0.0254	-0.0204	-0.0183	-0.0296	0.0462
	(0.0277)	(0.0340)	(0.0323)	(0.0348)	(0.0370)	(0.0519)
L.PcPartner	0.0025	0.0028	0.0033	0.0034	0.0039	-0.0010
	(0.0117)	(0.0145)	(0.0136)	(0.0150)	(0.0166)	(0.0255)
L.Asustek	-0.0361	-0.0557	-0.0601	-0.0755*	-0.0587	-0.0310
	(0.0298)	(0.0430)	(0.0395)	(0.0448)	(0.0482)	(0.0703)
L.MSI	0.0147	0.0204	0.0341	0.0300	0.0090	0.0269
	(0.0252)	(0.0335)	(0.0315)	(0.0357)	(0.0398)	(0.0676)
L.Leadtek	-0.0094	-0.0080	-0.0095	-0.0076	-0.0131	-0.0240
	(0.0140)	(0.0179)	(0.0169)	(0.0184)	(0.0205)	(0.0311)
L.Biostar	0.0209	0.0170	0.0224	0.0206	0.0147	0.0262
	(0.0193)	(0.0233)	(0.0223)	(0.0242)	(0.0270)	(0.0428)
L.ECS	0.0300	0.0514*	0.0425	0.0542*	0.0473	0.0460
	(0.0215)	(0.0283)	(0.0266)	(0.0292)	(0.0330)	(0.0502)
L.Asrock	0.0035	-0.0033	-0.0033	-0.0006	0.0017	-0.0081
	(0.0201)	(0.0244)	(0.0233)	(0.0251)	(0.0279)	(0.0414)
L.Gigabyte	0.0320	0.0240	0.0286	0.0176	0.0243	0.0149
	(0.0235)	(0.0285)	(0.0273)	(0.0294)	(0.0316)	(0.0464)
Constant	0.0019***	0.0025***	0.0024***	0.0024***	0.0021***	0.0025**
	(0.0004)	(0.0006)	(0.0005)	(0.0006)	(0.0007)	(0.0010)
AMD						
L.BTC	0.0185					
	(0.0127)					
L.ETH		0.0020				
		(0.0124)				

L.XPR			0.0048			
			(0.0098)			
L.LTC				0.0061		
				(0.0123)		
L.BNB					0.0123	
					(0.0141)	
L.NCI						0.0073
						(0.0302)
L.nVidia	0.0067	0.0177	0.0225	0.0036	-0.0126	-0.0363
	(0.0289)	(0.0343)	(0.0328)	(0.0348)	(0.0370)	(0.0489)
L.AMD	-0.0093	-0.0271	-0.0342	-0.0164	-0.0263	0.0150
	(0.0215)	(0.0277)	(0.0258)	(0.0292)	(0.0325)	(0.0488)
L.Intel	-0.0504	-0.0790**	-0.0574	-0.0702*	-0.0443	0.0055
	(0.0351)	(0.0398)	(0.0390)	(0.0396)	(0.0406)	(0.0523)
L.PcPartner	-0.0027	0.0062	0.0050	0.0074	0.0067	-0.0345
	(0.0148)	(0.0170)	(0.0164)	(0.0170)	(0.0182)	(0.0257)
L.Asustek	-0.0567	-0.0913*	-0.1037**	-0.0816	-0.0585	-0.0504
	(0.0377)	(0.0503)	(0.0477)	(0.0509)	(0.0529)	(0.0708)
L.MSI	0.0515	0.0673*	0.0976**	0.0616	0.0424	0.0933
	(0.0319)	(0.0392)	(0.0380)	(0.0406)	(0.0438)	(0.0681)
L.Leadtek	-0.0131	-0.0207	-0.0219	-0.0184	-0.0349	-0.0410
	(0.0178)	(0.0210)	(0.0204)	(0.0209)	(0.0225)	(0.0314)
L.Biostar	0.0312	0.0437	0.0470*	0.0419	0.0573*	0.0531
	(0.0244)	(0.0272)	(0.0269)	(0.0275)	(0.0297)	(0.0432)
L.ECS	0.0289	0.0294	0.0185	0.0258	0.0143	0.0098
	(0.0273)	(0.0331)	(0.0322)	(0.0332)	(0.0363)	(0.0505)
L.Asrock	0.0074	0.0103	0.0060	0.0180	0.0089	0.0112
	(0.0255)	(0.0286)	(0.0281)	(0.0286)	(0.0307)	(0.0417)
L.Gigabyte	0.0262	0.0028	0.0081	-0.0062	0.0073	0.0039
	(0.0298)	(0.0334)	(0.0330)	(0.0334)	(0.0348)	(0.0468)
Constant	0.0013**	0.0020***	0.0018***	0.0017**	0.0016**	0.0010
	(0.0005)	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0010)
Intel						
L.BTC	0.0053					
	(0.0073)					
L.nVidia	-0.0390**	-0.0362*	-0.0329*	-0.0340	-0.0316	-0.0617*
	(0.0166)	(0.0210)	(0.0196)	(0.0220)	(0.0249)	(0.0355)
L.AMD	-0.0119	-0.0265	-0.0244	-0.0339*	-0.0361*	0.0195
	(0.0124)	(0.0170)	(0.0154)	(0.0185)	(0.0219)	(0.0354)
L.Intel	0.0042	0.0125	0.0097	0.0143	0.0120	0.0766**
	(0.0202)	(0.0244)	(0.0233)	(0.0250)	(0.0274)	(0.0380)
L.PcPartner	0.0021	0.0009	0.0036	0.0008	0.0024	0.0081
	(0.0085)	(0.0104)	(0.0098)	(0.0108)	(0.0123)	(0.0187)

L.Asustek	-0.0303	-0.0562*	-0.0491*	-0.0641**	-0.0722**	-0.1038**
	(0.0217)	(0.0308)	(0.0285)	(0.0322)	(0.0357)	(0.0515)
L.MSI	0.0134	0.0032	0.0130	0.0028	-0.0005	0.0009
	(0.0183)	(0.0241)	(0.0227)	(0.0256)	(0.0295)	(0.0495)
L.Leadtek	0.0005	0.0007	-0.0010	0.0006	-0.0044	-0.0072
	(0.0102)	(0.0129)	(0.0122)	(0.0132)	(0.0152)	(0.0228)
L.Biostar	0.0058	0.0085	0.0107	0.0086	0.0062	0.0358
	(0.0140)	(0.0167)	(0.0161)	(0.0174)	(0.0200)	(0.0314)
L.ECS	0.0260*	0.0352*	0.0411**	0.0356*	0.0495**	0.0792**
	(0.0157)	(0.0203)	(0.0192)	(0.0210)	(0.0244)	(0.0367)
L.Asrock	0.0085	0.0113	0.0095	0.0134	0.0187	0.0014
	(0.0147)	(0.0175)	(0.0168)	(0.0180)	(0.0207)	(0.0303)
L.Gigabyte	0.0297*	0.0340*	0.0320	0.0317	0.0293	0.0256
	(0.0171)	(0.0205)	(0.0197)	(0.0211)	(0.0234)	(0.0340)
L.ETH		-0.0013				
		(0.0076)				
L.XPR			-0.0017			
			(0.0059)			
L.LTC				0.0012		
				(0.0078)		
L.BNB					0.0023	
					(0.0095)	
L.NCI						-0.0069
						(0.0219)
Constant	0.0004	0.0004	0.0004	0.0004	0.0003	-0.0002
	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0007)
PcPartner						
L.BTC	0.0659***					
	(0.0146)					
L.ETH		0.0721***				
		(0.0152)				
L.XPR			0.0330***			
			(0.0119)			
L.LTC				0.0517***		
				(0.0155)		
L.BNB					0.0599***	
					(0.0177)	
L.NCI						0.0508
						(0.0383)
L.nVidia	0.1846***	0.1922***	0.2088***	0.2000***	0.2244***	0.2006***
	(0.0332)	(0.0418)	(0.0396)	(0.0436)	(0.0467)	(0.0620)
L.AMD	0.0346	0.0369	0.0298	0.0417	0.0334	0.1046*
	(0.0248)	(0.0338)	(0.0311)	(0.0366)	(0.0409)	(0.0618)

