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DIGITAL ASSETS AS AN ASSET CLASS: FACTOR CREATION AND INTEGRATION WITHIN BPI GA FUNDS

Individual part:
DIGITAL ASSET ECOSYSTEM'S IMPACT ON THE SOFTWARE INDUSTRY

Carolina Hasslocher (49722)

Work project carried out under the supervision of:

Professor Emanuele Rizzo

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Abstract

In this paper, we aim to determine whether there is a risk premium captured by the digital asset ecosystem and how it affects the performance of BPI Gestão de Ativos (or "the client") equity funds. We found significant evidence of the influence of the digital asset space over BPI GA funds' performance. Further, assessing to what extent it impacts the software industry. My findings suggest that, even though a significant impact should be theoretically expected, quantitatively no significant exposure was found.

Keywords: Asset Pricing, Risk Factors, Factor Models, Cryptocurrency

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1. Introduction

Digital assets are disrupting the financial ecosystem, representing a controversial new asset class that has parted investors' judgement. On the one hand, optimists find digital assets to be the logical evolutionary step of a digital transformation era. On the other hand, sceptics perceive them as an overhyped form of imaginary value storage. Warren Buffet has been vocally positioning himself against digital assets. In a myriad of occasions, he expressed his disbelief towards cryptocurrencies, referring to Bitcoin as "probably rat poison squared" (CNBC, 2018), later ensuring he would not buy all the bitcoin in the world for $25 US dollars (CNBC, 2022). Then again, Buffet's perspective is legitimated by one of his most cited quotes:

“Never invest in a business you cannot understand”. Likewise, our research will be conducted based on that preceding ideology.

Ergo, our work project will initially focus on providing BPI GA an insightful picture of the digital asset landscape, whereupon we will address it from the investors’ side, guiding BPI GA through the evolution of investments carried out in this progressive ecosystem, as well as delving into investment strategies taken by the big players.

The final step is to develop a factor capable of justifying portfolio’s returns based on its exposure to digital assets, namely, cryptocurrencies. Wherefore, a value-weighted portfolio of the top ten cryptocurrencies (excluding stablecoins) was created and further used as a benchmark for the digital asset ecosystem, pending the factor derivation. That portfolio was incorporated in five distinct weekly and monthly regressions on BPI GA funds, along with both the 3 and 5 Fama-French factors, as well as supplemental factors (Momentum and Quality minus Junk). The models aimed to assess to what extent the crypto could explain BPI GA funds’ returns and infer whether a factor creation would behold meaningful results, i.e., capture variations across the funds.

Afterwards, based on two separate methods, we gathered the most cryptocurrency-correlated stocks to create the long leg, the least correlated for the short leg, and combined both into a long-short factor. This was used to model two sets of regressions, with rolling and static correlations, for two distinct approaches regarding the dataset selection, thus totaling four factors created.

Thereupon, a robustness check was performed to assess each factor’s accuracy when it comes to mimicking the crypto portfolio. Once determined the most suitable factor, we analyzed its exposure over the BPI GA funds, based on which we reckoned whether the factor

is a good proxy for the digital asset ecosystem. Ultimately, conclusions and limitations were drawn.

In summary, the thesis intends to test two hypotheses. First, that BPI GA funds' returns are, to some extent, explained by the digital asset ecosystem. Secondly, that a factor representing the digital asset universe can be significant.

2. Literature Review

2.1. Factor Models

Markowitz (1952) developed a framework for analyzing the relationship between the return and the risk of a security. Markowitz pioneered the Modern Portfolio Theory (MPT), also known as mean-variance analysis, demonstrating that a portfolio's volatility can be reduced by mitigating idiosyncratic risk through diversification. Therefore, investors should only be compensated for bearing systematic (non-diversifiable) risk. This means that in an efficient marketplace, investors can only obtain higher returns if they bear more systematic risk. The

Capital Allocation Line (CAL), in **Equation 1** below, depicts the linear relationship between a security's return and volatility, and it is given by the following equation:

$$(1)\ E\left[r_p\right] = r_f + \frac{E[r_i]-r_f}{\sigma_i} \times \sigma_p$$

- r_f is the risk-free rate
- $E[r_i]$ is the expected return of the risky asset *i*
- σ_i is the standard deviation of the risky asset *i*
- $E\left[r_p\right]$ is the expected return of a portfolio, *p* comprised of a single risky asset, *i*, and the riskless asset, r_f
- σ_p is the volatility of portfolio *p*

The Capital Asset Pricing Model (CAPM), of William Sharpe and John Lintner was the first theory that aimed to describe the relationship between a security's return and market (systematic) risk. The CAPM assumes that investors are mean-variance optimizers and therefore lie on the CAL, combining the tangency portfolio with the risk-free asset. In equilibrium, the aggregate demand for risky assets is the market portfolio of assets. Thus, the tangency portfolio is the Market portfolio, and the CAL is henceforth designated as the Capital Market Line, as all rational investors should hold the market portfolio in different quantities. Under the CAPM, the market risk is the sole source of risk that can affect an asset's returns. Hence, the expected return on a given security can be split into the risk-free rate and the market risk premia, $E[(r_M) - r_f]$, accounting for that security's exposure to the market itself, β. As such, the CAPM is given by **Equations 2** and **3**.

$$(2)\ E[r_i] = r_f + \beta_i \times E[(r_M) - r_f]$$

$$(3)\ \beta_i = \frac{Cov(r_i,r_M)}{\sigma^2(r_i,r_M)}$$

Fama and French (2003), among other authors demonstrated that the CAPM fails to explain stock returns. The Arbitrage Pricing Theory (APT) of Ross (1976) poses as an alternative to the model introduced by Sharpe and Lintner, considering several macroeconomic factors that entail systematic risk that cannot be diversified away and thus influence a security's returns. A factor can be viewed as a specific characteristic inherent in a group of securities that is able to explain both their return and risk. However, unlike the CAPM, the APT does not explicitly state what those factors are. In fact, there are *k* sources of systematic risk that drive an asset's returns. The APT is given by **Equation 4**.

$$(4)\ r_{i,t}^{e} = \beta_{i1}\lambda_{1,t} + \beta_{i1}\lambda_{2,t} + \cdots + \beta_{ik}\lambda_{k,t} + \varepsilon_{i,t}$$

- r_i^e is the excess return of security *i* for period *t*
- β_{ik} is the exposure of security *i* to factor *k*
- λ_k is the risk premia of factor *k* for period *t*

Beyond the CAPM, i.e., the market risk factor, academics usually look for factors that persist over time and that can be applied to abroad range of securities (Bender, et al. 2013). Connor (1995) divides multifactor models into three categories. Macroeconomic models, using variables such as interest rates and inflation. Statistical models, which derive factors from statistical analysis. Lastly, fundamental factor models use specific attributes in stocks to explain returns, like return on equity (ROE), the price-to-earnings (P/E) ratio or the market capitalization.

Banz (1981) previously found a significant size effect, inferring that, on average, small firms have earned higher risk adjusted returns than larger ones. Moreover, Basu (1977) showed that stocks with low P/E ratios have earned, on average, higher risk adjusted returns than high P/E ones. This suggests that there might be value and size risk premiums, not captured by the CAPM, that can predict returns. Following the research conducted by Basu (1977) and Banz

(1981), the Fama-French Three-Factor Model (FF3M) of Fama and French (1996) using market, value and size factors, shows that the ratio between the book value and the market value of a firm's equity, as well as its size, are powerful predictors of its returns. Fama and French argue that firms with a high book-to-market ratio are more likely to be financially distressed and that small market capitalization stocks are likely more prone to changes in economic and business conditions (Bodie, et al., 2014). The FF3M model can be described by **Equation 5**.

$$(5)\ r_i^e = \alpha_{i,t} + \beta_{i,M} r_{M,t}^e + \beta_{i,\mathrm{SMB}}\mathrm{SMB}_t + \beta_{i,\mathrm{HML}}\mathrm{HML}_t + \varepsilon_{\mathrm{i,t}}$$

- r_i^e is the excess return of security *I* for period *t*
- $r_{M,t}^e$ is the market risk premia for period *t*
- SMB_t is the size premia (Small Minus Big) for period *t*
- HML_t is the value premia (High Minus Low) for period *t*
- $\beta_{i,M}$, $\beta_{i,\mathrm{SMB}}$ and $\beta_{i,\mathrm{HML}}$ are the factor coefficients

SMB is the return that a portfolio of small market capitalization stocks earns in excess of the return on a portfolio of large cap stocks. HML is the return that a portfolio of stocks with a high book-to-market ratio earns in excess of the return on a portfolio of stocks with a low book-to-market ratio. The factor model in (5) seems to explain the majority of cross-sectional variance in average returns (Fama & French, 1996). However, motivated by the findings of a profitability premium by Novy-Marx (2013) and of the impact of capital investments on stock returns by Titman, et al. (2004), Fama and French (2014) recognize that (5) is an incomplete model, as it does not explain much of the variation in average returns driven by profitability and investment patterns. Hence, Fama and French added profitability and investment factors to the FF3M. This model is depicted in **Equation 6**.

$$(6)\ r_i^e = \alpha_{i,t} + \beta_{i,M} r_{M,t}^e + \beta_{i,\mathrm{SMB}}\mathrm{SMB}_t + \beta_{i,\mathrm{HML}}\mathrm{HML}_t + \beta_{i,\mathrm{RMW}}\mathrm{RMW}_t + \beta_{i,\mathrm{CMA}}\mathrm{CMA}_t + \varepsilon_{\mathrm{i,t}}$$

- RMW_t is the profitability premia (Robust Minus Weak) for period *t*

- CMA_t is the investment premia (Conservative Minus Aggressive) for period *t*
- $\beta_{i,\mathrm{RMW}}$ and $\beta_{i,\mathrm{CMA}}$ are the factor coefficients

RMW stands for the "difference between the returns on diversified portfolios of stocks with robust and weak profitability", while the CMA factor is "the difference between the returns on diversified portfolios of the stocks of low and high investment firms" (Fama & French, 2014). The factor model described in (6) is able to explain more of average stock returns than the FF3M. However, it fails to justify low average returns on small stocks.

The Carhart Four-Factor Model (FFCM) represents an extension of the FF3M in the sense that it includes one extra factor, momentum (Carhart, 1997). Previous research by Jegadeesh and Titman (1993) found that momentum strategies, i.e., investing in stocks that historically performed well and shorting the ones that historically performed poorly, yield significant and positive returns over holding periods spanning from 3 to 12 months. Furthermore, Jegadeesh and Titman (2001) substantiated those findings by stating that momentum strategies have shown to consistently deliver significant returns, not only in the United States, but also in other developed economies. The FFCM is described by **Equation 7**.

$$(7)\ r_i^e = \alpha_{i,t} + \beta_{i,M} r_{M,t}^e + \beta_{i,\mathrm{SMB}}\mathrm{SMB}_t + \beta_{i,\mathrm{HML}}\mathrm{HML}_t + \beta_{i,\mathrm{MOM}}\mathrm{MOM}_t + \varepsilon_{\mathrm{i,t}}$$

- MOM_t is the momentum premia for period *t*
- $\beta_{i,\mathrm{MOM}}$ is the factor coefficient

Asness, et al. (2013) documented the existence of the quality anomaly. The authors defined three critical attributes in a stock that determine its quality, for which investors are willing to pay more for. Profitability, measured by indicators like gross profits, margins, earnings, accruals, and cash flows; growth, captured by the five-year growth in each of the previously mentioned profitability metrics; and safety, measured by return and fundamental-

based measures of safety. On average, the prices of quality stocks are higher than the ones of companies that exhibit a lack of profitability, growth, and safety. Pioneered by AQR Capital Management, the Quality Minus Junk (QMJ) factor is constructed by going long on high-quality stocks and shorting low-quality i.e., junk stocks. This investment strategy is able to earn significant risk-adjusted returns in developed economies (AQR Capital Management, 2022). QMJ is a result of the average returns of two quality portfolios, sorted on size, minus the returns of two junk portfolios, also sorted on size (Larsson & Annink, 2019).

2.2. Cryptocurrency Factors

The literature suggests that macroeconomic factors have a significant impact on cryptocurrency prices. Van Wijk (2013) explained how the price of Bitcoin is affected by global macro-financial developments, which is captured, for instance, by stock market indices, exchange rates, and oil price indicators. Van Wijk finds proof that factors like the Dow Jones index, the euro-dollar exchange rate, and the price of oil, for instance, have a major influence on the value of Bitcoin on the long run. However, Ciaian, et al. (2016) suggested that global macro-financial developments had a significant impact on Bitcoin price only on the short run, while in the long run, the Dow Jones index, exchange rate and oil prices do not determine the price of Bitcoin. Dyhrberg (2016) found that interest rates and Bitcoin are positively correlated. The increase in interest rates will cause the USD exchange rate to appreciate, boosting demand for imports, which will probably lead to an increase in online sales or shopping. Zhu, et al. (2017), analyzed monthly data from 2011 to 2016 and found that factors such as CPI, US Dollar Index, Dow Jones Industry Average, Federal Funds Rate and price of gold all have along term impact on Bitcoin price, esepcially the US Dollar Index.

Amidst periods of high inflation, investors attempt to maintain their purchasing power by investing in assets like gold, real estate and stocks. The emergence of cryptocurrencies has opened the path for investing in a new alternative inflation hedge. Conlon, et al. (2021) assessed

the ability of Bitcoin and Ethereum to serve as a hedge against future inflation expectations. The authors indicate that cryptocurrencies do not offer consistent hedging properties and argue that Bitcoin and Ethereum "may derive price-related information from factors common to forward inflation expectations during times of crisis."

Hougan and Lawant (2021) analyzed 90-day rolling correlations between Bitcoin and U.S. large and small-cap stocks, emerging market equities, gold, commodities, corporate bonds (high-yield and investment grade), as well as emerging currencies, from January 1st, 2017, to September 30th, 2022. The authors found evidence to support the claim that the correlation between Bitcoin returns and traditional assets have historically been low, except for when the COVID-19 pandemic hit in the beginning of 2020.

Havidz, et al. (2021) analyzed the impact of foreign exchange, stock market, interest rates, gold and liquidity ratio on Bitcoin from 2017 to 2019. Using cross-section data for stock market indices, exchange rates and interest rates across eighteen countries, the authors found that foreign exchange and the price of gold, have a positive and significant effect over the price of Bitcoin. Liquidity was found to be the strongest factor when it comes to explaining Bitcoin's price, through an increase in its demand. Furthermore, an increase in interest rates was found to have a significant and negative impact on Bitcoin returns. While the stock market also showed a negative effect, it was found to be insignificant.

3. Client Overview

BPI Gestão de Ativos – Sociedade Gestora de Organismos de Investimento Coletivo, S.A, (BPI GA), was established in 1990 and since then, it has become the third largest asset manager in the Portuguese Undertakings for Collective Investment in Marketable Securities market, with a market share of 17.15 percent as of December 31, 2021. According to its latest annual report, BPI GA's strategy is based on adapting its client offering and portfolios to market

conditions. It can therefore, over time, opt for different combinations of products and exposures to the various financial risks to which the portfolios are naturally subject (BPI Gestão de Ativos, 2021).

Following the takeover of BPI by CaixaBank on April 13, 2018, BPI GA became a fully owned subsidiary of CaixaBank Asset Management, the leading management company in Spain in terms in terms of assets under management (AuM), with over €92 billion euros under management and advice, managing over 400 portfolios, including funds, SICAVs and discretionary management portfolios (CaixaBank Asset Management, 2022).

During the fiscal year of 2021, BPI GA reported a net income of €10.899 million euros and had €8,765 million euros of AuM at year-end, representing an increase of 21 percent in comparison to the homologous period. The company's activity is focused on managing fixed-income and equity mutual funds, accounting for 46 percent of AuM, unit-linked life-insurance products (40 percent), real estate investment funds (7 percent) and discretionary management portfolios (7 percent).

4. The Digital Asset Ecosystem

4.1. General Overview

This century marked the beginning of a new era, the age of digital transformation, characterized by a paradigm shift in several industries and economies. Financial markets are no exception to this, with the digital revolution driving innovation in financial operations on a global scale, culminating with the emergence of the digital asset market. Digital assets are anything that is minted and exchanged on a blockchain, representing value for the owner. With the digitalization of both currencies and investment assets, the digital asset space is becoming integrated in the contemporaneous traditional financial markets. In fact, Bitcoin was considered

the best performing asset of the decade, presenting returns ten times higher than the Nasdaq 100 Index (Sriram, 2021).

In terms of market capitalization, it is still very volatile. Following its peak in November 2021, the total market value of digital assets halved from $3 trillion USD to $1.5 trillion USD in just four months (Hoang, 2022). As of right now, based on the sum of values, that will further be presented individually, of the different types of digital assets that integrate the ecosystem, their market capitalization is about $0.8 to $0.9 trillion USD, with cryptocurrency representing more than 95 percent. However, unlike previous fluctuations driven mostly by speculation, the loss of value currently observed is perceived as a result of macroeconomic conditions e.g., inflation and rising interest rates, which are affecting most asset classes, which will be further addressed. Altogether, contrary to past expectations, digital assets are not the key to hedge against traditional investments, placing no longer on the fringe of the financial system.

Due to its complex and highly fragmented nature, it is crucial to make a clear distinction between the different types of assets that make up the digital asset market. Thus, we decided to break it down to four categories to be further elaborated: Cryptocurrency and Stablecoins, Non-Fungible Tokens (NFTs), Security Tokens, and Central Bank Digital Currencies (CBDCs).

4.2. The Evolution of Digital Assets and Blockchain

In 2008, less than two months after the collapse of Lehman Brothers, Satoshi Nakamoto published a paper that defended a purely peer-to-peer electronic cash system that would allow online payments to be sent directly from one party to another without the need for a financial institution as an intermediary (Nakamoto, 2008). At the core of this concept is a foundational technology with the disruptive power to change how economic agents interact with each other, called the blockchain. To this day, the identity of Nakamoto has yet to be uncovered.

In 2013, Ethereum was invented with smart contract technology. Smart contracts are computerized transaction protocols that execute the terms of a contract (Szabo, 1994). A specific event, such as the target price being met, or the date expiring causes the contract's terms to take effect. They differ from traditional contracts as the terms of the agreement are written and established as code on the blockchain and are therefore immutable and distributed. Some potential use cases of smart contracts include real estate transactions (digitally store the record of loan information against collateral), trade finance, supply chain management, insurance, inter alia.

From 2017 to 2018, we witnessed the so-called Initial Coin Offering (ICO) boom. According to CB Insights, total capital raised by ICOs amounted to $10 million USD in the first quarter of 2017. In the following quarter, that number jumped to $950 million USD, summing up to an estimated $6,450 million USD by year-end. The pace of funding gained further pace in the following year, with $12,620 million USD raised by the end of 2018, peaking at $6,880 million USD during the first quarter of that same year (CB Insights, 2019). Furthermore, the year of 2017 was denoted by the emergence of blockchain consortia, as many companies strived to capitalize on the power of blockchain to boost operational efficiency, while allowing for new business models and customer solutions.

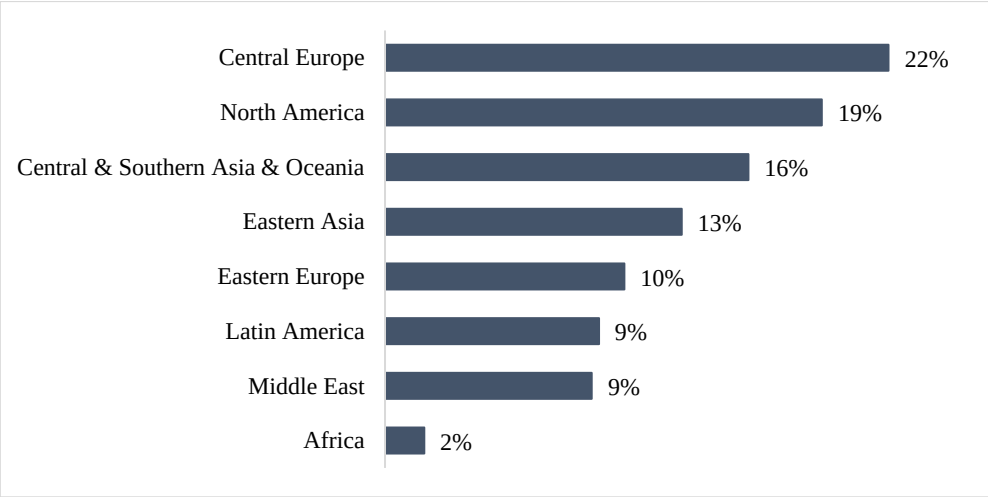
Lastly, in 2020, we saw new applications of blockchain emerging, namely NFTs, play-to-earn games and the metaverse. Moreover, governments started to consider nationwide adoption of cryptocurrency, namely CBDCs, which we fill further explore.

4.3. Geographical Breakdown

As supported by **Figure 1**, Central, Northern and Western Europe are currently the hub of the digital economy, accounting for nearly 22 percent of global cryptocurrency value received. Followed by North America with 19 percent, and Central and Southern Asia and

Oceania with 16 percent. Prior to September 2021, Eastern Asia used to dominate the cryptocurrency market. However, it now only accounts for 13 percent of global transactions, which was mainly driven by China's ban on cryptocurrency mining and trading activities, a topic we will further address in this report. The emergence of Central Europe as a digital hub was mainly driven by DeFi activity and is also shaped by the current regulatory environment in many countries in the EU, including Portugal, in which capital gains on cryptocurrency are not subject to taxes. Despite ranking last, the African region had the fastest adoption rate of cryptocurrencies in the world, rising 1,200 percent from July 2020 to June 2021 (The Africa Report, 2021). It goes without saying that the lack of technological advancements and access hurdles in the African region compromises its transaction volume, especially due to the disparity within different countries of the Continent. For instance, African countries like Nigeria and Kenya, ranked 11th and 19th on the Global Crypto Adoption Index (Chainalysis, 2022), whereas other less developed African countries were placed on the bottom of the ranking.

Figure 1: Share of cryptocurrency value received by region. Source: (Chainanalysis, 2022)



4.4. Growth Drivers and Restrains

As with every investment opportunity, there are always two sides of the coin that compose the growth drivers/restrains binomial. Firstly, the decentralization helps to keep the currency monopoly free, so no single institution can determine the flow and the worth of the coin, which will in turn safeguard it from an institution's collapse and malpractices, unlike fiat currencies that are controlled by the government. Withal, by assuring transparent and real-time data access to the investors, DeFi promotes financial independence, assigning the power entirely to the investor without jeopardizing privacy.

Secondly, the lack of value previously ascribed to digital assets has been defied by an increasing acceptance within value chain, with more institutions adopting digital assets as a payment source. According to a survey conducted by Deloitte in December 2021, covering a pool of 2,000 senior executives at retail organizations across the consumer goods and services industry in the United States, nearly 75 percent of those inquired reported plans to accept stablecoin payments and roughly the same percentage reported plans to accept cryptocurrency payments, both within the next 24 months. Nearly all respondents agreed that during the next few years, more consumers would start using digital currencies to perform routine, daily transactions (Deloitte, 2021).

Furthermore, the ease and reliability of exchanging digital asset took a notable step with the introduction of smart contracts, as they can limit and even eliminate intervention by the participating parties (IBM, 2022). The absence of these possible frictions offers blockchain users, both a fast and a vast exchange experience, replacing some traditional financial contracts. The next logical evolutionary step involves Artificial Intelligence (AI), making smart contracts even "smarter" by moving to more adaptive contracts. By efficiently training algorithms on the data to derive insights, AI can be synergistically combined with smart contracts to capitalize the virtues of each and uncover another level for financial contracts (The CPA Journal, 2022).

Lastly, on account of the restrictions associated to Covid-19, there was an urge to accelerate the digital transformation that was theretofore gradually taking place. People and institutions were forced to adopt technological measures. This digital reliance instigated by the pandemic, was the push needed to overcome some of the skepticism hovering digital assets. A more substantiated clarification on this subject will be further provided.

As for restrains that impact the growth of digital assets, high volatility has infamously been associated with this asset class. Foremost, Bitcoin, and the subsequent cryptocurrencies, were propelled by a frenetic state of volatility, and even though some crypto enthusiasts are, counterintuitively, lured by that hostile rhythm, a substantial share of investors find that discouraging and take an apprehensive position (Bloomberg, 2022). The intangibility property of digital assets, their immature state, as well as their speculative-based valuation, are often pointed as the underlying causes for the recurrent fluctuations. However, as it matures, there is a tendency for digital asset's volatility to stabilize (Bitcoin Volatility Index, 2022). As a matter of fact, in October 2022 Bitcoin's volatility dropped below the Nasdaq and S&P 500's for the first time in two years (CNBC, 2022).

On another note, there are a lot of legal gray areas preventing investors from taking more risks. Regulation widely varies depending on the local government and there are still countries without clear guidelines. In addition, cryptocurrencies are notoriously associated with fraudulent activities and black-market sales. In 2021, there were roughly $14 billion USD worth of fraudulent transactions, representing an increase of 79 percent when compared to the previous year, mainly driven by the rise of DeFi (Chainanalysis, 2022). All things considered, this asset class is overly discarded by risk averse investors, thanks to its inherent high degree of uncertainty and unpredictability. Thusly, and imparting the limitations on digital asset's historical data[1], the most common financial models, like discounted cash-flow models or valuation multiples, are not suitable to derive the intrinsic value of a digital asset. Lastly, the process behind digital transactions requires massive amounts of energy consumption, a topic which will be further addressed.

4.5. Portugal's Take on Digital Assets

It is noteworthy to outline that Portugal is considered one of the most crypto-friendly countries in the world (Bloomberg, 2022). The Portuguese population has a low appetite for risk, being more prone to invest in less risky assets such as properties and savings[2], it goes without saying that we are not the type of culture that would heavily invest in this new asset class, with only 2 percent of Portuguese investors committing to cryptocurrencies in 2021 (CMVM, 2021). We therefore ask ourselves why Portugal is on the spotlight.

