Information Bias and Trust in Bitcoin Speculation

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Abstract

The Internet pervades modern life, offering up opportunities to connect, inform and be informed. As the range and number of sources for information online explode, how people select and interpret information has become a pertinent area for study, not least in light of the prevalence of *fake-news*. People are well known to act upon information they believe to be trustworthy and where the decision to act incurs risk, an inability to accurately select and assess the credibility of information presents a challenge. Bitcoin, the nascent crypto-currency, presents a domain within which profound financial risk abounds. Even for those armed with experience and knowledge there are numerous challenges to assessing risk, especially as sources of Bitcoin information can be observed to be partisan and of questionable accuracy.

Within the domain of bitcoin speculation, this thesis asks the central research question of: *are people able to select and correctly evaluate information they might rely upon to make decisions?* In addressing this research question, this thesis offers - through the application of a psychological model of informational trust to bitcoin speculators - two fundamental contributions:

Firstly, that these users *are* able to identify relevant news without a reliance upon confirmation bias.

Secondly, that a notable percentage of users are not evaluating the credibility of online news by expertly interpreting the fundamentals of information but, rather deferring their trust to either the source news website or a more broad trust of information on the Internet.

For these users, chance or luck may mean that they are basing their decisions upon factually accurate news. But this is a position which makes them particularly vulnerable to *fake-news* where it is spread via sources which they might trust. This position of susceptibility provides evidence to support further security research of both the prevalence of, and counter-measures for *fake-news*.

Dedicated to my family and most importantly my long suffering wife, without whose support none of this would have ever even have gotten started let alone finsihed. Many thanks are also offered to my supervisors and close friends (you all know who you are) who have dragged me through a number of traumatic events over the years — my resilience would be nothing without you.

Declaration

This thesis is my own work and no portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification at this or any other institute of learning. It is the result of my own work with the exception of manuscript revision by the supervisor Awais Rashid.

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Chapter 1

Introduction

1.1 Overview

Within cyber security, navigating risks is commonly viewed as a process of decision making, normally as a precursor to taking evasive or mitigating action—*armed with information and the expertise to interpret that information we are well placed to make risk decisions.*

Such a perspective assumes the rational and systematic gathering and evaluation of that information, something prevalent in modern risk assessment frameworks [155, 71]. For example, the 'conduct assessment' phase of NIST 800-30r1 is split into two categories of task. Firstly, *identify* threats & vulnerabilities - synonymous with being *armed with the information.* Secondly, *determine* the likelihood, impact and risk - synonymous with having the expertise to interpret the information. A similar approach is contained within ISO 31010 (see Figure 1.1).

However, this approach requires that we not only possess the relevant information and the expertise *but* also bring both to bear on the task.

With the Internet becoming a primary source of information for many people, assessing the credibility of that information has become an important task for the everyday user, albeit a task for which many users are lacking the skills [52] and

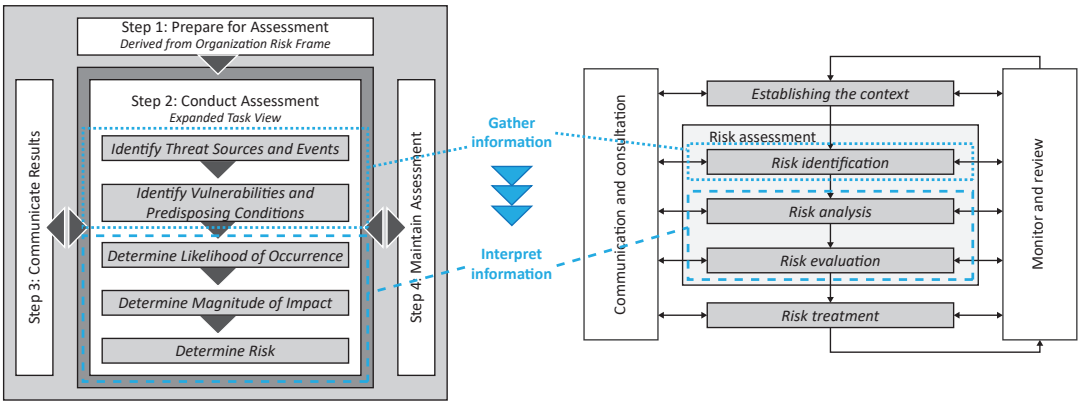


Figure 1.1: Information gathering and interpretation aspects of NIST800 (left) and ISO31010 (right).

find difficult [63]. Consequently information credibility online has been a significant area of study in cognitive science, HCI, privacy and security communities for many years. More recently, considerable media attention has been paid to such information quality concerns - commonly termed *fake-news* reporting (also known as disinformation) - where the boundaries between truth and fiction are blurred [81] and fact is traded for appealing to opinion or belief [135]. The race to tackle this very real form of decisional interference, by flagging suspicious news, is something of an admission that people are susceptible to acting upon 'news' that may have been manipulated or not be entirely truthful.

There are a number of cognitive biases which influence people's susceptibility to treating poor quality information as truth. Works by Lucassen and Schraagen [99, 100, 101, 102, 103] have sought to distil prevalent bias and trust theory into models of informational trust—seeing a continuum of decreasing expert analysis slide away to very basic human features of interpersonal trust whereby people are no longer concerned with fact but are happy to take it *on trust* from others than something is valid. This movement away from expert analysis of fact presents a very real challenge to the rational decision approach towards risk and requires further research within alternative contexts to those used in the creation of informational trust models. This thesis examines these issues within the context of speculative investment of bitcoin.

1.2 Motivation

Nomenclature: The uppercase form, 'Bitcoin' is used to refer to the Bitcoin ecosystem, including the protocol, based on community norms. Bitcoin with a lowercase 'b' written as 'bitcoin' is usually associated specifically with bitcoin as the currency [17].

On January 1st 2017 the crypto-currency bitcoin was valued at US$998 [1], six months later on June 11th bitcoin reached an all-time high of US$3,019 - a 303% jump in value. A month later the pricing had fallen away by US$686 (23%, July 11th '17), the drop being not far from the price of a whole bitcoin just a year prior (US$612, June 11th, '16). Just one month later on August 16th, 2017 bitcoin was US$4,425, and by October had reached an new all time high of US$5,844.

For the crypto-currency community this roller-coaster pricing was hardly a new phenomenom (see Figure 1.2) and seemed consistent with an *'speculative bubble'* [80] with erratic price fluctuations and seemingly no intrinsic value to the nascent currency. Prior to the demise of the then market leading exchange Mt.Gox, in February 2014, the pricing of a single bitcoin stretched from a mere US$14 to rivalling that of gold at US$1,147, far outstripping percentage increase yields from traditional stocks [159] and driving a body of works looking at the phenomenon [91, 126, 147, 159, 163].

During the first boom cycle for bitcoin, and for those early adopters with large stocks of bitcoin purchased early in the adoption cycle when prices were comparatively trivial, fortunes abounded. For others, the promise of vast returns saw investors flock to bitcoin speculation [25], pulling investment from other vehicles such as gold in the hope of realising profit. Research [20, 128] has found that this speculation has played a significant part in driving the very meteoric price rises which in turn has fuelled further adoption.

Research by Garcia *et al* [58] has shown that when making investment decisions, bitcoin speculators partake in self-reinforcing feedback loops - discussing,

[1] Pricing based on the Bitcoin Price Index published by Coindesk and rounded to nearest dollar. http://www.coindesk.com/price/bitcoin-price-index/

Figure 1.2: All time bitcoin pricing index (as at October 2017) - source:Coindesk.com

searching for and utilizing information in the form of social media and news reporting. Of course with such pricing volatility has also come more widespread news reporting of bitcoin further fuelling the feedback loop.

In order to mitigate the inherent risk in Bitcoin speculation, users not only need to be able to locate this relevant information, but also interpret and ascertain the truthfulness or credibility of the information they come across – the more credible they believe that information to be, the more likely they are to trust it and act upon it [112]. Yet, for investors the supply of *"credible information is limited"* [25]. This lack of information being likely to cause a sense of *fear* and *anticipation* with investors not used to this new *cashless* (non-tangible) currency [130]. Certainly information quality issues that directly relate to Bitcoin have been readily observable in recent years:

Social discussion - User discussions on forums and Internet Relay Chat (IRC) can range from talks of impending doom for Bitcoin ("*to the floor*") when negative news breaks, and stratospheric prices rises ("*to the moon*") accompanying positive news. These discussions can be frequent, boisterous and seemingly a collective attempt hoping to move prices up or down – this being not dissimilar to

information based market manipulations such as *'pump and dump'* [72] or *'short and distort'* [73].

News (mis)reporting - Positive stories in the mainstream press are balanced with those of a negative and often misleading tone. A good example is the widespread reporting that China had "*banned Bitcoin*" in early December 2013. In reality the People's Bank of China had explicitly stated that "*the public is free to participate in Internet transactions* [with bitcoin] *provided they take on the risk themselves*," [18] — a position which was far from a ban.

Misleading market data - A third information quality issue lays in the raw market trading data itself and specifically what is known as the order-book – a supposedly open declaration of users' buy and sell orders used to match trades. Whilst there is merely anecdotal evidence to support the order books themselves being incorrect, there is analysis that suggests order books have been manipulated. An example of this was the stagnation of trading volume towards the end of the first bitcoin pricing boom in 2013 where, certainly on the now defunct Mt.Gox exchange, orders were being placed and changed at a rate far quicker than a human could react, effectively stagnating trading volume whilst overt algorithmic trading 'bots' duelled with each other for bitcoin. An anonymous report [3] in May 2014 suggested this may have been a Mt.Gox 'bot' trying to recoup hitherto undisclosed losses.

The information quality issues within social discussion and news reporting exhibit features of the very post-truth ideal of appealing to opinion and belief rather than fact.