L.Intel	0.0287	0.0086	0.0285	0.0105	0.0016	-0.0480
	(0.0405)	(0.0485)	(0.0471)	(0.0497)	(0.0512)	(0.0663)
L.PcPartner	-0.0090	0.0081	0.0081	0.0094	0.0050	-0.0274
	(0.0171)	(0.0207)	(0.0198)	(0.0213)	(0.0229)	(0.0326)
L.Asustek	-0.0056	-0.0041	-0.0343	-0.0306	0.0106	0.1017
	(0.0435)	(0.0613)	(0.0576)	(0.0639)	(0.0667)	(0.0899)
L.MSI	0.0678*	0.0762	0.0818*	0.0805	0.0729	0.0758
	(0.0368)	(0.0479)	(0.0459)	(0.0509)	(0.0552)	(0.0864)
L.Leadtek	0.0089	0.0069	0.0071	0.0044	0.0046	0.0385
	(0.0205)	(0.0256)	(0.0247)	(0.0263)	(0.0284)	(0.0398)
L.Biostar	-0.0170	-0.0101	-0.0086	-0.0034	-0.0341	-0.0803
	(0.0281)	(0.0332)	(0.0324)	(0.0345)	(0.0374)	(0.0547)
L.ECS	0.0081	0.0090	0.0091	0.0143	0.0675	0.0219
	(0.0314)	(0.0404)	(0.0388)	(0.0416)	(0.0457)	(0.0641)
L.Asrock	0.0067	-0.0036	-0.0014	-0.0016	0.0039	0.0279
	(0.0294)	(0.0348)	(0.0339)	(0.0358)	(0.0386)	(0.0529)
L.Gigabyte	-0.0248	-0.0349	-0.0263	-0.0337	-0.0442	-0.0915
	(0.0343)	(0.0407)	(0.0398)	(0.0419)	(0.0438)	(0.0593)
Constant	0.0007	0.0013	0.0013	0.0015*	0.0008	0.0021
	(0.0006)	(0.0008)	(0.0008)	(0.0009)	(0.0009)	(0.0013)
Asustek						
L.BTC	0.0097					
	(0.0060)					
L.ETH		-0.0053				
		(0.0054)				
L.XPR			0.0015			
			(0.0043)			
L.LTC				-0.0012		
				(0.0055)		
L.BNB					-0.0040	
					(0.0065)	
L.NCI						0.0023
						(0.0154)
L.nVidia	0.0449***	0.0467***	0.0468***	0.0456***	0.0501***	0.0600**
	(0.0136)	(0.0149)	(0.0142)	(0.0154)	(0.0171)	(0.0249)
L.AMD	0.0349***	0.0376***	0.0367***	0.0400***	0.0444***	0.0487**
	(0.0101)	(0.0121)	(0.0112)	(0.0129)	(0.0150)	(0.0248)
L.Intel	0.0728***	0.0643***	0.0623***	0.0605***	0.0549***	0.0429
	(0.0166)	(0.0173)	(0.0169)	(0.0175)	(0.0188)	(0.0266)
L.PcPartner	0.0041	0.0038	0.0071	0.0037	0.0068	0.0073
	(0.0070)	(0.0074)	(0.0071)	(0.0075)	(0.0084)	(0.0131)
L.Asustek	-0.0694***	-0.0786***	-0.0790***	-0.0672***	-0.0667***	-0.0640*
	(0.0178)	(0.0219)	(0.0207)	(0.0225)	(0.0245)	(0.0361)

L.MSI	-0.0052	0.0011	0.0028	-0.0065	-0.0084	-0.0090
	(0.0151)	(0.0171)	(0.0165)	(0.0179)	(0.0202)	(0.0347)
L.Leadtek	-0.0074	-0.0034	-0.0067	-0.0041	-0.0080	-0.0212
	(0.0084)	(0.0091)	(0.0089)	(0.0093)	(0.0104)	(0.0160)
L.Biostar	0.0064	0.0044	0.0056	0.0020	0.0027	0.0040
	(0.0115)	(0.0119)	(0.0117)	(0.0122)	(0.0137)	(0.0220)
L.ECS	0.0096	0.0162	0.0175	0.0182	0.0279*	0.0243
	(0.0129)	(0.0144)	(0.0140)	(0.0147)	(0.0168)	(0.0257)
L.Asrock	0.0006	0.0009	-0.0017	0.0003	0.0042	-0.0044
	(0.0120)	(0.0124)	(0.0122)	(0.0126)	(0.0142)	(0.0212)
L.Gigabyte	0.0174	0.0217	0.0202	0.0238	0.0225	0.0526**
	(0.0140)	(0.0145)	(0.0143)	(0.0148)	(0.0161)	(0.0238)
Constant	0.0005*	0.0004	0.0004	0.0005	0.0006*	0.0005
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0005)
MSI						
L.BTC	0.0169**					
	(0.0078)					
L.ETH		0.0198***				
		(0.0076)				
L.XPR			0.0146**			
			(0.0059)			
L.LTC				0.0224***		
				(0.0076)		
L.BNB					0.0192**	
					(0.0088)	
L.NCI						0.0577***
						(0.0174)
L.nVidia	0.0779***	0.0810***	0.0888***	0.0823***	0.0749***	0.0334
	(0.0177)	(0.0209)	(0.0198)	(0.0213)	(0.0231)	(0.0283)
L.AMD	0.0352***	0.0339**	0.0273*	0.0288	0.0338*	0.0676**
	(0.0132)	(0.0169)	(0.0155)	(0.0179)	(0.0203)	(0.0282)
L.Intel	0.0605***	0.0650***	0.0645***	0.0650***	0.0714***	0.0131
	(0.0216)	(0.0243)	(0.0235)	(0.0242)	(0.0254)	(0.0302)
L.PcPartner	0.0296***	0.0320***	0.0354***	0.0307***	0.0321***	0.0061
	(0.0091)	(0.0104)	(0.0099)	(0.0104)	(0.0114)	(0.0149)
L.Asustek	0.0479**	0.0121	0.0335	0.0025	0.0152	0.0652
	(0.0232)	(0.0307)	(0.0287)	(0.0312)	(0.0330)	(0.0410)
L.MSI	-0.0645***	-0.0729***	-0.0718***	-0.0669***	-0.0772***	-0.0962**
	(0.0196)	(0.0239)	(0.0229)	(0.0248)	(0.0273)	(0.0394)
L.Leadtek	-0.0079	-0.0070	-0.0042	-0.0059	-0.0085	-0.0211
	(0.0109)	(0.0128)	(0.0123)	(0.0128)	(0.0141)	(0.0181)
L.Biostar	0.0073	0.0062	0.0069	0.0039	0.0078	-0.0040
	(0.0150)	(0.0166)	(0.0162)	(0.0168)	(0.0185)	(0.0249)