This is mainly driven by the fact that it is currently one of the few countries that do not impose a tax on capital gains from cryptocurrency trading, although a 28% taxation on short-term gains on digital assets is expected to be implemented in 2023 (Bloomberg, 2022). On top

[1] Within the different types of digital assets, we have distinctive timelines. Historical data might be unavailable.
[2] Based on a report conducted by KPMG and VVA, in cooperation with the European Commission, 52 percent and 19 percent invest in properties and savings respectively (CMVM, 2021).

of that, Portugal offers attractive tax incentives for high net-worth individuals, like the Golden Visa, and, more recently, the Digital Nomad Visa (Bloomberg, 2022) that might potentially be a strategy to compensate for the new upcoming taxation. Tough, Pedro Borges, founder of CriptoLoja, Portugal's first crypto trading platform registered with the Bank of Portugal, believes taxation to be a favorable step towards the way Portuguese banks perceive crypto (Bloomberg, 2022), amid clearer regulation, institutional investment in digital assets is more likely to thrive in our country. These factors, allied with great weather, affordable living costs, an English proficient population[3] and safety conditions[4], is luring nomads and other individuals who invest in digital assets, to pursuit a quality of life and stability that characterize Portugal. In fact, based on the Work from Wherever Index [5], Portugal was considered the best country to work remotely in 2022 (Kayak, 2022).

Furthermore, according to a survey conducted by EY, based on a representative panel of 200 international decision-makers, that intended to assess Portugal's attractiveness in terms of Foreign Direct Investment (FDI), Portugal is perceived as the comfort zone for investors to deal with uncertainty (EY, 2022). In 2022, our country's attractiveness increased substantially, with more than 60 percent of surveyed investors stating they had plans to invest in Portugal within the next year, compared to 37 percent in 2021 (EY, 2022). Interestingly, the digital economy is at the top of investors' interest, with 52 percent of investors expecting it to be the business sector that will drive Portugal's growth in the coming years, far above cleantech and renewables (29 percent), and real estate and construction (28 percent) (EY, 2022). Moreover, the Software and Information Technology (IT) services sector dominated the FDI investments in 2021, accounting for roughly 30 percent, more than twice the share of the next in order sector

[3] Portugal ranked 7th and 9th on the English Proficiency Index of 2021 and 2022, respectively (EF EPI, 2022)
[4] Portugal ranked 4th and 6th on the Global Peace Index of 2021 and 2022, respectively (IEP, 2022).
[5] Covering 111 countries.

(EY, 2022). FDI in the digital asset space looks promising, placing Portugal on an optimistic scenario for digital assets.

4.6. Breakdown

4.6.1. Cryptocurrency

Evolution of Cryptocurrency

Since Satoshi Nakamoto published his white paper entitled «Bitcoin: A Peer-to-Peer Electronic Cash System», which eventually led to the birth of Bitcoin, the first cryptocurrency, many other coins have now become part of the cryptocurrency landscape. As of November 2022, there are over 20,000 coins available across more than five hundred exchanges globally, representing a total cryptocurrency market capitalization, including stablecoins, of $837,456 million USD (CoinMarketCap, 2022). All other coins other than Bitcoin are referred to as *altcoins*. Despite numerous coins being launched since Bitcoin in 2008, it has always retained its dominance, remaining the largest coin by market capitalization. That is the reason Bitcoin is often referred as the "King of Crypto". Its market capitalization evolution is depicted in **Graph 1**.

Graph 1: Evolution of Bitcoin market cap, in millions of USD. Source: Nasdaq (2022)

In the beginning of 2014, Bitcoin dominated the market with approximately 88 percent of market share. By the beginning of 2017 that number had dropped to an all-time low of circa 32 percent, mainly driven by the ICO boom that occurred during 2017 and 2018, coupled with the rise of Ethereum as the second-largest coin by market cap during that same period (CoinMarketCap, 2022). As of November 2022, Bitcoin had 38.5 percent of market share, followed by Ethereum with 17.8 percent. From **Graph 1** we can see that Bitcoin's market capitalization started to rise in late 2020. With the COVID-19, investment in Bitcoin grew, as fears of inflation became a pressuring concern across the globe. Entering in 2021, Bitcoin experienced a steep surge in price, driven by a crypto rally across institutional and retail investors, and also fueled by the emergence of DeFi. In late July 2021, Bitcoin's market cap dropped to $556 billion USD, coinciding with a drop in stock markets worldwide, driven by fears that the COVID-19 Delta variant could set back economies worldwide. Bitcoin hit its all-time high capitalization of nearly $1.28 trillion USD in November 2021 and, one year later, now sits at approximately $317 billion USD (Nasdaq, 2022), leading to the so-called crypto winter. This bearish digital market we are currently witnessing is likely attributable to, not only the current macroeconomic landscape, but also by the scandals that have rocked the cryptocurrency market over the crypto world over the last year.

Altcoins

Ethereum is currently the largest coin after Bitcoin, with a market cap of $147,860 million USD as of the date of writing this report (CoinMarketCap, 2022). Ethereum is a decentralized, open source blockchain and it includes its own coin, Ether (ETH). It was initially introduced by Vitalik Buterin in 2013 and it officially went live in 2015 (CoinMarketCap, 2022). Ethereum is an extension from the Bitcoin blockchain, in the sense that it allows for the execution of smart contracts, that eventually gave rise to Decentralized Applications (dApps) and Decentralized Finance (DeFi). Under the Ethereum blockchain other cryptocurrencies i.e.,

"tokens", can be built on top of it, like the stablecoins Tether (USDT), USD Coin (USDC) and Binance USD (BUSD). Ethereum tokens entail a significant market share, with a market capitalization of approximately $221 billion USD, which translates to a sector dominance of 27 percent (CryptoSlate, 2022).

Stablecoins are a specific type of cryptocurrency designed for price stability, whose value is pegged to other assets, such as commodities or other crypto assets. However, the most widespread use case for stablecoins is for fiat currency, essentially being used as a mean of exchange. For consumers, similarly to some cryptocurrencies, stablecoins can offer attractive, high yields on USD deposits through a process called staking, in which the holder receives a reward simply by holding the cryptocurrency for a certain amount of time. Depending on the type of stablecoin, it may or may not hold reserve assets. To maintain their peg, fiat-collateralized coins must hold a reserve of the fiat currency itself or commodities. Crypto-collateralized coins hold reserves of other cryptocurrencies. Algorithmic stablecoins preserve their value through an algorithm. As opposed to fiat currency, these coins provide investors with same benefits of "traditional" cryptocurrencies, while minimizing volatility. Nevertheless, they represent a relatively new kind of investment, with the first stablecoin, BitUSD being launched in 2014. Furthermore, they certainly do not come without risks, as on May 9, 2022, the algorithmic coin TerraUSD (UST) lost its peg to the U.S. Dollar, plunging to $0.18 in just a week. (CoinMarketCap, 2022). According to CoinMarketCap, it went from being the tenth-largest cryptocurrency worldwide, with a market capitalization of $18.6 billion USD on May 8, 2022, to less than $1 billion USD by May 20, 2022.

With a market capitalization surpassing $65 billion USD, Tether (USDT) is the largest stablecoin. It is a fiat-collateralized coin that maintains its 1:1 ratio to the U.S. Dollar by holding a mix of cash and cash equivalents, as well as corporate bonds, funds, and precious metals. To provide transparency to investors, Tether's reserves are subject to quarterly independent

assurance reports conducted by BDO Italy (Tether, 2022). Together with USD Coin (USDC), Binance USD (BUSD) and Dai (DAI), these four currencies have a combined market capitalization of more than $138 billion USD, effectively representing around 17 percent of the overall cryptocurrency market (CoinMarketCap, 2022).

According to CoinMarketCap (2022), the remainder of the cryptocurrency market is split between more than 21,000 coins that make up circa 26 percent of market share. We would like to highlight Binance Coin (BNB), the currency that was developed by Binance in July 2017, the largest crypto exchange globally, fueling its ecosystem. With a market cap of more than $42 billion USD, it ranks as the fifth largest coin worldwide, accounting for nearly 5 percent of the market. Ripple (XRP) with a share of 2.3 percent of the total market is a payment settlement currency. Cardano (ADA) with a 1.4 percent market share is considered as an alternative to ETH, while Dogecoin (DOGE), which is regarded as a *memecoin* i.e., a cryptocurrency that originated from a meme or that was created as a joke, accounts for 1.3 percent of the market and has no apparent use cases.

Cryptocurrency Derivatives

As cryptocurrency finds its way into traditional markets, we have witnessed the emergence of crypto derivatives. Much like the derivatives that trade on the financial markets, these financial instruments are traded on designated exchanges. As of November 2022, there are currently forty-three crypto derivatives exchanges, with Binance being by far the largest one, with a daily trading volume surpassing $31 billion USD (CoinMarketCap, 2022). In fact, cryptocurrency derivatives make up more than half of the overall crypto trading volume, rising to 69 percent in July 2022, which translates to $3.12 trillion USD (Reuters, 2022). In parallel to traditional markets, digital asset derivatives exist in the form of swaps, futures, forwards, and options, while structured products and exotics are still in development. The reason for why one

investor might choose to trade them instead of the spot currency pertains to the fact that crypto derivatives, besides offering the ability to enact on speculation and to hedge, are subject to a different regulatory framework that allows them to trade on regular exchanges, while the spot currency cannot, which we will further addressed on the topic of investments in digital assets.

4.6.2. Non-Fungible Tokens

Overview

Non-Fungible Tokens (NFTs) are blockchain-based digital items whose units are designed to be unique, unlike traditional cryptocurrencies whose units are meant to be interchangeable, therewith, the non-fungible nomenclature. NFTs can store data on blockchains, containing media such as images, videos, audio, and other online collectibles. That data is tokenized, and its ownership is sold to the holder on specialized marketplaces. Most NFTs are part of the Ethereum blockchain and the properties of each NFT can be specified through smart contracts.

Attributable to its intrinsic unique characteristics, NFTs are categorized as a high-risk asset (Nansen, 2022). Hence, investors gravitate towards a more prudent approach, with around half of the recorded NFT sales exchanging for less than $200 USD (Nansen, 2022). Based on the adoption profile, it is interesting to find similar adoption rates across both ends of the wealth spectrum. In fact, the predisposition of individuals with a maximum annual income of $25,000 USD is equivalent as of high-income individuals (>$150,000 USD a year) (Nansen, 2022). Ultimately, NFTs derive their value largely from the strength of the community that supports them (Nansen, 2022). Thus, having access to the right channels e.g., Twitter[6] and Reddit, is of utmost importance to carry out proficient investments.

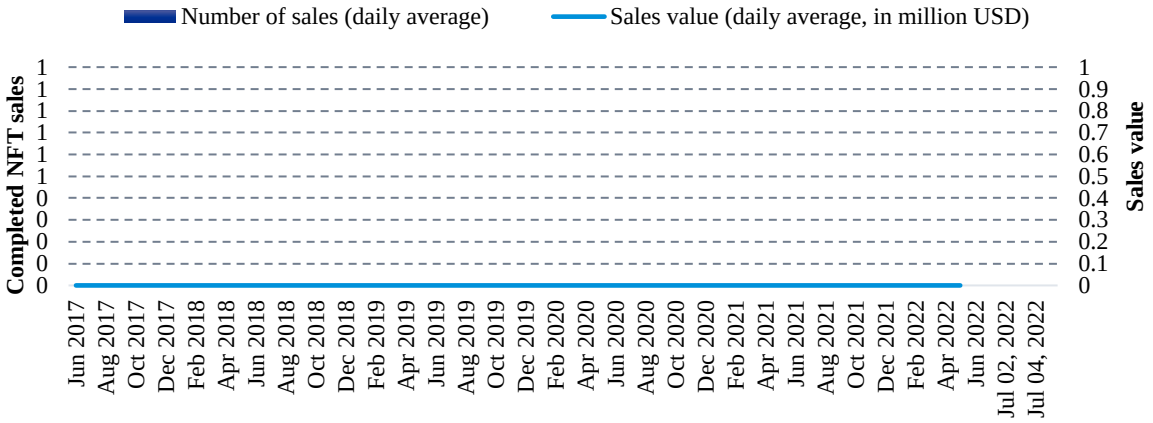
[6] Twitter is the number one channel for digital asset's promotion (Httpool, 2022).

Evolution

Although NFTs have been around since 2014, they have recently started to emerge as an increasingly trendy way to buy and sell digital artwork. Throughout their evolution, owning an NFT now has become a powerful representation of one's wealth, akin to that of owning a Rolex watch. In fact, according to Statista (2022), 17 percent of NFT investors alleged "bragging rights" to have motivated the purchase. As supported by **Figure 3**, the year of 2021 witnessed a parabolic growth of NFTs, accompanied by a raging bull market. As so, the third quarter of 2021 experienced a trading volume increase of more than 21,000 percent[7] compared to the first quarter. Thereafter, the number of weekly traded NFTs went from, the below-hundred figures in 2017, to thousands of NFT exchanged across the marketplaces. NFTs are not immune to the crypto market crash, and the once-booming NFT market, suffered, as of September 2022, a 97 percent loss in trading value after its peak in January 2022 (Bloomberg, 2022). Among other causes[8], we can highlight the decline of interest measured by Google searches for the term NFT, that, upon the peak, fell by 90 percent according to Google trends (Google, 2022). Nevertheless, with a current market capitalization of about $8.9 billion USD (Coincodex, 2022), and a market valuation of $11.32 billion USD in 2021, the market size is projected to reach $231.98 billion USD by 2030 (Verified Market Research, 2022). Objectively growing at a 33.7 percent CAGR, likely due to the incremental interest for its utility applications and forays into the metaverse, moving from its initial preposition as mainly a collectible and speculative asset (Yahoo Finance, 2022).

[7] Calculated based on sales volume – Refer to **Figure 3**.
[8] Factors that affected the digital asset market in general, as well as social media impact.

Figure 2: Evolution of NFT sales in Ethereum[9]. Source: *(Statista, 2022)*



Pros and Cons

The pros and cons of the different types of digital assets will be address as a comparison to the correspondent traditional asset. On the upside, the technology is eminently secure. Contrary to other assets, like paintings, NFTs stored on the blockchain have distinct records of authenticity, which, theoretically, prevents them from being subject to mishandling and theft. In addition, since NFTs provide a digital ledger for every sale, the NFT creator can automatically collect royalties for each exchange. Furthermore, the fact that NFTs can easily and seamless be transferred among people wheresoever in the globe, shapes a more efficient market. As a drawback, we can point out its illiquidity and volatility, expected given its relatively immature state and intangible property. As easily as NFTs can double in value in a matter of hours, they can as well lose all their value. Lastly, as afore stated, deriving the value of the NFT requires profound understanding of the NFT's community, being at the right place, at the right time and have the knowledge and intuition to sense the ambiance of the members. Whereas comparable traditional assets typically have an estimated value associated to, inferring NFT's worth can be very psychologically draining and time consuming, preventing smaller player from partaking in the virtual asset engagement.

[9] Ethereum accounts for 60% of NFT sales in 2022 (Statista, 2022).

Main Marketplaces

According to a Statista (2022), as of November 2021, the NFT market is highly concentrated, with the top four marketplaces accounting for more than 90 percent of market share. OpenSea is responsible by nearly 60 percent dominance of the market, presenting an all-time trading volume three times higher than the online game Axie Infinity, the next in line marketplace with about 18 percent share. Followed, sequentially, by CryptoPunks (9 percent) and NBA Top Shot (4 percent). How these so-called "marketplaces" operate varies somewhat from one another. Axie Infinity and NBA Top Shot, for instance, are NFT games that rely on collectibles or the metaverse. In contrast, OpenSea operates more like a decentralized exchange for users to trade NFT or cryptocurrency. At last, CryptoPunks acts as a platform dedicated to crypto art, namely, special pixel image characters.

Types of NFTs

It is a challenge to break NFTs to distinctive categories, since has not yet been defined an agreeable consensus for each nomenclature. On an effort to guide you through the NFT landscape, we will elaborate on the most general use cases: Art, Gaming and Metaverse.

The Art category is the most popular, representing collectible art pieces in different forms. Whether it is a photograph, a digital artwork, music or sport collectibles, artists have access to a broader audience to sell their work while insuring ownership rights. Not only can they profit from the initial sale, as they have the option to embed royalties into the smart contracts.

Although the Art category has stolen the mainstream attention, video-game assets, namely Axie Infinity, holds the highest value of sales volume (Nansen, 2022). The gaming industry was staggered by the rise of Play-to-Earn (P2E), a paradigm shift from traditional prizes, from which players were unable to extract value, to digital asset’s rewards. On the

former, players can play to own in-game assets, which can be furthered sold and converted to money.

Lastly, however, paramount, the Metaverse, in its yet infancy state, has the potential to metamorphose NFT's ecosphere. In the Metaverse, users should be able to trade a myriad of NFTs with endless uses. By way of illustration, we can buy pieces of virtual land, concert to tickets or other events held on the virtual space, fashion items and avatar features, etcetera. Noteworthy companies are already exploring positioning strategies on the Metaverse, with heftily investments being taken on that matter. More consideration will be further given on this topic.

4.6.3. Security Tokens

Overview

Essentially, tokenized securities are the crossroad between digital assets and traditional financial markets. In plain language, they represent a digital form of traditional investments like stocks, bonds, or other securitized assets (CoinMarketCap, 2022). Typically, this asset class is issued via a Security Token Offering (STO), that specifies the asset features. In particular, security tokens enable users to tokenize an asset according to certain criteria that are embedded into the blockchain. Analogous to traditional securities, these criteria entitle the holder of security tokens certain rights, e.g., voting and dividend rights, coded into smart contracts. Ultimately, security tokens can enhance trade efficiency and scalability, reducing costs and attracting more investors. Likewise, its applications extend to different classes: Equity, Debt and Real Assets.

Equity tokens are a type of security tokens that represent ownership of an underlying asset, usually shares of a company, with smart contracts specifying the terms and circumstances that apply. The holder may be entitled to dividends and voting rights (Cointelegraph, 2022). So

far, equity tokens are still mainly used for startups and digital asset related companies. On a recent note, blockchain platforms have started exchanging tokenized stocks of major companies such as Twitter, Apple, Tesla, Amazon and Netflix (Cointelegraph , 2021). These tokenized stocks are not issued by the parent company and are instead offered by other companies with that specific purpose, such as CM Equity or DigitalAssets.AG, that hold the stock itself, using it to fully collateralize the tokenized stock (STO Market, 2021). Despite the holders of the tokenized stocks not having a direct share of the company they are investing in, they can still be offered dividends and voting rights.

Debt-based tokens represent debt instruments such as real estate mortgages and corporate bonds, being the price dictated by two factors, risk and dividend (Fintech Legal Center, 2022). Tokenized debt is the most successful class with an accumulate achievement of 96 percent of the target capital (Cointelegraph, 2021), likely due to the reduced perceived risk. Corporate and government debt are gaining momentum. For instance, in 2019 the Bank of China issued $2.8 billion USD on a tokenized bond for micro and small companies (Cointelegraph, 2021). Furthermore, the Bank of Thailand raised $1.6 billion USD by issuing a tokenization of a government saving bond (Cointelegraph, 2021).

Lastly, real asset tokens represent ownership to a certain asset, being real estate and commodities the most generic. More oddly, real assets such as classic cars, paintings and film-production rights, as well as every sort of asset with intrinsic value, have the potential to be fractionalized and securitized. In 2020, a real estate tokenization worth $2.2 billion USD was responsible for almost half of the volume raised by security tokens that year (Cointelegraph, 2021).

The primary difference between a security token and a traditional security is the property registration method. A traditional security is registered in a database and can be accompanied

by a paper certificate. Whereas a security token is recorded in a blockchain and exchanged through smart contracts. The lifecycle of traditional securities is divided into four main stages: issuer onboarding, deal structuring, primary market, and secondary trading (Asifma, 2019). Similarly, the marketplace landscape of security tokens is complex, with a robust ecosystem of primary issuance platforms e.g., Neufund, Securitize, Polymath, secondary markets exchanges e.g., Uniswap, INX, Coinbase, tZero, custodians e.g., BitGo, Coinbase, Swiss Crypto Vauls, Crypto Storage, infrastructure e.g., Crypto Finance, Smartlands, Templum and distributors e.g., Black Manta, TokenMarket, STOCheck (Cointelegraph , 2021).

According to a BNY Mellon survey, while almost all (91 percent) of institutional respondents are interested in investing in tokenized products, up to 63 percent would only be comfortable trading tokenized assets with traditional institutions, pointing out the lack of regulatory clarity as their core concern (BNY Mellon, 2022). JP Morgan predicted that, amid regulatory clarity, 2022 could be the year for financial tokenization and further drive institutional adoption (JP Morgan, 2022). In the same line, SWIFT has announced plans to explore the tokenized asset space (Yahoo Finance, 2021). As an increasing number of high-profile traditional banks e.g., Goldman, JPMorgan, Citi and BNY Mellon, are pursuing to offer crypto custody services, the next reasonable step would be to explore the tokenized securities offerings (Crypto Research, 2021).

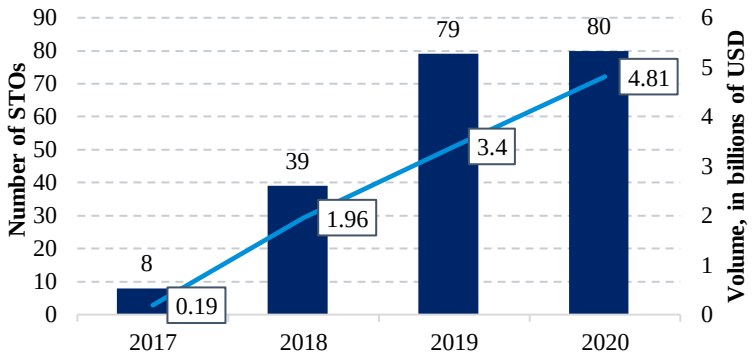
Evolution

Security tokens started in 2017 as a mean to replace IPO (Initial Public Offerings) for STO (Security Token Offering), by combining the benefits of blockchain-enabled crowdfunding with a reassuring level of regulatory oversight, STOs can mitigate the risk of investors being swindler by low quality projects and frauds. Since then, different asset classes have been tokenized, as aforementioned. In Europe, security tokens were responsible for less

than 3 percent of the overall digital asset market in 2021, with expectation to represent more than half of the total digital asset market in 2026 (Shemeliak, 2022). This trend is explained by the growing interest in tokenized assets, which offer high liquidity and a way to save and increase funds for investors of any scale (Shemeliak, 2022).

Security tokens have had a rough start, as exhibited in **Figure 3**, with more than half of STOs failing to reach their fund-raising targets in 2017 (Cointelegraph , 2021). As the community gets more familiarized with this innovation, an increase of success rate is expected. The last available data for this metric refers to 2020, when nearly 80 percent of the offerings achieved their goal. This almost twenty percentual points increase on the success rate compared to the year before (2019) (Cointelegraph , 2021) might have been the underlying driver for the boost of market capitalization. In fact, upon this result, according to Stobox analytics (Stobox, 2022), the market capitalization increased 500 percent and the trading volume 1,000 percent in 2021. Moreover, in May 2022, the total market capitalization surpassed the $19 billion USD, corresponding to a twenty times annual increase. This relentless growth shows no sign of slowing down, as many leading analysts tip security tokens as the shining crypto asset class of the coming decade. Even tough forecasts for the market capitalization of security tokens, by 2025, estimated by KPMG/WEF ($8 trillion USD) and Finoa ($9.5 trillion USD) (Cointelegraph, 2021) seem too optimistic, these numbers are modest when compared with the size of the equity ($124.45 trillion USD) or bond ($126.9 trillion USD) markets in 2021 (SIFMA, 2022). In case most securities to be tokenized by 2030, as suggested by Raiffeisen Bank International in an exclusive interview for the Cointelegraph Report, the foregoing predictions made by KPMG and Finoa are not sizable enough.

Figure 3: Evolution of STOs. Source: (Cointelegraph , 2021)



Pros and Cons

The fractionalization of assets gives the investor an advantage compared to traditional assets, since it reduces the entrance capital, allowing smaller investors to invest in expensive investments, which otherwise would be a threshold too high for participation. To serve as an example, only a small portion of people have the capital to invest in real estate, the fractionalization and tokenization of the property offers a more liquid way to gain access to one of the most illiquid asset class, the real estate sector, broadening the horizon for less wealthy investors. Similarly, with the tokenization of stocks, one can purchase a partial share of a hundred dollars' worth stock, for a pittance. The barriers to entry are, therefore, meaningfully reduced for both sides of the exchange. On the business side, companies are not forced to go from private to public in order to reach investors, contrary to Initial Public Offerings (IPOs) (Cointelegraph , 2021). Furthermore, the use of smart contracts leads to more transparent and faster processes, in a matter of minutes the security token can be fully realized, reducing the traditional two days (T+2) settlement time to zero days (T+0) (Nasdaq, 2022). These processes are not only faster, as they are also available at a 24/7 basis, mitigating some of the inefficiencies of the traditional financial markets, as traders can take immediate action based on business developments and news (Asifma, 2019).

On the other hand, security tokens are a considerably recent innovation with new technical features and ambiguous regulation. Hence, valuing virtual assets and perform due

diligence might be more challenging for the moment, translating into an increase in compliance costs. However, this effect is somehow deceptive and temporary, as compliance with regulations can be programmed into smart contracts, thereby reducing and automating the regulatory compliance burden (Asifma, 2019) . Although security tokens aim to place financial markets to date with modern technology, there is still a long path to educate the public and increase the tokenization adoption. The lack of a clear regulatory framework has long been a major drawback for security tokens' institutional adoption.

Regulation

Nowadays, security tokens are not uniformly regulated. Instead, they are reliant on the countries' jurisdiction. In some jurisdictions, STOs do not meet the requirements to be legally classified as securities, causing a lot of discrepancies in the framework. However, both in the US and in most of the European Members (Clifford Chance, 2020), regulators consider that security tokens fall under the same legal definition of regulated securities. Ergo, they are primary subject to the same legal and compliance standards as traditional securities, i.e., the asset and its associated activities are governed by the correspondent financial regulator of the country, regardless of the digital medium on which they operate (The Tokenizer, 2022). For instance, in the US, platforms that trade security tokens must register with the SEC (Quinlan & Associates, 2021), whereas European STOs are subject to ESMA compliance (The Tokenizer, 2022), with securities being regulated under MiFID II (Clifford Chance, 2020). According to ESMA, the responsibility to classify crypto-assets as financial instruments falls under the national competent authorities (ESMA, 2019). Therefore, as conditions for assets to be classified as securities differ within European member states, ambiguity can disrupt the legal framework. For instance, Czech Republic, Poland and Slovakia do not recognize them as securities, treating security token as, for example, intangible assets (Clifford Chance, 2020). Unlike most decentralized crypto-assets, security tokens cannot fully eradicate intermediates,

since securities' legislation forcefully requires a regulated market infrastructure with traditional intermediaries. Not only might progressive legislation be the needed catalyst to prompt institutional investment, as also coordination between regulators would encourage active investments across national borders.