1.3 Research Question

This thesis asks the central research question of: *'to what extent are people able to select and correctly evaluate information they might rely upon to make decisions?'* Given the information quality issues observed (see Section 1.2), this

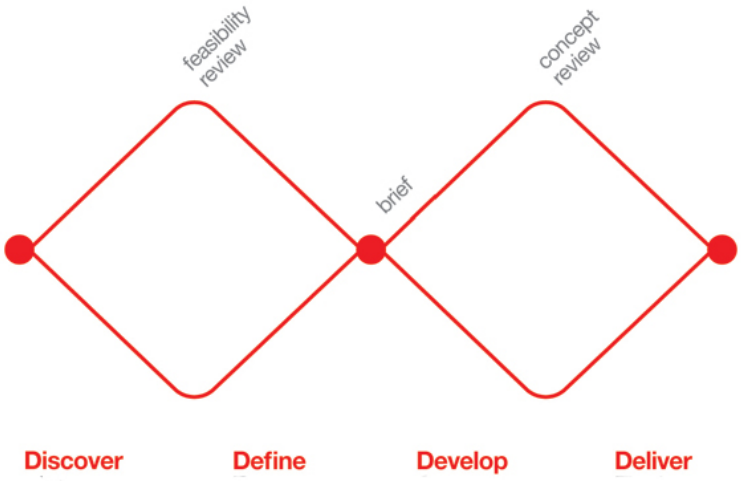


Figure 1.3: Design Council 'Double Diamond' Model - source:dbstudio.ubc.ca

research question is homed within the Bitcoin ecosystem—specifically the speculative investment sub-community, for whom news reporting is a pertinent type of information used when making investment decisions.

1.4 Research Methodology

This thesis is broadly based upon the 'double diamond' design process model (see Figure 1.3) developed by the Design Council in 2005 [43]. The model was developed based upon studied similarities between the processes used by eleven companies and groups tasks into different phases, diverging and converging to reach a goal.

To address the research question (see Section 1.3), this thesis is divided into three research objectives which align with the 'double diamond' process (see Figure 1.4):

Objective 1 - Investigation of Human Notions of Trust

Within the Bitcoin ecosystem, certain sub-communities can be regularly seen to express a lack of need for trust, or that trust being solely vested in *computation alone* [4]. As trust pervades human society [35, 104], and that people are more likely to utilise information the more credible (trustworthy) they believe it to be [112] this sub-community viewpoint on trust seems rather narrow. This objective looks to investigate broader disclosed

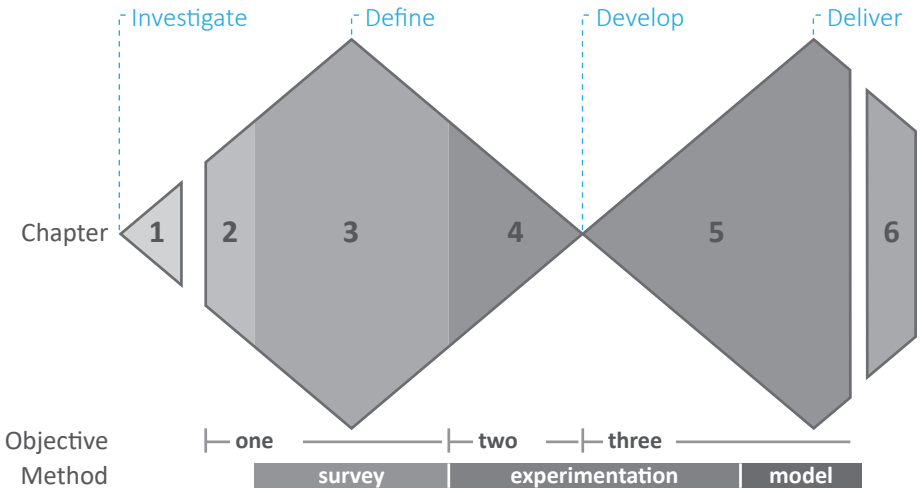


Figure 1.4: Overview of the thesis structure mapped to the design process

human notions of trust within the Bitcoin ecosystem, including the trust and reliance upon news information within the speculative investment sub-community.

The *Investigation* objective aligns neatly with the initial divergent quarter of the process model and explores trust using an online survey of 125 Bitcoin users, in which questions (see Appendix A) about their news, Internet and Bitcoin usage were asked. Constructs for propensity to trust (a personality type), self-rated expertise and general sentiment towards Bitcoin were created and tested against four key trust related facets: interpersonal, institutional, technological and informational.

Objective 2 - Evaluation of Potential Confirmation Bias

The process of choosing which news information to base decisions upon—the first part of the primary research question—is critical in the adoption and usage of Bitcoin [58] when describing positive *feedback loops* in which users discuss, search for and utilize information. Humans are pre-programmed to take *short-cuts* with complex tasks [77] and tend to operate within a form of '*bounded rationality*' [76, 143, 144]. It is reasonable to suspect that Bitcoin speculators, when faced with the vast potential range of news information and observable quality issues, defer their selection process in the same way. Given the partisan sentiment found both within online

communities and news reporting towards Bitcoin there is potential that the *short-cut* being employed might be a simple confirmation bias—one where the speculator overly favors news that aligns with their own sentiment.

The *Evaluation* objective aligns with the later part of the convergent second quarter of the process model. Using stimulus experimentation, 57 Bitcoin speculators evaluated the credibility of 6 news stories each. Statistical analysis of two key markers for potential confirmation bias—overly favourable assessment and length of time on task—was made.

Objective 3 - Development of a Model of Informational Trust

The process of assessing credibility of information—the second part of the primary research question—has been described as being both heuristic and systematic [29] as well as being contextually dependent upon user motivation [115], with users more likely to use information they believe to be credible [112]. Whilst the online Bitcoin communities present their discussions as expertise, understanding whether or not speculators are actually able to correctly discern fact from fiction and the biases upon how that assessment is made is critical for the design, implementation and maintainence decisions for systems.

The *Development* objective aligns with the final half of the process model in developing and delivering a model of information trust grounded in this experimentation with Bitcoin speculators. Using the same stimulus experimentation and participants as *Objective 2*, a statistical model for each user's information trust was derived.

It could be argued that in meeting *Objective 3*, this thesis completes the *'double diamond'* process in delivering a model of informational trust. However, there are limitations to this model inherent with any attempt to model trust. As human trust is so contextual, changes to the stimulus alone would likely change the shape of the model, as might the participant's experiences and any other number of potential independent variables. Simply, as Tweney & Dohery assert in their work on rationality and inference, *"there is... no experiment which clearly reveals what mental processes underlie the tendency to seek... only information which can verify a conditional rule."* [153]. To truly deliver a model of informational trust may be impossible but any attempt to build a more generic model would re-

quire significantly more data than that collected in this thesis. These limitations are discussed in section 6.4.1. Withstanding potential generalizability to wider use-cases, the model of informational trust presented in this thesis is valid for the Bitcoin speculators who participated in the study who are, in turn, representative of the broader socially-engaged online crypto-currency sub-community of users.

1.5 Thesis Contributions

This thesis makes two key contributions to both the crypto-currency and security communities:

Firstly, in investigating where human trust is evident in the Bitcoin ecosystem—as it transitions towards mainstream adoption—this study sheds light on the potential barriers to that adoption, not only Bitcoin but also other blockchain-based technologies. In particular this study highlights the consequences of design choices such as the impact of loss or media exposure upon a user's trust and sentiment towards and within the ecosystem.

Secondly, through answering the research question of *'to what extent are people able to select and correctly evaluate information they might rely upon to make decisions?'*—exposes a model of informational trust for a sub-community of users whom claim expertise yet exhibit a number of biases which suggests that they do not actually utilise that expertise when making risky investment decisions. Such deference to bias, rather than true understanding of information, presents a challenge to the rational and systematic process of evaluating risk normally found in security frameworks. Whilst these frameworks are traditionally employed at an organisational level for evaluating risk, this model suggests the same rationality and systematization is not necessarily true of users themselves.

Other contributions are grouped around the three research objectives:

Objective 1 - Investigation of Human Perspectives of Trust

An empirical study of human notions of trust within the speculative Bitcoin investment community, based upon an online survey of 125 users.

C1: A summary of our respondents' history and perception of Bitcoin including how and when they discovered the crypto-currency, how are they using it, general sentiments towards Bitcoin and self-perceived expertise levels.

C2: Findings of trust within the Bitcoin ecosystem, beyond computation alone, including:

- interpersonal trust in other users and those maintaining Bitcoin along with how loss of bitcoin impacts upon trust. Surprisingly, whilst the errant behaviours of others tends to have a negative impact upon interpersonal trust, such losses (that can be attributed to the respondent's own actions) can actually increase certain types of trust not least with those sustained during gambling activities.
- informational trust in the mediums and sources of information used. Mediums displaying social interaction engendered the most trust. Mediums with little or no social interaction were trusted where the author could be identified and demonstrated expert opinion.

Objective 2 - Evaluation of Potential Confirmation Bias

An empirical study of the extent to which confirmation bias might be influencing bitcoin speculator's selection of new reporting (as a source of information) to trust when making investment decisions. Based upon an online stimulus evaluation task undertaken by 57 bitcoin speculators.

C1: Findings, of no statistical evidence within this sample population relying upon confirmation bias in selecting news information.

C2: Findings, that speculators with sentiment alignment (negative or positive) to news information spend significantly less time evaluating stimulus, contrary to prior works which found sentiment alignment led to more time being spent on task.

C3: Evidence within approximately 1/3 of evaluations that another form of bias (source bias) might be influencing decision making.

Objective 3 - Development of a Model of Informational Trust

An empirical study and development of a model of how bitcoin speculators form trust decisions about news information that they might rely upon to support their investment decisions. Based upon an online stimulus evaluation task undertaken by 57 bitcoin speculators.

C1: A summary of the types of news-based information being used by bitcoin speculators.

C2: Findings, that significant percentages of these investors, i) are unable to identify and discount information that is of low quality, and ii) would act upon their poor evaluations.

C3: Findings, that expertise based credibility evaluation strategies are not significantly being used by these investors and that trust is not being placed in the fundamentals of the information itself.

C4: Findings, that Bitcoin investors are making credibility evaluations based upon un-mediated biases for either the source or medium of the information. For those making correct evaluations there is a trust in the source of the information, otherwise trust is deferred to a more general trust of information based on the Internet.