L.ECS	-0.0080	-0.0078	-0.0037	-0.0016	0.0128	-0.0202
	(0.0168)	(0.0202)	(0.0194)	(0.0203)	(0.0226)	(0.0292)
L.Asrock	0.0127	0.0076	-0.0031	0.0139	0.0021	-0.0094
	(0.0157)	(0.0174)	(0.0169)	(0.0175)	(0.0191)	(0.0241)
L.Gigabyte	0.0073	0.0173	0.0132	0.0146	0.0197	0.0987***
	(0.0183)	(0.0204)	(0.0198)	(0.0205)	(0.0217)	(0.0270)
Constant	0.0009***	0.0006	0.0006	0.0004	0.0005	-0.0001
	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0006)
Leadtek						
L.BTC	0.0862***					
	(0.0135)					
L.ETH		0.0672***				
		(0.0140)				
L.XPR			0.0356***			
			(0.0108)			
L.LTC				0.0927***		
				(0.0143)		
L.BNB					0.0879***	
					(0.0170)	
L.NCI						0.2197***
						(0.0363)
L.nVidia	0.1123***	0.1190***	0.1344***	0.1161***	0.1414***	0.1537***
	(0.0308)	(0.0387)	(0.0361)	(0.0404)	(0.0446)	(0.0587)
L.AMD	0.0331	0.0306	0.0262	0.0341	0.0302	0.0385
	(0.0230)	(0.0313)	(0.0283)	(0.0339)	(0.0391)	(0.0586)
L.Intel	0.0055	-0.0258	-0.0088	-0.0373	-0.0473	-0.0827
	(0.0376)	(0.0449)	(0.0429)	(0.0460)	(0.0490)	(0.0628)
L.PcPartner	0.0065	0.0045	0.0135	-0.0014	0.0032	-0.0258
	(0.0159)	(0.0192)	(0.0180)	(0.0197)	(0.0220)	(0.0309)
L.Asustek	0.0293	0.0653	0.0287	0.0415	0.0691	0.1626*
	(0.0403)	(0.0568)	(0.0524)	(0.0591)	(0.0638)	(0.0851)
L.MSI	0.0111	0.0259	0.0378	0.0346	0.0241	0.0460
	(0.0342)	(0.0443)	(0.0418)	(0.0471)	(0.0528)	(0.0819)
L.Leadtek	0.0891***	0.0853***	0.0858***	0.0894***	0.0775***	0.0235
	(0.0190)	(0.0237)	(0.0225)	(0.0243)	(0.0272)	(0.0377)
L.Biostar	0.0122	0.0110	0.0219	0.0105	0.0243	0.0243
	(0.0261)	(0.0308)	(0.0295)	(0.0319)	(0.0358)	(0.0519)
L.ECS	0.0231	0.0369	0.0249	0.0399	0.0392	0.0277
	(0.0292)	(0.0374)	(0.0354)	(0.0385)	(0.0437)	(0.0607)
L.Asrock	0.0310	0.0207	0.0281	0.0258	0.0125	-0.0080
	(0.0273)	(0.0323)	(0.0309)	(0.0332)	(0.0370)	(0.0501)
L.Gigabyte	0.0253	0.0289	0.0178	0.0210	0.0263	0.0899
	(0.0318)	(0.0377)	(0.0362)	(0.0388)	(0.0419)	(0.0562)

Constant	0.0003	0.0003	0.0003	0.0005	0.0005	0.0001
	(0.0006)	(0.0008)	(0.0007)	(0.0008)	(0.0009)	(0.0012)
Biostar						
L.BTC	0.0836***					
	(0.0102)					
L.ETH		0.0659***				
		(0.0112)				
L.XPR			0.0382***			
			(0.0086)			
L.LTC				0.0829***		
				(0.0113)		
L.BNB					0.0577***	
					(0.0135)	
L.NCI						0.1030***
						(0.0283)
L.nVidia	0.1036***	0.1141***	0.1275***	0.1168***	0.1233***	0.1206***
	(0.0233)	(0.0309)	(0.0286)	(0.0320)	(0.0356)	(0.0459)
L.AMD	0.0235	0.0249	0.0169	0.0175	0.0336	0.0611
	(0.0174)	(0.0250)	(0.0224)	(0.0268)	(0.0312)	(0.0458)
L.Intel	0.0007	-0.0162	-0.0044	-0.0196	-0.0180	-0.0501
	(0.0284)	(0.0359)	(0.0340)	(0.0364)	(0.0391)	(0.0491)
L.PcPartner	0.0091	0.0097	0.0127	0.0068	0.0093	0.0082
	(0.0120)	(0.0153)	(0.0142)	(0.0156)	(0.0175)	(0.0241)
L.Asustek	0.0433	0.0459	0.0454	0.0361	0.0492	0.1302*
	(0.0305)	(0.0454)	(0.0415)	(0.0468)	(0.0509)	(0.0665)
L.MSI	-0.0073	-0.0079	-0.0051	0.0062	-0.0011	-0.0237
	(0.0258)	(0.0354)	(0.0331)	(0.0373)	(0.0421)	(0.0640)
L.Leadtek	-0.0166	-0.0263	-0.0253	-0.0277	-0.0374*	-0.0500*
	(0.0144)	(0.0189)	(0.0178)	(0.0192)	(0.0217)	(0.0294)
L.Biostar	0.0396**	0.0427*	0.0495**	0.0482*	0.0553*	0.0130
	(0.0197)	(0.0246)	(0.0234)	(0.0253)	(0.0286)	(0.0405)
L.ECS	-0.0073	-0.0151	-0.0175	-0.0176	-0.0070	-0.0032
	(0.0221)	(0.0299)	(0.0280)	(0.0305)	(0.0349)	(0.0475)
L.Asrock	0.0129	0.0081	0.0134	0.0054	0.0163	-0.0010
	(0.0206)	(0.0258)	(0.0244)	(0.0263)	(0.0295)	(0.0392)
L.Gigabyte	0.0307	0.0284	0.0276	0.0275	0.0246	0.0652
	(0.0241)	(0.0301)	(0.0287)	(0.0307)	(0.0335)	(0.0439)
Constant	0.0001	0.0005	0.0004	0.0005	0.0004	-0.0003
	(0.0004)	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0009)
ECS						
L.BTC	0.0093					
	(0.0084)					
L.ETH		0.0039				