4.6.4. Central Bank Digital Currencies

Overview

So far, we have seen that cryptocurrencies are extremely volatile assets and are mainly used for speculative purposes. This makes them an unsuitable option for widespread use across the economy as a mean of exchange. In contrast, a Central Bank Digital Currency (CBDC) is "the digital form of a country's fiat currency that is also a claim on the central bank. Instead of printing money, the central bank issues electronic coins or accounts backed by the full faith and credit of the government" (Atlantic Council, 2022). Therefore, the value of a CBDC is pegged to a country's fiat currency, ensuring price stability and safety. They can be divided into retail and wholesale (interbank) CBDCs. On the one hand, retail ones can be used by consumers and businesses and, in contrast to cryptocurrency, they mitigate the risk that the issuer of the currency might go bankrupt and default. On the other hand, the use of interbank CBDCs is restricted to financial institutions, working in a similar manner to a bank's reserves, where the bank can use the money to settle interbank transfers and financial operations. One of the main motivations behind the use of CBDCs is to provide people an easy and secure access to money, especially unbanked and underbanked individuals and therefore boosting financial inclusion. Undoubtedly, the access to banking and credit services from traditional financial institutions has a profound impact on a society, particularly on its financial and economic well-being. According to the Fed, 5 percent of the U.S. adult population does not hold a bank account and 13 percent of adults were underbanked, meaning that they had access to insufficient banking services (Federal Reserve System, 2021). This issue is especially exacerbated in emerging and

developing economies whose population has limited access to financial services providers. CBDCs also increase the efficiency in payments and reduce cross-border transaction costs. In addition to this, it can minimize the risks of illegal financial transactions. However, CBDCs can also entail unwanted consequences. The effects of a nationwide adoption of a CBDC on a country's financial system is still widely unknown, as it is a relatively recent and only a very limited number of nations have implemented it. Also, it would require a drastic redesign of a country's financial infrastructure.

Adoption Landscape

As of November 2022, 108 countries that represent over 95 percent of global GDP are either exploring the potential adoption or have already launched CBDCs (Atlantic Council, 2022). In October 2020, The Bahamas became the first country to officially launch a CBDC, the Sand dollar. Subsequently, Jamaica, Nigeria and 8 other Eastern Caribbean countries had nationwide launches of CBDCs. Russia, Saudi Arabia and South Africa are among the 15 countries that are currently in pilot phase, with China being the first major economy to pilot such project back in April 2022. According to local media reports, all of China's six state-owned banks have implemented trials for the usage of a digital Renminbi (BNP Paribas, 2022). The U.S. Federal Reserve has been actively researching this topic. In January 2020, the Fed issued a report in which it tackled the potential benefits and challenges that could arise from of a nationwide adoption of CBDCs (Federal Reserve System, 2020). Furthermore, the Biden administration released the first-ever comprehensive framework for responsible development of digital assets, in which it was recognized the possibility of a U.S. CBDC in the future (The White House, 2022). As for Europe, in July 2021, the European Central Bank (ECB) decided to launch the investigation phase of the digital euro, which will last 24 months and its main goal is to address the design and distribution of a CBDC (ECB, 2021).

4.7. Blockchain

Blockchain is a technology that enables the recording of transactions on a digital ledger. That ledger or database is then duplicated and distributed across the nodes of a computer network, that are then responsible for assuring the validity of new transactions added on to the blockchain by solving a number of equations. Once a transaction is confirmed to be legitimate by the majority of nodes through a consensus mechanism, the data is then aggregated into a block that is attached to the chain, after which it is permanently stored on the blockchain ledger. One core aspect of this is that the ledger is immutable, as it is append-only i.e., information can only be added, but never deleted. Transactions are packed into blocks via proof-of-work (PoW) or proof-of-stake (PoS) depending on the type of consensus mechanism employed. Two key attributes of its architecture that makes it the backbone technology of digital assets is the fact that blockchain is *decentralized*, in the sense that there is no central authority controlling the transaction process, since there is a peer-to-peer network of computer systems holding identical duplicates of all the transactions that occurred on the chain and it is *distributed*, meaning that parts of the system exist at different locations. Regarding its architecture, blockchain can be divided into public or private, depending on the ownership of the data infrastructure. Depending on the scope of the authorization to read or write onto the blockchain, it can be classified as permissionless or permissioned.

Blockchain has the potential to fundamentally disrupt the way traditional businesses and societies operate and to transform how humans transact. It is expected that nearly 10 percent of global gross domestic product (GDP) will be stored on blockchain technology by 2027 (World Economic Forum, 2015). Moreover, estimates point out that blockchain will boost global GDP by $1.76 trillion USD over the next decade, with the capacity to enhance value creation across every industry, from healthcare, government and public sector to finance and retail (PwC, 2020). Nevertheless, it is worth noting that it is still an immature technology. In fact,

blockchain's use cases and applications are still heavily focused on cryptocurrency and smart contracts. Even though large organizations including Google, BlackRock, Morgan Stanley and Samsung have invested an estimated combined amount of over $4.6 billion USD into blockchain ventures (Blockdata, 2022), there is a large gap between potential and actual use in business, with most existing applications still being in test phase (Ostern, et al., 2022). Despite its tremendous potential, there are several barriers that can explain why blockchain has not yet achieved mainstream adoption. According to the literature and experts, the most frequent stated reasons include interoperability issues, reluctance, lack of knowledge and management support, as well as technological immaturity and scalability issues, to name a few (Rejeb, et al., 2022).

4.8. Regulatory Landscape

We believe that it is utterly important for BPI GA to be in the forefront of the current regulatory framework, not only in Portugal, but also in other major economies across the globe. Mapping the regulatory ecosystem for digital assets is a not an easy task. It can be overwhelming to keep up with the new developments that are constantly emerging worldwide, leading the way to several local perspectives and interpretations, as well as uncertainty and speculation. Additionally, the ever-changing digital asset market is still relatively immature and highly fragmented. But one thing is certain: as digital assets find their way into the global economy, regulators and lawmakers will play a more active role overseeing this asset class. The fact that the cryptocurrency world has been rocked by an array of scandals over the few last years has led countries to rethink and redesign their regulatory strategy. Following the crash of the algorithmic stablecoin UST and its sister token Luna (LUNC) on May 9, 2022, plunging from a market capitalization of $18.6 billion and $21.8 billion USD, respectively, on May 8, 2022, to less than $1 billion each by May 20, 2022 (CoinMarketCap, 2022), U.S. Treasury Secretary, Janet Yellen, called for additional federal regulations, admitting that a regulatory framework must be in place by year-end in order to safeguard investors from such risks. Yellen

highlighted the risks of tokens pegged to the U.S. dollar, however this asset class has not reached a scale «where they are financial stability concerns» (Yahoo Finance, 2022).

The latest incident that sent shockwaves through the cryptocurrency market was the bankruptcy of FTX which, at the time of writing this report, was still unfolding, with further details being continuously revealed in the media. FTX is a spot cryptocurrency exchange funded in 2019 that, before filing for Chapter 11 bankruptcy on November 11, 2022, was the 5th largest crypto exchange by trading volume, with a year-to-date trading volume of nearly $627 billion USD as of November 9, 2022 (Reuters, 2022). Following concerns regarding the group's undisclosed solvency and indebtedness by CoinDesk, an online news outlet that focuses on digital assets, FTX faced a liquidity crisis, driven by a run on assets. When investor started demanding withdrawals, FTX did not possess the assets in place to meet customer demand. Unlike banks or credit unions, because cryptocurrency is not regulated in the same way as deposits, investors do not benefit from the same protections, such as deposit insurance, against a system failure. It is reasonable to state that this fallout led to an approximate $200 billion USD plunge in the total cryptocurrency market capitalization, going from more than $1 trillion USD on November 8, 2022, to less than $800 billion USD just a day after (CoinMarketCap, 2022). In addition, this may further deter people that were already reluctant to invest in the crypto market. It is somewhat expected that the SEC and other regulators will increase their scrutiny and oversight mechanisms over this market, and in particular crypto exchanges. Congresswoman Maxine Waters, Chairwoman of the House Financial Services Committee, which oversees the work of the SEC and other financial services regulators, released a statement stressing the urgent need for legislation (Waters, 2022). At least eleven major exchanges have announced plans to report on their reserves more regularly, with independent auditors signing of on their proof of reserves (PoR) (CoinMarketCap, 2022).

Notwithstanding the efforts for regulatory clarity, one needs to acknowledge that regulation is often a journey, not a destination, that usually evolves with advances in innovation within the market ecosystem. The digital asset market is in constant development, as so, the regulatory framework is steadily adjusting. In January 2021, the United States banking regulator, The Office of the Comptroller of the Currency (OCC), authorized national banks and federal savings associations to use stablecoins to conduct payments and other banking transactions. In that same year, the Department of Justice announced in October the creation of the National Cryptocurrency Enforcement Team (NCET), to investigate and prosecute criminal misuses of cryptocurrency (U.S. Department of Justice, 2021). On June 7, 2022, the Senate proposed the "Responsible Financial Innovation Act", which would classify most of digital assets as commodities, making the Commodities Futures Trading Commission (CFTC) the primary regulator of the vast majority of the crypto industry (Mayer Brown LLP, 2022). The following day, the New York State Department of Financial Services (NYDFS) issued the New Regulatory Guidance on Baseline Criteria for USD-backed stablecoins, setting the regulatory framework for «virtual currency companies looking to issue USD-backed stablecoins in New York» (NYDFS, 2022).

Regarding tax legislation, on August 2021 the U.S. Senate passed a bill expanding the definition of a "broker" for Internal Revenue Service (IRS) reporting purposes to any entity that provides services related to crypto transfers on behalf of customers, while also considering crypto gains as any other capital gain, being subject to ordinary tax rates (EY, 2021). Furthermore, the IRS created a team dedicated to identifying potential undisclosed virtual currency transactions and capital gains in previous tax returns (IRS, 2022).

In Europe, the European Parliament and the Council of the European Union published the Distributed Ledger Technology (DLT) Pilot Regime in the Official Journal of the E.U., entering into effect in March 2023. This legislation outlays the conditions for a company to

have permission to operate in a DLT market infrastructure, detailing which DLT financial instruments can be traded (European Parliament and Council, 2022).

China, however, has followed a different approach than Europe and the U.S. by banning all cryptocurrency transactions in September 2021, with the People's Bank of China (PBOC) saying that cryptocurrency not only jeopardizes the country's economic stability, but also plays a significant role in illicit activities like money laundering, terrorism financing and drug trafficking (World Economic Forum, 2022). This came after China restricted cryptocurrency mining activities in May of that same year, driven by the environmental impact it causes (Library of Congress, 2022). According to the latest report on cryptocurrency regulation around the world, published the Library of the U.S. Congress, Algeria, Egypt, Iraq, Morocco and Qatar are also among the 9 countries with absolute bans on crypto (Library of Congress, 2021).

4.9. Selected Applications

4.9.1. Marketplaces

Users can spend their digital assets to purchase other digital assets such as NFTs but also other goods and services outside of the blockchain ecosystem. The expectation is that consumers will buy products at real stores using their digital assets. Eventually, every point-of-sale system would come equipped with the capacity to take digital assets as a form of payment (PwC, 2022).

4.9.2. Decentralized Finance

Decentralized finance (DeFi) is a term for an alternative financial system built on top of the blockchain that specializes in smart contracts to develop protocols that mimic traditional financial services (Schär, 2020). The outlook for decentralized finance is to being able to get a loan, insurance or other financial instrument automatically agreed to by a provider via the blockchain. As opposed to centralized finance (CeFi), in which the flow of money is controlled

by intermediaries, DeFi cuts out the middleman in transactions using decentralized applications (dApps) that manage the transactions on the blockchain.

As of 2022, 1.4 billion adults across the globe remain unbanked, with this issue being more frequent among poorer, undereducated, and rural communities (The World Bank, 2022). As previously mentioned in this report, in the U.S. alone, 5 percent of the adult population is unbanked, while 13 percent were underbanked (Federal Reserve System, 2021), with this concern becoming especially aggravated in emerging and developing economies where traditional financial services providers lack the necessary infrastructure to meet the demand of the general public. Furthermore, it becomes even more challenging for these people as economies tend shifts towards e-commerce and digital forms of payment. This also poses as an issue for merchants, especially small ones with a low transaction volume, with the average credit card processing fees ranging from 1.5 to 3.5 percent (Forbes, 2022) and payment processing times usually taking anywhere from 24 to 72 hours (Retail Merchant Services, 2020). Therefore, DeFi can present as an alternative to traditional, centralized finance, by overcoming the abovementioned obstacles. It offers a competitive approach that not only benefits businesses, but also consumers, allowing for a greater financial inclusivity, while enabling faster settlements and diminished transaction costs. However, DeFi is still at a very early stage and faces some adoption challenges. Its scalability is often put into question due to the fact that its transaction capacity is quite limited when compared to payment network companies like Visa or MasterCard. For instance, Visa is able to process up to 24,000 transactions per second, while Ethereum can only process twenty (Crypto.com, 2020). In addition, these DeFi blockchain protocols consume massive amounts of energy, raising concerns regarding its efficiency and environmental sustainability.

In the context of cryptocurrencies, Nasdaq defines the Total Value Locked (TVL) as the sum of all assets deposited in decentralized finance (DeFi). Therefore, this metric can be

considered a proxy for the DeFi market size. According to the website DeFiLlama, that aggregates DeFi TVL data, the TVL across DeFi blockchains has declined from its peak of circa $315,72 billion USD on the December 26, 2021, to an estimated value of $93,06 billion USD on the October 26, 2022 (DeFiLlama, 2022). This significant change was mainly driven by the crash of Terra (LUNA) and its stablecoin TerraUSD (UST) in May 2022, with uncertainty still present today. As of the October 27, 2022, the chains that make up the most percentage of TVL across the DeFi industry are Ethereum (65.94 percent), Binance Smart Chain (9.14 percent) Tron (6.37 percent), Avalanche (2.88 percent) and Solana (1.92 percent).

4.9.3. Exchanges

Like stocks or bonds, digital assets can be traded on dedicated exchanges. These platforms enable investors to trade fiat money for cryptocurrency or other digital assets, such as NFTs. They can be divided into Centralized (CEX) and Decentralized (DEX) Exchanges. On the one hand, CEX act as a third party between buyers and sellers, generating income from transaction fees and commissions. The largest CEX globally is Binance, with a trading daily volume of $16,432 million USD, followed by Coinbase, with $2,058 million USD, Kraken with $873 million USD, and KuCoin with $628 million USD (CoinMarketCap, 2022). On the other hand, DEX are peer-to-peer exchanges, differing from CEX as they do not require a middleman, relying on smart contract technology. Additionally, when compared to CEX, DEX are substantially smaller in terms of trading volume. The largest decentralized exchange, Uniswap (v3), represents 0.0018 percent of the overall market, which translates to a trading volume of $1,389 million USD, followed by dYdX with $1,111 million USD and Curve Finance with $430 million USD (CoinMarketCap, 2022).

4.9.4. Gaming

Over the first quarter of 2022, the blockchain gaming industry grew by 2,000 percent in comparison to the homologous period, attracting more than $2.5 billion USD in investments

(DappRadar, Blockchain Game Alliance, 2022). Users that play games built on a blockchain can purchase in-game items with tokenized currency. The fact that the money is a digital asset allows users to really own the wealth they generate. This includes the ability to exchange goods or services with other players in a way that has never been provided by conventional game developers. Some of the biggest players in this industry include Animoca Brands, Forte Labs and Sky Mavis.

4.9.5. Metaverse

The metaverse, with a market size valued at $63.83 billion USD in 2021 (Fortune Business Insights, 2022), is a digital environment operating on the blockchain. Referred as the inevitable evolution of the internet, is a complex concept continually evolving to become a single, shared, immersive, 3D virtual space where humans can experience life, work, play, shop, trade, learn and interact with each other, using Virtual Reality (VR) and Augmented Reality (AR) to impersonate avatars from the comfort of their homes. This, not that futuristic, concept is filled with unlimited social interaction and business opportunities, which will further be mentioned. While the web 1.0 connected people to information and web 2.0 connected them to the social media revolution, the bound of web 3.0 to metaverse, instead, will connect people digitally to virtual places and things. Rather than accessing the internet through a two-dimensional screen, metaverse enables users to interact in a three-dimensional online space (Forbes, 2022). Blockchain is crucial to develop the financial connectivity that allows currencies and tokens to be exchanged within the metaverse across the different ecosystems, and then transfer this value to the physical world.

The concept is not recent, the pioneer of the term “metaverse” dates back decades ago, when in 1982 an American sci-fi writer Neal Stephenson, first mentioned it on his book Snow Crash, which depicts a dystopian future world where rich people, connected by 3D reality, would escape to a digital alternative (Forbes, 2022). For several years, this has been a concept

developed in the gaming industry, on a simpler basis. However, the metaverse household awareness was ignited by Mark Zuckerberg in October 2021, amid the corporate identity rebranding of Facebook to Meta and its plans to invest, per year, $10 to $15 billion USD in the Metaverse project (The Guardian, 2021). The interest measured by Google searches for the term "metaverse" skyrocketed 7,200 percent from Zuckerberg announcement through May 2022. Thuswise, it is challenging to detach the hype from the reality. The Facebook founder believes "We'll be able to feel present – like we're right there with people no matter how far apart we actually are" (The Guardian, 2021).

Owning a 0.11 percent share in Meta, Brad Gerstner, CEO of Altimeter Capital, a technology investment firm, published, on October 24, 2022, an open letter directed to Mark Zuckerberg and the board of directors intending to alert Meta to scale down its foray in the metaverse as stock prices have been tumbling. Indeed, a 60.54 percent sinking of Meta Platform's share price was observed from October 2021 to October 2022, a weightier fall in the current bear market than its big-tech peers e.g., Apple, Amazon and Google (CoinTelegraph, 2022). Gerstner commented that, a long-term investment that may take ten years to yield results, on an estimated of more than $100 billion USD expended to bet on an unknown futuristic concept, is super-sized and terrifying, even by Silicon Valley standards (CoinTelegraph, 2022).

Undoubtedly, Meta is going through a rough path, but chances are that it is not directly related to Metaverse. The Metaverse project appeared on the worst timing, that does not mean it will be a failure, and it certainly does not imply that the stock price trajectory is somehow a reflection of the Metaverse efforts. On one hand, the project is, in fact, draining money from Meta's coffers. On the other hand, Meta is struggling to overcome two main underlying issues. For starters, Meta is facing its biggest competition in years with the raising popularity of TikTok. Instagram, part of Meta's network, has already adjusted to resemble to some of the competitors' features (Yahoo Finance, 2022). Nonetheless, the main trigger for this collapse,

was Apple's responsibility. According to Meta's financial reports, more than 90% of its revenues comes from advertising, therefore, the change of privacy settings for IOS users, have shaken Meta's foundation (Financial Times, 2021).

The next so-called secular trend is drawing company leaders, to address this effect, PwC surveyed over 5,000 US consumers and 1,000 US business leader (PwC, 2022). Amounting for a total of 87 percent of businesses planning to create metaverse synergies within 3 years, 20 percent is forethought to do to it, while 67 percent is actively engaged in the metaverse, either by building proofs of concept, testing use cases or even generating revenue from metaverse space or the inherent technologies. From the consumer's side, while half of consumers are aroused by the prospects of metaverse, only 9 percent currently makes use of the existing metaverse environments.

McKinsey & Company (2022) believes that, by 2030, the average internet user will be spending up to six hours a day in the metaverse, whilst its economy will reach $5 trillion USD in value. Moreover, merely in the first semester of the year (2022), there have been already over than $120 billion of investments in the metaverse. The e-commerce is expected to be the dominant sector of the metaverse, the AI technology can deliver an immersive and nearly real shopping experience, a promptly investment in this technology can be key for companies in the fashion and cosmetic business (McKinsey & Company, 2022). Gaming, entertainment, education and marketing are also expected to play a vital role.

4.10. External Factors Impacting Digital Asset Investments

4.10.1. Social Media

The quality of the digital asset offering is significantly defined by the overall sentiment towards the respective (Elsevier, 2022). Unlike some traditional investments, for instance, stocks of companies for which we can analyze its performance by observing their financial

statements, most digital assets do not have any representation of value which, in turn, makes them more susceptible to the effects of speculation. Hence, social media is a good reflection of the digital asset's value, offering insightful data to forecast fluctuations. However, one needs to understand that social media does not represent each voice equally. To make an analogy, social media's impact is like a function of the weighted average opinion based on the number of followers each account has, therefore, it can be manipulated by the so-called influencers. As a popular fictional Marvel's character once said, with great power comes great responsibility, howbeit, abuse of power for personal gain in the digital asset ecosystem has been reported in several occasions. For instance, Elon Musk's tweets about Dogecoin were responsible for huge price spikes, as is the case of January 2021, when a single tweet about Dogecoin made its price gallop over 300 percent in four hours (CNET, 2021). The nature of these tweets led to a $258 billion USD lawsuit against the billionaire, alleging he was responsible for intentionally driving Dogecoin's price by 36,000 percent over two years, profiting tens of billions of dollars from it, and then letting it crash (Reuters, 2022).

In the same vein, Elon Musk was accused of market manipulation when Tesla bought a significant amount of Bitcoin, further stating that it would start accepting it as a form of payment and, few months after, it dumped its position on Bitcoin and revoked the previous statement claiming it was driven by environmental concerns (BBC, 2022). Similarly, other celebrities such as Paul Pierce, Floyd Mayweather and Kim Kardashian, had fingers pointed at for profiting from cryptocurrencies at the expense of their followers (CBS News, 2022). Twitter is the number one channel for digital asset's promotion (Httpool, 2022), its concerning influence on price variations, intensifies the risk associated with owning these assets. On the other hand, it stimulates investors to stay interested in the topic and instigates transactions.

Circling back to Elon Musk, a recognized supporter of Dogecoin, he acquired Twitter on October 27, 2022, for $44 billion USD (New York Times, 2022), increasing Dogecoin value

by 40 percent that same week (Forbes, 2022). A day later, Twitter announced it will allow users to exchange NFTs via NFT Tiles (Business Today, 2022), the extent to which this acquisition will affect digital assets is still to be ascertained. However, Elon Musk, with his unmarkable visionary trait, is regarded by some as the most revolutionary businessman alive, hence, expectations for a groundbreaking Twitter rebirth are on place, with chances of being a game changer for the digital asset space.

4.10.2. Environmental Concerns

Since their dawn, digital assets have been associated with environmental concerns, triggering investors reluctancy. Indeed, the process behind the transaction of digital assets requires an incredible amount of computational energy use and consequently, raises pollution levels and harms the environment.

Quantitatively speaking, the total global electricity usage for crypto assets in 2022 is estimated to range between 120 and 240 billion kilowatt-hours per year (The White House, 2022). For comparison purposes, according to World Data, this value corresponds to the annual electricity usage of Argentina (121 billion kilowatt-hours) or Australia (229.4 billion kilowatt-hours) alone, and it represents two and a half to five times the annual electricity consumption of Portugal (46.9 billion kilowatt-hours). Another concerning metric is the emission of carbon dioxide, being crypto-asset activity responsible for between an estimated 110 to 170 million metric tons per year of emissions globally (The White House, 2022), representing about three to four times the annual CO2 released by Portugal alone (39.7 million) (Statista, 2021).

These numbers are alarming, carrying an environmental heft and raising ethical concerns. Sustainability concerns are also playing a proliferating role in consumer decisions, with 85 percent of people indicating to have shifted their purchase behavior based on environmental awareness (Business Wire, 2021). With respect to this, the energy efficiency of

the equipment for mining cryptocurrencies has been improving, although not enough to compensate for the rise of transactions.

The energy consumption of each cryptocurrency by transaction depends on the consensus mechanism, a system that connects all the computers in a crypto network to consent over the legitimacy of the process of verifying new transactions, add them to the blockchain and create new tokens. Those who adopted proof of stake consensus mechanisms are more environment-friendly, as for those who use proof of work systems are more energy intensive. Proof of stake, despite offering weaker security terms, is considered to outperform the older system, proof of work (Insider, 2022). Consistently, newer cryptocurrencies tend to adopt the former, for instance, Ethereum 2.0, Cardano and Tezos. The older cryptocurrencies are run by proof of work, as is the case of the classic Bitcoin and Ethereum 1.0, amongst others (Coinbase, 2022). DeFi, NFTs, smart contracts and other digital asset related transactions are also processed via proof of stake consensus mechanisms, as most are exchanged in the Ethereum space. Actually, the emergence of Ethereum's blockchain as more than a cryptocurrency, drove the creation of the mechanism of proof of stake, as Ethereum started realizing proof of work's limitation in scalability (Coinbase, 2022). As for Bitcoin, it has been making efforts towards not only to reduce its climate footprint, as well as to improve profits by lowering energy costs. Francesco La Camera, Director-General of IRENA, stated that renewable energies are the cheapest form of power today (IRENA, 2022), so it comes as no surprise that Bitcoin's mining electricity mix rose to 59.5 percent of sustainable energy in the second quarter of 2022 (Bitcoin Mining Council, 2022).

5. Investment Outlook

5.1. Current Adoption Landscape

In September 2021, Fidelity Digital Assets published its annual Institutional Investor Digital Assets Study. It included 1,100 institutional investors from the United States, Europe

and Asia. Respondents were comprised of financial advisors (312), high-net-worth investors (302), family offices (170), pension funds and defined benefit plans (107), venture capital funds (86), hedge funds (85) and endowments and foundations (38).

Looking at the current adoption landscape, we observed that 52 percent of investors shared that they have an investment in digital assets, carried out either by investing directly in them, via an investment product that is exposed to digital asset companies or through futures contracts. Asian investors showed the greatest propensity for digital assets, with 71 percent of respondents stating they have allocations to digital assets. Within a portfolio context, this study revealed that nearly 8 out of 10 investors surveyed felt that digital assets have a place in a portfolio.