1.6 Structure

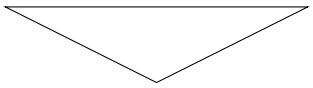
This thesis is presented as three interconnecting parts, each of which addresses one of the research objectives (see Figure 1.4). *Chapter 3* aligns to the *Investigation* objective, *Chapter 4* aligns to the *Evaluation* objective and *Chapter 5* to the *Development* objective. Each of these parts, whist building to answer the research question, is dependent upon differing sets of literature and as such these are contained within each chapter, along with the method of analysis, findings and discussion as relates to the objective in question.

These chapters are preceded by this introduction (*Chapter 1*) and background motivation for studying Bitcoin (*Chapter 2*). This thesis is concluded (*Chapter 6*) with a reflection upon these works, the extent to which they have explored trust within Bitcoin speculation and answered the research question, contributions to

the wider community and a discussion of future work.

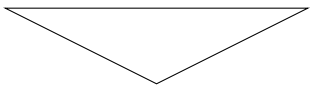
Chapter 3 (*Objective 1*) - Investigation of Human Perspectives of Trust in Bitcoin

Within crypto-currency interested communities the term *'trustless'* is often used to describe the underlying trust model of bitcoin as a protocol for the exchange of ownership of the currency unit. This trust model being based solely in the mathematical basis of bitcoin rather than in human or organisational intermediaries as is normally the case with currency. In light of how bitcoin has evolved into the broader Bitcoin socio-technical ecosystem, this article explores whether *trustless* is still a reasonable viewpoint to hold and where trust does extend far beyond that cryptographic computation alone.



Chapter 4 (*Objective 2*) - Evaluation of Potential Confirmation Bias

News reporting of Bitcoin has been shown to be part of a feedback loop found in bitcoin speculation, and *Objective 1* found evidence that speculators used and trusted news information in their investment decision making process, along with strongly held sentiments towards aspects of Bitcoin. This chapter looks to whether those sentiments might be overly influencing which news information speculator's select and trust.



Chapter 5 (*Objective 3*) - Development of a Model of Informational Trust

With evidence of informational trust and a lack of support for confirmation bias, this chapter explores how speculators form their decisions about which news stories to use and, borrowing methodology for distinguishing between true expert information evaluation and source biases, builds the first model of informational trust for Bitcoin speculators.

Chapter 2

Bitcoin Background

2.1 Trustless Inception

Conceptually bitcoin was a product of its time. By the late 2000s intrusive organizational demands for personal data were being recognized [7, 28] and world economies were in the early stages of incredible decline. The indiscretions of financial institutions were laid bare for all to see and it was apparent that a great many people were going to suffer loss in the years to come. Mistrust of the handling of this crisis by financial institutions, central banks and governments was growing. In a period of such uncertainty and, arguably, fear it was very easy to view this as being an opportunity for an alternative approach to the hitherto centrally regulated payment channels.

When Nakamoto [121] first proposed bitcoin as an alternative payments system, the intention was to remove the need for this trust between or of parties, human or institutional. Trust, in these parties, was viewed as a necessary evil in traditional economics, borne out of the need to mitigate inherent risks where bad actors exist in a system. Nakamoto argued that this was leading to organizations "*hassling*" customers for "*more information than they would otherwise need*", the implication being that this was in some way a form of risk mitigation against customer's potentially fraudulent behaviors.

By design bitcoin is trustworthy by being *trustless* in those very persons or

organizations that one may mistrust. Following a Giddens [60] viewpoint that there is no need for trust where the user has insight into the reasoning and functionality of a system—rather than by opaque monetary policy, bitcoin was to be created through an open source algorithm with transactions being logged forever in a publicly viewable ledger (latterly named the blockchain). Auditability and transparency was paramount. Evidence was... evident.

It appears Nakamoto never actually referred to bitcoin as being *trustless* – the term was seemingly coined by an early adopter community with a converged (arguably part anarchic, part libertarian [107, 148]) world-view. Yet for many in and around Bitcoin this purist view of *trustless* is because the trust model for payments is "*based in computation rather than people*" [4]. There is no need to trust other people or organizations as trustlessness is afforded by the decentralization of creation and governance to the distributed peers in the network, away from centralized organizations. In trust literature parlance this would be referred to as institutional (mis)trust being defined as both the environment and the institutions that shape and influence it [111].

A note on decentralization: Whilst the creation and transactional logging remain decentralized there are a great many organizations (effectively synonymous with institutions) active within Bitcoin as an ecosystem. As Gervais *et al* [59] articulate, for example, the core development team (who whilst being a distributed group of individual people) are collectively an organization within whom is vested centralized decision making and control over the maintenance and ongoing development of Bitcoin. Laurie [96] argues that hard-coded blockchain checkpoints (used to prevent deep forking - a process which could undermine the veracity of information stored in a blockchain) are indicative of bitcoin not being truly decentralized as they are chosen in a centralized manner. Further large mining pools, who again may be distributed, can exert centralized control over the network (e.g. a 51% attack) [106].

But Bitcoin has evolved beyond payments into a more socio-technical ecosystem; new use cases have emerged (e.g., investment speculation, gambling, laundering, digital asset signing etc...) and the community around it has grown. And organizations, decentralized or not, including mining pools, exchanges, wal-

let providers and product/service vendors all need trust in order to cooperate, negotiate and transact [164].

2.2 Locus of Existing Bitcoin Research

Taking the Nakamoto paper of 2008 [121] as a starting point for bitcoin research, to the beginning of July 2017 nearly 15,000[1] research papers have been published (see Figure 2.1). Even allowing for duplicates and multiple copies of the same research, this is a significant body of research in such a short period of time. Whilst not about bitcoin *per se*, it is still necessary to situate this thesis within this spiralling body of work. What follows is a synopsis of existing bitcoin works to highlight the current lack of research into human trust within bitcoin, which is where this thesis sits.

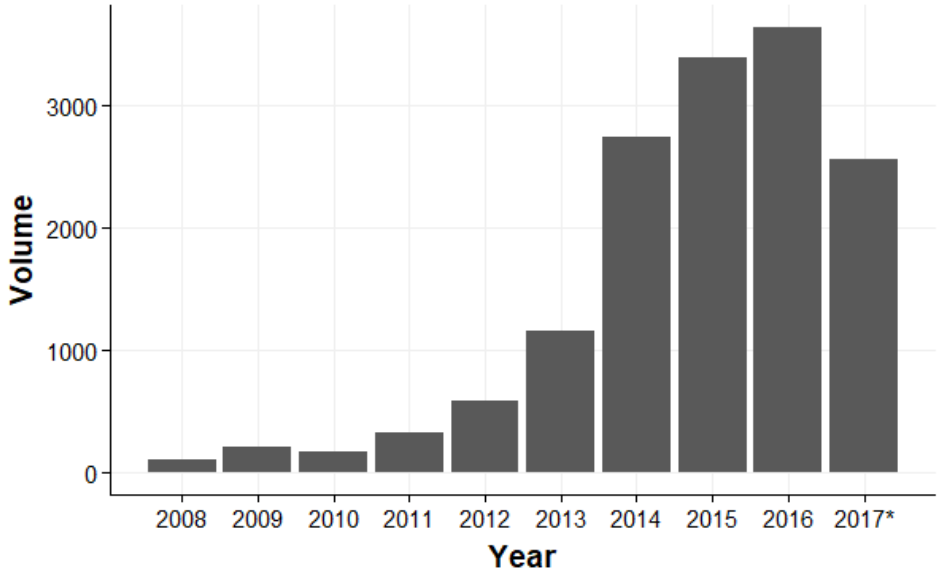


Figure 2.1: Google Scholar search for "*Bitcoin*" keyword published research. *Noted that volume for 2017 is only for months January - June

[1]https://scholar.google.co.uk/scholar?q=bitcoin+&hl=en&as_sdt=1%2C5&as_ylo=2008&as_yhi=2017

Bonneau *et al*'s systemization of knowledge work [21] affords a more in depth review of the primarily technical research to its publication in late 2015. Key research in Bitcoin falls, predominantly, into four primary streams (see Table 2.1) being:

1 Technical aspects Research in and around Bitcoin is heavily weighted, as one might expect of nascent technology, towards the three main technical components of the system [21, 157, 164]: **Transactions** (including scripts) within the Bitcoin world are a series of messages which are published to transfer the bitcoin from one user to another. Bonneau *et al* [21] affirm that "[transactions are] *the only state in bitcoin. There is no built-in notion of higher-level concepts such as users, account balances or identities—these all exist only to the extent that they can be imputed from the list of published transactions.*" **The consensus protocol** being the permanent publicly accessible ledger (the blockchain) used to record transactions, however to prevent fraud prior to inclusion on the blockchain transactions must be verified by other peers in the network. **The communication network** to bind these peers together in a network is on an *ad hoc* basis and used to announce new transactions and proposed additions (blocks) to the blockchain.

2 Security & stability The second main focus of study in Bitcoin has been in and around security and stability. Even at its foundation security was viewed as an intrinsic need within bitcoin with models for malicious mining [121]. Eyal & Sirer [49] and Bonneau *et al* [21] expanded this to look more broadly at potential vulnerability within bitcoin. Numerous other studies including [2, 4, 5, 10, 38, 87, 88, 56, 59, 92, 113, 119, 156] explore notions of security and privacy within bitcoin.

3 Economic aspects & governance With bitcoin falling within the auspices of financial markets the economic nature of bitcoin factors such as the economic fundamentals of supply and demand, pricing factors, valuation and volatility are widely researched, e.g., [19, 25, 30, 91, 92, 126, 128]. The inherent risk of bitcoin

as a cross-governance jurisdiction financial technology has driven studies looking at the uses and regulation/legal aspects of bitcoin, e.g., [20, 33, 58, 157, 158].

4 Alternative uses A fourth stream, adjunct to Bitcoin, looks at alternative uses (primarily) for blockchains or distributed ledger technology (DLT) as it is becoming known, e.g., [41, 88]. Shukla [142] suggests that blockchains might present a scalable technology for helping secure the rapidly expanding Internet of Things.