		(0.0083)				
L.XPR			0.0136**			
			(0.0064)			
L.LTC				0.0162*		
				(0.0084)		
L.BNB					0.0022	
					(0.0095)	
L.NCI						0.0248
						(0.0213)
L.nVidia	0.0600***	0.0587**	0.0570***	0.0578**	0.0757***	0.1128***
	(0.0192)	(0.0228)	(0.0214)	(0.0236)	(0.0251)	(0.0344)
L.AMD	0.0246*	0.0229	0.0245	0.0257	0.0276	0.0047
	(0.0143)	(0.0184)	(0.0168)	(0.0199)	(0.0220)	(0.0344)
L.Intel	0.0406*	0.0374	0.0386	0.0355	0.0322	0.0091
	(0.0233)	(0.0264)	(0.0254)	(0.0269)	(0.0276)	(0.0368)
L.PcPartner	0.0103	0.0074	0.0070	0.0059	0.0067	0.0157
	(0.0099)	(0.0113)	(0.0107)	(0.0116)	(0.0123)	(0.0181)
L.Asustek	-0.0121	-0.0211	-0.0131	-0.0247	-0.0205	-0.0179
	(0.0251)	(0.0334)	(0.0311)	(0.0346)	(0.0359)	(0.0499)
L.MSI	0.0121	0.0103	0.0227	0.0218	0.0301	0.0104
	(0.0212)	(0.0261)	(0.0248)	(0.0276)	(0.0297)	(0.0480)
L.Leadtek	-0.0178	-0.0165	-0.0159	-0.0164	-0.0191	-0.0660***
	(0.0118)	(0.0139)	(0.0133)	(0.0142)	(0.0153)	(0.0221)
L.Biostar	0.0007	0.0046	0.0035	0.0073	0.0115	0.0037
	(0.0162)	(0.0181)	(0.0175)	(0.0187)	(0.0201)	(0.0304)
L.ECS	0.0193	0.0095	0.0153	0.0059	-0.0104	0.0107
	(0.0181)	(0.0220)	(0.0210)	(0.0226)	(0.0246)	(0.0356)
L.Asrock	0.0013	-0.0050	-0.0032	-0.0051	-0.0021	-0.0050
	(0.0170)	(0.0190)	(0.0183)	(0.0194)	(0.0208)	(0.0294)
L.Gigabyte	0.0321	0.0327	0.0306	0.0282	0.0186	0.0342
	(0.0198)	(0.0222)	(0.0215)	(0.0227)	(0.0236)	(0.0330)
Constant	0.0004	-0.0000	-0.0001	0.0001	-0.0001	-0.0004
	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0005)	(0.0007)
Asrock						
L.BTC	0.0516***					
	(0.0095)					
L.ETH		0.0344***				
		(0.0102)				
L.XPR			0.0158**			
			(0.0078)			
L.LTC				0.0398***		
				(0.0104)		
L.BNB					0.0139	

					(0.0122)	
L.NCI						0.0724***
						(0.0281)
L.nVidia	0.1105***	0.1155***	0.1219***	0.1173***	0.1215***	0.1262***
	(0.0217)	(0.0281)	(0.0261)	(0.0294)	(0.0321)	(0.0455)
L.AMD	0.0306*	0.0389*	0.0308	0.0395	0.0627**	0.0797*
	(0.0161)	(0.0227)	(0.0205)	(0.0247)	(0.0281)	(0.0454)
L.Intel	0.0168	0.0196	0.0253	0.0180	0.0204	0.0117
	(0.0264)	(0.0326)	(0.0311)	(0.0334)	(0.0352)	(0.0486)
L.PcPartner	0.0167	0.0196	0.0190	0.0181	0.0212	0.0245
	(0.0111)	(0.0139)	(0.0130)	(0.0144)	(0.0158)	(0.0239)
L.Asustek	0.0135	-0.0306	-0.0140	-0.0487	-0.0302	0.0129
	(0.0283)	(0.0413)	(0.0380)	(0.0430)	(0.0458)	(0.0659)
L.MSI	0.0517**	0.0619*	0.0612**	0.0654*	0.0778**	0.0662
	(0.0240)	(0.0322)	(0.0303)	(0.0343)	(0.0379)	(0.0634)
L.Leadtek	-0.0087	-0.0181	-0.0102	-0.0178	-0.0106	-0.0226
	(0.0133)	(0.0172)	(0.0163)	(0.0177)	(0.0195)	(0.0292)
L.Biostar	-0.0357*	-0.0430*	-0.0384*	-0.0380	-0.0660**	-0.0877**
	(0.0183)	(0.0224)	(0.0214)	(0.0232)	(0.0257)	(0.0402)
L.ECS	-0.0186	-0.0206	-0.0075	-0.0223	-0.0208	-0.0234
	(0.0205)	(0.0272)	(0.0256)	(0.0281)	(0.0314)	(0.0470)
L.Asrock	0.0055	0.0001	-0.0037	0.0020	-0.0022	0.0090
	(0.0191)	(0.0234)	(0.0224)	(0.0241)	(0.0266)	(0.0388)
L.Gigabyte	0.0433*	0.0640**	0.0539**	0.0598**	0.0640**	0.1144***
	(0.0223)	(0.0274)	(0.0262)	(0.0282)	(0.0301)	(0.0435)
Constant	0.0003	0.0008	0.0006	0.0010*	0.0008	0.0003
	(0.0004)	(0.0006)	(0.0005)	(0.0006)	(0.0006)	(0.0009)
Gigabyte						
L.BTC	0.0463***					
	(0.0087)					
L.ETH		0.0233**				
		(0.0093)				
L.XPR			0.0134*			
			(0.0071)			
L.LTC				0.0261***		
				(0.0095)		
L.BNB					0.0255**	
					(0.0114)	
L.NCI						0.0660**
						(0.0260)
L.nVidia	0.1271***	0.1399***	0.1494***	0.1385***	0.1470***	0.1488***
	(0.0198)	(0.0257)	(0.0238)	(0.0267)	(0.0301)	(0.0422)
L.AMD	0.0356**	0.0462**	0.0324*	0.0505**	0.0633**	0.1059**

	(0.0148)	(0.0207)	(0.0187)	(0.0225)	(0.0264)	(0.0421)
L.Intel	0.0330	0.0305	0.0351	0.0308	0.0218	-0.0196
	(0.0242)	(0.0297)	(0.0283)	(0.0305)	(0.0330)	(0.0451)
L.PcPartner	0.0176*	0.0219*	0.0233**	0.0222*	0.0247*	0.0042
	(0.0102)	(0.0127)	(0.0119)	(0.0131)	(0.0148)	(0.0222)
L.Asustek	0.0609**	0.0452	0.0483	0.0441	0.0431	0.0978
	(0.0260)	(0.0376)	(0.0345)	(0.0392)	(0.0430)	(0.0611)
L.MSI	0.0216	0.0306	0.0223	0.0347	0.0439	-0.0547
	(0.0220)	(0.0293)	(0.0275)	(0.0312)	(0.0355)	(0.0588)
L.Leadtek	-0.0052	-0.0041	0.0015	-0.0040	-0.0129	-0.0298
	(0.0122)	(0.0157)	(0.0148)	(0.0161)	(0.0183)	(0.0271)
L.Biostar	-0.0038	-0.0079	-0.0059	-0.0069	-0.0063	-0.0367
	(0.0168)	(0.0204)	(0.0195)	(0.0212)	(0.0241)	(0.0372)
L.ECS	-0.0116	-0.0138	-0.0027	-0.0126	0.0006	0.0055
	(0.0188)	(0.0247)	(0.0233)	(0.0255)	(0.0294)	(0.0436)
L.Asrock	-0.0054	-0.0057	-0.0113	-0.0055	-0.0057	0.0051
	(0.0176)	(0.0214)	(0.0204)	(0.0220)	(0.0249)	(0.0360)
L.Gigabyte	0.0026	0.0076	0.0019	0.0072	0.0037	0.0908**
	(0.0205)	(0.0250)	(0.0239)	(0.0257)	(0.0282)	(0.0403)
Constant	0.0006*	0.0007	0.0006	0.0007	0.0008	0.0008
	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0009)
Observations	3454	2361	2602	2242	1926	960