5.2. The Evolving Landscape of Digital Asset Investments

To better grasp the evolution of investments in digital assets we believe it is fundamental to split it into two different cycles: On the one hand, the cycle from 2016 to 2019, characterized by a retail driven rally, while on the other hand, the cycle from 2020 until today, denoted by broader institutional participation.

Between 2016 to 2019 we witnessed the emergence of bitcoin as an alternative asset class for retail investors. This cycle was characterized by a relatively low trading volume and high volatility, highlighted by the fact that during the first quarter of 2018, according to quarterly public fillings, Coinbase trading volume amounted to $66 billion USD. Nearly 80 percent of volume traded came from retail investors, accounting for $45 billion USD, while institutional investors accounted for just $11 billion USD. Furthermore, this cycle was denoted by a lack of institutional grade infrastructure for service such as trade execution, custody and credit.

From the previous cycle to the current one, we have witnessed a paradigm shift in crypto investing, with institutional participation increasing. Institutional investor made up nearly 80 percent of Coinbase $217 billion USD trading volume during the three months ended on June 30, 2022, while retail investors accounted for $46 billion USD. Simultaneously, we have observed record trading volumes, with Bitcoin reaching its all-time high of $68,934 USD in November 2021 (Coinbase, 2022) and it is now safe to state that Bitcoin is widely recognized as an asset class across both institutional and retail investors.

Coinbase defines itself as a «leading provider of end-to-end financial infrastructure and technology for the cryptoeconomy». In fact, at the date of writing this report, according to CoinMarketCap, Coinbase Exchange was the 10th largest cryptocurrency spot exchange globally, with a daily trading volume of $2,598 million USD (CoinMarketCap, 2022).

5.3. Opportunities for BPI GA to Capitalize On

The digital asset landscape is quickly gathering pace, opening an array of opportunities for financial institutions to capitalize on. Having BPI GA's business model and future strategy in mind, we have identified four segments where BPI GA can tap into: custody services, research coverage, investment services and fund launch.

Firstly, it is important to understand how asset custodianship works for traditional assets. Custodian banks are financial institutions hold an investor's assets and their main purpose is to safekeep them for a fee, while committing to offering protection against theft or loss. They often offer related services such as trade settlement and exchange and management of a client's investments.

Within the digital asset ecosystem, custody services work in a similar manner to traditional assets, in the sense that their main goal is to safekeep a client's assets. However, unlike traditional assets, digital asset custody is achieved simply by holding the private key on

behalf of the customer. Digital assets can only be accessed through a specific combination of a public and a private key. A public key is a cryptographic code that can be shared with everyone, as it does not give a person direct access to someone's property. However, while a private key is also a cryptographic code, when it is paired with the corresponding public key enables a transaction to be executed. We can think of this as an analogy to a user's username and password.

Even though self-custody is the option that provides an investor greater control over their assets, the private key is more prone to being hacked or lost. Another option is custodianship through an exchange wallet, where an exchange has complete control and manages a customer's private and public keys. Although this option is widely considered to be the most straightforward approach for most investors, it is highly subject to counterparty risk, which was recently highlighted by the bankruptcy of FTX. Given the ever-growing volume of digital asset transactions across the financial system, third party digital asset custody arises as the option that complies with institutional grade security standards. This alternative, however, might not be the most viable way for retail investors to safeguard their assets due the high cost it entails.

Currently, digital assets' custody is achieved through two main methods of storage. Hot storage is an online option that brings an increased ease of access for investors. Cold storage is an offline method, where the private key is stored in a physical location, like a flash drive or any other kind of hardware. Although this last option is less convenient than hot storage, as it involves manually accessing the private keys, it is deemed as much safer alternative. In fact, hot wallets are rather vulnerable to being hacked. For instance, in December 2021, hackers were able to misappropriate $196 million USD worth of funds from the cryptocurrency exchange BitMart, by stealing private keys from hot wallets (CoinDesk, 2021). Another method referred

to as warm storage involves a combination of cold and hot storage, where the assets are allocated between hot and cold wallets.

With the ever-growing number of transactions and cryptocurrency users, this opportunity presents great potential to BPI GA and its clients. Concerning investor sentiment, in a survey conducted by Bank of New York Mellon (BNY) in October 2022, covering 271 institutional investors across the globe, where 41 percent held cryptocurrency in their portfolios, it was reported that, regarding custody and execution, 72 percent of surveyed investors would like an integrated provider for all digital asset needs. So far, we have witnessed some Wall Street banks announcing they would provide digital asset custodianship to their clients. The first major notice came from BNY Mellon, the world's largest custodian bank, following a previous announcement in February 2021, launched in October 2022 its digital asset custody platform for select clients in the U.S., after being approved by the New York Department of Financial Services. This financial infrastructure will now allow clients to transfer and hold Bitcoin and Ether (BNY Mellon, 2022). State Street has also announced plans to offer such services in March 2022 and is currently awaiting approval from the Federal Reserve (Bloomberg, 2022). In one on the first moves for a major European bank, in a World Economic Forum report published in December 2020, Deutsche Bank revealed plans to develop an integrated digital asset custody platform, aimed at institutional investors, enabling them to trade digital assets through prime brokers and to have them insured, while also providing services such as fund administration and tax advisory (World Economic Forum, 2020).

To provide a solid investment framework and better guide investors within the digital asset landscape, BPI GA can offer research coverage services. Within this segment, we have been witnessing a number of big banks and asset managers offering resources to both retail and institutional investors. For instance, in October 2021, Bank of America launched digital asset research coverage, stating that the sector is «too large to ignore» (Bank of America Securities,

2021). Morgan Stanley established a dedicated cryptocurrency research team in September 2021, focused on analyzing the impact of cryptocurrencies on fixed-income and equity markets (Surane, 2021). Furthermore, within the asset management landscape, VanEck and Fidelity Investments are among the biggest players in research coverage.

In a move to target institutional clients that wish to invest in cryptocurrency, some Wall Street banks are leveraging on this opportunity by expanding their product offerings. According to SEC documents filed by Goldman Sachs, the bank started offering institutional investors a chance to invest in Bitcoin and Ethereum through Galaxy's funds that are directly invested in each cryptocurrency. Investors must meet a minimum capital requirement of $250,000 USD in order to be considered. As of March 2022, 28 clients have invested in the Ether fund, which translates to $50 million USD.

Lastly, fund launch poses as being probably the most attractive opportunity for BPI GA. Although the sector is tremendously volatile, we are witnessing a proliferation in crypto funds, not only driven by the creation of specialized cryptocurrency funds, but also by traditional asset managers investing in digital assets, whether directly or indirectly.

Investments with direct exposure to digital assets can be achieved through investing in digital currency products, such as Exchange Traded Funds (ETFs), single currency trusts or diversified funds. These investment products enable investors to gain exposure to cryptocurrency in a form of a security, without having to physically buy the cryptocurrency themselves. Furthermore, they offer an easily accessible alternative to shareholders, by avoiding the logistics of buying, transferring and safekeeping of digital assets, given that such tasks are entrusted to an appointed custodian by the fund.

With $12.38 billion USD AuM as of September 30, 2022, Grayscale Bitcoin Trust (GBTC) is the largest trust solely and passively invested in Bitcoin globally, tracking the

CoinDesk Bitcoin Price Index (XBX), an index that provides a reference rate for the spot price of Bitcoin in US dollars. Its investment objective is for its share value, based on the Bitcoin spot price per share, to reflect the value of Bitcoin held by the fund, excluding fees and expenses (Grayscale Investments, 2022).

As of the date of writing this report, there are six Bitcoin Exchange Traded Funds (ETFs) approved for trading by the Securities and Exchange Commission (SEC) (Curry & Adams, 2022). On October 19, 2022, the ProShares Bitcoin Strategy ETF (BITO) launched as the first U.S. Bitcoin ETF (Dore, 2021) and has since then reached circa $687 million USD of AuM as of the date of writing this report. It aims to «provide capital appreciation primarily through managed exposure to Bitcoin futures contracts» (ProShares, 2022). Like BITO, all other Bitcoin ETFs, such as the Valkyrie Bitcoin Strategy ETF (BTF) or the VanEck Bitcoin Strategy ETF (XBTF) do not hold Bitcoin directly, but instead are invested in the Chicago Mercantile Exchange (CME) Bitcoin futures. The reason for this is because the SEC is reluctant to accept applications for ETFs that directly invest in Bitcoin, mainly driven by the fact that the asset is predominantly traded on non-regulated exchanges (Todorov, 2021). In contrast to the U.S., Jacobi Bitcoin ETF (BCOIN) is a spot Bitcoin fund that, in October 202, became the first Bitcoin ETF to be approved in Europe (Jacobi Asset Management, 2022).

In addition to single currency funds, diversified, passively managed cryptocurrency funds, such as the Bitwise 10 Crypto Index Fund (BITW) and the Galaxy Crypto Index Fund, tracking the performance of the Bitwise 10 Large Cap Crypto Index and the Bloomberg Galaxy Crypto Index respectively, provide investors exposure to the most liquid and the largest cryptocurrencies, weighing their constituents by market capitalization.

Instead of pursuing investments with direct exposure to digital assets, one may wish to attain indirect exposure through actively managed funds that invest in companies that operate

within the digital asset ecosystem, namely stocks exposed to blockchain technology. Many investors regard the cryptocurrency market as being especially volatile and may therefore be reluctant to invest in funds with direct exposure to it, while many of these indirect funds are invested in blue-chip stocks across a broad spectrum of industries, with holdings in companies like JPMorgan Chase & Co., Mastercard and SAP. Moreover, regulators are still hesitant to approve ETFs that directly invest in coins. There is increasing interest from institutional investors to hold indirect exposure to cryptocurrency. A BNY Mellon survey found that 50 percent of institutional investors are currently investing or exploring this kind of products, while 41 percent of those surveyed stated that, although they are not indirectly invested in cryptocurrency at the moment, they believe they will be in 2 to 5 years from now (BNY Mellon, 2022).

According to VettaFi ETF database, the largest ETF by AuM is Amplify Transformational Data Sharing ETF (BLOK), with over $447 million USD under management as of the date of writing this report. Other funds include the First Trust Index Innovative Transaction & Process ETF (LEGR) with circa $107 million USD AuM and the Siren Nasdaq NexGen Economy ETF (BLCN) with over $101 million USD AuM. Furthermore, BlackRock, the world's largest asset manager with over $10 trillion USD AuM, is starting to push into the crypto market: a clear change of tune from previous remarks made by BlackRock's CEO, Laurence Fink, labelling Bitcoin as an "index of money laundering". Back in April 2022 BlackRock launched the iShares Blockchain and Tech ETF (IBLC), with over $5 million USD AuM, and in August 2022, the company announced the launch of a spot Bitcoin private trust to institutional clients in the United States (Chipolina & Masters, 2022).

6. Geopolitical Context

6.1. COVID-19 Impact

As mentioned in the market overview, the COVID-19 pandemic was a catalyst for digital assets, prompting greater use of digital finance and emancipating a true upheaval in the way payments are made. For instance, the pandemic plight was responsible for a 200 percent rise in mobile banking adoption, hand in hand with a 160 percent increase of tap-to-pay[10] usage, and an 82 percent shift to digital payments on US small businesses' side (Nium, 2022).

The digital transformation affected every sector, with people and institutions forced to adopt unfathomable technological measures to adapt to the reshaped world. Was not for the digital, the economy would have collapsed, people would not be able to connect and circumvent the adverse situation we were facing. The reliance on technology proved to be the thrust needed for the population to overcome some of the skepticism edging digital assets. Also, contrary to other financial services, digital assets do not rely on any physical infrastructure, hence, its performance would not be shaken by pandemic restrictions.

Moreover, the decentralized feature of digital assets allows the investor to be in charge, as far as no centralized organization, that due to economic mishaps were considered instable, holds power over the individual money. The evolution triggered by the wake of COVID-19 pandemic should not withdraw, these hasty and unprecedent developments should remain, forasmuch as the world as we knew will never be restored. Unambiguously, digital assets are here to stay, how they will evolve after COVID-19 is still, nonetheless, onerous to foretell.

6.2. Russia-Ukraine War Impact

On February 24, 2022, Russia invaded Ukraine, marking the beginning of a war doomed to have worldwide repercussions. Cryptocurrencies have emerged as a financial weapon in the Russia-Ukraine war, steering demand for Bitcoin in both countries. In fact, between February 20 and 28, Bitcoin volume of BTC/RUB pair traded via Binance increased by 243 percent (Wall Street Journal, 2022).

[10] Secure and contactless payments using short-range wireless technology.

The majority of countries placed on Ukraine's side, enforcing several sanctions on Russian banks and financial institutions. On March, seven Russian banks were removed from SWIFT (BBC, 2022), a global financial artery, created in 1973 to transfer money across borders, linking 11,000 banks and institutions in more than two hundred countries. This measure aimed to disconnect Russia from the international financial system, disrupting their ability to operate globally by restraining Russia's valuable exportations on energy and agriculture. Herein, Russia shifts to digital asset payments, moving toward central bank digital currencies (CBDCs) for cross border payments (Insights, 2022). By March, Ukraine had raised $63.8 million dollars in digital asset donations (Elliptic, 2022) by crypto industry leaders, prominent blockchain businesses and anonymous crypto traders, once more validating crypto's strength in times of crisis.

Notwithstanding the ephemeral positive impact of the war in crypto volume traded, the extended duration of the disagreement slowed the recovery of the post-pandemic economy, translating into unfavorable macroeconomic repercussions. Major economies are facing recession risk (The Guardian, 2022), what started with rising food and fuel costs, turned out to be one of the biggest inflation crises of the last four decades (Aljazeera, 2022). Thereupon, investors are poorer and more risk averse, distress periods ask for more cautious decisions, culminating on a cease of investments on digital assets. All in all, the invasion fractured the international monetary system, dragging digital assets with it. Confirming, once again, that the digital asset sphere, upholds bull-market luxuries rather than reliable, inflation-resistant investments (Yahoo Finance, 2022).

7. Macroeconomic Analysis

To provide BPI GA with a solid and data-driven understanding of the main factors that influence digital assets, we aimed to research how macroeconomic factors impact cryptocurrency prices. More specifically, we analyzed the effect that inflation, interest rates,

exchange rates, stock market indices, liquidity, stock market volatility and gold had on the returns of a both a value-weighted cryptocurrency portfolio, as a proxy for the cryptocurrency market, and Bitcoin.

To derive a capitalization-weighted portfolio, we screened the top ten cryptocurrencies, excluding stablecoins, by market capitalization, relying on historical data retrieved from Coinmarketcap.com, a leading source of information for cryptocurrencies volume, price and market capitalization, covering over 500 exchanges. CoinMarketCap lists both active and inactive cryptocurrencies, which may help to reduce survivorship bias. Moreover, to be included on an exchange website, a cryptocurrency must have non-zero trading volume during the past 24 hours. According to information retrieved from CoinGecko.com and our own calculations, we estimate that at the date of writing this report the portfolio covered approximately 80 percent of the total cryptocurrency market, excluding stablecoins, therefore providing us assurance that it is representative of the whole cryptocurrency market.

We then aggregated the historical end-of-day prices in USD of the eligible cryptocurrencies from the period of October 20, 2017, until October 18, 2022, and, instead of using daily returns, we computed both weekly and monthly log returns, given that, unlike the bond or stock market, the cryptocurrencies are traded 24 hours a day, 365 days a year. The portfolio weights at each rebalancing date are given by:

$$(1)\ W_{i,t} = \frac{MCAP_{i,t}}{TCAP_t},\ i = 1,2,\dots,10$$

Where:

- $W_{i,t}$ is the weight of cryptocurrency *i* at rebalancing date *t*
- $MCAP_{i,t}$ is the market capitalization of cryptocurrency *i* at rebalancing date *t*

- $TCAP_t$ stands for the sum of the market capitalization of the top ten cryptocurrencies at rebalancing date *t*

The portfolio is rebalanced monthly, on the first day of each month, as digital assets are added, removed or re-weighted. Portfolio returns are calculated as the product between each cryptocurrency weight and its return. To mitigate forward-looking bias, we lagged weekly returns by one week for the weekly time series and by one month for the monthly one. **Table 1** depicts the descriptive statistics of the weekly time series of returns for the value-weighted portfolio and for Bitcoin. Measuring risk-adjusted returns of both portfolios, we can see that the value-weighted one has an Info Sharpe Ratio of 0.00466, while Bitcoin's is almost eight times higher at 0.03593. **Table 2** depicts the descriptive statistics of the monthly time series of returns of the value-weighted cryptocurrency portfolio and Bitcoin. Measuring risk-adjusted returns of both portfolios, we can observe that they significantly improve for both portfolios. The value-weighted one now has an Info Sharpe Ratio of 0.01647. Bitcoin still presents higher risk-adjusted returns, with an Info Sharpe Ratio of 0.08634.

Table 1: Descriptive Statistics, weekly time series of returns

Variables	Obs	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
Cryptocurrency	266	.00055	.118	-.56	.301	-.385	.267	-.866	5.783
Bitcoin	266	.00406	.113	-.535	.321	-.371	.256	-.576	5.359

Table 2: Descriptive Statistics, monthly time series of returns

Variables	Obs	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
Cryptocurrency	60	.0041	.249	-.539	.47	-.539	.47	-.149	2.535
Bitcoin	60	.0196	.227	-.466	.481	-.466	.481	-.105	2.506

The dependent variables in the these first set of tests are: the returns of the value-weighted portfolio of cryptocurrencies; the returns of Bitcoin. The independent variables are as follows: the price of gold (G), on a global scale. For interest rates (IR), we included both short and long-term interest rates, utilizing the yield of US 3-month Treasury Bills (3MIR) and on

US 10-year Treasury Notes (10YIR), respectively. Inflation, captured by both the US Consumer Price Index (CPI) and the Personal Consumption Expenditures (PCE) Index. Pertaining to stock market volatility, we used the CBOE Volatility Index (VIX), that reflects the expected implied volatility given by options on the S&P 500. As for liquidity, we use the US M2 monetary aggregate. Cross-sectional data was used for foreign exchange (FX) and stock market indices (SM) across ten countries. Given that stock market indices are quoted in the country's local currency, to account for the effect of foreign exchange, all fund data was converted to US dollars. The data for G, IR, SM, the VIX, and FX was retrieved from Bloomberg. M2 and US CPI and PCE were taken from the website of the Federal Reserve of St. Louis. **Table 3** shows the indicators of FX and SM for each country.

Table 3: Indicators of **FX** and **SM**

Country	**FX**	**SM**
United States	USD	S&P 500 Nasdaq Russell 2000
United Kingdom	USD/GBP	FTSE 100
Japan	USD/JPY	Nikkei 225
Australia	USD/AUD	S&P/ASX 200
Russia	USD/RUB	MOEX
China	USD/CNY	Shanghai
Brazil	USD/BRL	Bovespa
Portugal	USD/EUR	PSI 20
Spain	USD/EUR	IBEX 35
Germany	USD/EUR	DAX

We performed a regression analysis on the variables mentioned above, using both weekly and monthly data, to infer the impact that each one of the independent variables had on

each dependent variable. Considering both the coefficient and its significance level, we assessed the highest correlated variable from each set of independent variables and selected that variable as the representative of the correspondent set. Those variables were then incorporated on a more concise regression model (exhibited in **Table 4**), whilst the others were left out on an attempt to mitigate multicollinearity[11] effects. The output of this procedure is described by the model in **Table 4**, which explains 38.9% of the variance in the cryptocurrency value-weighted portfolio monthly returns.

Table 4: Cryptocurrency Portfolio Regression Analysis, monthly basis

VARIABLES	(1) Crypto Returns
Δ VIX	0.244*
	(0.135)
Δ Gold	-0.264
	(0.829)
Δ USD/RUB	0.928*
	(0.500)
Δ PCE.	-6.210
	(16.71)
Δ M2	2.553
	(2.419)
Δ ASX 200	2.776***
	(0.611)
Δ Interest rates (3M)	-0.0562
	(0.0531)
Alpha	-0.000948
	(0.0552)
Observations	59
R-squared	0.389

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[11] If high intercorrelations exist among two or more independent variables in a multiple regression model, it can lead to skewed or misleading results. To prevent this, analysts avoid using more than one technical indicator of the same type (Investopedia, 2022).

In the first instance, we can observe the ASX 200 coefficient being strongly positive and significant at the 1% level. We should expect, holding everything else constant, a 2.776% increase in the returns of the crypto portfolio amid a 1% change in the ASX 200 Index's returns. Therefore, in the event of an outperformance of the Australian Index, the crypto portfolio is anticipated to achieve even greater returns. Likewise, the model indicates that volatility, measured by VIX, and the Russian ruble exchange rate, are positively correlated with crypto returns, at a 10% confidence level. The coefficients suggest that ceteris paribus, a 1% increase in the returns of VIX and USD/RUB, result, correspondingly, on a 0.244% and 0.928% change in portfolio's returns. The statistical significance of the exchange rate corroborates what the literature has previously found when it comes to the effect of foreign exchange on Bitcoin prices (Dyhrberg, 2016). The remaining metrics display a confidence interval inferior to 90%. Although insignificant, the inflation effect captured by the Personal Consumption Expenditures Index (PCE), is heavily negative on the portfolio returns. Despite in a different magnitude as of the PCE, gold and short-term interest rates also exhibit a negative effect over the returns of cryptocurrency. At last, the effect of liquidity, captured by the M2 is largely positive. Overall, the model depicted in **Table 4** exhibits an insignificant alpha that is close to zero.

8. Cryptocurrency Exposure to Traditional Factors

To evaluate if our crypto portfolio's returns were driven by the traditional factors, we ran 3 regressions with our crypto portfolio's returns as the dependent variable, and the traditional factor models (5FF, 3FF + Momentum and 3FF + Quality Minus Junk) as the independent variables. The weekly results are depicted in **Table 5**.

Table 5: Regression of the traditional factors over the crypto portfolio, weekly timeseries

VARIABLES	Crypto PF	Crypto PF	Crypto PF
Market	1.123***	1.095***	0.784***
	(0.260)	(0.251)	(0.270)
SMB	0.695	0.982**	-0.118
	(0.541)	(0.492)	(0.593)
HML	-0.182	-0.338	-0.0489
	(0.453)	(0.327)	(0.317)
RMW	-0.954		
	(0.636)		
CMA	0.380		
	(0.812)		
Momentum		0.0184	
		(0.680)	
QMJ			-6.482***
			(2.112)
α	-0.000699	-0.00131	0.00143
	(0.00706)	(0.00704)	(0.00705)
Observations	261	261	258
R-squared	0.111	0.102	0.131

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

On a weekly basis, traditional factors are able to explain 10 to 13% of the crypto portfolio's weekly returns. It is mostly related to the Risk Premia Factor, with its coefficient being positive and significant at the 1% level, for the three models. This means that, for every 1% increase in the weekly Risk premium, our crypto portfolio's weekly returns would also increase by percentages ranging from 0.784 to 1.123. The Quality Minus Junk factor seems to have a strong negative correlation with our crypto portfolio, with our regressions pointing out that, for a 1% increase in the weekly QMJ, the crypto portfolio would decrease by 6.48%.

It is also important to assess the results on a monthly basis (**Table 6**), although it demonstrates that the results are similar.

Table 6: Regression of the traditional factors over the crypto portfolio, monthly timeseries

VARIABLES	Crypto PF	Crypto PF	Crypto PF
Market	1.872***	1.806***	1.231*
	(0.666)	(0.658)	(0.634)
SMB	-0.605	-0.262	-1.872
	(1.401)	(1.225)	(1.342)
HML	0.177	-0.0722	0.172
	(1.066)	(0.806)	(0.723)
RMW	-0.751		
	(1.642)		
CMA	-0.280		
	(1.676)		
Momentum		-0.0255	
		(2.241)	
QMJ			-9.912**
			(4.458)
α	-0.00435	-0.00751	0.0132
	(0.0322)	(0.0311)	(0.0311)
Observations	60	60	60
R-squared	0.154	0.151	0.221

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Traditional factors explain 15% to 22% of the crypto portfolio's monthly returns. Risk premia is still positive and significant at the 1% level for the two first models, but only at 10% for the third one. This is probably due to the high coefficient of QMJ, that is still negative and now close to 10%.

9. BPI Funds Regression Analysis: Cryptocurrency

To assess the impact of the digital asset ecosystem in BPI GA's operations, we measured the exposure of a selected number of BPI GA funds to some of the most common risk premia factors jointly with our crypto portfolio. We decided to analyze equity-only funds, since there is a widely known correlation between cryptocurrencies and the stock market (International Monetary Fund, 2022). The funds selected for this analysis were: BPI Euro Large Cap (BPIEURO PL Equity), mainly focused on European large capitalization stocks; BPI Europa (BPIACCS PL Equity), mainly focused on European large and mid-cap stocks; BPI Iberia

(BPIIBER PL Equity), mainly focused on Portuguese and Spanish stocks; BPI Ações Mundiais (BPIREST PL Equity), mainly focused on large-cap stocks from developed markets; BPI America – Class D (BPIAMER PL Equity) and Class E (BPIAMEE PL Equity), mainly focused on US stocks; BPI Africa (BPIAFRC PL Equity), mainly focused on African equities; BPI Asia Pacific (BPIAPAC PL Equity); mainly focused on Asian and Australian stocks; BPI Portugal (BPIPORT PL Equity), mainly focused on Portuguese equities; and BPI Reforma GLB (BPIGLRE PL Equity), a fund invested in stocks, ETFs, open-end funds and futures from mostly developed economies.

Using historical prices of the funds from 03/10/2017 until 30/09/2022, we computed both weekly and monthly log returns and subsequently regressed their excess returns over different factors using the OLS method. Initially, we used the market risk premia, SMB, and HML, subsequently adding RMW and CMA. The final step included the addition of QMJ and Momentum.

Formerly, we applied the Fama-French 3-Factor (FF3) model to regress the weekly excess returns of the funds on the market risk premia, SMB, HML and further included the weekly returns of the crypto portfolio. **Table 7** depicts the results obtained.