Study	Technical	Security & Stability	Economics & Governance	Alternative Usage	Human Aspects	
Androulaki, Karame, Roeschlin, Scherer, and Capkun, (2013), *"Evaluating user privacy in bitcoin"*		•				[2]
Apostolaki, Zohar, and Vanbever, (2017), *"Hijacking Bitcoin: Routing Attacks on Cryptocurrencies"*		•				[5]
Bastiaan, (2015), *"Preventing the 51%-attack: a stochastic analysis of two phase proof of work in bitcoin"*	•	•				[10]
Böhme, Christin, Edelman, and Moore, (2015), *"Bitcoin: Economics, technology, and governance"*	•		•			[19]
Bohr and Bashir, (2014), *"Who Uses Bitcoin? An exploration of the Bitcoin community"*			•		•	[20]
Bonneau, Miller, Clark, Narayanan, Kroll, and Felten, (2015), *"SoK: Research Perspectives and Challenges for Bitcoin and Cryptocurrencies"*	•	•	•	•		[21]
Bukovina and Martiček, (2016), *"Sentiment and Bitcoin Volatility"*			•		•	[25]
Carboni, (2015), *"Feedback based Reputation on top of the Bitcoin Blockchain"*				•		[26]
Carroll and Bellotti, (2015), *"Creating value together: The emerging design space of peer-to-peer currency and exchange"*				•		[27]
Cheah and Fry, (2015), *"Speculative bubbles in Bitcoin markets? An empirical investigation into the fundamental value of Bitcoin"*			•			[30]
Christin, (2013), *"Traveling the Silk Road: A measurement analysis of a large anonymous online marketplace"*		•	•			[32]

Table 2.1: Categorised Bitcoin literature (continued over...)

Study	Technical	Security & Stability	Economics & Governance	Alternative Usage	Human Aspects	
Christopher, (2014), *"Why on Earth to People Use Bitcoin"*			•	•	•	[33]
Courtois and Bahack, (2014), *"On subversive miner strategies and block withholding attack in bitcoin digital currency"*		•				[38]
Danezis and Meiklejohn, (2016), *"Centrally Banked Cryptocurrencies"*	•		•	•		[41]
Dyhrberg, (2016), *"Bitcoin, gold and the dollar–A GARCH volatility analysis"*			•			[46]
Eyal and Sirer, (2014), *"Majority Is Not Enough: Bitcoin Mining Is Vulnerable"*	•	•				[49]
Gao, Clark, and Lindqvist, (2016), *"Of Two Minds, Multiple Addresses, and One Ledger: Characterizing Opinions, Knowledge, and Perceptions of Bitcoin Across Users and Non-Users"*					•	[55]
Garay, Kiayias, and Leonardos, (2015), *"The bitcoin backbone protocol: Analysis and applications"*	•			•		[56]
Garcia, Tessone, Mavrodiev, and Perony, (2014), *"The digital traces of bubbles: feedback cycles between socio-economic signals in the Bitcoin economy"*			•		•	[58]
Garcia and Schweitzer, (2015), *"Social signals and algorithmic trading of Bitcoin"*			•		•	[57]
Gervais, Karame, Capkun, and Capkun, (2014), *"Is Bitcoin a decentralized currency?"*	•	•				[59]
Glaser, Zimmermann, Haferkorn, Weber, and Siering, (2014), *"Bitcoin-asset or currency? revealing users' hidden intentions"*			•		•	[61]
Kazan, Tan, and Lim, (2015), *"Value Creation in Cryptocurrency Networks: Towards A Taxonomy of Digital Business Models for Bitcoin Companies"*			•	•		[78]
Khairuddin, Sas, Clinch, and Davies, (2016), *"Exploring motivations for bitcoin technology usage"*					•	[82]

Table 2.1: Categorised Bitcoin literature (continued over...)

Study	Technical	Security & Stability	Economics & Governance	Alternative Usage	Human Aspects	
Kogias, Jovanovic, Gailly, Khoffi, Gasser, and Ford, (2016), *"Enhancing bitcoin security and performance with strong consistency via collective signing"*	•	•				[87]
Kosba, Miller, Shi, Wen, and Papamanthou, (2015), *"Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts"*	•	•		•		[88]
Kristoufek, (2013), *"BitCoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet era"*			•		•	[90]
Kristoufek, (2015), *"What are the main drivers of the Bitcoin price? Evidence from wavelet coherence analysis."*			•		•	[91]
Kroll, Davey, and Felten, (2013), *"The economics of Bitcoin mining, or Bitcoin in the presence of adversaries"*		•	•			[92]
Kumaresan, Moran, and Bentov, (2015), *"How to use bitcoin to play decentralized poker"*				•		[94]
Laurie, (2011), *"Decentralised currencies are probably impossible (but let's at least make them efficient)"*	•					[96]
Lustig and Nardi, (2015), *"Algorithmic Authority: The Case of Bitcoin"*	•				•	[105]
Maurer, Nelms, and Swartz, (2013), *"When perhaps the real problem is money itself!: the practical materiality of Bitcoin"*					•	[107]
Meiklejohn, Pomarole, Jordan, Levchenko, McCoy, Voelker, and Savage, (2013), *"A fistful of bitcoins: characterizing payments among men with no names"*		•	•			[114]
Meiklejohn and Orlandi, (2015), *"Privacy-enhancing overlays in bitcoin"*		•				[113]
Miers, Garman, Green, and Rubin, (2013), *"Zerocoin: Anonymous distributed e-cash from bitcoin"*				•		[116]
Miller, Kosba, Katz, and Shi, (2015), *"Nonoutsourceable scratch-off puzzles to discourage bitcoin mining coalitions"*	•	•				[117]
Moore and Christin, (2013), *"Beware the Middleman: Empirical Analysis of Bitcoin-Exchange Risk"*		•				[119]

Table 2.1: Categorised Bitcoin literature (continued over...)

Study	Technical	Security & Stability	Economics & Governance	Alternative Usage	Human Aspects	
Moser, Bohme, and Breuker, (2013), *"An inquiry into money laundering tools in the Bitcoin ecosystem"*		•				[120]
Pavel, Miroslava, and d'Artis, (2014), *"The Economics of BitCoin Price Formation"*			•			[126]
Perä, (2015), *"Sharing behaviour of bitcoin investors - evidence of confirmation bias?"*					•	[127]
Polasik, Piotrowska, Wisniewski, Kotkowski, and Lightfoot, (2015), *"Price Fluctuations and the Use of Bitcoin: An Empirical Inquiry"*			•			[128]
Reid and Harrigan, (2011), *"An analysis of anonymity in the bitcoin system"*		•				[133]
Ruffing, Kate, and Schröder, (2015), *"Liar, liar, coins on fire!: Penalizing equivocation by loss of bitcoins"*	•	•	•			[137]
Sas and Khairuddin, (2015), *"Exploring trust in Bitcoin technology: a framework for HCI research"*					•	[138]
Sas and Khairuddin, (2017), *"Design for Trust: An exploration of the challenges and opportunities of bitcoin users"*					•	[139]
Shcherbak, (2014), *"How should Bitcoin be regulated?"*			•			[141]
Shukla, (2017), *"Editorial: Cyber Security, IoT, Block Chains-Risks and Opportunities"*				•		[142]
Smyth, (2014), The Politics of Bitcoin			•			[148]
Vasek, Thornton, and Moore, (2014), *"Empirical analysis of denial-of-service attacks in the Bitcoin ecosystem"*		•				[156]
Viglione, (2015), *"Does Governance Have a Role in Pricing? Cross-Country Evidence from Bitcoin Markets"*			•			[158]
Vockathaler, (2015), *"The Bitcoin Boom: An In Depth Analysis Of The Price Of Bitcoins"*			•			[159]
Yelowitz and Wilson, (2015), *"Characteristics of Bitcoin users: an analysis of Google search data"*					•	[163]
Zarifis, Cheng, Dimitriou, and Efthymiou, (2015), *"Trust in Digital Currency Enabled Transactions Model"*					•	[164]

Table 2.1: Categorised principal Bitcoin literature

2.3 Human Aspects Research in Bitcoin

Works examining the human aspects of Bitcoin are far more limited in number than those looking to the four primary streams identified by Bonneau *et al* [21]. A summary of related human aspects research in Bitcoin is given below (see Table 2.2). Within this research there are three themes of study: *1)* user characterization, intention and motivation, *2)* social, behavioral & socio-economic signals driving pricing / volatility, and *3)* aspects of trust. Most of this research spans two, or all three, themes.

2.3.1 User characterization, intention and motivation

Understandably, after the more technical streams of research (see Section 2.2), studies looking to identify, characterize and explore user motivation are the most numerous human aspects research. Principle work by Maurer, Nelms & Swartz established an anthropological position of Bitcoin users [107], contrasting the promise of Bitcoin to address issues of concern around governance and regulation with those of privacy, equity for miners and true value of Bitcoin. Bohr & Bashir [20] looked at the culture of those using Bitcoin identifying that a number of demographic features of users determined how attracted they were to Bitcoin. Yelowitz & Wilson [163] further honed analysis of user characteristics finding that users with enthusiasm for *computer programming* and/or *illegal activities* were further driving interest in Bitcoin.

Christopher [33] and Khairuddin *et al* [82] looked to understand why people use Bitcoin. Christopher explored four distinct motivations (speculation, algorithmic trust, spending power & money laundering). Of these motivations speculation and money laundering are somewhat obvious. *Spending power* as discussed is something of a misnomer in that Christoper really talks to the perceived

anonymity of Bitcoin and its cross-border application. Spending power in Bitcoin would normally be more related to its deflationary nature in that as the supply of new bitcoins dwindles there is an inevitable demand-driven increase in value thusly affording greater spending power. This could be viewed as *"if a coffee costs me one bitcoin today, in a year it will likely be a quarter a bitcoin."*

Khairuddin *et al* found three motivations (a role in monetary revolution, user empowerment and perception of real value) although these were on the basis of only 9 user interviews which are unlikely to capture the diversity of the entire Bitcoin community. Some similarities between *user empowerment & perception of real value* and Christopher's *spending power* can be drawn.

Gao *et al* [55] found that users held misconceptions about aspects of Bitcoin and were not well versed in how Bitcoin technically functions. The study also drew parallels in user motivation with both Christoper and Khairuddin *et al* with regards perceptions on how Bitcoin might represent a future of payment systems. Glaser *et al* [61] contrast this and looked at user intention within the very specific use case of changing domestic (fiat) currency into a digital currency finding that new and uninformed users had a biased intent towards speculation, as opposed to using Bitcoin for payments.