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix B: VOLATILITY & SHOCK SPILLOVERS

Spillover	From	To	Chi-Square	p-Value
Volatility	AMD	Asrock	0.33	0.5654
Volatility	AMD	Asustek	0.3	0.5812
Volatility	AMD	Biostar	1.51	0.2185
Volatility	AMD	Binance Coin	0.13	0.7188
Volatility	AMD	Bitcoin	0.1	0.7532
Volatility	AMD	ECS	0.9	0.3439
Volatility	AMD	Ethereum	0.03	0.8645
Volatility	AMD	Gigabyte	0.06	0.8044
Volatility	AMD	Intel	0.73	0.3923
Volatility	AMD	Leadtek	0.09	0.7657
Volatility	AMD	Litecoin	0.08	0.7833
Volatility	AMD	MSI	0.71	0.398
Volatility	AMD	NCI	0.44	0.5074
Volatility	AMD	nVidia	4.47	0.0345
Volatility	AMD	PC Partner	0.94	0.3323
Volatility	AMD	XPR	0.06	0.8061
Volatility	Asrock	AMD	5.69	0.017
Volatility	Asrock	Asustek	1.33	0.2489
Volatility	Asrock	Biostar	14.19	0.0002
Volatility	Asrock	Binance Coin	0.03	0.8646
Volatility	Asrock	Bitcoin	0.35	0.5533
Volatility	Asrock	ECS	0.92	0.3365
Volatility	Asrock	Ethereum	1.35	0.2461
Volatility	Asrock	Gigabyte	1.84	0.1751
Volatility	Asrock	Intel	6.76	0.0093
Volatility	Asrock	Leadtek	4.96	0.0259
Volatility	Asrock	Litecoin	6.07	0.0137
Volatility	Asrock	MSI	1.82	0.1769
Volatility	Asrock	NCI	1.64	0.1999
Volatility	Asrock	nVidia	5.07	0.0243
Volatility	Asrock	PC Partner	0.54	0.4634
Volatility	Asrock	XPR	4.68	0.0306
Volatility	Asustek	AMD	1.27	0.2603
Volatility	Asustek	Asrock	0.07	0.785
Volatility	Asustek	Biostar	0.81	0.3673
Volatility	Asustek	Binance Coin	1.18	0.2778
Volatility	Asustek	Bitcoin	0.1	0.7538
Volatility	Asustek	ECS	11.08	0.0009
Volatility	Asustek	Ethereum	2.35	0.1257
Volatility	Asustek	Gigabyte	0.47	0.494
Volatility	Asustek	Intel	3.37	0.0665
Volatility	Asustek	Leadtek	1.42	0.2342
Volatility	Asustek	Litecoin	0.29	0.5889

Volatility	Asustek	MSI	1.52	0.2182
Volatility	Asustek	NCI	1.21	0.2711
Volatility	Asustek	nVidia	0.94	0.3317
Volatility	Asustek	PC Partner	0.12	0.7241
Volatility	Asustek	XPR	0.09	0.7588
Volatility	Biostar	AMD	1.26	0.2609
Volatility	Biostar	Asrock	0.03	0.8712
Volatility	Biostar	Asustek	0.01	0.9371
Volatility	Biostar	Binance Coin	0.37	0.5447
Volatility	Biostar	Bitcoin	0.01	0.9037
Volatility	Biostar	ECS	3.65	0.0561
Volatility	Biostar	Ethereum	0.03	0.8648
Volatility	Biostar	Gigabyte	0.47	0.4912
Volatility	Biostar	Intel	2.79	0.0948
Volatility	Biostar	Leadtek	6.1	0.0135
Volatility	Biostar	Litecoin	0.73	0.3923
Volatility	Biostar	MSI	0.18	0.674
Volatility	Biostar	NCI	1.07	0.3017
Volatility	Biostar	nVidia	5.83	0.0157
Volatility	Biostar	PC Partner	3.89	0.0487
Volatility	Biostar	XPR	0.03	0.8714
Volatility	Binance Coin	AMD	0.04	0.8472
Volatility	Binance Coin	Asrock	0.01	0.9026
Volatility	Binance Coin	Asustek	0.24	0.621
Volatility	Binance Coin	Biostar	4.83	0.028
Volatility	Binance Coin	Bitcoin	2.2	0.1378
Volatility	Binance Coin	ECS	0.05	0.8151
Volatility	Binance Coin	Ethereum	4.46	0.0347
Volatility	Binance Coin	Gigabyte	0.12	0.7275
Volatility	Binance Coin	Intel	0.52	0.4709
Volatility	Binance Coin	Leadtek	0.03	0.8661
Volatility	Binance Coin	Litecoin	11.49	0.0007
Volatility	Binance Coin	MSI	0.09	0.7584
Volatility	Binance Coin	NCI	0.41	0.5196
Volatility	Binance Coin	nVidia	0.41	0.5233
Volatility	Binance Coin	PC Partner	0.11	0.7375
Volatility	Binance Coin	XPR	27.38	<.0001
Volatility	Bitcoin	AMD	4.18	0.041
Volatility	Bitcoin	Asrock	1.02	0.3121
Volatility	Bitcoin	Asustek	0.03	0.87
Volatility	Bitcoin	Biostar	0.19	0.6648
Volatility	Bitcoin	Binance Coin	6.11	0.0134
Volatility	Bitcoin	ECS	0.48	0.4883
Volatility	Bitcoin	Ethereum	6.77	0.0093
Volatility	Bitcoin	Gigabyte	1.68	0.1943
Volatility	Bitcoin	Intel	2.88	0.0895

Volatility	Bitcoin	Leadtek	0.25	0.6138
Volatility	Bitcoin	Litecoin	1.56	0.2114
Volatility	Bitcoin	MSI	5.55	0.0185
Volatility	Bitcoin	NCI	1.08	0.2978
Volatility	Bitcoin	nVidia	1.39	0.2385
Volatility	Bitcoin	PC Partner	0.16	0.6877
Volatility	Bitcoin	XPR	1.35	0.2457
Volatility	ECS	AMD	0.39	0.5313
Volatility	ECS	Asrock	2.12	0.145
Volatility	ECS	Asustek	2.75	0.0974
Volatility	ECS	Biostar	0.61	0.434
Volatility	ECS	Binance Coin	0.6	0.438
Volatility	ECS	Bitcoin	0.01	0.9072
Volatility	ECS	Ethereum	0	0.9536
Volatility	ECS	Gigabyte	2.02	0.155
Volatility	ECS	Intel	2.57	0.1088
Volatility	ECS	Leadtek	5.6	0.018
Volatility	ECS	Litecoin	0	0.9937
Volatility	ECS	MSI	0.53	0.4648
Volatility	ECS	NCI	0.61	0.4356
Volatility	ECS	nVidia	4.86	0.0274
Volatility	ECS	PC Partner	0.9	0.3431
Volatility	ECS	XPR	0.14	0.7098
Volatility	Ethereum	AMD	3.26	0.0709
Volatility	Ethereum	Asrock	0.25	0.6178
Volatility	Ethereum	Asustek	0.16	0.687
Volatility	Ethereum	Biostar	3.5	0.0613
Volatility	Ethereum	Binance Coin	5.37	0.0205
Volatility	Ethereum	Bitcoin	0.02	0.8895
Volatility	Ethereum	ECS	1.48	0.2235
Volatility	Ethereum	Gigabyte	1.15	0.2828
Volatility	Ethereum	Intel	1.46	0.2273
Volatility	Ethereum	Leadtek	0.33	0.5677
Volatility	Ethereum	Litecoin	10.18	0.0014
Volatility	Ethereum	MSI	0.01	0.9327
Volatility	Ethereum	NCI	0.28	0.5983
Volatility	Ethereum	nVidia	0.01	0.9373
Volatility	Ethereum	PC Partner	0.2	0.6526
Volatility	Ethereum	XPR	2.6	0.1068
Volatility	Gigabyte	AMD	3.48	0.0622
Volatility	Gigabyte	Asrock	10.88	0.001
Volatility	Gigabyte	Asustek	0.31	0.5766
Volatility	Gigabyte	Biostar	10.4	0.0013
Volatility	Gigabyte	Binance Coin	0.77	0.3808
Volatility	Gigabyte	Bitcoin	1.34	0.2478
Volatility	Gigabyte	ECS	3.09	0.0787