Table 7: Regression of weekly excess returns on FF3 + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	0.551***	0.471***	0.410***	0.666***	0.780***	0.186***	0.378***	0.407***	0.900***	0.467***
	(0.0502)	(0.0487)	(0.0460)	(0.0409)	(0.0417)	(0.0441)	(0.0444)	(0.0440)	(0.0283)	(0.0569)
SMB	0.364***	0.303***	0.313***	-0.161**	-0.168**	0.158*	0.0908	0.241***	-0.125**	0.185*
	(0.0933)	(0.0905)	(0.0855)	(0.0759)	(0.0775)	(0.0819)	(0.0824)	(0.0817)	(0.0527)	(0.105)
HML	0.149**	0.104*	0.278***	-0.180***	-0.0906*	0.0540	-0.158***	0.295***	-0.0589*	-0.0866
	(0.0595)	(0.0577)	(0.0545)	(0.0484)	(0.0494)	(0.0522)	(0.0526)	(0.0521)	(0.0336)	(0.0614)
Crypto	0.0187	0.0240**	0.0249**	-0.00632	-0.0166*	0.00602	-0.00115	0.0204*	-0.00930	0.0406**
	(0.0121)	(0.0117)	(0.0111)	(0.00985)	(0.0101)	(0.0106)	(0.0107)	(0.0106)	(0.00683)	(0.0165)
α	-0.000818	-0.000319	0.000950	0.00122	0.00148	0.000251	-0.000302	0.000975	0.000170	0.000891
	(0.00136)	(0.00132)	(0.00125)	(0.00111)	(0.00113)	(0.00120)	(0.00120)	(0.00119)	(0.000769)	(0.00171)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.452	0.395	0.429	0.537	0.590	0.119	0.267	0.430	0.810	0.463

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results indicate that, on two opposite ends, variations of the independent variables are able to explain most (81%) of the variation in BPI America – Class E excess returns, whereas in BPI Africa fund, only an insignificant share (11.9%) can be explained by these same variables. The rest of the funds, aside from the BPI Asia Pacific (R-squared of 0.267), display an acceptable R-squared within the range of 0.4 and 0.6. Is it noteworthy to highlight the positive and greatly significant effect of the market risk premium in every BPI GA fund. This may be a result of two possible scenarios. Either there is a preference for stocks that are listed in the NYSE, AMEX or NASDAQ, or there is an inclination for stocks that, despite not being listed in the U.S., are highly correlated with the U.S. market overall, since the stocks used to compute the market risk premium factor are all the stocks listed in the NYSE, AMEX and NASDAQ (French, 2022).

Apart from the BPI Asia Pacific fund, which has no meaningful correlation with SMB factor, the BPI GA funds are significantly exposed to this factor, with more emphasis on BPI Euro Large Cap, BPI Europa, BPI Iberia and BPI Portugal that exhibit a positive coefficient with a 1% significance level. Suggesting that BPI GA European funds are heavier on small market cap stocks, which comes as a surprise for the BPI Euro Large Cap fund; however, studies have found that even large cap tilted portfolios can have a positive SMB coefficient (Bassett, 2014). Although SMB is positively correlated with most funds, there is an exception for BPI America – Class E and Class D and BPI Ações Mundiais. In these funds, SMB exhibits a negative coefficient, significant at the 5% level, intuitively implying a weightier investment on large market cap stocks. The contrast seems reasonable, considering that the American stock market is larger than the European (Statista, 2022).

The HML factor does not have a statistically significant impact on BPI Africa fund and the BPI Reforma GLB fund. With a 99% confidence interval, while BPI Portugal and BPI Iberia exhibited a positive weight of, respectively, 0.295 and 0.278, BPI Ações Mundiais and BPI

Asia Pacifico are, respectively, negatively correlated at -0.180 and -0.158. The former funds evidence greater preference for high book-to-market stocks, which are acknowledged as value stocks. Conversely, the funds with negative coefficients demonstrate an inclination towards growth stocks (BPI Ações Mundiais and BPI Asia Pacifico).

The leading purpose of our model is to analyze the impact that the crypto portfolio has over BPI GA's funds. Foremost, the magnitude of the coefficients is small in all funds, suggesting that, even though there might be a correlation, the coefficient is not sizable to have a substantial impact on BPI GA funds' excess returns, possibly due to low exposure of these funds' holdings to crypto. However, we would like to highlight the following: BPI Reforma GLB is the most impacted by cryptocurrency, with a positive and significant coefficient at the 5% level. In fact, ceteris paribus, a 1% increase in the returns of the cryptocurrency portfolio leads to a 0.0406% increase in its excess returns. Further, regarding BPI Europa and BPI Iberia, the coefficient is also positive and statistically significant at the 5% level: a 1% increase in the returns of the cryptocurrency portfolio leads to a 0.0240% and 0.0249% increase in excess returns, respectively. In addition, the crypto portfolio has little, but statistically significant impact at the 10% level, in BPI America – Class D and BPI Portugal. On one hand, a 1% increase in the returns of the cryptocurrency portfolio leads to a 0.0166% decrease in the excess returns of BPI America – Class D. On the other hand, that same 1% increase leads to a 0.0204% increase in the excess returns of BPI Portugal. In the remaining funds, the crypto portfolio has an insignificant impact.

In the monthly time series regression, the results observed are widely different. The most drastic difference lies in the R-squared of the regression on the funds, with the highest value being 0.284 on the BPI Reforma GLB fund i.e., 28.4% of the variation in its excess returns is explained by the variation in the factors, compared to 81% on the weekly regression. This is expected, as the R-squared value depends on the amount of data, i.e., the number of

observations. Our model comprises a rather small time period (5 years), regressing 261 weekly observations covers a wider scope than the 60 monthly observations[12], leveraging a more substantiated model capable of better explaining return variations. Regarding the factors, the market risk premium, SMB and HML have no coefficients with statistical significance, whereas the crypto portfolio still holds its correlation with some of the funds. Interestingly, in BPI Reforma GLB, the coefficient of the crypto portfolio is, in absolute values, higher than the one of the market risk premia and HML, and it is now statistically significant at the 1% level. In fact, a 1% increase in the returns of the cryptocurrency portfolio leads to a 0.116% increase in its excess returns. Despite increasing in BPI Europa and BPI Iberia, the crypto coefficient is no longer statistically significant at any conventional confidence level. Furthermore, it gains statistical significance in BPI Ações Mundiais, at the 10% level, and in BPI Africa and BPI America – Class E, at the 5% level. It is also worth mentioning that this regression captured a significant alpha. More specifically we can reject the null hypothesis that alpha is equal to zero in BPI America – Class D and there is convincing evidence that there are other risk premia factors, not included in the independent variables, which are able to explain the fund's excess returns. **Table 8** depicts the results obtained for the monthly regression.

Table 8: Regression of monthly excess returns on FF3 + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	-0.108	-0.0674	-0.105	-0.128	-0.145	0.0663	-0.0398	-0.107	-0.132	-0.0433
	(0.145)	(0.132)	(0.125)	(0.126)	(0.134)	(0.124)	(0.102)	(0.127)	(0.122)	(0.142)
SMB	0.333	0.315	0.166	0.127	0.116	-0.352	-0.0128	0.0695	0.114	-0.169
	(0.277)	(0.253)	(0.240)	(0.241)	(0.256)	(0.238)	(0.195)	(0.243)	(0.234)	(0.291)
HML	-0.136	-0.112	0.151	-0.212	-0.198	-0.0336	-0.143	0.189	-0.171	-0.0266
	(0.174)	(0.159)	(0.151)	(0.152)	(0.161)	(0.150)	(0.123)	(0.153)	(0.147)	(0.163)
Crypto	0.0405	0.0427	0.0425	0.0495*	0.0461	0.0645**	0.0212	0.0397	0.0576**	0.116***
	(0.0299)	(0.0273)	(0.0259)	(0.0261)	(0.0277)	(0.0257)	(0.0211)	(0.0263)	(0.0253)	(0.0356)
α	-0.000888	0.000707	0.00659	0.0104	0.0121*	0.000796	0.00131	0.00657	0.00693	0.00619
	(0.00722)	(0.00660)	(0.00626)	(0.00630)	(0.00668)	(0.00621)	(0.00509)	(0.00635)	(0.00611)	(0.00786)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.078	0.090	0.090	0.116	0.096	0.125	0.050	0.079	0.132	0.284

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[12] With the exception of the BPI Reforma GLB fund, with 152 weekly and 35 monthly observations.

In the next set of tables, we assess BPI GA's funds exposure to additional factors, namely the risk premia factors in the Fama-French 5-Factor model (FF5) by including the RMW and CMA factors. The results obtained are depicted in **Table 9**.

Table 9: Regression of weekly excess returns on FF5 + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	0.515***	0.452***	0.396***	0.654***	0.763***	0.188***	0.359***	0.406***	0.886***	0.441***
	(0.0517)	(0.0506)	(0.0480)	(0.0414)	(0.0422)	(0.0456)	(0.0462)	(0.0460)	(0.0284)	(0.0576)
SMB	0.367***	0.333***	0.298***	-0.0444	-0.0582	0.244***	0.0778	0.246***	-0.0465	0.317***
	(0.104)	(0.102)	(0.0968)	(0.0834)	(0.0850)	(0.0920)	(0.0930)	(0.0927)	(0.0573)	(0.121)
HML	0.225**	0.118	0.322***	-0.258***	-0.151**	-0.0250	-0.104	0.292***	-0.0982**	-0.158*
	(0.0870)	(0.0851)	(0.0808)	(0.0697)	(0.0710)	(0.0768)	(0.0777)	(0.0774)	(0.0479)	(0.0935)
RMW	0.162	0.162	0.0157	0.384***	0.385***	0.242**	0.0445	0.0168	0.286***	0.385***
	(0.123)	(0.120)	(0.114)	(0.0982)	(0.100)	(0.108)	(0.110)	(0.109)	(0.0675)	(0.132)
CMA	-0.380**	-0.192	-0.152	-0.107	-0.160	0.0256	-0.206	-0.00740	-0.137	-0.143
	(0.156)	(0.153)	(0.145)	(0.125)	(0.127)	(0.138)	(0.139)	(0.139)	(0.0858)	(0.166)
Crypto	0.0213*	0.0261**	0.0254**	-0.00238	-0.0125	0.00823	-0.000145	0.0206*	-0.00620	0.0474***
	(0.0120)	(0.0118)	(0.0112)	(0.00963)	(0.00982)	(0.0106)	(0.0107)	(0.0107)	(0.00662)	(0.0163)
α	-0.000715	-0.000339	0.00104	0.000945	0.00124	1.84e-05	-0.000207	0.000965	3.89e-06	0.000633
	(0.00136)	(0.00133)	(0.00126)	(0.00109)	(0.00111)	(0.00120)	(0.00121)	(0.00121)	(0.000746)	(0.00168)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.469	0.403	0.431	0.565	0.616	0.136	0.274	0.430	0.825	0.497

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

By incorporating the RMW and CMA factors, the regression results captured more effects than the previous model. As a result, all the R-squared values increased, indicating that BPI GA fund returns are better explained by the FF5 model. Nonetheless, the results of the former FF3 factors (Market risk premium, SMB and HML) still exhibit similar values. The main divergence lays within the SMB factor, which lost its statistical significance over the BPI Ações Mundiais, BPI America – Class D and BPI America – Class E funds. Similarly, the HML factor is no longer statistically significant over the BPI Europa, BPI Asia Pacifico funds, whereas the BPI Reforma GLB's coefficient moved from being insignificant to display a 90% confidence interval.

RMW reveals a positive coefficient for all funds, with statistical significance over BPI Ações Mundiais, BPI America – Class D, BPI America – Class E, BPI Reforma GLB, all at the 1% level, and BPI Africa at the 5% level. As for CMA, apart from BPI Africa fund, it exhibits

a negative coefficient, only significant for BPI Euro Large Cap, indicating poor correlation with investment policies.

The extension of the model, triggered some changes regarding the coefficients of the crypto portfolio, gaining statistical significance over the BPI Euro Large Cap and BPI Reforma GLB (from no statistical significance to statistically significant at the 10% level, and from statistically significant at the 5% level to 1% level, respectively). Further, it no longer exhibited a statistically significant impact over the BPI America – Class D fund. Overall, this model highlights marginal correlation improvements.

Again, the results are drastically different in the monthly time series. **Table 10** depicts the results obtained.

Table 10: Regression of monthly excess returns on FF5 + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	-0.137	-0.0915	-0.109	-0.166	-0.168	0.0985	-0.0749	-0.129	-0.171	-0.125
	(0.156)	(0.143)	(0.137)	(0.140)	(0.149)	(0.139)	(0.113)	(0.138)	(0.134)	(0.154)
SMB	0.663**	0.606**	0.393	0.277	0.267	-0.346	0.0773	0.328	0.348	-0.0161
	(0.317)	(0.291)	(0.279)	(0.284)	(0.302)	(0.283)	(0.231)	(0.281)	(0.272)	(0.342)
HML	-0.420*	-0.365	-0.0736	-0.294	-0.309	-0.101	-0.169	-0.0352	-0.336	-0.0369
	(0.244)	(0.223)	(0.214)	(0.218)	(0.232)	(0.217)	(0.177)	(0.216)	(0.208)	(0.239)
RMW	0.692*	0.608*	0.447	0.358	0.335	-0.0457	0.237	0.540	0.524	0.443
	(0.373)	(0.342)	(0.327)	(0.334)	(0.355)	(0.332)	(0.271)	(0.330)	(0.319)	(0.351)
CMA	0.410	0.371	0.372	0.0467	0.132	0.193	-0.0409	0.327	0.183	-0.168
	(0.385)	(0.353)	(0.338)	(0.345)	(0.366)	(0.343)	(0.280)	(0.341)	(0.329)	(0.371)
Crypto	0.0447	0.0465*	0.0456*	0.0512*	0.0480*	0.0649**	0.0221	0.0430	0.0604**	0.126***
	(0.0294)	(0.0270)	(0.0258)	(0.0263)	(0.0280)	(0.0262)	(0.0214)	(0.0261)	(0.0252)	(0.0363)
α	-0.00464	-0.00263	0.00376	0.00907	0.0105	0.000226	0.000702	0.00362	0.00456	0.00481
	(0.00736)	(0.00675)	(0.00646)	(0.00659)	(0.00701)	(0.00655)	(0.00535)	(0.00652)	(0.00630)	(0.00833)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.144	0.151	0.134	0.134	0.112	0.131	0.065	0.131	0.176	0.333

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Although the R-squared values improved in comparison to the model depicted in **Table 8** (Regression of monthly excess returns on FF3 + cryptocurrency portfolio), it is evident that they decline when we move to a monthly time series. Comparing these two models, we can observe that the coefficient of the SMB factor over the BPI Euro Large Cap and BPI Europa funds almost doubled and gained statistical significance at the 5% level. Additionally, the coefficient for HML almost tripled its value over the BPI Euro Large Cap fund, gaining

statistical significance at the 10% level. In the remaining funds it is statistically insignificant. Cryptocurrency maintained its statistical significance over the same funds as in the model in **Table 8**. In addition, the crypto portfolio is now statistically significant at the 10% level over BPI Europa, BPI Iberia and BPI America – Class D.

Comparing the model in **Table 10** (Regression of monthly excess returns on FF5 + cryptocurrency portfolio) with the model in **Table 9** (Regression of weekly excess returns on FF5 + cryptocurrency portfolio), we can observe that, on the one hand, RMW lost its statistical significance over BPI Ações Mundiais, BPI America – Class D, BPI Africa, BPI America – Class E and BPI Reforma GLB BPI. On the other hand, it gained statistical significance at the 10% level over the BPI Euro Large Cap and BPI Europa. Furthermore, the coefficients for the CMA factor lost their statistical significance.

To better assess the impact of this factors and their relevance, we compared them with two extra factors, MOM and QMJ. Firstly, we regressed the Fama-French 3 factors with momentum and the crypto portfolio, over the funds. **Table 11** depicts the results obtained for the weekly time series.

Table 11: Regression of weekly excess returns on FF3 + MOM + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	0.537***	0.460***	0.398***	0.662***	0.777***	0.184***	0.375***	0.401***	0.898***	0.462***
	(0.0497)	(0.0486)	(0.0457)	(0.0411)	(0.0419)	(0.0443)	(0.0446)	(0.0441)	(0.0285)	(0.0570)
SMB	0.296***	0.256***	0.259***	-0.178**	-0.181**	0.145*	0.0750	0.214**	-0.135**	0.156
	(0.0945)	(0.0924)	(0.0869)	(0.0781)	(0.0798)	(0.0843)	(0.0848)	(0.0839)	(0.0542)	(0.107)
HML	0.0829	0.0568	0.224***	-0.197***	-0.104**	0.0415	-0.173***	0.269***	-0.0683*	-0.110*
	(0.0624)	(0.0611)	(0.0574)	(0.0516)	(0.0527)	(0.0557)	(0.0561)	(0.0555)	(0.0358)	(0.0642)
MOM	-0.397***	-0.281**	-0.320***	-0.103	-0.0805	-0.0749	-0.0927	-0.155	-0.0566	-0.164
	(0.130)	(0.127)	(0.119)	(0.107)	(0.110)	(0.116)	(0.117)	(0.115)	(0.0745)	(0.135)
Crypto	0.0188	0.0240**	0.0249**	-0.00630	-0.0166	0.00603	-0.00114	0.0204*	-0.00929	0.0405**
	(0.0119)	(0.0117)	(0.0110)	(0.00986)	(0.0101)	(0.0106)	(0.0107)	(0.0106)	(0.00684)	(0.0165)
α	-0.000874	-0.000358	0.000905	0.00120	0.00147	0.000241	-0.000315	0.000953	0.000162	0.000862
	(0.00134)	(0.00131)	(0.00123)	(0.00111)	(0.00113)	(0.00120)	(0.00121)	(0.00119)	(0.000770)	(0.00171)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.471	0.406	0.444	0.539	0.591	0.120	0.269	0.434	0.810	0.468

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We can see that the market risk premium still maintains a statistically significant impact over every fund, while the SMB factor does not have a statistically significant impact only over the BPI Asia Pacific and BPI Reforma GLB funds. HML has no statistical significance over BPI Euro Large Cap, BPI Europa and BPI Africa. MOM demonstrates a negative statistically significant impact over BPI Euro Large Cap, BPI Europa and BPI Iberia. The crypto portfolio maintains a statistically significant impact over the BPI Europa, BPI Iberia, BPI Portugal and BPI Reforma GLB funds. Comparing with the model that included the 3 Fama-French factors and cryptocurrency (**Table 7**), we can see that the R-squared values residually increased with the inclusion of MOM. However, the results for the R-squared are mixed when comparing this regression with the one that included the 5 Fama-French factors and crypto (**Table 9**). This leads us to believe that momentum can better explain the excess returns of some BPI funds than RMW and CMA, which is the case for BPI Iberia and BPI America – Class E.

Substituting momentum for QMJ yields some differences in the regression analysis, depicted in **Table 12**.

Table 12: Regression of weekly excess returns on FF3 + QMJ + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	0.539***	0.468***	0.382***	0.719***	0.836***	0.210***	0.382***	0.395***	0.944***	0.498***
	(0.0529)	(0.0514)	(0.0482)	(0.0418)	(0.0425)	(0.0462)	(0.0468)	(0.0463)	(0.0286)	(0.0585)
SMB	0.314***	0.292***	0.198*	0.0558	0.0588	0.255**	0.106	0.190*	0.0520	0.361***
	(0.115)	(0.112)	(0.105)	(0.0909)	(0.0926)	(0.101)	(0.102)	(0.101)	(0.0622)	(0.138)
HML	0.162***	0.106*	0.307***	-0.235***	-0.148***	0.0296	-0.161***	0.308***	-0.104***	-0.130**
	(0.0620)	(0.0601)	(0.0564)	(0.0489)	(0.0498)	(0.0541)	(0.0547)	(0.0542)	(0.0335)	(0.0648)
QMJ	-0.310	-0.0707	-0.712*	1.345***	1.405***	0.601	0.0926	-0.317	1.101***	0.926*
	(0.418)	(0.406)	(0.381)	(0.330)	(0.336)	(0.366)	(0.370)	(0.366)	(0.226)	(0.475)
Crypto	0.0170	0.0236**	0.0209*	0.00108	-0.00886	0.00933	-0.000644	0.0186*	-0.00324	0.0473***
	(0.0123)	(0.0120)	(0.0112)	(0.00974)	(0.00992)	(0.0108)	(0.0109)	(0.0108)	(0.00667)	(0.0167)
α	-0.000701	-0.000292	0.00122	0.000710	0.000947	2.40e-05	-0.000337	0.00109	-0.000246	0.000617
	(0.00137)	(0.00133)	(0.00125)	(0.00108)	(0.00110)	(0.00120)	(0.00121)	(0.00120)	(0.000742)	(0.00170)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.453	0.395	0.436	0.565	0.616	0.128	0.268	0.431	0.826	0.477

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Comparing the model portrayed in **Table 12** with the one in **Table 11** (Regression of weekly excess returns on FF3 + MOM + cryptocurrency portfolio), we wish to point out the

fact that SMB is now statistically significant at the 1% level over BPI Reforma GLB, however it is no longer significant in BPI Ações Mundiais and BPI America – Class D. As for HML, it gains statistical significance at the 1% level over BPI Euro Large Cap and is now significant over every fund, except for BPI Africa. The quality factor has a clear direct effect over the funds analyzed, especially in the ones that are heavily invested on quality stocks. The impact of QMJ over BPI Ações Mundiais, BPI America – Class D and BPI America – Class E is positive and statistically significant at the 1% level. An exception to this is BPI Iberia, which presents a negative statistically significant coefficient at the 10% level, as well as BPI Euro Large Cap and BPI Europa, although insignificant. The crypto portfolio did not suffer major changes with the substitution of the factors, as it maintained the same statistical influence over the same funds. Regarding the R-squared values, they slightly increased upon the replacement of MOM for QMJ, with the exception of BPI Europa, BPI Iberia and BPI Asia Pacific.

As a final step, we included both QMJ and MOM in the regression analysis. We confirmed the previously mentioned influence of the momentum factor over some funds. For instance, the BPI Euro Large Cap fund lost HML significance upon the introduction of the momentum factor. Its significance was further recovered by substituting MOM for QMJ. Signaling that, for the mentioned fund, MOM captures a great share of risk that, in its absence, is captured by the HML factor. **Table 13** depicts the results obtained for the weekly time series.

Table 13: Regression of weekly excess returns on FF3 + QMJ + MOM + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	0.528***	0.460***	0.373***	0.715***	0.832***	0.208***	0.379***	0.390***	0.941***	0.492***
	(0.0522)	(0.0511)	(0.0478)	(0.0418)	(0.0426)	(0.0464)	(0.0469)	(0.0464)	(0.0287)	(0.0585)
SMB	0.260**	0.253**	0.156	0.0379	0.0437	0.243**	0.0926	0.169*	0.0411	0.333**
	(0.115)	(0.112)	(0.105)	(0.0920)	(0.0938)	(0.102)	(0.103)	(0.102)	(0.0630)	(0.139)
HML	0.0931	0.0574	0.253***	-0.257***	-0.167***	0.0143	-0.178***	0.281***	-0.117***	-0.155**
	(0.0651)	(0.0637)	(0.0596)	(0.0521)	(0.0531)	(0.0578)	(0.0585)	(0.0578)	(0.0357)	(0.0675)
MOM	-0.392***	-0.280**	-0.307**	-0.130	-0.109	-0.0872	-0.0949	-0.150	-0.0788	-0.172
	(0.130)	(0.127)	(0.119)	(0.104)	(0.106)	(0.116)	(0.117)	(0.116)	(0.0714)	(0.133)
QMJ	-0.231	-0.0147	-0.651*	1.370***	1.427***	0.618*	0.112	-0.287	1.117***	0.943**
	(0.413)	(0.404)	(0.378)	(0.330)	(0.337)	(0.367)	(0.371)	(0.367)	(0.226)	(0.474)
Crypto	0.0175	0.0239**	0.0213*	0.00124	-0.00873	0.00944	-0.000525	0.0188*	-0.00314	0.0473***
	(0.0122)	(0.0119)	(0.0111)	(0.00973)	(0.00992)	(0.0108)	(0.0109)	(0.0108)	(0.00666)	(0.0167)
α	-0.000786	-0.000353	0.00115	0.000682	0.000924	5.14e-06	-0.000358	0.00106	-0.000263	0.000581
	(0.00135)	(0.00132)	(0.00124)	(0.00108)	(0.00110)	(0.00120)	(0.00122)	(0.00120)	(0.000742)	(0.00170)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.472	0.406	0.451	0.568	0.618	0.130	0.269	0.435	0.827	0.483

Standard errors in parentheses

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

The market risk premium still maintains a positive and significant impact over every fund, while SMB only holds its statistical significance over five funds i.e., BPI Euro Large Cap, BPI Europa, BPI Africa, BPI Portugal, and BPI Reforma GLB. HML is significant over every fund, except in BPI Euro Large Cap, BPI Europa, and BPI Africa. MOM reveals a negative and statistically significant influence over the BPI Euro Large Cap, BPI Europa, and BPI Iberia funds. Moreover, the QMJ factor has a positive statistically significant influence over BPI Ações Mundiais, BPI America – Class D, BPI Africa, BPI America – Class E and BPI Reforma GLB, and a negative statistically significant influence over BPI Iberia. The impact of including these QMJ and MOM instead of RMW and CMA results on the loss of statistical significance of the crypto portfolio over BPI Euro Large Cap. It is also worth mentioning that, on a weekly basis, the R-squared values do not change much when using one set of factors over the other.

Further, we studied the monthly time series for the same regressions, where it is evident the influence of momentum over BPI GA's funds, portrayed on **Table 14**.