2.3.2 Social, behavioral & socio-economic signals

A second research theme looks to how social interactions and user behavior plays a role in Bitcoin, both its adoption and pricing.

Kristoufek [90, 91] looked to what drives user interest in Bitcoin. Within this work, Kristoufek found that, beyond economic fundamentals, as the pricing of bitcoin moved beyond pricing-trend norms there was a pronounced increase in online search behavior of people looking for information about Bitcoin. Garcia *et al* [57, 58] built upon Kristoufek's discovery of the link between pricing and search

behavior and developed a model of how social interactions between users not only drove bitcoin pricing but also that very search behavior. In this study Garcia *et al* identified two positive feedback loops (see Figure 2.2) which, in essence, meant that as the price of bitcoin increased it created user attention through information search volumes. This, in turn, lead to an increase in word-of-mouth discussion driving a further increase in pricing.

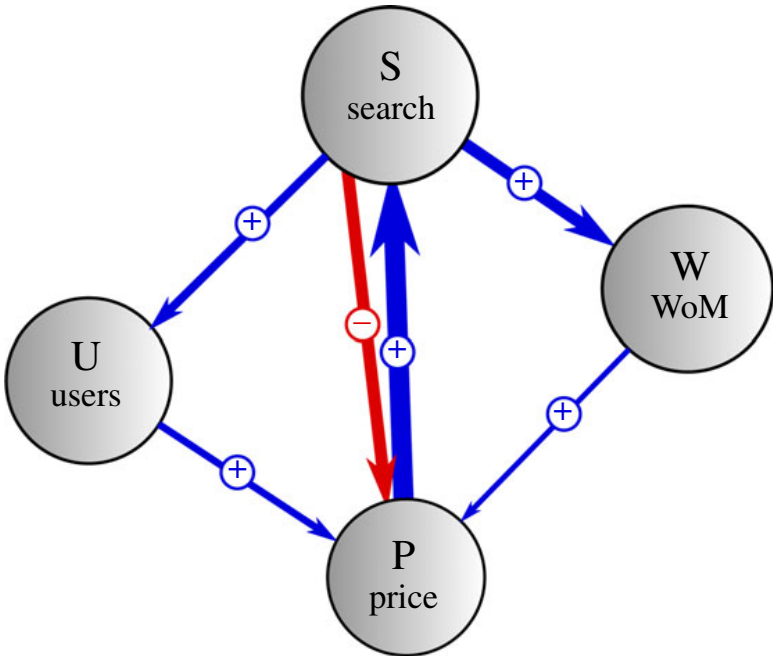


Figure 2.2: Garcia *et al's* socio-economic feedback cycles

Perä [127] also looked at this user information sharing behavior and questionned whether this might be subject to confirmation bias - a cognitive fallacy which might leave speculators open to making poor investment decisions where that information forms part of the cycles found by both Kristoufek and Garcia *et al*. Perä concluded that there was evidence that users were sharing information when it aligned within their own sentiment towards Bitcoin. Glaser *et al*, in their work with users' intentions, found that these users displayed a lack of *"professionalism and objectivity"* when using Bitcoin. Most markedly, *"highlighted by*

their bias towards positive news" [61] - this being confirmation bias.

2.3.3 Aspects of trust

Works examining the human dimensions of trust and how they impact the adoption and usage of Bitcoin are even more scarce. Works with either full or partial attention to the role of trust are highlighted below (see Table 2.2).

Maurer, Nelms & Swartz observed that *"the social dynamics of community and trust [are] evident in the prose... produced by Bitcoin users"* [107]. An observation that was the first to counter the promise of Bitcoin's trust being *"based [solely] in computation"* [4]. Part of their rationale being based around the fact that those algorithms were being trusted based on a community of users—something embodying the distributed nature of Bitcoin itself and neatly summarized by Gavin Andersen from the Bitcoin core-development team who found it, *"more comforting than thinking that politicians or central bankers wont screw it up. I actually trust the wisdom of the crowds more"* [62].

With regards algorithmic trust, Nakamoto when initially proposing bitcoin did so as a *"system for electronic transactions without relying on trust"* [121]. As the community around Bitcoin grew the definition of this lack of trust evolved to a more pragmatic view that the trust was shifted to the algorithms or computation. Christopher [33] determined that it was this very shift away from institutional to algorithmic trust that was comforting to Bitcoin users as it was *"mathematically driven and not manipulated by central bankers"* as these were mistrusted due to their handling of the 2008 global financial crisis. Lustig & Nardi, whilst exploring the culture of Bitcoin users, also found traces of algorithmic authority, *"the trust in algorithms to direct human action and to verify information, in place of trusting or preferring human authority"* [105]. Interestingly whilst this authority was observable, they also found that this was not a '*blind faith*' but rather users

saw great value in that authority requiring/needing to be mediated by human judgement. Ostensibly this mediation being a statement of mistrust in those algorithms. Why else would one need to mediate that authority if it were fully trusted?

Zarifis *et al* examined the nature of trust in the relationship between organizations and consumers as transacting parties [164]. Their model of transactional trust built upon McKnight *et al's* web trust model [110] by adding validated constructs specific to digital currencies. Whilst the model demonstrates how mediated transactions can benefit organizations and consumers alike, it is unclear how this model holds up where fulfilment by the organization is not made. In summary, whilst digital currencies can allow for trust in a payment having been made, the model does not discuss how the use of digital currencies does not assure delivery.

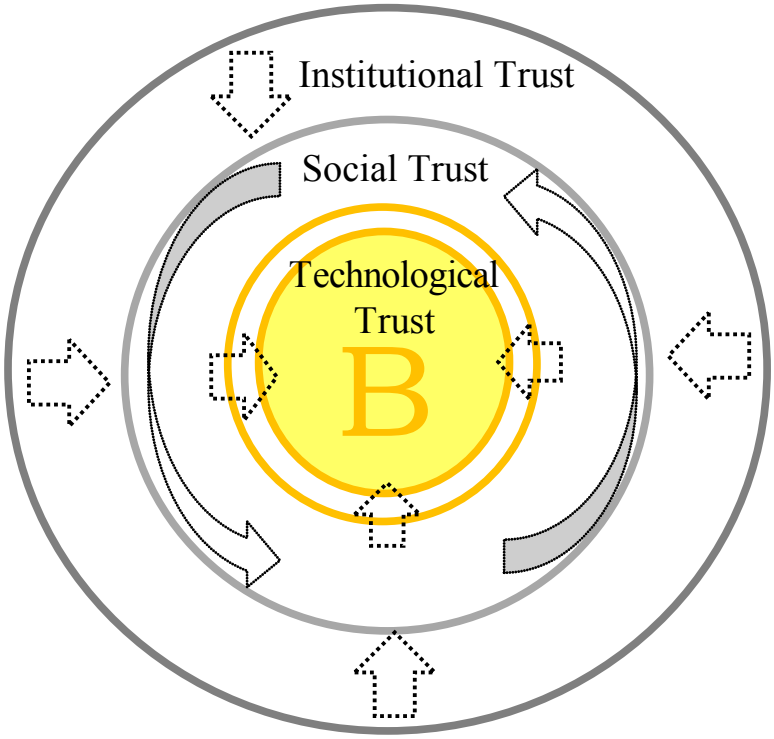


Figure 2.3: Sas & Khairuddin's research framework

Sas & Khairuddin, in a position paper predominantly to the HCI community, presented an exploratory framework for trust research (see Figure 2.3) within Bitcoin [138]. Broadly the framework identifies a need for research in the domains of institutional, social and technological trust, these being based on well founded works. However the framework has two key shortcomings. Firstly, the work is grounded in Shcherbak's stakeholder categorization [141] which strictly falls into the trap of seeing Bitcoin not as an evolving ecosystem but only as its initial intended payments-only mechanism. As such Shcherbak, and there-in Sas & Khairuddin, only recognize four types of Bitcoin stakeholder—users, miners, exchanges and merchants—making no mention of the role that governments, third party service parties (as non-merchants) or any other parties might play. Nor does this categorization differentiate between any of the many and varied use cases for Bitcoin and, therefore, effectively views all users as being analogous. As trust is contextually sensitive, these differing use cases will likely require differing views on trust. The second shortcoming lays in the framework model not recognizing the role that informational trust plays—given its well documented importance to both the adoption and use of Bitcoin, nor the interplay between information and the three layers presented.

Later work by Sas & Khairuddin, with 20 Bitcoin users, explored trust issues in relation to key technical characteristics of Bitcoin [139]. Through interviews, it was found that the main challenge to trust was from *'insecure transactions'* and dealing with *'dishonest traders'* both aspects that bitcoin (as the payments mechanism) itself is unable to resolve. Directly addressing concerns from these users, Sas & Khairuddin suggest two key design implications for Bitcoin for creating trust: i) support for transparency of two-way transactions, and ii) tools to support reversible transactions. Technically some types of transaction are already reversable, namely those marked as '*multisignature*' [45] however to extend this

to all transactions would be non-trivial, as accepted by Sas & Khairuddin.