Volatility	Gigabyte	Ethereum	0.11	0.7456
Volatility	Gigabyte	Intel	6.77	0.0093
Volatility	Gigabyte	Leadtek	13.39	0.0003
Volatility	Gigabyte	Litecoin	0.94	0.332
Volatility	Gigabyte	MSI	0.27	0.6038
Volatility	Gigabyte	NCI	0.7	0.4024
Volatility	Gigabyte	nVidia	3.95	0.0467
Volatility	Gigabyte	PC Partner	0.32	0.5694
Volatility	Gigabyte	XPR	0.05	0.8161
Volatility	Intel	AMD	1.97	0.1602
Volatility	Intel	Asrock	1.61	0.2038
Volatility	Intel	Asustek	0.25	0.6147
Volatility	Intel	Biostar	1.85	0.1742
Volatility	Intel	Binance Coin	0	0.9873
Volatility	Intel	Bitcoin	0.26	0.6106
Volatility	Intel	ECS	11.53	0.0007
Volatility	Intel	Ethereum	0.51	0.4735
Volatility	Intel	Gigabyte	1.08	0.2991
Volatility	Intel	Leadtek	5.67	0.0173
Volatility	Intel	Litecoin	0.89	0.3463
Volatility	Intel	MSI	0.23	0.6305
Volatility	Intel	NCI	1.88	0.1709
Volatility	Intel	nVidia	15.67	<.0001
Volatility	Intel	PC Partner	0.39	0.5328
Volatility	Intel	XPR	0.01	0.916
Volatility	Leadtek	AMD	1.21	0.2707
Volatility	Leadtek	Asrock	7.96	0.0048
Volatility	Leadtek	Asustek	0.49	0.4836
Volatility	Leadtek	Biostar	10	0.0016
Volatility	Leadtek	Binance Coin	7.81	0.0052
Volatility	Leadtek	Bitcoin	3.48	0.0621
Volatility	Leadtek	ECS	0.54	0.4645
Volatility	Leadtek	Ethereum	1.22	0.2699
Volatility	Leadtek	Gigabyte	5.93	0.0149
Volatility	Leadtek	Intel	0.7	0.4035
Volatility	Leadtek	Litecoin	1.67	0.196
Volatility	Leadtek	MSI	0.36	0.5509
Volatility	Leadtek	NCI	1.85	0.1737
Volatility	Leadtek	nVidia	1.15	0.2844
Volatility	Leadtek	PC Partner	4.1	0.0428
Volatility	Leadtek	XPR	1.61	0.2039
Volatility	Litecoin	AMD	0	0.9815
Volatility	Litecoin	Asrock	0	0.9894
Volatility	Litecoin	Asustek	2.91	0.0878
Volatility	Litecoin	Biostar	3.82	0.0506
Volatility	Litecoin	Binance Coin	1.82	0.1778

Volatility	Litecoin	Bitcoin	1.64	0.1998
Volatility	Litecoin	ECS	1.01	0.314
Volatility	Litecoin	Ethereum	2.52	0.1121
Volatility	Litecoin	Gigabyte	2.29	0.1303
Volatility	Litecoin	Intel	1.91	0.1665
Volatility	Litecoin	Leadtek	1.87	0.1714
Volatility	Litecoin	MSI	1.65	0.1989
Volatility	Litecoin	NCI	0.48	0.4897
Volatility	Litecoin	nVidia	0.11	0.741
Volatility	Litecoin	PC Partner	0.35	0.5553
Volatility	Litecoin	XPR	16.9	<.0001
Volatility	MSI	AMD	4.78	0.0288
Volatility	MSI	Asrock	3.2	0.0736
Volatility	MSI	Asustek	0.57	0.4518
Volatility	MSI	Biostar	2.55	0.1103
Volatility	MSI	Binance Coin	10.25	0.0014
Volatility	MSI	Bitcoin	3.36	0.0666
Volatility	MSI	ECS	11.64	0.0006
Volatility	MSI	Ethereum	4.63	0.0315
Volatility	MSI	Gigabyte	1.39	0.2392
Volatility	MSI	Intel	2.13	0.1444
Volatility	MSI	Leadtek	7.5	0.0062
Volatility	MSI	Litecoin	3.08	0.0794
Volatility	MSI	NCI	3.2	0.0735
Volatility	MSI	nVidia	0.93	0.3343
Volatility	MSI	PC Partner	2.09	0.1487
Volatility	MSI	XPR	3.08	0.0794
Volatility	NCI	AMD	0.02	0.8761
Volatility	NCI	Asrock	0.2	0.6531
Volatility	NCI	Asustek	0.08	0.7785
Volatility	NCI	Biostar	13.6	0.0002
Volatility	NCI	Binance Coin	15.7	<.0001
Volatility	NCI	Bitcoin	7.29	0.0069
Volatility	NCI	ECS	4.99	0.0254
Volatility	NCI	Ethereum	12.72	0.0004
Volatility	NCI	Gigabyte	1.84	0.175
Volatility	NCI	Intel	0.89	0.3453
Volatility	NCI	Leadtek	9.12	0.0025
Volatility	NCI	Litecoin	0.87	0.3519
Volatility	NCI	MSI	1.63	0.2015
Volatility	NCI	nVidia	0.24	0.6229
Volatility	NCI	PC Partner	0.38	0.5355
Volatility	NCI	XPR	0.39	0.531
Volatility	nVidia	AMD	1.87	0.172
Volatility	nVidia	Asrock	6.35	0.0117
Volatility	nVidia	Asustek	0.2	0.6554