Table 14: Regression of monthly excess returns on FF3 + MOM + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	0.0900	0.0936	0.0640	-0.0567	-0.0559	0.199*	0.0234	0.0400	-0.0303	0.000413
	(0.125)	(0.121)	(0.110)	(0.130)	(0.136)	(0.118)	(0.104)	(0.118)	(0.122)	(0.136)
SMB	0.141	0.160	0.00312	0.0588	0.0299	-0.480**	-0.0739	-0.0724	0.0163	-0.264
	(0.232)	(0.222)	(0.202)	(0.240)	(0.251)	(0.218)	(0.193)	(0.218)	(0.224)	(0.280)
HML	-0.0189	-0.0165	0.252*	-0.170	-0.145	0.0450	-0.105	0.276**	-0.111	-0.00720
	(0.146)	(0.140)	(0.127)	(0.151)	(0.158)	(0.137)	(0.121)	(0.137)	(0.141)	(0.155)
MOM	-1.836***	-1.491***	-1.566***	-0.658*	-0.827**	-1.228***	-0.586*	-1.361***	-0.938***	-0.892**
	(0.356)	(0.342)	(0.311)	(0.369)	(0.386)	(0.335)	(0.296)	(0.335)	(0.345)	(0.429)
Crypto	0.0210	0.0269	0.0259	0.0425	0.0374	0.0515**	0.0149	0.0252	0.0476*	0.0975***
	(0.0250)	(0.0240)	(0.0218)	(0.0259)	(0.0271)	(0.0235)	(0.0208)	(0.0235)	(0.0242)	(0.0349)
α	-0.000285	0.00120	0.00710	0.0106*	0.0124*	0.00120	0.00151	0.00702	0.00724	0.00661
	(0.00596)	(0.00573)	(0.00521)	(0.00618)	(0.00647)	(0.00561)	(0.00497)	(0.00560)	(0.00578)	(0.00745)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.382	0.327	0.381	0.165	0.167	0.300	0.114	0.295	0.237	0.377

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In comparison to **Table 8** (Regression of monthly excess returns on FF3 + cryptocurrency portfolio), there is no worth mentioning the impact on the 3 Fama-French factors. The crypto portfolio, however, lost some of its explanatory power, as it is now captured by the momentum factor. It is now only statistically significant over BPI America – Class E and BPI Reforma GLB. As for MOM, it clearly demonstrates a strong impact over excess returns. In fact, it is the variable with the most explanatory power over the entire scope of BPI GA funds. All of them display a largely negative and significant loading on momentum, mostly at the 1% level, pointing a preference for stocks that underperformed over the selected time-period. Furthermore, the R-squared values show a significant improvement when compared to the ones in the models depicted by **Tables 8** (Regression of monthly excess returns on FF3 + cryptocurrency portfolio) and **10** (Regression of monthly excess returns on FF5 + cryptocurrency portfolio).

Following the same procedure, we replaced MOM with QMJ. **Table 15** depicts the results obtained for the monthly time series.

Table 15: Regression of monthly excess returns on FF3 + QMJ + cryptocurrency portfolio

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	GLB Reforma
Market	-0.0751	-0.0402	-0.0707	-0.120	-0.134	0.0872	-0.0110	-0.0707	-0.114	-0.0434
	(0.140)	(0.129)	(0.118)	(0.128)	(0.135)	(0.123)	(0.0959)	(0.119)	(0.122)	(0.143)
SMB	0.197	0.203	0.0254	0.0971	0.0696	-0.438*	-0.131	-0.0791	0.0404	-0.196
	(0.272)	(0.251)	(0.231)	(0.248)	(0.263)	(0.240)	(0.187)	(0.232)	(0.237)	(0.297)
HML	-0.0972	-0.0798	0.192	-0.204	-0.184	-0.00895	-0.109	0.232	-0.150	-0.0194
	(0.168)	(0.155)	(0.143)	(0.154)	(0.162)	(0.148)	(0.116)	(0.144)	(0.147)	(0.165)
QMJ	-1.942**	-1.593**	-2.014***	-0.433	-0.663	-1.222*	-1.688***	-2.122***	-1.053	-0.491
	(0.826)	(0.762)	(0.700)	(0.754)	(0.797)	(0.727)	(0.567)	(0.705)	(0.719)	(0.787)
Crypto	0.0167	0.0232	0.0179	0.0442	0.0380	0.0495*	0.000466	0.0137	0.0447*	0.106**
	(0.0305)	(0.0281)	(0.0258)	(0.0278)	(0.0294)	(0.0268)	(0.0209)	(0.0260)	(0.0265)	(0.0393)
α	0.00267	0.00363	0.0103*	0.0112*	0.0133*	0.00304	0.00441	0.0105*	0.00886	0.00701
	(0.00710)	(0.00656)	(0.00602)	(0.00648)	(0.00685)	(0.00626)	(0.00488)	(0.00607)	(0.00619)	(0.00804)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.164	0.158	0.211	0.121	0.108	0.169	0.184	0.211	0.165	0.293

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The coefficients of the 3 Fama-French factors lost their statistical significance over every fund, except for SMB in BPI Africa, which is negative and significant at the 10% level. The QMJ coefficients are strong, negative, and statistically significance across six funds i.e., BPI Euro Large Cap, BPI Europa, BPI Iberia, BPI Africa, BPI Asia Pacifico and BPI Portugal. The crypto portfolio has a significant impact over the BPI Africa and BPI America – Class E, both at the 10% level, as well as BPI Reforma GLB, at the 5% level. As for the R-squared values, there is an overall decline when comparing to the model in **Table 14** (Regression of monthly excess returns on FF3 + MOM + cryptocurrency portfolio). Balancing the R-squared values with the ones in **Table 8** (Regression of monthly excess returns on FF3 + cryptocurrency portfolio), it is possible to notice a slight increase. However, in comparison to the model in **Table 10** (Regression of monthly excess returns on FF5 + cryptocurrency portfolio), the results are mixed, increasing in some funds, while decreasing in others. Further comparing this model and the one in **Table 14** (Regression of monthly excess returns on FF3 + MOM + cryptocurrency portfolio) we can observe the latter featuring a superior R-squared for every fund, except for BPI Asia Pacific.

For our final BPI GA funds' regression, we incorporated both MOM and QMJ, with the 3 Fama-French factor and crypto portfolio. **Table 16** depicts the results obtained.

Table 16: Regression of monthly excess returns on FF3 + MOM + QMJ + cryptocurrency portfolio

VARIABLES	Euro Lare Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.0893	0.0930	0.0630	-0.0567	-0.0560	0.198	0.0222	0.0388	-0.0307	0.000589
	(0.125)	(0.121)	(0.108)	(0.131)	(0.137)	(0.119)	(0.1000)	(0.115)	(0.122)	(0.139)
SMB	0.0980	0.123	-0.0549	0.0589	0.0229	-0.505**	-0.151	-0.145	-0.00938	-0.263
	(0.235)	(0.226)	(0.202)	(0.246)	(0.257)	(0.222)	(0.187)	(0.215)	(0.229)	(0.286)
HML	-0.0111	-0.0100	0.262**	-0.170	-0.144	0.0494	-0.0912	0.289**	-0.106	-0.00739
	(0.146)	(0.140)	(0.125)	(0.152)	(0.160)	(0.138)	(0.116)	(0.133)	(0.142)	(0.158)
MOM	-1.700***	-1.377***	-1.383***	-0.658	-0.805*	-1.151***	-0.343	-1.133***	-0.857**	-0.896*
	(0.377)	(0.363)	(0.324)	(0.394)	(0.413)	(0.357)	(0.301)	(0.345)	(0.368)	(0.462)
QMJ	-0.821	-0.684	-1.101*	0.000966	-0.132	-0.463	-1.462**	-1.375*	-0.487	0.0183
	(0.751)	(0.723)	(0.646)	(0.786)	(0.823)	(0.711)	(0.599)	(0.688)	(0.733)	(0.797)
Crypto	0.0124	0.0197	0.0143	0.0425	0.0360	0.0466*	-0.000405	0.0108	0.0425	0.0978**
	(0.0262)	(0.0252)	(0.0225)	(0.0274)	(0.0287)	(0.0248)	(0.0209)	(0.0240)	(0.0255)	(0.0378)
α	0.00117	0.00241	0.00906*	0.0106	0.0126*	0.00202	0.00411	0.00946*	0.00810	0.00658
	(0.00610)	(0.00588)	(0.00525)	(0.00639)	(0.00669)	(0.00578)	(0.00487)	(0.00559)	(0.00596)	(0.00769)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.396	0.338	0.413	0.165	0.167	0.305	0.203	0.344	0.243	0.377

Standard errors in parentheses

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

Analogous to what was described in **Table 15** (Regression of monthly excess returns on FF3 + QMJ + cryptocurrency portfolio)**,** the model lacks statistical significance with respect to the 3 Fama-French factors, since exclusively BPI Africa and BPI Iberia held a significant coefficient (SMB and HML, respectively). MOM remains very impactful, having a significant influence over every fund, expect for BPI Ações Mundiais and BPI Asia Pacific. As for QMJ, it reveals a statistically significant correlation with BPI Iberia, BPI Asia Pacific, and BP Portugal. Withal, the crypto portfolio displays a statistically significant coefficient over BPI Africa, at the 10% level, and BPI Reforma GLB funds, at the 5% level. In BPI Iberia, BPI America – Class D and BPI Portugal there are significant alphas at the 10% level, which suggests that returns are not accurately explained by the factors, i.e., some effects are not being captured by the factors. Even though the R-squared values are not very high, they are still greater than the ones in **Tables 10** (Regression of monthly excess returns on FF5 + cryptocurrency portfolio), **14** (Regression of monthly excess returns on FF3 + MOM + cryptocurrency portfolio) and **15** (Regression of monthly excess returns on FF3 + QMJ + cryptocurrency portfolio).

10. Factor Construction

10.1. Methodology

For the interest of our studies, we created a factor that captures the risk premia associated with the digital asset ecosystem, namely cryptocurrencies. We followed the same methodology employed by Fama and French when developing SMB or HML, for instance. Hence, the process comprised the creation of two portfolios differentiated by their exposure (high vs low) to the cryptocurrency ecosystem, captured by our crypto portfolio. Firstly, we assessed the correlation between our crypto portfolio and specific companies selected by us (80), further reproducing the approach on a broader scope of stocks (1,500).

For the former, we used a database of roughly 7,000 publicly traded companies globally[13] that have been listed for, at least, five years. We initially screened for stocks that, at first sight, we expected to exhibit high correlation with cryptocurrency. These are companies that are directly exposed to the cryptocurrency, carrying out their operations within the digital asset landscape. Our selection included a set of cryptocurrency exchanges, crypto mining companies, inter alia. Simultaneously, we screened for stocks that we expected to present negative correlations or, at the very least, correlations close to zero. For the later, we covered healthcare, consumer discretionary, consumer staples, among other sectors that could be negatively, or nil affected by the rise of digital asset adoption. To ensure a reliable monthly rebalancing, we included a wide range of stocks. The outcome was a final dataset of eighty companies that included what we considered to be the expected forty least and highest correlated stocks to digital assets, based on the aforementioned assumptions. Furthermore, we sought choosing stocks that traded in developed markets, namely in North America, Europe,

[13] Combining various Bloomberg equity indices comprising distinct regions.

and Australia. The correlations were subsequently tested upon two approaches: static and rolling correlations.

For the static approach, we regressed the final dataset of eighty[14] companies with our crypto portfolio and assessed the top and bottom ten correlated companies, thereupon retrieving their prices and market capitalization from Bloomberg of the last five years. The curtailed size of the portfolio, comprising only twenty stocks out of the former eighty, intended to create a factor as pure as possible, mitigating the risk of the portfolio being heavy on less correlated stocks. To create a zero-investment strategy, the highest correlated stocks were included in the long leg of the factor, whereas the weaker correlated were shorted by the same amount and included in the short leg. The factor constructed through this method is called SMW (Strong Minus Weak), which effectively captures the risk premia associated with going long on stocks that exhibit strong correlation with cryptocurrency and shorting the ones with the weakest correlations.

In a broader sense, the SMW represent the difference between the returns of the top ten and bottom ten value weighted portfolios (monthly rebalanced), i.e., between the long portfolio and the short portfolio. These results were aggregated into monthly and weekly time series.

In due course, we studied rolling correlations. In this approach, rather than considering a fixed correlation value for the time period, we integrated the effect of the correlations change over time, on a daily basis. We used a rolling window of 52 weeks, i.e., correlations of the eighty companies with the crypto portfolio would be regressed daily but for the previous 52 weeks. The process for the rolling SMW factor creation mimics the one used for the static factor, with the introduction of a new step: instead of the monthly rebalancing only affecting

[14] Excluding companies with missing market cap values.

the weight of the stocks, it also rebalances the top and bottom ten stocks based on the correlations exhibited in the first day of each month.

We decided to take a step further and clarify whether SMW was the factor that better captures a risk premia associated with cryptocurrency. Therefore, we constructed a second factor, called "Global", based on a selection of a broader spectrum of companies worldwide. As such, we initially retrieved from Bloomberg the constituents of the iShares MSCI World UCITS, an ETF that tracks the performance MSCI World Index, as of the 21st of November 2022. This index covers over 1,500 large and mid-cap stocks across twenty-three developed economies, representing nearly 85 percent of the free float adjusted market capitalization in each country (MSCI , 2022). We dropped any bonds present within the list of constituents.

By retrieving the price history and market capitalizations for the last 5 years of these companies, we computed their daily returns and regressed them over the crypto portfolio. For the factor construction we followed the same methodology used for the SMW factor, applying both a static and rolling correlation.

Ultimately totalizing four distinct factors: SMW and Global, each constructed with both rolling and static correlations.

10.2. Robustness Check

The final step in the factor construction consisted of measuring the performance of all factors in capturing the risk associated with the crypto portfolio. We regressed both weekly and monthly returns of the cryptocurrency portfolio on each of the four factors. **Table 17** depicts the results obtained from this regression.

Table 17: Regression analysis of cryptocurrency returns on the factors

VARIABLES	Monthly Cryptocurrency Returns				Weekly Cryptocurrency Returns			
SMW (Static)	0.522***				0.465***			
	(0.123)				(0.0544)			
Global (Static)		0.574***				0.496***		
		(0.202)				(0.0914)		
SMW (Rolling)			0.0939				0.156***	
			(0.0564)				(0.0360)	
Global (Rolling)				0.678***				0.417***
				(0.172)				(0.0804)
Alpha	0.0256	0.00517	0.00483	-0.00232	0.00454	2.56e-05	-4.64e-05	-5.40e-05
	(0.0288)	(0.0303)	(0.0330)	(0.0294)	(0.00646)	(0.00691)	(0.00751)	(0.00737)
Observations	60	60	48	48	264	264	210	210
R-squared	0.236	0.122	0.057	0.252	0.218	0.101	0.083	0.115

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

By analysing **Table 17**, we can see that all four factors are positive and statistically significant at the 1% level in both time series, with the exception of the rolling SMW, in the monthly time series. On a weekly basis, the SMW factor constructed with static correlations clearly outperforms the other three. In fact, 21.8% of the variations in cryptocurrency returns are explained by the SMW static factor. Interestingly, that same factor, but with rolling correlations yielded the lowest R-squared in both time series. In the monthly time series, the use of the Global rolling factor seems more appropriate, although not too far from the SMW static, is able to explain 25.2% of the variations in the returns of cryptocurrency, while explaining merely 11.5% in the weekly regression. Overall, the SMW static factor seems to be the more consistent and effective alternative at capturing a cryptocurrency risk premium, wherefore being the selected for the regression analysis with BPI GA's funds.

11. BPI Funds Regression Analysis: SMW

In the next set of tables, we assessed how well can the static SMW replicate the returns of cryptocurrency and determine whether it is capable to capture a risk premium associated with the digital asset ecosystem. We started by regressing the excess returns of BPI funds on the 3

Fama-French factors and SMW. The results obtained for the weekly time series are depicted in **Table 18**.

Table 18: Regression of weekly excess returns on FF3 + SMW

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.593***	0.502***	0.448***	0.692***	0.804***	0.199***	0.404***	0.416***	0.930***	0.528***
	(0.0581)	(0.0565)	(0.0535)	(0.0470)	(0.0480)	(0.0508)	(0.0510)	(0.0510)	(0.0324)	(0.0627)
SMB	0.405***	0.332***	0.350***	-0.131	-0.138*	0.171**	0.118	0.246***	-0.0919*	0.254**
	(0.0990)	(0.0964)	(0.0912)	(0.0801)	(0.0819)	(0.0866)	(0.0869)	(0.0870)	(0.0553)	(0.111)
HML	0.126*	0.0916	0.261***	-0.203***	-0.117**	0.0472	-0.178***	0.299***	-0.0860**	-0.117*
	(0.0644)	(0.0627)	(0.0593)	(0.0520)	(0.0532)	(0.0563)	(0.0565)	(0.0565)	(0.0360)	(0.0674)
SMW (Static)	-0.0103	-0.00243	-0.00550	-0.0160	-0.0205	-0.00297	-0.0128	0.00675	-0.0191**	-0.00579
	(0.0153)	(0.0149)	(0.0141)	(0.0124)	(0.0127)	(0.0134)	(0.0135)	(0.0135)	(0.00857)	(0.0159)
α	-0.000976	-0.000382	0.000846	0.00102	0.00123	0.000205	-0.000468	0.00104	-6.63e-05	0.000805
	(0.00138)	(0.00135)	(0.00127)	(0.00112)	(0.00114)	(0.00121)	(0.00121)	(0.00122)	(0.000773)	(0.00176)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.447	0.385	0.418	0.539	0.590	0.118	0.270	0.422	0.812	0.442

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results initially indicate that this model can explain approximately the same variations in the dependent variables as the one in with the crypto portfolio (**Table 7)**. The market risk premium is still positive and significant at the 1% level across all BPI Funds. As for SMB, we can witness a loss in its statistical significance over BPI Ações Mundiais, going from 5% significance to insignificance, and BPI America – Class D and E, only significant at the 10% level. Nonetheless, the SMB over BPI Reforma is now significant at the 5% level, versus 10% level in **Table 7**.

Regarding HML, overall, it loses some statistical significance, with the exceptions of BPI America – Class D and E and BPI Reforma. Moreover, the coefficient value decreases slightly in most funds, with the exception of BPI Portugal, which goes on the opposite direction. Regarding the SMW factor, it seems to fail to replicate the cryptocurrency portfolio, as it is not statistically significant in any of the funds that the crypto portfolio is. It is negative and statistically significant at the 5% level over BPI America – Class E. As for the effect of cryptocurrency, we can see that it no longer has a significant impact on BPI Europa, BPI Iberia, BPI America – Class D, BPI Portugal, and BPI Reforma. Although weak and insignificant, SMW has a negative, effect over all funds, except for BPI Portugal, which is actually positive.

It only exhibits statistical significance, at the 5% level, over the BPI America – Class E: a 1% increase in the returns of SMW leads to a 0.0191% decrease in its excess returns, which is in line with the findings of the model depicted in **Table 7**.

Considering the monthly time series, the results are widely different. **Table 19** depicts the results obtained.

Table 19: Regression of monthly excess returns on FF3 + SMW factor

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.00579	0.0388	-0.0220	0.0108	0.00792	0.174	0.0618	-0.0119	0.0275	0.0211
	(0.136)	(0.125)	(0.123)	(0.108)	(0.110)	(0.121)	(0.0880)	(0.122)	(0.0954)	(0.131)
SMB	0.217	0.219	0.113	-0.0130	-0.0593	-0.399*	-0.152	-0.0130	-0.0452	-0.0942
	(0.253)	(0.233)	(0.229)	(0.201)	(0.205)	(0.225)	(0.164)	(0.227)	(0.177)	(0.254)
HML	-0.109	-0.0902	0.161	-0.179	-0.154	-0.0286	-0.106	0.207	-0.134	-0.0572
	(0.159)	(0.146)	(0.144)	(0.126)	(0.129)	(0.142)	(0.103)	(0.143)	(0.112)	(0.146)
SMW (Static)	0.104***	0.0968***	0.0748***	0.127***	0.141***	0.0960***	0.0944***	0.0864***	0.146***	0.122***
	(0.0296)	(0.0271)	(0.0268)	(0.0234)	(0.0240)	(0.0263)	(0.0191)	(0.0265)	(0.0207)	(0.0277)
α	0.00263	0.00398	0.00915	0.0147***	0.0168***	0.00411	0.00446	0.00950	0.0118**	0.0129*
	(0.00670)	(0.00614)	(0.00606)	(0.00530)	(0.00542)	(0.00594)	(0.00432)	(0.00599)	(0.00468)	(0.00722)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.223	0.228	0.164	0.385	0.417	0.216	0.330	0.196	0.500	0.412

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In parallel to what happened when we moved from the model in **Table 7** to **Table 8**, the 3 Fama-French factors became overall insignificant, with the exception of SMB over BPI Africa, at the 10% level. Interestingly, SMW is now positive and significant at the 1% level across all funds, with values ranging from 0.0748 over BPI Iberia to 0.146 over BPI America – Class E. It is also worth noting that, in comparison to the model in **Table 8**, there is a general improvement in the R-Squared, meaning that switching from the cryptocurrency portfolio to SMW on a monthly basis, causes an increase in the explanatory power of the independent variables over the dependent one. We can witness the presence of significant, but small, alphas in BPI Ações Mundiais and BPI America (D), at the 1% level, BPI America – Class E, at the 5% level, and BPI Reforma, at the 10% level.

Following the same procedure as in **Tables 9** and **10**, we added the RMW and CMA factors. The results for the weekly time series are depicted in **Table 20**.

Table 20: Regression of weekly excess returns on FF5 + SMW factor

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.556***	0.480***	0.437***	0.665***	0.772***	0.190***	0.385***	0.416***	0.905***	0.498***
	(0.0591)	(0.0580)	(0.0551)	(0.0470)	(0.0480)	(0.0519)	(0.0524)	(0.0526)	(0.0322)	(0.0634)
SMB	0.395***	0.350***	0.326***	-0.0354	-0.0491	0.245***	0.0981	0.249***	-0.0309	0.365***
	(0.107)	(0.105)	(0.0999)	(0.0853)	(0.0871)	(0.0942)	(0.0950)	(0.0955)	(0.0585)	(0.125)
HML	0.213**	0.114	0.312***	-0.263***	-0.159**	-0.0236	-0.116	0.295***	-0.108**	-0.177*
	(0.0886)	(0.0870)	(0.0826)	(0.0705)	(0.0720)	(0.0778)	(0.0785)	(0.0789)	(0.0483)	(0.0969)
RMW	0.127	0.138	-0.0198	0.375***	0.377***	0.240**	0.0223	0.00909	0.271***	0.344**
	(0.126)	(0.123)	(0.117)	(0.1000)	(0.102)	(0.110)	(0.111)	(0.112)	(0.0685)	(0.138)
CMA	-0.377**	-0.182	-0.146	-0.112	-0.172	0.0307	-0.214	0.00464	-0.147*	-0.110
	(0.157)	(0.154)	(0.146)	(0.125)	(0.128)	(0.138)	(0.139)	(0.140)	(0.0857)	(0.171)
SMW (Static)	-0.00851	0.000384	-0.00659	-0.00686	-0.0115	0.00329	-0.0131	0.00700	-0.0128	0.00195
	(0.0155)	(0.0153)	(0.0145)	(0.0124)	(0.0126)	(0.0137)	(0.0138)	(0.0138)	(0.00848)	(0.0160)
α	-0.000824	-0.000353	0.000945	0.000871	0.00112	4.90e-05	-0.000353	0.00103	-0.000134	0.000671
	(0.00137)	(0.00135)	(0.00128)	(0.00109)	(0.00112)	(0.00121)	(0.00122)	(0.00122)	(0.000750)	(0.00174)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.463	0.392	0.420	0.566	0.615	0.134	0.277	0.422	0.826	0.467

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall, and as before, there is a slight increase of the R-Squared across all funds when adding the two extra factors. The previous factors maintain similar values as in **Table 18**, as one would expect. The RMW, in accordance with **Table 9**, has significant impact of the same level across three of the funds i.e., BPI Ações Mundiais, BPI America (D) and BPI America (E), but is now only significant at the 5% level over the BPI Reforma. The CMA is still negative and significant at the 5% level over the BPI Euro Large Capitalizations and becomes statistically significant at the 10% level over the BPI American Equities. On the one hand, as in **Table 18**, the SMW factor is not statistically significant across any fund. On the other hand, unlike as in **Table 9**, the SMW factor fails to replicate the statistical significance of the crypto portfolio over five of the funds and even has small opposite signs across some of them.

Table 21 depicts the results of the monthly time series regressions. As with the results of **Table 19**, it is worth noting the increase of the explanatory power of the model when using our digital factor instead of the crypto portfolio, as in **Table 10**.

Table 21: Regression of monthly excess returns on FF5 + SMW factor

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	-0.0217	0.0159	-0.0251	-0.0310	-0.0202	0.201	0.0232	-0.0326	-0.0152	-0.0273
	(0.143)	(0.132)	(0.133)	(0.117)	(0.119)	(0.134)	(0.0957)	(0.130)	(0.0982)	(0.143)
SMB	0.591**	0.549**	0.367	0.192	0.157	-0.360	-0.0147	0.280	0.251	0.107
	(0.284)	(0.261)	(0.263)	(0.232)	(0.237)	(0.266)	(0.190)	(0.257)	(0.195)	(0.305)
HML	-0.428*	-0.374*	-0.0843	-0.303*	-0.316*	-0.118	-0.170	-0.0441	-0.347**	-0.161
	(0.219)	(0.201)	(0.203)	(0.178)	(0.182)	(0.205)	(0.146)	(0.198)	(0.150)	(0.216)
RMW	0.804**	0.706**	0.516	0.488*	0.486*	0.0292	0.346	0.627**	0.674***	0.413
	(0.336)	(0.310)	(0.312)	(0.274)	(0.280)	(0.315)	(0.225)	(0.305)	(0.231)	(0.317)
CMA	0.454	0.408	0.395	0.0978	0.194	0.214	0.00679	0.359	0.241	0.0622
	(0.346)	(0.319)	(0.321)	(0.282)	(0.288)	(0.324)	(0.232)	(0.314)	(0.238)	(0.340)
SMW (Static)	0.113***	0.104***	0.0806***	0.132***	0.146***	0.0969***	0.0975***	0.0931***	0.152***	0.127***
	(0.0286)	(0.0264)	(0.0266)	(0.0234)	(0.0239)	(0.0268)	(0.0192)	(0.0260)	(0.0197)	(0.0282)
α	-0.00134	0.000455	0.00622	0.0129**	0.0147**	0.00325	0.00342	0.00638	0.00901*	0.0109
	(0.00665)	(0.00613)	(0.00618)	(0.00543)	(0.00555)	(0.00624)	(0.00445)	(0.00604)	(0.00457)	(0.00763)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.309	0.308	0.219	0.420	0.450	0.222	0.359	0.265	0.571	0.445

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Like when using the crypto portfolio, the market risk premia is insignificant across all funds and the SMB is positive and significant at the 5% level across BPI Euro Large Cap and BPI Europa. The HML factor is now significant across five funds, three more than the previous model in **Table 10** i.e., BPI Ações Mundiais, BPI America (D) and BPI American (E). Also, the CMA factor continues to show no significant impact over BPI's funds. In similar fashion to what happened in the model depicted in **Table 19**, SMW is positive and significant at the 1% level across all funds, again being able to capture more of the variations of the dependent variables than the crypto portfolio. Regarding the alpha, it decreases its significance by one conventional level, when comparing with the results from **Table 19**.