Study / Description	Trust Focus
Bohr and Bashir, (2014) Analysis of public Bitcoin survey data (1,193 responses) to explore demographic structure of Bitcoin users.	
Bukovina and Martičček, (2016) Attempt to model bitcoin pricing with user sentiment. Limitations in only using single source of sentiment noted as possible explanation of finding that sentiment only played a minor part of total pricing volatility.	
Christopher, (2014) Discussion of literature around speculation, algorithmic trust, spending power & money laundering to explain motivations for using bitcoin	•
Gao, Clark, and Lindqvist, (2016) Empirical study (20 user interviews) of user perceptions of Bitcoin, highlighting user trade-offs and barriers to entry, misconceptions about privacy and a mistaken user belief that they are *"incapable of using Bitcoin."*	
Garcia, Tessone, Mavrodiev, and Perony, (2014) Model of socio-economic signals, discovering existence of reinforcing feedback cycles between *pricing*, the volume of social *discussion online*, volume of *information search* and *user base growth*.	
Garcia and Schweitzer, (2015) Development of algorithmic trading strategies, integrating the previously found socio-economic signal feedback cycles.	
Glaser, Zimmermann, Haferkorn, Weber, and Siering, (2014) Exploration the intentions behind users converting domestic (fiat) currency into bitcoin, providing an empirical view on user interest in bitcoin is driven by its appeal as an *asset* or a *currency* based upon econometric modelling.	
Khairuddin, Sas, Clinch, and Davies, (2016) Empirical study (9 user interviews) reporting 3 key motivations for using Bitcoin: role in monetary revolution, increased empowerment & perception of real value in bitcoin currency.	
Kristoufek, (2013) Study of the relationship between interest in Bitcoin (using online search queries for information as a proxy) and pricing. Asymmetry in effects of interest noted, where as pricing fall below or exceeds trend an increase in interest reinforces the trend.	
Kristoufek, (2015) Study of bitcoin price drivers. Findings that standard market fundamentals have a long term impact upon price. Further evidence that user interest drives price both up and down, especially in periods of rapid price rise or decline.	
Lustig and Nardi, (2015) Empirical study (521 survey respondents & 22 user interviews) of the culture of Bitcoin users and their perceptions of trust in the algorithms that underpin bitcoin. Findings include that users do not *blindly* trust algorithms, acknowledging need for human judgement.	•
Maurer, Nelms, and Swartz, (2013) View on the semiotics of Bitcoin broadly seeing users as being drawn by signals of privatized transactions and a grounding of value in algorithmic authority as opposed to centralized monetary policy. Social trust is attributed to the distributed nature of the code behind bitcoin meaning many people can attest to its validity.	•

Table 2.2: Human aspects of Bitcoin literature (continued over...)

Study / Description	Trust Focus
Perä, (2015) Empirical analysis of whether Bitcoin users share information with other users in a confirmation-biased manner. Findings that sharing behavior exhibits signs of confirmation bias with users holding stronger beliefs being more willing to share sentiment aligned information.	
Sas and Khairuddin, (2015) Position paper that highlights where in the wider Bitcoin ecosystem trust may be necessary and proposes an HCI framework calling for the study of trust in Bitcoin.	•
Sas and Khairuddin, (2017) Empirical study (20 user interviews) exploring Bitcoin characteristic impacts upon trust and proposing designing for trust.	•
Yelowitz and Wilson, (2015) Empirical analysis of Google trends (searches) in an attempt to unmask user characteristics for Bitcoin users, whom are able to mask their profile beyond the anonymity of Bitcoin. Key finding that *computer programming enthusiasts* and *illegal activity* are key drivers for user interest in Bitcoin.	
Zarifis, Cheng, Dimitriou, and Efthymiou, (2015) Exploration of business:consumer trust, and validation of digital currency transactions trust model. Incorporates both user propensity to trust and institutional trust aspects. Highlights the role of ex-Bitcoin third parties in creating and maintaining trust.	•

Table 2.2: Human aspects of Bitcoin literature. Research with specific focus (in full or part) upon trust is highlighted.

2.4 Research Agenda

In the human aspects research discussed above it is clear social and behavioral cues include the acquisition, evaluation and sharing of information by Bitcoin users [58, 57, 90, 91]. Further that information sharing is subject to some cognitive bias [61, 127]. Whilst works [33, 107, 138, 139, 164] have explored trust none have looked to the importance of informational trust. Further none have explored the processes by which information is evaluated or how it is actually trusted. This thesis directly situates itself within this gap in asking *'to what extent are people [speculative users of Bitcoin] able to select and correctly evaluate information they might rely upon to make decisions?'*

Chapter 3

Investigation of Human Perspectives of Trust in Bitcoin

This part of the thesis addresses the first objective—*investigation of human perspectives of trust*—and, through the use of an online survey questions 125 Bitcoin users for their knowledge and attitudes towards a number of aspects of Bitcoin and news reporting.

3.1 Introduction

The crypto-trust that underpins Bitcoin is essential in securing the whole ecosytem but as with all technologies relied upon to secure assets (informational or otherwise) people are responsible for design, implementation and operation of these technological tools [74, 95]. As Lacey [95] points out "*despite the presence of advanced technical controls, information systems remain vulnerable because of human behavior*" – something which Bitcoin's inception was designed to actively mitigate against. Yet cases of miscreant and inadvertent detrimental behavior abound.

Thusly, understanding human behavior, and more specifically concepts of trust [138], is a critical underpinning to the design, implementation and maintenance of any technological attempt to mitigate security risk.

Given this need to understand human concepts of trust within Bitcoin, and commonly expressed conflations of trustlessness & institutional mistrust as meaning Bitcoin is devoid of trust (especially in people) it is, therefore, fundamentally important to examine whether *trustless* is still an entirely appropriate way to describe Bitcoin. This chapter examines this very question through an online study of users in the socio-technical Bitcoin ecosystem.

3.1.1 Contributions

181 subjects responded to the advertised online study, out of which 125 provided valid responses. In-depth examination of responses to a range of questions and information scenarios shows that, contrary to opinions suggesting a lack of need for trust in people when using Bitcoin, respondents do rely upon informational trust – this often being under-pinned by a high degree of reliance upon interpersonal trust. This chapter's key contributions are as follows:

- A summary of respondents' history and perception of Bitcoin: how and when they discovered the crypto-currency, how are they using it, general sentiments towards Bitcoin and self-perceived expertise levels.
- Findings of interpersonal trust in other users and those maintaining Bitcoin along with how loss of bitcoin impacts upon trust.

  Surprisingly, whilst the errant behaviours of others tends to have a negative impact upon interpersonal trust, such losses (that can be attributed to the respondent's own actions) can actually increase certain types of trust not least with those sustained during gambling activities.
- Findings of informational trust in the mediums and sources of information used in making speculative decisions in Bitcoin. Mediums which display social interaction (such as discussion forums or news websites with active comment communities) engendered the most trust. Those mediums with little or no social interaction were clearly trusted where the author could be identified and demonstrate expert opinion. In both cases it is clear that trust in information mediums is based in, at least in part, interpersonal trust of those authoring the text.

Design Implications - As this study highlights perceptions of trust within the Bitcoin ecosystem, it seems fair to expect similar trust aspects within other crypto-currency implementations as well as technologies being built upon the blockchain. With this in mind, design choices being made at the time of development of similar socio-technical systems are likely to have consequences upon the trust that users have in those systems—the less a user finds a system trustworthy, the less likely they are to adopt and use it. Two key areas of system design that impact upon user trust relate to the loss of bitcoin are, ***transaction confirmation*** and ***pseudonymity***.

It is all but impossible to reverse erroneous transactions in Bitcoin. This is a result of the design choice to not mandate multi-signatory transactions (which are facilitated by the protocols) where at least two of the confirmations are made by the transacting parties and the casting vote is made by a third party in the event of disagreement. As confirmations are left open to peers on the network, confirmations are blind to transaction fulfilment, and the loss of bitcoin due to fraudulent or theft events is permanent. Further, the pseudonomity afforded in Bitcoin means that attempts to recover losses via mechanisms such as legal action are at best unlikely.

Thusly, it should come as no surprise that trust in exchanges, people and Bitcoin itself is impacted negatively by loss events (see Section 3.4.3.3). In an ecosystem where loss through fraud and theft is widely publicized, the knowledge that the transfer of one's bitcoins is one-way is perceived as a huge trust issue by potential users, with potential to hamper mainstream adoption.

For designers, understanding how technical implementations impact upon user trust is critical. It is with no small irony that, despite Nakamoto's intention to remove the need for institutional trust in transactions, the decision to not mandate multi-signatory confirmation has meant users deferring institutional trust to third-party mechanisms such as escrow. The technical protocols of Bitcoin may be *trustless*, but in order for humans to feel secure when using Bitcoin they very much rely upon trust — a key insight of this study.

The rest of this chapter is structured as follows. Firstly, related literature is provided for both interpersonal and informational trust (*Section 3.2*). Secondly, a description of the method by which the questions surrounding trust in Bitcoin (*Section 3.3*) are examined, followed by a presentation of results from the online study (*Section 3.4*). Thirdly, a discussion of key findings of this study is presented, along with areas for further investigation (*Section 3.5*). Finally, this chapter concludes (*Section 3.7*) that whilst not technically incorrect, *trustless* is too narrow a notion to be applied to Bitcoin given the complexities and intricacies of how the ecosystem has evolved and its heavy reliance on interpersonal trust.

3.2 Related Work

In this section works related to trust in people (interpersonal) and in information are presented, along with how Bitcoin actually has need for both.

3.2.1 Interpersonal trust (trust in people)

Trust is often defined as being empirically based and probabilistic: "*to a degree consistent with our perception of the available evidence. In human interaction, we trust individuals and institutions to the degree that they have, over time, proved trustworthy*" [48]. Mayer *et al* [108] similarly argue that any such trust is cyclically developed based upon the trustor's perception of the other party and their own propensity to trust and that without both factors, trust cannot exist.

Trust also lies at the core of almost all theories of interpersonal relationships [145]. There are few aspects of life within which trust does not play an indispensable role – trust pervades human society [35, 60, 104]. Kramer and Carnevale [89] argue that trust involves a set of beliefs and expectations that another's actions will be in some way beneficial to long term self-interest; a position that could only be established were the trustor able to cognitively assess another person's (or organization's) actions from an empathetic perspective.

Within Bitcoin an emergent notion of trustlessness comes from its practical use as a pseudonymous peer-to-peer based network. Once a transaction has been logged within the blockchain it is known to everyone, in the network, that it has been concluded. Consequently, there is no need to trust, or even know, who a counter-party is when transacting – merely that they have made payment.

However this view is problematic in that it only caters for the payment side of a transaction and in no way affords guarantee that the goods or services being

purchased will actually be delivered. This non-fulfilment being either a result of a deliberate exploitation or, simply the counter-party being unable to deliver that which is expected [44].

With the pseudonymous nature of Bitcoin, and therefore a breakdown in the ability to rely upon Raub & Weeise's *temporal*, *social* or *institutional embeddedness* [132], this assurity [53] of fulfilment is utterly dependent upon either trust of, and intermediation by a third party. This, in turn, requires institutional trust (of that third party) from the users. The third party intermediary being seen as trustworthy not only by being identifiable, but also likely subject to some form of penalty - reputation, legal or loss of trade congruent with Raub & Weeise's embeddedness factors. With people needing to mitigate risk by placing trust in something beyond computation alone, services like escrow and smart contracts built around the blockchain fill the void – and incidentally also act as as explicit statements of mistrust in the initial trustee. Ironically this very signalling to the trustee that they are not trusted - by using a third party service such as escrow - *"may actually reduce their motivation to act in a trustworthy manner"* [134].