Volatility	nVidia	Biostar	0	0.9908
Volatility	nVidia	Binance Coin	0.17	0.6766
Volatility	nVidia	Bitcoin	1.26	0.2609
Volatility	nVidia	ECS	1.97	0.1605
Volatility	nVidia	Ethereum	1.92	0.166
Volatility	nVidia	Gigabyte	1.19	0.2745
Volatility	nVidia	Intel	1.58	0.2087
Volatility	nVidia	Leadtek	0.84	0.3587
Volatility	nVidia	Litecoin	0.09	0.7651
Volatility	nVidia	MSI	0.03	0.8554
Volatility	nVidia	NCI	0.24	0.6256
Volatility	nVidia	PC Partner	0.71	0.4003
Volatility	nVidia	XPR	0.01	0.9424
Volatility	PC Partner	AMD	0.08	0.7717
Volatility	PC Partner	Asrock	5.16	0.0232
Volatility	PC Partner	Asustek	4.51	0.0337
Volatility	PC Partner	Biostar	0.22	0.6361
Volatility	PC Partner	Binance Coin	4.16	0.0413
Volatility	PC Partner	Bitcoin	0.65	0.4218
Volatility	PC Partner	ECS	0.75	0.3853
Volatility	PC Partner	Ethereum	1.73	0.1879
Volatility	PC Partner	Gigabyte	0.26	0.6076
Volatility	PC Partner	Intel	2.6	0.1068
Volatility	PC Partner	Leadtek	0.08	0.7809
Volatility	PC Partner	Litecoin	1.33	0.2491
Volatility	PC Partner	MSI	0.24	0.6252
Volatility	PC Partner	NCI	0.14	0.7038
Volatility	PC Partner	nVidia	6.15	0.0132
Volatility	PC Partner	XPR	0.01	0.928
Volatility	XPR	AMD	1.58	0.2095
Volatility	XPR	Asrock	0.22	0.6395
Volatility	XPR	Asustek	0.77	0.3812
Volatility	XPR	Biostar	2.44	0.1179
Volatility	XPR	Binance Coin	1.12	0.2889
Volatility	XPR	Bitcoin	4.9	0.0269
Volatility	XPR	ECS	0.36	0.5494
Volatility	XPR	Ethereum	4.03	0.0446
Volatility	XPR	Gigabyte	1.12	0.2899
Volatility	XPR	Intel	1.56	0.2121
Volatility	XPR	Leadtek	0.55	0.4577
Volatility	XPR	Litecoin	21.49	<.0001
Volatility	XPR	MSI	0.35	0.5525
Volatility	XPR	NCI	2.33	0.1273
Volatility	XPR	nVidia	3.59	0.0581
Volatility	XPR	PC Partner	0.46	0.498
Shock	AMD	Asrock	0.39	0.532

Shock	AMD	Asustek	0.2	0.6581
Shock	AMD	Biostar	0.36	0.5492
Shock	AMD	Binance Coin	0	0.9905
Shock	AMD	Bitcoin	0.23	0.6331
Shock	AMD	ECS	1.31	0.2517
Shock	AMD	Ethereum	0.52	0.4721
Shock	AMD	Gigabyte	0.8	0.3708
Shock	AMD	Intel	0.13	0.7154
Shock	AMD	Leadtek	0.02	0.8839
Shock	AMD	Litecoin	0.56	0.453
Shock	AMD	MSI	1.43	0.2315
Shock	AMD	nVidia	0.03	0.8622
Shock	AMD	PC Partner	1.64	0.1999
Shock	Asrock	AMD	6.86	0.0088
Shock	Asrock	Asustek	0.1	0.7514
Shock	Asrock	Biostar	17.32	<.0001
Shock	Asrock	Binance Coin	0.24	0.6235
Shock	Asrock	Bitcoin	2.9	0.0884
Shock	Asrock	ECS	4.47	0.0344
Shock	Asrock	Ethereum	15.53	<.0001
Shock	Asrock	Gigabyte	12.92	0.0003
Shock	Asrock	Intel	13.07	0.0003
Shock	Asrock	Leadtek	9.21	0.0024
Shock	Asrock	Litecoin	2.03	0.1538
Shock	Asrock	MSI	2.18	0.1395
Shock	Asrock	nVidia	21.24	<.0001
Shock	Asrock	PC Partner	3.42	0.0646
Shock	Asustek	AMD	3.22	0.0727
Shock	Asustek	Asrock	0.16	0.6931
Shock	Asustek	Biostar	4.86	0.0276
Shock	Asustek	Binance Coin	0.52	0.4705
Shock	Asustek	Bitcoin	1.07	0.2999
Shock	Asustek	ECS	13.42	0.0002
Shock	Asustek	Ethereum	0.35	0.5567
Shock	Asustek	Gigabyte	2.57	0.1087
Shock	Asustek	Intel	13.98	0.0002
Shock	Asustek	Leadtek	0.14	0.7113
Shock	Asustek	Litecoin	1.44	0.2309
Shock	Asustek	MSI	2.37	0.124
Shock	Asustek	nVidia	9.93	0.0016
Shock	Asustek	PC Partner	0.7	0.4016
Shock	Biostar	AMD	0.02	0.8855
Shock	Biostar	Asrock	13.06	0.0003
Shock	Biostar	Asustek	0.01	0.9075
Shock	Biostar	Binance Coin	1.39	0.239
Shock	Biostar	Bitcoin	8.09	0.0045

Shock	Biostar	ECS	0.04	0.836
Shock	Biostar	Ethereum	6.64	0.01
Shock	Biostar	Gigabyte	5.91	0.0151
Shock	Biostar	Intel	13.77	0.0002
Shock	Biostar	Leadtek	2.3	0.1291
Shock	Biostar	Litecoin	13.68	0.0002
Shock	Biostar	MSI	2.94	0.0866
Shock	Biostar	nVidia	8.53	0.0035
Shock	Biostar	PC Partner	0.06	0.8052
Shock	Binance Coin	AMD	0.53	0.4656
Shock	Binance Coin	Asrock	1.07	0.302
Shock	Binance Coin	Asustek	0.52	0.4712
Shock	Binance Coin	Biostar	2.98	0.0845
Shock	Binance Coin	Bitcoin	0	0.9897
Shock	Binance Coin	ECS	0.01	0.9324
Shock	Binance Coin	Ethereum	2.85	0.0913
Shock	Binance Coin	Gigabyte	4.48	0.0343
Shock	Binance Coin	Intel	3.49	0.0616
Shock	Binance Coin	Leadtek	1.76	0.1848
Shock	Binance Coin	Litecoin	1.99	0.1586
Shock	Binance Coin	MSI	13.42	0.0002
Shock	Binance Coin	nVidia	0.09	0.7633
Shock	Binance Coin	PC Partner	3.65	0.0559
Shock	Bitcoin	AMD	4.25	0.0393
Shock	Bitcoin	Asrock	2.46	0.1168
Shock	Bitcoin	Asustek	7.14	0.0075
Shock	Bitcoin	Biostar	0.91	0.3398
Shock	Bitcoin	Binance Coin	12.14	0.0005
Shock	Bitcoin	ECS	0.56	0.4547
Shock	Bitcoin	Ethereum	6.79	0.0091
Shock	Bitcoin	Gigabyte	1.96	0.1614
Shock	Bitcoin	Intel	1.71	0.1905
Shock	Bitcoin	Leadtek	0.08	0.7791
Shock	Bitcoin	Litecoin	0	0.9848
Shock	Bitcoin	MSI	0.86	0.3526
Shock	Bitcoin	nVidia	7.87	0.005
Shock	Bitcoin	PC Partner	0.14	0.7093
Shock	ECS	AMD	0.18	0.6704
Shock	ECS	Asrock	1.59	0.207
Shock	ECS	Asustek	0.15	0.7018
Shock	ECS	Biostar	3.28	0.0702
Shock	ECS	Binance Coin	0.28	0.5975
Shock	ECS	Bitcoin	0.18	0.6719
Shock	ECS	Ethereum	0.03	0.8561
Shock	ECS	Gigabyte	2.78	0.0957
Shock	ECS	Intel	5	0.0253