In the next set of tables, we ditched RMW and CMA and included instead either momentum, quality, or both. Following the same procedure as in the regression analysis with the cryptocurrency portfolio, we started by regressing the excess weekly returns of BPI funds over the 3 Fama-French factors, in addition to MOM. **Table 22** depicts the results obtained.

Table 22: Regression of weekly excess returns on FF3 + MOM + SMW

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.587***	0.498***	0.444***	0.690***	0.803***	0.198***	0.402***	0.413***	0.929***	0.526***
	(0.0571)	(0.0562)	(0.0529)	(0.0470)	(0.0481)	(0.0509)	(0.0510)	(0.0510)	(0.0325)	(0.0626)
SMB	0.345***	0.291***	0.302***	-0.148*	-0.153*	0.159*	0.103	0.224**	-0.103*	0.227**
	(0.0992)	(0.0975)	(0.0918)	(0.0816)	(0.0835)	(0.0883)	(0.0886)	(0.0885)	(0.0564)	(0.113)
HML	0.0514	0.0392	0.201***	-0.225***	-0.135**	0.0329	-0.197***	0.271***	-0.0994**	-0.144**
	(0.0677)	(0.0665)	(0.0627)	(0.0557)	(0.0570)	(0.0603)	(0.0605)	(0.0604)	(0.0385)	(0.0707)
MOM	-0.408***	-0.285**	-0.326***	-0.116	-0.0980	-0.0778	-0.104	-0.151	-0.0727	-0.172
	(0.131)	(0.128)	(0.121)	(0.107)	(0.110)	(0.116)	(0.117)	(0.117)	(0.0743)	(0.138)
SMW (Static)	-0.0146	-0.00549	-0.00900	-0.0173	-0.0215*	-0.00381	-0.0140	0.00513	-0.0199**	-0.00761
	(0.0151)	(0.0149)	(0.0140)	(0.0125)	(0.0127)	(0.0135)	(0.0135)	(0.0135)	(0.00861)	(0.0160)
α	-0.00109	-0.000462	0.000754	0.000986	0.00121	0.000183	-0.000497	0.000994	-8.67e-05	0.000747
	(0.00136)	(0.00134)	(0.00126)	(0.00112)	(0.00114)	(0.00121)	(0.00122)	(0.00121)	(0.000773)	(0.00176)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.468	0.396	0.434	0.541	0.591	0.120	0.272	0.426	0.813	0.447

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Comparing the results for the R-squared of the models in **Tables 18** (FF3 + SMW) and **20**, we can see that they are fairly similar. Further, there is no significant change regarding the magnitude and significance of the coefficients: the market risk premium maintains its positive and significant impact across all funds. SMB only gains statistical significance at the 10% level over BPI Ações Mundiais; HML is no longer significant in BPI Euro Large Cap and SMW is now significant over BPI America (D). The next step involved switching MOM for QMJ, as per **Table 23**.

Table 23: Regression of weekly excess returns on FF3 + QMJ + SMW

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.578***	0.494***	0.420***	0.734***	0.849***	0.217***	0.405***	0.402***	0.964***	0.548***
	(0.0596)	(0.0581)	(0.0544)	(0.0469)	(0.0478)	(0.0520)	(0.0524)	(0.0523)	(0.0320)	(0.0643)
SMB	0.332***	0.296**	0.213**	0.0665	0.0755	0.253**	0.124	0.183*	0.0697	0.373***
	(0.118)	(0.115)	(0.107)	(0.0925)	(0.0943)	(0.103)	(0.104)	(0.103)	(0.0632)	(0.143)
HML	0.142**	0.0992	0.289***	-0.245***	-0.163***	0.0297	-0.179***	0.312***	-0.120***	-0.143**
	(0.0657)	(0.0641)	(0.0601)	(0.0517)	(0.0527)	(0.0574)	(0.0579)	(0.0577)	(0.0353)	(0.0702)
QMJ	-0.481	-0.239	-0.899**	1.302***	1.408***	0.545	0.0368	-0.416	1.064***	0.640
	(0.419)	(0.408)	(0.382)	(0.329)	(0.336)	(0.365)	(0.368)	(0.368)	(0.225)	(0.484)
SMW (Static)	-0.0134	-0.00401	-0.0114	-0.00744	-0.0112	0.000607	-0.0126	0.00402	-0.0121	-0.00227
	(0.0156)	(0.0152)	(0.0142)	(0.0123)	(0.0125)	(0.0136)	(0.0137)	(0.0137)	(0.00836)	(0.0161)
α	-0.000832	-0.000310	0.00112	0.000628	0.000812	4.13e-05	-0.000479	0.00116	-0.000386	0.000669
	(0.00139)	(0.00135)	(0.00127)	(0.00109)	(0.00111)	(0.00121)	(0.00122)	(0.00122)	(0.000746)	(0.00176)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.450	0.386	0.430	0.566	0.616	0.126	0.270	0.425	0.827	0.448

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results depicted in **Table 23** are somewhat similar to the ones in **Table 12**. The main difference lies in the fact that the digital factor, captured by SMW, is no longer significant across any fund, while it was significant across four funds using the crypto portfolio. The same

comments can be made when we include both MOM and QMJ, as the results are similar to the ones in **Table 13**, but the digital factor is not significant at any of the funds that it was when using the crypto portfolio. **Table 24** depicts the results obtained.

Table 24: Regression of weekly excess returns on FF3 + MOM + QMJ + SMW

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.574***	0.491***	0.417***	0.732***	0.848***	0.216***	0.404***	0.401***	0.963***	0.546***
	(0.0586)	(0.0577)	(0.0538)	(0.0468)	(0.0478)	(0.0520)	(0.0525)	(0.0523)	(0.0320)	(0.0642)
SMB	0.282**	0.261**	0.174	0.0496	0.0608	0.243**	0.111	0.165	0.0587	0.348**
	(0.117)	(0.115)	(0.107)	(0.0933)	(0.0952)	(0.104)	(0.105)	(0.104)	(0.0637)	(0.144)
HML	0.0661	0.0461	0.230***	-0.271***	-0.185***	0.0135	-0.198***	0.284***	-0.137***	-0.171**
	(0.0692)	(0.0681)	(0.0636)	(0.0553)	(0.0564)	(0.0615)	(0.0619)	(0.0617)	(0.0377)	(0.0734)
MOM	-0.402***	-0.282**	-0.314***	-0.136	-0.119	-0.0860	-0.105	-0.145	-0.0885	-0.174
	(0.131)	(0.129)	(0.120)	(0.104)	(0.107)	(0.116)	(0.117)	(0.117)	(0.0713)	(0.138)
QMJ	-0.423	-0.198	-0.853**	1.322***	1.425***	0.557	0.0520	-0.395	1.077***	0.649
	(0.412)	(0.406)	(0.379)	(0.329)	(0.336)	(0.366)	(0.369)	(0.368)	(0.225)	(0.483)
SMW (Static)	-0.0174	-0.00676	-0.0145	-0.00877	-0.0124	-0.000234	-0.0136	0.00260	-0.0130	-0.00408
	(0.0154)	(0.0151)	(0.0141)	(0.0123)	(0.0125)	(0.0137)	(0.0138)	(0.0137)	(0.00838)	(0.0161)
α	-0.000962	-0.000402	0.00101	0.000584	0.000773	1.34e-05	-0.000513	0.00111	-0.000414	0.000608
	(0.00137)	(0.00134)	(0.00125)	(0.00109)	(0.00111)	(0.00121)	(0.00122)	(0.00122)	(0.000745)	(0.00176)
Observations	261	261	261	261	261	261	261	261	261	152
R-squared	0.470	0.397	0.445	0.569	0.618	0.128	0.272	0.429	0.828	0.454

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

It is also important to cover the monthly time series regressions, as they yield different results when comparing to the weekly time series. Following the same chronological order, we started with the regression of the Fama-French 3-factor model, adding only the MOM factor, besides using our SMW factor, as can be seen in the **Table 25** below.

Table 25: Regression of monthly excess returns on FF3 + MOM + SMW factor

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.137	0.143	0.0968	0.0307	0.0368	0.259**	0.0820	0.0838	0.0667	0.0423
	(0.121)	(0.116)	(0.109)	(0.112)	(0.114)	(0.116)	(0.0907)	(0.115)	(0.0966)	(0.129)
SMB	0.0871	0.116	-0.00410	-0.0326	-0.0878	-0.483**	-0.172	-0.107	-0.0840	-0.164
	(0.220)	(0.211)	(0.199)	(0.203)	(0.207)	(0.211)	(0.165)	(0.209)	(0.176)	(0.253)
HML	-0.0146	-0.0156	0.246*	-0.165	-0.133	0.0325	-0.0915	0.276**	-0.105	-0.0419
	(0.139)	(0.133)	(0.125)	(0.128)	(0.130)	(0.133)	(0.104)	(0.132)	(0.111)	(0.143)
MOM	-1.606***	-1.272***	-1.455***	-0.244	-0.354	-1.042***	-0.248	-1.171***	-0.481*	-0.635
	(0.354)	(0.340)	(0.321)	(0.328)	(0.333)	(0.341)	(0.266)	(0.336)	(0.284)	(0.418)
SMW (Static)	0.0660**	0.0663**	0.0399	0.121***	0.132***	0.0711***	0.0885***	0.0584**	0.134***	0.106***
	(0.0268)	(0.0257)	(0.0243)	(0.0248)	(0.0252)	(0.0258)	(0.0202)	(0.0254)	(0.0215)	(0.0292)
α	0.00186	0.00337	0.00844	0.0146***	0.0166***	0.00361	0.00434	0.00894	0.0116**	0.0124*
	(0.00575)	(0.00553)	(0.00521)	(0.00533)	(0.00542)	(0.00554)	(0.00433)	(0.00546)	(0.00461)	(0.00708)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.437	0.387	0.395	0.391	0.429	0.331	0.341	0.344	0.525	0.455

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As it can be observed, with the monthly time series, the 3 Fama-French factors do not have a statistically significant influence over most funds, with the market risk premium only having a positive statistically significant coefficient over BPI Africa. SMB only has a negative statistically significant coefficient over the same fund, while the HML factor is only statistically significant with a positive coefficient over the BPI Iberia and BPI Portugal funds. On the other hand, the MOM factor is very impactfull and statistically significant over most assessed funds, with exceptions for the BPI Ações Mundiais, BPI America – Class D, BPI Asia Pacific and BPI Reforma GLB funds. In fact, the MOM factor presents negative coefficients for every fund over which it has statistically significant influence. Which translates into the fact that the funds in question are invested in equities that have depicted a downward trend during the time-series selected, meaning the last 5 years. So far, the results seem aligned with the regression using the crypto portfolio.

The greatest difference observed lies in the SMW factor, which exhibits positive results, as it presents statistically significant coefficients over every fund analyzed, mostly at a 1% level, except for the BPI Iberia fund. The coefficients are greater than with the crypto portfolio, indicating that the factor is capable of capturing and explaining risk associated with the digital asset ecosystem, not formerly captured by the crypto portfolio. In addition, there is statistically significant alpha for four funds: BPI Ações Mundiais, BPI America – Class D and E and BPI Reforma GLB.

It is also important to summarize what happens when we replace MOM by QMJ. **Table 26** depicts the results of the regression with the monthly time series.

Table 26: Regression of monthly excess returns on FF3 + QMJ + SMW

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.00366	0.0372	-0.0250	0.0119	0.00896	0.172	0.0603	-0.0148	0.0277	0.0197
	(0.135)	(0.124)	(0.119)	(0.108)	(0.111)	(0.121)	(0.0867)	(0.117)	(0.0962)	(0.133)
SMB	0.139	0.158	0.00524	0.0267	-0.0217	-0.450*	-0.206	-0.117	-0.0388	-0.107
	(0.256)	(0.236)	(0.225)	(0.205)	(0.210)	(0.229)	(0.165)	(0.223)	(0.183)	(0.263)
HML	-0.0847	-0.0712	0.195	-0.192	-0.166	-0.0127	-0.0891	0.240*	-0.136	-0.0534
	(0.159)	(0.146)	(0.139)	(0.127)	(0.130)	(0.142)	(0.102)	(0.138)	(0.113)	(0.149)
QMJ	-1.202	-0.947	-1.682**	0.618	0.586	-0.794	-0.844	-1.618**	0.0998	-0.170
	(0.811)	(0.748)	(0.713)	(0.650)	(0.665)	(0.726)	(0.521)	(0.706)	(0.579)	(0.725)
SMW (Static)	0.0843**	0.0809***	0.0466	0.137***	0.151***	0.0828***	0.0803***	0.0594**	0.147***	0.119***
	(0.0323)	(0.0298)	(0.0284)	(0.0259)	(0.0265)	(0.0289)	(0.0207)	(0.0281)	(0.0230)	(0.0311)
α	0.00414	0.00517	0.0113*	0.0139**	0.0161***	0.00511	0.00551	0.0115*	0.0117**	0.0131*
	(0.00670)	(0.00618)	(0.00589)	(0.00537)	(0.00549)	(0.00600)	(0.00431)	(0.00584)	(0.00478)	(0.00735)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.253	0.250	0.242	0.395	0.425	0.233	0.361	0.267	0.500	0.413

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Right off the bat, we can see that the market risk premium has no significant impact over any fund. SMB only maintains its statistical significance over BPI Africa and the same happens for HML, but in BPI Portugal instead. One possible explanation for this is that QMJ is capturing risk premia that was previously given credit to the 3 Fama-French factors. Having this in mind, it is important to note that QMJ only has a statistically significant impact over BPI Iberia and BPI Portugal, both with negative coefficients, which means that these funds are heavy on equities deemed as "junk" i.e., stocks that generally exhibit poor profitability, growth and that are often associated with greater risk. Regarding SMW, comparing the model above with the one in **Table 25**, we can see that it still maintains a significant impact over the same funds, apart from BPI Iberia. Further, its coefficients increase, which might indicate that some of the excess returns explained by SMW were being previously captured by momentum. It is also important to refer that there is a small, but statistically significant alpha for six funds i.e., BPI Iberia, BPI Ações Mundiais, BPI America – Class D and E, BPI Portugal and BPI Reforma GLB.

To finalize this analysis, it is imperative to include in the regression both momentum and QMJ. The monthly results are depicted in **Table 27**.

Table 27: Regression of monthly excess returns on FF3 + MOM + QMJ + SMW

VARIABLES	Euro Large Cap	Europa	Iberia	Ações Mundiais	America (D)	Africa	Asia Pacific	Portugal	America (E)	Reforma GLB
Market	0.132	0.139	0.0843	0.0408	0.0472	0.256**	0.0724	0.0702	0.0715	0.0443
	(0.122)	(0.117)	(0.108)	(0.112)	(0.113)	(0.117)	(0.0902)	(0.113)	(0.0974)	(0.131)
SMB	0.0662	0.100	-0.0571	0.0102	-0.0435	-0.497**	-0.213	-0.165	-0.0638	-0.157
	(0.224)	(0.216)	(0.199)	(0.206)	(0.209)	(0.217)	(0.166)	(0.209)	(0.180)	(0.260)
HML	-0.00982	-0.0119	0.259**	-0.175	-0.144	0.0358	-0.0821	0.289**	-0.110	-0.0445
	(0.140)	(0.134)	(0.124)	(0.128)	(0.130)	(0.135)	(0.104)	(0.130)	(0.112)	(0.146)
MOM	-1.554***	-1.232***	-1.324***	-0.349	-0.463	-1.007***	-0.146	-1.028***	-0.530*	-0.659
	(0.369)	(0.355)	(0.328)	(0.339)	(0.344)	(0.356)	(0.274)	(0.344)	(0.296)	(0.443)
QMJ	-0.391	-0.304	-0.991	0.801	0.828	-0.269	-0.768	-1.081	0.377	0.140
	(0.734)	(0.706)	(0.652)	(0.673)	(0.684)	(0.708)	(0.544)	(0.683)	(0.588)	(0.740)
SMW (Static)	0.0607**	0.0622**	0.0265	0.132***	0.144***	0.0675**	0.0781***	0.0437	0.139***	0.108***
	(0.0288)	(0.0277)	(0.0255)	(0.0263)	(0.0268)	(0.0277)	(0.0213)	(0.0268)	(0.0230)	(0.0314)
α	0.00237	0.00377	0.00975*	0.0135**	0.0155***	0.00396	0.00535	0.0104*	0.0111**	0.0122
	(0.00587)	(0.00565)	(0.00522)	(0.00538)	(0.00547)	(0.00566)	(0.00435)	(0.00546)	(0.00470)	(0.00723)
Observations	60	60	60	60	60	60	60	60	60	35
R-squared	0.440	0.389	0.420	0.407	0.444	0.333	0.365	0.373	0.529	0.456

Standard errors in parentheses

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

With the inclusion of MOM and QMJ, these results are quite similar to the previous monthly regressions. The market risk premium has a significant positive influence over the BPI Africa fund. This is also true for SMB, although its coefficient is negative. HML has a positive and significant impact at the 5% level over BPI Iberia and BPI Portugal. The lack of significant coefficients. On the one hand, MOM presents six negative statistically significant coefficients, over the BPI Euro Large Cap, BPI Europa, BPI Iberia, BPI Africa, BPI Portugal and BPI America – Class E funds. The QMJ factor, on the other hand, presents no statistically significant coefficient over any fund on a monthly basis. The SMW factor again presents encouraging results, as it has a statistically significant coefficient over all funds, with the exception of BPI Iberia and BPI Portugal. This is evidence that our factor has a significant influence over the funds' excess returns. Finally, the alpha presented is statistically significant for five funds i.e., BPI Iberia, BPI Ações Mundiais, BPI America – Class D and E, and BPI Portugal.

12. Conclusion

In this paper, our goal was to confirm the existence of a crypto factor that could explain a risk premium that was not previously captured by so-called "traditional" factors e.g., market

risk premia, SMB, HML, RMW, CMA, QMJ. Moreover, in the context of the consulting project developed alongside the client, we aimed to measure BPI GA funds' exposure to the digital asset ecosystem.

To cater our need for a benchmark to support our study, a crypto portfolio designed to mimic the performance of the cryptocurrency market was created. Subsequently, we assessed the influence that macroeconomic variables e.g., stock market volatility, exchange rates and interest rates, and "traditional" factors had on the returns of that same cryptocurrency portfolio.

As a result of the macroeconomic analysis performed, we found evidence that the VIX, Gold, USD/RUB and, especially, the returns of the ASX 200 had a positive and significant impact over the benchmark. As for the traditional factors, the Market Risk Premia and QMJ displayed strong correlations. Based on data provided by BPI GA, we tested the exposure of 10 funds to the crypto portfolio across five models. As a result, we found sufficient evidence to support the claim that BPI GA's funds were somehow exposed to digital asset space. Due to limitations regarding direct investment in digital assets, we aimed to replicate the cryptocurrency portfolio with stocks from the traditional markets, culminating with the creation of four factors.

Furthermore, we performed a robustness check, and verified that the static SMW offered the best indirect exposure to digital assets. Thereupon, we replicated the previous regressions, replacing the crypto portfolio by SMW. We found significant evidence of the influence of the digital asset space over BPI GA funds' performance, chiefly with monthly data. This impact is somewhat bigger the one exhibited by the crypto portfolio. One plausible interpretation for this, is the "addition" of the indirect influence that the digital asset space has in the companies, as we are not only considering the direct effect of cryptocurrencies, but also associated

investments, the adoption of blockchain technology and other implications that emerge upon the rise of digital assets.

13. Limitations

It should be noted that the dataset used is relatively small. Cryptocurrency is still an immature asset class when compared to stocks or bonds. Furthermore, there is a general lack of reliable data providers e.g., Bloomberg and Refinitiv, for this specific asset class. Moreover, given that this asset class is quite volatile when compared to equities, for instance, the recurrent variations that occur on a weekly basis are not captured by the monthly time series. This could explain why the results are so different with weekly versus monthly data.

Additionally, some other limitations can be pointed out. The conducted research does not contemplate transaction costs i.e., implicit, and explicit trading costs, which can be quite high with factor investing, especially with monthly rebalancing, which is our case. Moreover, the construction of our factor relied on the use of static correlations. Although this is the best performing factor, it is not as adaptive as a rolling one. For future reference the effect of narrower rolling windows should be considered, as, intuitively, could be more representative. Furthermore, the portfolio construction could be done in several ways, using a 1/n approach, a risk-adjusted or correlation-weighted approach instead of a value-weighted-one which we studied.

1. Introduction

One needs to understand that the economy is an ecosystem of intertwined industries that cohabit and adapt to survive amid our ever-evolving needs and preferences (Philip E. Auerswald, 2018) (Rabie, 2016). Indeed, assessing the impact of an infant market, as digital assets, on a mature industry like software, presents an onerous challenge. Likewise, the study will not only cover a

practical analysis of the SMW in the referred industry, as it will also elaborate on theoretical interferences the digital assets might instigate within the software industry.

The digital asset sphere encompasses beyond-asset applications, namely blockchain-related activities, provided that this asset class is built on top of blockchain technology. The effect of digital assets on the software industry can be described by (1) the growing demand to create software for digital asset-enable products and services and (2) the use of its underlying technology (blockchain) in software development for businesses. Instead of determining the impact of digital assets as an asset class, this study elaborates on the blockchain and infers how it affects the software field. It is noteworthy to understand that blockchain is not a software, instead, is a decentralized database that uses a network of computers to store and manage data (Nakamoto, 2008).

Blockchain's influence on the software industry is stimulated from within, with blockchain-oriented software (BOS) answering consumers' demands. The businesses served by the software industry are a considerable driver for blockchain offerings, hence the increase in blockchain adoption by overall industries should be a sufficient catalyst to reshape the studied industry. Therewith, understanding what is driving demand on the consumer's side, as well as blockchain's role in it, is of uttermost importance to support the analysis.

Firstly, this study sheds light on prior research, presenting the key findings of the literature covering this topic. Secondly, both the software industry and blockchain will be the scope of individual discussion. Thirdly, I will illustrate how industries embrace blockchain technology and its role in the contemporary software trends. Fourthly, I will conduct an evaluation of BPI GA's software holdings' representativeness by the iShares Expanded Tech-Software Sector ETF (IGV), an ETF that captures the software industry's performance. The IGV will be the

object of six distinct regressions, aiming at quantifying its exposure to SMW. Lastly, the conclusions and encountered limitations will be drawn.

2. Literature Review

2.1. Blockchain and Software Framework

Marchesi M. (2018) identified blockchain applications as one of the hastiest emerging fields of computer science, instigating wide demand for software applications in the past few years. Ansif Arooj, et al. (2022) considered blockchain's disruptive nature analogous to the rise of the Internet, which consequently places blockchain in the spotlight for myriad research. While Nakamoto (2008) introduced it as a technology to transfer electronic cash without the assistance of financial institutions, extensive literature supports that the range of blockchain applications is unfolding beyond cryptocurrency, including healthcare, E-government, insurance, Internet of Things (IoT), decentralized application (DAAPS), games, supply chain, real estate, communication, social welfare, security, privacy, inter alia (Pilkington 2015).

Mahdi Fahmideh, et al. (2020) argued that the field of software engineering has developed to fulfill business models' demands and to stay current with cutting-edge computer technologies that drive the adoption of software systems. In Swan's (2015) paper, blockchain is referred to as a "blueprint for a new economy", making only sense that a growing awareness of the technology fathoms the software industry (Murat Yilmaz, et al. 2019). In fact, Swan (2015) suggested that enterprise software offerings, such as Software as a Service (SaaS), can benefit from blockchain customization. And vice-versa, as blockchain scalability and performance can be augmented with cloud computing software (Mahdi Fahmideh, 2020). In line with this, Porru S., et al. (2017) introduced the concept of blockchain-oriented software (B0S) as "a new type of software that uses the implementation of blockchain in its components".

Mahdi Fahmideh, et al. (2020) evidence that implementing BOS raises new hurdles for software engineers, as a consequence of poor quality supporting materials to guide blockchain developers and the trade-off between security and performance whilst balancing budget and time requirements. The former is attributed to its immature state and the latter to intrinsic blockchain features. Amiangshu Bosu, et al. (2018) mentioned challenges associated with updating the software after release, greater expenses concerning software faults, and a hostile environment. Nonetheless, Pilkington (2015) and most researchers see promising socio-economic benefits from blockchain adoption.

All considered, the body of literature supports the hypothesis that blockchain can offer theoretical and managerial contributions to the software industry, as Ammar AL-Ashmori, et al. (2022) recently validated. Hence, suggesting that blockchain's role in the software development process, as well as organizational aspects, should be the ambit of exhaustive investigation.

2.2. Supply Chain

Kshetri (2018) deems IoT as a dominant trend in supply chain management (SCM), suggesting that blockchain plays a vital role in it, whereas Hackius N., et al. (2017) advised logisticians to start considering blockchain for their SCM offerings. Even though Joon-Seok Kim, et al. (2019) highlights SCM has not yet fully explored blockchain benefits, many research evidence great synergies for all participants in the operations and supply chain network. For example, Kshetri (2018) found enhanced transparency and accountability to be associated with blockchain in SCM, further supported by Saveen Abeyratne, et al. (2016). Wong, et al. (2017) corroborates the previous authors, drawing attention to blockchain's role as a trust mediator, and Arim Park, et al. (2021) highlighted its potential to improve the supply chain's sustainability performance while decreasing the financial burden. In an international operations and supply chain

management (OSCM) journal, Rosanna Cole, et al. (2019) identifies supplementary blockchain implications in the OSCM field. In particular, enhancement of product safety and security, advanced quality management, reduced illegal counterfeiting, improved inventory replenishment and management, reduced cost of transaction among supply chain parties, and amended product design and development.