Zarifis *et al* point out that a user's "*level of trust in a technology is an important factor in the level of its adoption particularly when there is some financial risk*" [164]. A viewpoint echoed by most researchers, agreeing that trust is required where an individual takes a risk [108, 104]. And financial risk is particularly prevalent in Bitcoin. Aside from fluctuations in exchange rates, criminal activity (such as fraud or theft) and organizational collapse, Bitcoin can be also considered a speculative investment [25, 41]. A number of works, e.g., [20, 58, 128], highlight that this speculative investment has been a key use for Bitcoin and a contributing factor for its growth. Speculative investment, by its very definition, is risky.

It follows that, with as new uses emerge for Bitcoin and the blockchain, the ecosystem is evolving not to remove centrality or the need to trust a governing institution but rather to cater for a very human need to be able to understand and remove risk in everyday life – to be able to see certainty in outcomes. As such, and whilst some will argue that Bitcoin is still just a cryptographically signed payments mechanism *trustless* by design, to the wider world Bitcoin is more a conflation of all uses and one in which interpersonal trust is instrumental.

3.2.2 Trust in information

Garcia *et al* [58] looked at socio-economic traces in the behaviors of Bitcoin investors and identified positive '*feedback loops*' in which users discuss, search for and utilize information (in the form of social media and news) when making decisions as to whether to adopt and use Bitcoin. Prior work looking at video summarization [40], addressing the intention gap between the information sought and returned, has shown that a user's ability to interpret the information being presented to him/her was fundamental to his/her ability to make a decision. Yet with Bitcoin, more than any other investment market before, the lay person replete with basic technical capability can readily create an account on a Bitcoin exchange and begin trading, with no training or professional/expert advice.

Therefore, in order to mitigate risk, users need to be able to ascertain the truthfulness or credibility of the information they come across – the more credible they believe that information to be, the more likely they are to act upon it [112]. For anyone who followed Bitcoin news and markets during the period of the bitcoin pricing *boom* from mid-2013 through to the global collapse following the demise of Mt.Gox in early 2014, the variety of information available was incredible. Similarly, Bukoniva and Martiek [25] have noted that the supply of "*credible information is limited*" for those using Bitcoin.

During this period, for those trying to ascertain the trustworthiness of other parties within the Bitcoin ecosystem or whether the information they might act upon was credible, any such assessment must have been particularly difficult.

Next, the reference information trust model used as the basis of this study is presented, followed by a summary of respondents and the method used - discussing both the questions and information constructs used during the study.

3.3 Method

3.3.1 Reference information trust model

Information credibility assessment can be thought of as both a heuristic and systematic process [29]. Decisions as to which process to use are dependent upon user motivation at the time [115]. Lucassen & Schraagen [103] extend this decision to being based upon '*rules-of-thumb*' (cognitive bias) and offer a clear model for trust in information which takes account of these biases by partitioning trust into four key layers (see Figure 3.1).

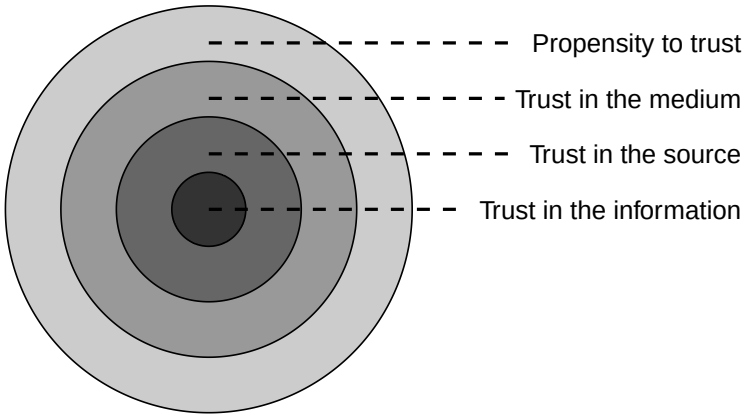


Figure 3.1: Lucassen & Schraagen's model of informational trust

This study does not seek to reconstruct a model of respondents' information trust (this being within *Chapter 5*). This study does, however, re-purpose Lucassen & Schraagen's three outermost layers for exploring respondents' notions of trust. To explore interpersonal and informational trust we utilize propensity to trust as a construct (see Section 3.3.3). It also looks to mediums and sources of information utilized by respondents when speculating in Bitcoin.

3.3.2 Participants

The study was widely advertised to a number of online forums, websites, social media and also through direct email asking for voluntary participation with no offer of payment. The study was split into two key parts. Part one was a series of questions looking at (i) discovery and use of the cryptocurrency, general sentiment towards Bitcoin and its long-term prospects; (ii) self perceived levels of knowledge and expertise; and (iii) a general set of questions around technology and news consumption. Part two was a news report stimulus evaluation task, open to respondents who had usage experience of Bitcoin, and forms the basis of *Chapters 4 & 5*. The normal ethical principles of informed consent, data storage and anonymization were observed (with ethical review and approval given by the relevant body at the authors' institution prior to the study). In total 181 responded to the invitation with fifty-six excluded from the analysis for either not having completed the questionnaire part of the study or for bogus participation. Respondents were allowed to only participate once (enforced by client-side cookie and server-side IP registration) with the ability to take the study in stages over a maximum of five days in total. A fully copy of the questions asked is given in *Appendix A*.

Demographics Of the qualified responses (N=125), overwhelmingly 88% of respondents were male. Sixty-seven percent of all respondents considered themselves 'employed' with another 26% 'still in education'. Looking into educational backgrounds, 64% had a college degree or higher with only 2 respondents believing they had had no education and 12 having gone no further than high school. Eighty-eight percent were located in either Europe (n = 68) or the Americas (North & South) (n = 42).

Respondent Source The majority (78%) came from respondents recruited from Reddit (see Table 1) and were spread across 9 sub-Reddit forums (r/Bitcoin 32, r/SampleSize 23, r/BTC 12, r/Economics 12, r/BitcoinBeginners 11, r/Markets 3, r/Mining 2, r/CryptoCurrency 1 and r/CryptoMarkets 1).

Bitcoin Usage Exposure to Bitcoin amongst respondents peaked in 2012-2013 (as did the price of bitcoin) with 86% having heard of Bitcoin prior to the collapse in pricing in early 2014 (see Figure 3.2). Amongst respondents, online discussion forums provided first exposure for 43%, with friends/family member/colleagues and online news websites accounting for another 41%.

Ninety-four (94) respondents expressed how they have or are using Bitcoin. Of those: purchasing or selling things was the most prevalent use (86%), then investment/speculation (71%) (see Table 3.1). Investment / speculation was the highest ranked use by respondents.

Whilst only 9% of the 125 respondents agreed that Bitcoin was primarily being used for criminal activity, 36% felt theft was hampering Bitcoin's adoption. Three respondents admitted to having used Bitcoin to launder money themselves.

Source	n	Has Used	Purchase or Sale	Transfer funds	Launder money	Investment	Drive adoption	Other	Study or Research
Reddit	97	77	67	54	2	57	35	6	5
Internal	8	3	2	1	-	1	-	-	1
Twitter	7	3	3	3	-	3	2	-	-
BitCoinTalk	5	5	5	3	1	5	4	-	-
Unknown	5	4	3	3	-	1	-	1	1
Email	1	1	-	-	-	-	-	1	-
Facebook	1	-	-	-	-	-	-	-	-
StackExchange	1	1	1	1	-	-	1	-	-
Total	125	94	81	65	3	67	42	8	7

Table 3.1: Bitcoin usage by survey respondent source

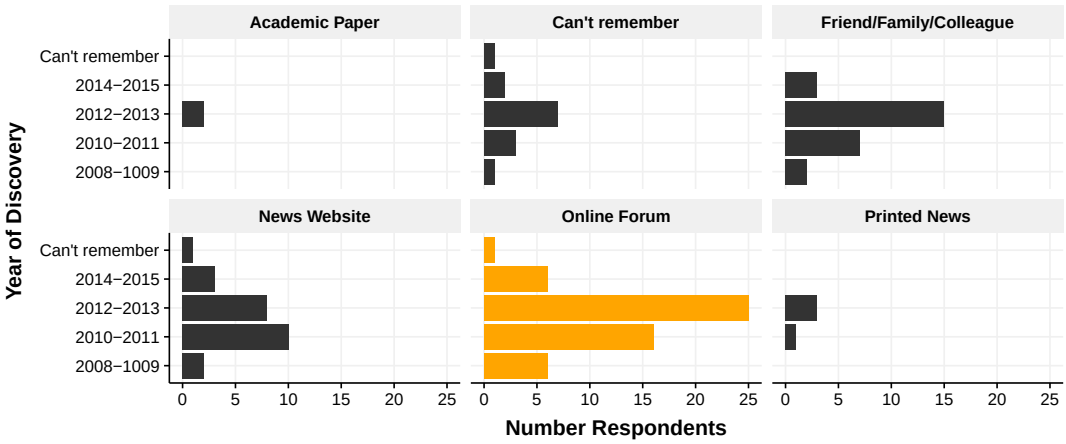


Figure 3.2: When and how survey respondents first heard about Bitcoin

3.3.3 Measures and constructs

This study was designed to reveal aspects of interpersonal and informational trust amongst respondents. Firstly, a number of broad questions around Bitcoin including discovery and usage were asked. Secondly, each respondent's levels of interpersonal trust in other Bitcoin users (T_U) and the people maintaining Bitcoin (T_D) was directly extracted — each determined through a single five-point Likert response. Thirdly, three constructs for each respondent were created:

3.3.3.1 Construct 1: Propensity to trust

The NEO Personality Inventory (NEO-PI-R) [37] looks to define the *'Big Five'* personality domains of neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. Taken together, the five domains with their underlying thirty facets (or sub-traits) are viewed as a *"comprehensive and detailed assessment of normal adult personality."* This study looks to the domain of *agreeableness* which is a personality trait where a low score relates to selfish behaviors and lack of empathy. Congruent with Lucassen and Schraagen [103] there

is not a full application of the NEO-PI-R questionnaire as other traits (and sub-traits) are not relevant to this study, choosing to only apply sub-trait questions for propensity to trust.