Shock	ECS	Leadtek	2.67	0.1024
Shock	ECS	Litecoin	0.63	0.4268
Shock	ECS	MSI	0.14	0.7106
Shock	ECS	nVidia	10.72	0.0011
Shock	ECS	PC Partner	1.33	0.2494
Shock	Ethereum	AMD	0	0.9583
Shock	Ethereum	Asrock	0.49	0.4854
Shock	Ethereum	Asustek	0.09	0.7668
Shock	Ethereum	Biostar	6.49	0.0109
Shock	Ethereum	Binance Coin	9.65	0.0019
Shock	Ethereum	Bitcoin	1.68	0.1949
Shock	Ethereum	ECS	0.18	0.6756
Shock	Ethereum	Gigabyte	0.28	0.5978
Shock	Ethereum	Intel	0.02	0.8924
Shock	Ethereum	Leadtek	0.44	0.507
Shock	Ethereum	Litecoin	0.51	0.4772
Shock	Ethereum	MSI	4.28	0.0386
Shock	Ethereum	nVidia	0.38	0.5403
Shock	Ethereum	PC Partner	1.27	0.2596
Shock	Gigabyte	AMD	2.07	0.1504
Shock	Gigabyte	Asrock	33.9	<.0001
Shock	Gigabyte	Asustek	10.9	0.001
Shock	Gigabyte	Biostar	25.31	<.0001
Shock	Gigabyte	Binance Coin	0.01	0.9193
Shock	Gigabyte	Bitcoin	1.52	0.2169
Shock	Gigabyte	ECS	1.73	0.1888
Shock	Gigabyte	Ethereum	0.05	0.8209
Shock	Gigabyte	Intel	30.18	<.0001
Shock	Gigabyte	Leadtek	40.26	<.0001
Shock	Gigabyte	Litecoin	0.13	0.7176
Shock	Gigabyte	MSI	2.2	0.138
Shock	Gigabyte	nVidia	37.44	<.0001
Shock	Gigabyte	PC Partner	5.14	0.0234
Shock	Intel	AMD	0.47	0.492
Shock	Intel	Asrock	10.25	0.0014
Shock	Intel	Asustek	9.97	0.0016
Shock	Intel	Biostar	9.71	0.0018
Shock	Intel	Binance Coin	0.87	0.3507
Shock	Intel	Bitcoin	0.19	0.6595
Shock	Intel	ECS	11.66	0.0006
Shock	Intel	Ethereum	0.77	0.3815
Shock	Intel	Gigabyte	11.04	0.0009
Shock	Intel	Leadtek	10.71	0.0011
Shock	Intel	Litecoin	0.04	0.8446
Shock	Intel	MSI	0.63	0.4279
Shock	Intel	nVidia	20.74	<.0001

Shock	Intel	PC Partner	2.49	0.1148
Shock	Leadtek	AMD	0.74	0.3902
Shock	Leadtek	Asrock	9.07	0.0026
Shock	Leadtek	Asustek	0.01	0.927
Shock	Leadtek	Biostar	12.19	0.0005
Shock	Leadtek	Binance Coin	8.7	0.0032
Shock	Leadtek	Bitcoin	7.64	0.0057
Shock	Leadtek	ECS	4.1	0.0429
Shock	Leadtek	Ethereum	3.75	0.0529
Shock	Leadtek	Gigabyte	18.85	<.0001
Shock	Leadtek	Intel	5.74	0.0166
Shock	Leadtek	Litecoin	8.76	0.0031
Shock	Leadtek	MSI	2.66	0.1029
Shock	Leadtek	nVidia	1.46	0.2275
Shock	Leadtek	PC Partner	4.77	0.029
Shock	Litecoin	AMD	0.06	0.8104
Shock	Litecoin	Asrock	7.4	0.0065
Shock	Litecoin	Asustek	0.01	0.9082
Shock	Litecoin	Biostar	4.39	0.0362
Shock	Litecoin	Binance Coin	4.64	0.0313
Shock	Litecoin	Bitcoin	0.02	0.8806
Shock	Litecoin	ECS	1.2	0.2741
Shock	Litecoin	Ethereum	0	0.984
Shock	Litecoin	Gigabyte	0.45	0.5022
Shock	Litecoin	Intel	0.11	0.7391
Shock	Litecoin	Leadtek	4.59	0.0322
Shock	Litecoin	MSI	0.67	0.4134
Shock	Litecoin	nVidia	0.2	0.6509
Shock	Litecoin	PC Partner	1.15	0.283
Shock	MSI	AMD	9.22	0.0024
Shock	MSI	Asrock	14.15	0.0002
Shock	MSI	Asustek	3.11	0.078
Shock	MSI	Biostar	6.78	0.0092
Shock	MSI	Binance Coin	7.42	0.0065
Shock	MSI	Bitcoin	0.5	0.4781
Shock	MSI	ECS	2.72	0.0989
Shock	MSI	Ethereum	2.7	0.1005
Shock	MSI	Gigabyte	8.7	0.0032
Shock	MSI	Intel	18.34	<.0001
Shock	MSI	Leadtek	9.53	0.002
Shock	MSI	Litecoin	0	0.9581
Shock	MSI	nVidia	15.54	<.0001
Shock	MSI	PC Partner	5.92	0.015
Shock	nVidia	AMD	0.32	0.5703
Shock	nVidia	Asrock	10.65	0.0011
Shock	nVidia	Asustek	1.09	0.2955

Shock	nVidia	Biostar	3.34	0.0675
Shock	nVidia	Binance Coin	1.65	0.1986
Shock	nVidia	Bitcoin	2.94	0.0862
Shock	nVidia	ECS	5.92	0.0149
Shock	nVidia	Ethereum	1.16	0.2806
Shock	nVidia	Gigabyte	12.97	0.0003
Shock	nVidia	Intel	12.85	0.0003
Shock	nVidia	Leadtek	0.05	0.8152
Shock	nVidia	Litecoin	0.37	0.5415
Shock	nVidia	MSI	5.91	0.0151
Shock	nVidia	PC Partner	0.76	0.3821
Shock	PC Partner	AMD	2.91	0.088
Shock	PC Partner	Asrock	1.2	0.2738
Shock	PC Partner	Asustek	0.54	0.4634
Shock	PC Partner	Biostar	0.87	0.352
Shock	PC Partner	Binance Coin	7.4	0.0065
Shock	PC Partner	Bitcoin	5.83	0.0157
Shock	PC Partner	ECS	0	0.9687
Shock	PC Partner	Ethereum	3.31	0.0689
Shock	PC Partner	Gigabyte	2.48	0.1151
Shock	PC Partner	Intel	6.29	0.0121
Shock	PC Partner	Leadtek	1.89	0.1695
Shock	PC Partner	Litecoin	2.69	0.1011
Shock	PC Partner	MSI	1.9	0.1685
Shock	PC Partner	nVidia	28.8	<.0001