More recently, Jacob Lohmer, et al. (2022) corroborated the prior statements, providing further insight into the prevailing vulnerabilities slowing blockchain adoption in SCM, namely, unclear network governance and lack of homogeneous regulation.

Albeit most authors study blockchain integration comprehensively in SCM, some narrow it to specific industry's supply chains, covering the auto industry (Alam, 2016), healthcare (Ik-Whan G. Kwon, 2016) (Abdellatif A., 2021), energy (Stubs M., 2020) (Chen S., 2019) (Srivastava A., 2018), agriculture (Hu S., 2021), education (Tiago M. Fernandez-Caramés, 2019), inter alia.

In general, authors, like Vinay Surendra Yadav, et al. (2022), measure supply chain efficiency over three pillars: increasing customer satisfaction, reducing cost, and improving responsiveness among the supply chain parties. As such, the body of literature suggests that blockchain can contribute to improve performance in all three pillars, recently substantiated by Al-Zaqeba, et al. (2022).

2.3. Main applications

2.3.1. IoT

Ansif Arooj, et al. (2022) found IoT to be the principal field leaning toward blockchain. Hitesh (2016) cited blockchain as "the silver bullet needed by the IoT industry", due to its potential to allow substantial savings for IoT manufacturers, create a more resilient ecosystem for devices to run on, and enforce data privacy. Christidis, et al. (2016) presented a compelling case that combining blockchain and IoT with smart contracts can solve paramount challenges faced by

the IoT sector, forcing a paradigm shift in business models profound enough to disrupt several industries. Supplementary studies conducted by He Xue, et al. (2022) and Xu Wang, et al. (2019) substantiated Christidis' findings. At the time of the papers, the former authors agreed that blockchain-IoT was in preliminary stages and further research was vital to seamlessly combine the technologies and overcome scalability problems, pointed as the bottleneck for this fusion. Several authors studied scenarios to solve these practical limitations, mainly by adapting blockchain's consensus mechanisms (Ittay Eyal, 2016) (Sukhwani H., 2017) (Vukolic, 2016).

2.3.2. Cybersecurity

Ayman Alkhalifah, et al. (2020) presented a taxonomy for blockchain threats and vulnerabilities over five different categories, namely, clients, consensus mechanism, mining pool, network, and smart contracts. As a way of illustration, the author identified the 51% vulnerability of the consensus mechanism, emerging when a single identity controls over 50% of the blockchain network, which, in turn, can lead to manipulation of the networks, double-spending, thievery, inter alia. This is just one example of the multiple vulnerabilities Ayman exploited.

Sanjay S, et al. (2021) conducted comprehensive research on the topic, introducing three key pillars of blockchain security. Firstly, confidentiality. Albeit blockchain allows for transparency and tracking of transactions, the only interface between a user and their information is the user key, which can easily be anonymous, whereupon conserving the user's identity. Secondly, data integrity, as strong cryptographic techniques prevent data from being altered or deleted. Lastly, availability, since a large number of nodes secures that, even in the event of one node being compromised, the information remains accessible.

Furthermore, the previous author argues that traditional cybersecurity solutions are not sufficient to sustain the increasing complexity of the networks, placing blockchain as the answer to security concerns. Sanjay identifies the pros and cons of blockchain use for cybersecurity.

On the one hand, the author highlighted secure data storage, processing and transfer, data transparency and traceability, user confidentiality and customer trustfulness, and no unique point of failure. On the other hand, it addressed issues associated with scalability, adaptability, lack of governance, blockchain literacy, and reliance on private keys.

While Marina Liu, et al. (2021) found how blockchain technology can answer cybersecurity questions in different contexts, Alotaibi (2019) manifested his belief that blockchain can solve IoT barriers associated with cybersecurity. Vinden Wylde, et al. (2022) not only proposed a framework merging other technological techniques (e.g., Big Data, Machine Learning, and Visualization) with blockchain to approach cybersecurity, as the author also assessed blockchain's enhanced ability to carry secure business operations in the digital domain when coupled with smart contracts.

Lastly, Ravi Prakash, et al. (2022) analyzed an extensive body of literature, finding that, whereas blockchain has attributes that support its suitability in the cybersecurity realm, it is still a target of ever-evolving security threats. Ravi Prakash concluded the research by drawing attention to the utmost importance of redesigning secure blockchain platforms.

3. Software Industry

The last decades marked a technology revolution, consistently, the Information Technology (IT) sector stands as the largest with, by the time of this paper, a market capitalization of $12.03 trillion USD (Fidelity, s.d.). Determined upon its core production activities, the IT sector integrates six industries, namely, communications equipment, electronic equipment, IT services, semi-conductors and semi-conductor equipment, technology hardware, storage and peripherals, and, lastly, software (Fidelity, s.d.), the core of the paper. Holding a market cap of $3.85 trillion USD (Fidelity, s.d.), software is the largest industry in the economy, comprising the development, distribution, and maintenance of software. This field, once said to "be eating

the world" (Andreessen, 2011), has grown at a rate twice as high as the overall market between 2011 and 2018 (McKinsey, 2020). Moreover, the industry's players totalize a market cap of $7.799 trillion USD (CompaniesMarketCap, s.d.), whereas cumulative revenues exhibited an annualized increase of 31.1% in 2021 (Muhlberg, 2021), possibly catalyzed by the Covid-19's induced shift on consumer preferences, now tilted to digital channels.

As mobiles are increasingly a cane to mundane activities, the gap between reality and virtuality tightens, therewith multiplying the number of customers served by the software industry (Feinstein, 2017). This paradigm shift is the cornerstone for new business models, and inadequate engagement can jeopardize companies' fate (Saueressig, 2021). Ergo, companies are reshaping the way a service or good is delivered. Perhaps Uber is the most illustrative case, as it developed a software that fundamentally changed the way people move. In the same vein, Amazon is remodeling retail and Airbnb revamping the hospitality sector.

4. Blockchain

4.1. Blockchain Evolution

Blockchain was first introduced in 2008 by the pseudonym of Satoshi Nakamoto amid the creation of Bitcoin (Nakamoto, 2008). The technology, Blockchain 1.0., kept growing at a slow pace as the backbone of cryptocurrencies. It was not until 2014, when The Ethereum Project paper proposed beyond cryptocurrencies applications for blockchain and introduced the concept of smart contracts (Buterin, 2014), that the technology started gaining traction, upon entering a new generation, Blockchain 2. 0.. One year later, NASDAQ began to explore blockchain technology for trading shares in private companies (NASDAQ, 2015), followed by the announcement of a blockchain approach to cloud-based business solutions by IBM (Kimmell, 2020). The year 2017 was marked by Dubai's announcement as the first blockchain-powered government by 2020 (Forbes, 2017). Henceforth, blockchain entered the next and

supposably last development stage, Blockchain 3.0., broadening its usage outside the domain of finance and economics, accordingly, disrupting business models on a global scale. Facebook committed to creating a blockchain project (Upson, 2018), large banks (e.g., Citi and Barclays) signed up to use IBM's blockchain platform (Hardcastle, 2018), the health sector relied on blockchain application amid Covid-19 (Çekani, 2021), inter alia. From 2021 on, metaverse engagement should further promote blockchain uses on a mainstream level (Hyun-Joo Jeon, 2021).

4.2. Blockchain Properties

The distinct properties of blockchain and how they address contemporary proclivities are revolutionizing technology at its core. First, the decentralization property consists of eliminating control from a single central authority or server. Instead, it is administered by a network of computers that work together to validate and record transactions (Bhalla, 2022). Secondly, immutability assures that data added to a block, cannot be altered once it is added to the chain. Hence, enriching security and reliability of the information stored and transferred on the network (Doubleday, 2018). Thirdly, due to its transparency nature, all transactions on a blockchain are visible to whoever accesses the network, which in turn, facilitates tracking past transactions of a particular asset or piece of information (Jung, 2019). Lastly, encryption adds another layer of security by combining decentralization with strong cryptographic techniques, making it resistant to tampering and fraud (Zhai, 2019).

4.3. Blockchain in the Software Industry

There is a duality concerning this topic, as blockchain can be both the instigator and the competitor of the software industry. On the one hand, not only can blockchain applications create an opportunity for associated and accessory software, as also blockchain innovative

properties can trigger the demand for BOS. On the other hand, blockchain companies can answer some of the traditional software challenges, overtaking their place in some markets.

Ergo, the study will shed light on how the disruptive technology can address the software's demand side, focusing on its customers, the industries, and what they are demanding (i.e., IoT and Cybersecurity).

4.3.1. Blockchain in Industries

Amid the digital transformation era, further empowered by Covid-19, it is of ultimate importance for organizations to reinvent their business models. In fact, based on research conducted by Harvard Business School, 97% of respondents agreed that companies need to embark on a digital transformation to remain competitive (Hill, 2022), fueling enterprise-software demand. Upon the dawn of blockchain technology, industry leaders have made a priority to understand how this emerging technology can add value to their business models (Deloitte, 2017), with 89% of executives presuming digital assets to play a very or somewhat important role in their industry within three years (Deloitte, 2020).

The common applications for blockchain (e.g. cryptocurrency and NFTs) are just the tip of the iceberg for the potential case uses of tokenization (Gartner, 2022), which will surface upon rising adoption and organization collaboration (Deloitte, 2017). Deloitte's 2020 Global Blockchain Survey, with a sample of 1,488 senior executives across different industries throughout fourteen countries, suggests that the preceding doubts edging the technology's avail, seem to have substantially faded away, with 88% believing in blockchain's scalability and its eventual mainstream adoption (Deloitte, 2020). The same study found that 55% of organizations place blockchain as a top-five priority, and 83% of businesses believe blockchain's adoption to be an instrument to gain competitive advantage. Lastly, it found that the share of organizations that had already adopted blockchain nearly doubled from 23% in

2019 to 39% in 2020, and that only 1% was not planning on investing in the technology within the next year, whereas 30%, 24%, and 12% projected investments of $1-5 million USD, $5-10 million USD, and more than $10 million USD, respectively. Overall, the adoption of blockchain technology is disrupting the traditional software industry and is fostering the development of a new generation of applications that offer users greater security, transparency, and control over enterprises' value chain, cybersecurity, and financial transactions.

4.3.2. Software Trends

Understanding the industry's dynamics is vital to illustrate how blockchain can shake the software ecosystem.

4.3.2.1. Blockchain-Cybersecurity

Cybersecurity is a discipline employed in safeguarding computer systems, networks, and data, from unauthorized access, manipulation, or destruction (CISA, s.d.). It is a growing trend in the software industry (Shivsharan, 2022), as software is a key part of most computer systems and networks and is often the target of cyber-attacks. Covid-19 emancipated the digital transaction, uplifting a cyber pandemic (Lohrmann, 2020), with a 400% rise in daily cyber-attack complaints in April 2020 compared to pre-pandemic figures (Aldridge, 2021). At the current growth rate, cybercrime is expected to account for $10.5 trillion USD in damages in 2025, compared to $3 trillion USD in 2015 (Morgan, 2020), acknowledged by McKinsey as an opportunity for the cybersecurity market to reach $1.5-2 trillion USD values. These dynamics uncover a significant potential for software companies and their imperative need to improve technology and rethink cybersecurity through blockchain. The appeal of blockchain as a weapon against cyber-attacks is ambiguous, while 66% reported cybersecurity as the main obstacle to digital assets mainstream adoption, only 3% believe blockchain to be less safe than traditional software (Deloitte, 2020). One aspect of blockchain technology that makes it

particularly useful for cybersecurity is its decentralized nature. Because the data in a blockchain is distributed across a network of computers, it is very difficult to alter or delete. This makes it resistant to tampering and fraud, which are major concerns in the realm of cybersecurity. Moreover, blockchain technology uses a fundamental cybersecurity tool, encryption (Gupta, 2020), that scrambles data to hinder intruders' access, ensuring the security and integrity of the data stored in the network (Menders, 2019). On the one hand, blockchain is gaining momentum in the cyber security industry by offering a myriad of advantages, namely, user confidentiality, data transparency and traceability, automation provided by the use of smart contracts (Comendador, 2022), inter alia. On the other hand, there are still some inevitable vulnerabilities when it comes to scalability and operational costs, considering the massive amounts of computing power required, as well as the lack of experienced blockchain developers and international regulation (Comendador, 2022).

Many new blockchain businesses are currently emerging to provide fresh services in this field (Comendador, 2022), if software companies do not catch up with the trends, they are at risk of losing their cybersecurity market to blockchain companies.

4.3.2.2.Blockchain-IoT

Another trend reshaping the software industry is the IoT (Shivsharan, 2022), a technology exhibiting growing adoption by several industries, predicted to be the most impactful Industry 4.0'[15]s technology on organizations (Deloitte, 2020). IoT is a network of physical objects (e.g., equipment, devices, and vehicles) embedded with software connectivity to collect and exchange data to be digitally monitored and controlled, connecting the digital to the physical world (McKinsey, 2022). The global IoT market is forecast to surpass the $1 trillion USD market cap by 2024 at a 15% CAGR from the $622 billion USD figures in 2020, when enterprise IoT

[15] Fourth industrial revolution, characterized by increasing automation and smart technologies (IBM, s.d.)

accounted for 76% of the overall market (GlobalData, 2022), and further predicted to reach a global value of $5.5 trillion USD up to $12.6 trillion USD by 2030 (Michael Chui, 2021).

According to Deloitte, blockchain proprieties, namely, the robust level of encryption and decentralization, can overcome some IoT hurdles, propelling IoT adoption (Deloitte, s.d.). For instance, the IoT' centralized client-server model raises security concerns, combining blockchain decentralization adds security layers, wherefore diminishing IoT' vulnerability, as mentioned in the cybersecurity section. Similarly, IoT can benefit from blockchain transparency as any authorized agent can track and pinpoint all past transactions, taking immediate action upon suspicious events (Arim Park, 2021). On enterprise level, the distributed ledger in a blockchain system assures that no single agent holds control, eliminating the need for trust between parties, heretofore faced by IoT adopters. The use of smart contracts can further address trust concerns as blockchain technology can automate the execution of contractual arrangements, securing parties' fulfillment and reducing overhead costs associated (Deloitte, s.d.). Moreover, blockchain comprises sustainability benefits (Arim Park, 2021), prominent to an economy in which 96% of the 250 largest companies report on sustainability (KPMG, 2022).

Notwithstanding, mainstream adoption of IoT-blockchain technology is still facing technical and practical handicaps (Deloitte, s.d.). For instance, as the number of interconnected devices grows, so does the need for faster processing and bigger storage. The integration of blockchain technology requires more computational power than centralized networks, amplifying the effect of scalability and placing it as the bottleneck for blockchain.

4.4.Software Companies using Blockchain

Despite the struggles associated with blockchain implementation, such as its hindrance to integrating the technology into the traditional software's project life cycle, software companies aim to adapt to the new market demands (Ammar AL-Ashmori, 2022). As a result, several

software players have been actively exploring blockchain use cases in their business models. In fact, IBM, AWS, Google, Oracle, and Microsoft, have adopted a distributed ledger technology developed by the Linux Foundation called Hyperledger Fabric (HF), an open-source framework that operates permissioned blockchains enterprise-oriented (Hyperledger Fabric, s.d.).

IBM is an IT company that has been a leader in the development and deployment of blockchain technology, serving big players such as Citi and Barclays. HF serves as the foundation for the IBM Blockchain Platform, a cloud-based platform, with advanced privacy features, that allow its users to tailor resources to specific business scenarios and control the blockchain network (IBM, s.d.) (Mengjie Ding, 2021). In addition to HF solutions, companies developed their own blockchain services (Azure, s.d.). More recently, after discontinuing Microsoft Azure Blockchain service, the company introduced Azure Confidential Ledger, offering a tamperproof and decentralized ledger for data entry supported by blockchain (Azure, s.d.). Moreover, Oracle developed the Oracle Blockchain Cloud Service which allows users to easily integrate blockchain through a cloud service, an on-premises edition, or a Software as a service (SaaS) application for supply chain (Oracle, 2023). In addition, Salesforce and SAP, leading software companies focused on customer relationship management and business operations, have launched their individual cloud blockchain platform HF-based in order to adapt to the distributed ledger model adopted by companies (Schuster, 2018) (Partz, 2019).

5. Software Industry Regression Analysis: SMW

5.1. iShares Expanded Tech-Software Sector ETF (IGV) and BPI GA's Holdings

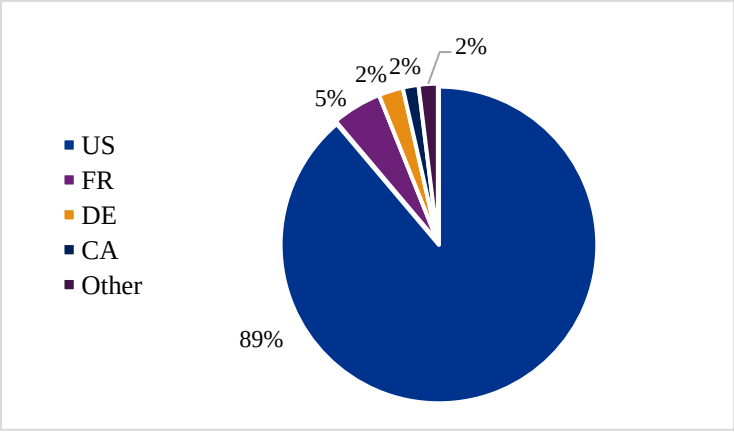
The IGV ETF comprises leading companies in the North American software industry, caping individual weights at 8.5% to assure diverse exposure to a concentrated industry. Accounting for more than 40%, the top five holdings are, downwardly, Salesforce, and Adobe. Oracle, Microsoft., and Intuit. The top ten further comprises ServiceNow, Activision Blizzard,

Synopsys, Roper Technologies, and Cadence Design Systems, totalizing almost 60% of the ETF.

The IT sector[16] accounts for almost one-third of BPI GA holdings and the software industry is the weightiest industry within the funds, accounting for 8.20% of common stock's holdings' value. BPI GLOBAL INV FD - BPI TECHNOLOGY REVOL is the highest allocated fund to the software industry. Although 74.82% of the fund holds companies in the IT sector, only 21.29% is attributed to the software industry, therefore is not a good representative of the industry.

Within BPI GA software's holdings, the top five accounts for 63.66%, represented by Microsoft, Intuit, MSCI, Cadence Design Systems, and Adobe. The top ten further integrate Autodesk, SAP, Salesforce, Fair Isaac, and Snowflake, capturing a 78.17% share. Apart from MSCI, all BPI GA's top five holdings are present in the IGV top ten holdings. IGV's suitability to capture the BPI GA fund's effect can be further supported by **Graph 1**, since it evidences a 91% allocation to the North American market, the scope of IGV investments.

Graph 1: Geographical Share of BPI GA Software's Holdings



[16] Industries in the IT sector: Computers + Internet + Semiconductors + Electronics + Electronic Components & Equipment + Software

5.2. Methodology

To assess the software industry's exposure to the digital asset ecosystem, a total of six weekly and monthly regressions were performed on the IGV. The regressions combined the Strong Minus Weak factor (SMW) created, which captures the digital asset effect, and the 3 Fama-French factors (Market risk premium, Small Minus Big, and High Minus Low), with additional factors. Respectively, the 5 Fama-French extension (Robust Minus Weak and Conservative Minus Aggressive), Momentum and Quality Minus Junk factor, as depicted below.

5.3. Weekly Regressions

Table 1: Regression of traditional factors + SMW over the IGV, weekly time series

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	IGV	IGV	IGV	IGV	IGV	IGV
Market	1.025***	0.992***	1.025***	1.009***	1.009***	0.983***
	(0.0358)	(0.0342)	(0.0358)	(0.0365)	(0.0365)	(0.0369)
SMB	0.0805	-0.0563	0.0840	0.00198	0.00587	-0.0483
	(0.0610)	(0.0620)	(0.0622)	(0.0720)	(0.0729)	(0.0685)
HML	-0.566***	-0.336***	-0.562***	-0.549***	-0.543***	-0.296***
	(0.0396)	(0.0512)	(0.0425)	(0.0402)	(0.0432)	(0.0558)
RMW		-0.237***				-0.186*
		(0.0726)				(0.103)
CMA		-0.537***				-0.596***
		(0.0908)				(0.0955)
SMW	**0.0115**	**0.00326**	**0.0117**	**0.00807**	**0.00838**	**0.00506**
	(0.00944)	(0.00899)	(0.00950)	(0.00954)	(0.00959)	(0.00901)
MOM			0.0237		0.0313	0.161*
			(0.0820)		(0.0816)	(0.0828)
QMJ				-0.517**	-0.522**	-0.154
				(0.256)	(0.257)	(0.339)

Constant	8.30e-05	0.000539	8.97e-05	0.000238	0.000248	0.000636
	(0.000852)	(0.000795)	(0.000854)	(0.000850)	(0.000852)	(0.000795)
Observations	261	261	261	261	261	261
R-squared	0.857	0.878	0.857	0.859	0.860	0.880

Standard errors in parentheses

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

First and foremost, one can observe the regressions in **Table 1** to be able to explain over 85% of the software ETF (IGV) variations, slightly increasing hand-to-hand with the number of independent variables. The results do not suffer a substantial change across the six models, instead, the market risk premium is highly statistically significant within the range of 1 ± 0.03. Also, the HML variable suggests, with a 1% confidence level, that amid a 1% positive variation, it will decrease IGV's returns approximately by 0.3% when integrating the FF5 factors, and by 0.55% without. This can be explained by the effect captured by the extra factors, both presenting negative and significant coefficients, with special emphasis on the CMA factor.

Not only are the coefficients of the SMW for all six regressions marginal, as they are also statistically insignificant, providing negligible material to validate the hypothesis that the software industry is somehow exposed to the digital asset realm.

5.4. Monthly Regressions

Table 2: Regression of traditional factors + SMW over the IGV, monthly time series

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	IGV	IGV	IGV	IGV	IGV	IGV
Market	0.966***	1.023***	0.989***	0.939***	0.961***	0.995***
	(0.0777)	(0.0720)	(0.0791)	(0.0815)	(0.0822)	(0.0893)
SMB	0.0630	-0.135	0.0971	-0.0131	0.0161	-0.115
	(0.113)	(0.113)	(0.115)	(0.132)	(0.133)	(0.122)
HML	-0.481***	-0.218**	-0.439***	-0.469***	-0.423***	-0.185**

	(0.0737)	(0.0871)	(0.0798)	(0.0743)	(0.0806)	(0.0912)
RMW		-0.383***				-0.246
		(0.137)				(0.199)
CMA		-0.569***				-0.586***
		(0.144)				(0.146)
SMW	**0.0247**	**-0.00266**	**0.0284**	**0.0244**	**0.0284**	**0.00265**
	(0.0190)	(0.0176)	(0.0191)	(0.0190)	(0.0190)	(0.0182)
MOM			0.280		0.299	0.258
			(0.213)		(0.212)	(0.206)
QMJ				-0.482	-0.528	-0.398
				(0.438)	(0.435)	(0.551)
Constant	0.00161	0.00291	0.00148	0.00263	0.00259	0.00340
	(0.00312)	(0.00273)	(0.00311)	(0.00326)	(0.00323)	(0.00289)
Observations	61	61	61	61	61	61
R-squared	0.885	0.916	0.889	0.888	0.892	0.919

Standard errors in parentheses

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

Above all else, one can observe the model displayed in **Table 2** to behave analogously to the weekly regression **(Table 1)**. The disparities are almost microscopic, with all variables holding the identical significance level. Contrary to the findings of the group paper, the monthly model can explain a wider range of the variations in IGV's returns. Pertaining to the statistically significant coefficients, one can observe HML exhibits values slightly less negative compared to **Table 1**. Likewise, the SMW coefficient's gap between both time series is minor, not altering the coefficient's interpretation. The other values can be disregarded since they add no substantial insights to the study. The conclusion sustains identically, as the model in **Table 2** does not offer evidence of an exposure to digital assets.

6. Conclusion

Although the purpose of the study is to assess linear exposure, an extra aspect had to be taken into consideration. Hence, the paper elaborates on a trilateral dynamic, analyzing the affinity of blockchain, the software industry, and overall industries, with one another. Key findings highlight blockchain's potential to disrupt a myriad of industries. However, its utilitarian applications are, hitherto, under-explored. Also, the restructuring of traditional industries is a time and cost consuming requirement to capitalize blockchain integration.

Respecting enterprises, on the one hand, the technology promises to reduce data breach costs, increase cross-border remittances, and improve supply chain efficiency, further exacerbated when coupled with smart contracts. On the other hand, energy costs, scalability hurdles, and unclear regulation are hampering mainstream adoption.

Perhaps the most interesting finding lies in the parallel between blockchain and the software industry, evidenced by the similarity in the market needs that each can satisfy. There are three likely scenarios. Either software companies make use of blockchain technology and outrun blockchain companies, or vice-versa, or they unite efforts to develop joint solutions.

From the qualitative angle, the study evidences the extent to which blockchain technology can answer software challenges in prevailing trends, as well as the businesses' belief and demand for the technology. Whereas, in quantitative terms, no significant exposure was identified in any of the regression models. One possible interpretation is that blockchain, albeit originally adjacent to digital assets, has widened its applications to the point that is no longer dependent on cryptocurrency fluctuations. Ergo, the SMW factor, which solely comprises cryptocurrencies' variations, does not capture blockchain's impact. On another note, the complex parallel afore-described can disturb dynamics and justify the lack of conclusive results.

7. Limitations

The main limitation encountered was the possible lack of representation of blockchain in the digital asset factor. The paper could have turned to another direction and consider a blockchain ETF instead, however, the existing ETFs are too recent and the analysis would not be as wide-ranging. For future reference, upon a more mature blockchain, the aforementioned should be performed.

It should be noted that blockchain for businesses application is at a premature phase, thereon most of the research available is, yet, predictive. Hence, it was challenging to deliver a paper speculative-free. Moreover, blockchain can be seen as both an opportunity and a threat, or a driver and a competitor of the software industry. This complexity compromised the delivery of a clear outcome, and this dynamic should be scope for following studies.

Lastly, for a more comprehensive analysis, the impact of blockchain in each industry served by the software industry and software contribution to it should be assessed.

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