Respondents answered eight questions (see below) as to how much they felt the statements applied to themselves, with the total sum of results being used to assign a score to the participant (T_P). The construct T_P allows to determine as to whether this underlying personality trait is having significant influence upon the participant's credibility assessment of the stimuli.

Propensity to Trust (T_P)

Propensity to trust is based upon the sub-questions in *'Q2.13 Without spending too much time thinking about each question; how much do the following statements apply to you?'*, being:

- Regarding the intentions of others I am rather cynical and sceptical.
- I believe that you will be used by most people if you allow them to.
- I believe that most people have good intentions.
- I believe that most people, with whom I have dealings, are honest and trustworthy.
- I become distrustful when someone does me a favour.
- My first reaction is to trust people.
- I tend to assume the best of others.
- I have a good deal of trust in human nature.

3.3.3.2 Construct 2: Sentiment towards Bitcoin

Sentiment towards Bitcoin was measured using 6 questions about aspects of Bitcoin: price rises, adoption, regulation, viability as a currency, investment potential and criminal activity. The total sum of results being used to assign a sentiment score to the respondent (S). The construct S allows approximation of whether a respondent's underlying sentiment (positive or negative) to Bitcoin might influence interpersonal or information trust ratings.

Sentiment towards Bitcoin (S)

Sentiment towards Bitcoin is based upon a selection of the sub-questions in *'Q5.3 How much do you agree with the following statements about Bitcoin?'*, being:

- Long term (3 years +) bitcoin prices will always rise.
- Long term adoption by retailers will be good for Bitcoin.
- Governments will regulate Bitcoin.
- Bitcoin provides a viable alternative to traditional fiat (currency).
- Long term bitcoin offers a better financial return (as an investment) than stocks.
- Bitcoin is primarily a tool for criminal activity.

3.3.3.3 Construct 3: Self-rated expertise in Bitcoin

A participant's self-rated expertise (as perceived knowledge) was determined to be a suitable proxy for actual expertise. Alternative approaches to assessing expertise such as using discriminality and consistency protocols [140] or infer-

ence models [97] require further effort on the part of the participant and were deemed onerous for the purposes of this study. Following the lead of Park*et al's* study into information valuation and confirmation bias with stock pricing [125], self-rated expertise in Bitcoin was created using three questions around how well informed participants believed they were with regards to Bitcoin technologies, markets and other related news that might impact Bitcoin (e.g., sovereign monetary policy). The total sum being used to assign a score to the participant (E) allowing observation the influence of expertise upon credibility evaluation. Based upon Lucassen & Schraagen's work it would be expected to see some differences between respondents' trust levels in relation to their expertise in the subject — E affords the ability to differentiate respondents by their own perception of personal expertise in Bitcoin.

Self-Rated Expertise in Bitcoin (E)

Self-Rated expertise in Bitcoin is based upon a selection of the sub-questions in *'Q5.6 How well do these statements describe you?'*, being:

- I am well informed about bitcoin technologies.
- I am well informed about bitcoin markets.
- I am well informed about non-Bitcoin news that might impact the bitcoin markets.

For all three constructs (T_P, S & E) questions used a five-point Likert scale where 1 = 'strongly disagree' and 5 = 'strongly agree'. Cronbach's Alpha (α) was used to test the internal reliability of each construct.

3.4 Results

3.4.1 Validity of construct questions

Cronbach's Alpha (α), is a commonly used statistical method for estimating the reliability of a psychometric test. As a function of the number of items in a test, it measures the covariance between item-pairs in a construct and the variance of the total score. As such α can be viewed as the expected correlation that tests measure the same construct. For example the construct T_P had 8 questions, each being an item. In psychometric testing, common '*rule-of-thumb*' minimum acceptable requirements for internal reliability are $\alpha \geq 0.7$.

Respondent's propensity to trust (T_P) is derived from the NEO-PI-R questionnaire [37] and had a Cronbach's α of 0.81 indicating good reliability in the questions as an indicator of trust. Sentiment (S) had a Cronbach's α of 0.70 indicating acceptable reliability. Self-rated expertise (E) had a Cronbach's α of 0.90 indicating excellent reliability.

3.4.2 Constructs

Overall, respondents (see Table 3.2) were moderately trusting in general ($\bar{x} = 27$, SD = 5.1) with a positive sentiment towards Bitcoin ($\bar{x} = 21$, SD = 4.3) and a high level of self-rated expertise in Bitcoin ($\bar{x} = 11$, SD = 3.2).

Testing for statistical dependence between these constructs and when the respondent discovered Bitcoin was assessed using Pearson's Chi Squared (x^2) tests. This determines the statistical likelihood of any observed difference between two categorical sets (constructs to when) might be to chance. Simply, Pearson's Chi Squared tests whether when a respondent discovered Bitcoin impacts upon

their sentiment (S) towards, or expertise (E) in Bitcoin. Slightly surprisingly, no significant relationship to S was observed ($x^2(16, N = 125) = 20.553, p = 0.196$), meaning that how long a respondent had known about Bitcoin was not influencing their sentiment. A significant relationship between self-rated expertise (E) and when a respondent first discovered Bitcoin ($x^2(20, N = 123) = 53.866, p < 0.05$) was found, with the longer a respondent had known about Bitcoin the greater their perception of their own expertise.

	Propensity for Trust (T_P)		Sentiment towards Bitcoin (S)		Self-rated Expertise (E)	
Category	Score	%	Score	%	Score	%
Very high	36-40	3.2%	26-30	15.2%	13-15	29.3%
High	31-35	24.8%	21-25	44.0%	10-12	39.0%
Moderate/Neutral	20-30	68.0%	16-20	32.0%	9-9	10.6%
Low	13-19	3.2%	11-15	8.0%	6-8	13.8%
Very Low	8-12	0.8$	6-10	0.8%	3-5	7.3%
		100% (N=125)		100% (N=125)		100% (N=123)
Mean score	$\bar{x}T_P = 27$, SD = 5.1		$\bar{x}S = 21$, SD = 4.3		$\bar{x}E = 11$, SD = 3.2	

Table 3.2: Summary of survey participant constructs

3.4.3 Interpersonal trust

3.4.3.1 Trust in users of Bitcoin

The average rating for trust in users of Bitcoin ($\bar{x}T_U = 2.928$, SD = 0.805) was just below neutral, indicating a slight mistrust. Using ordinal logistic regression to test the null hypothesis that neither T_P or S have no influence upon T_U, three models are built as shown in Table 3.3. As zero is within the interval of models $T_U \sim T_P$ and $T_U \sim T_P + S$ these models are rejected. Only the model $T_U \sim S$ can reject the null hypothesis, i.e, sentiment towards Bitcoin has a significant estimated effect of sensitivity upon trust rating of users with $0.112 \in < 0.030, 0.194 >$ at 95% confidence level.

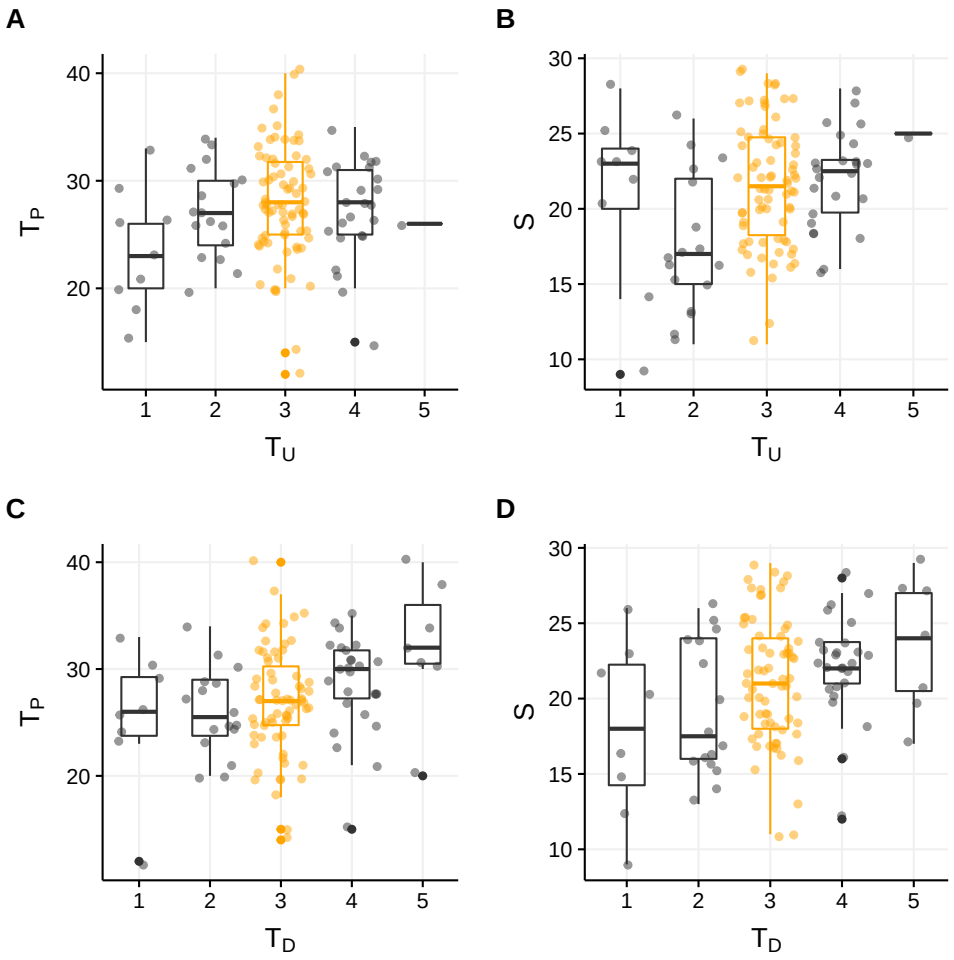


Figure 3.3: Trust in people (T_U & T_D) against Trust propensity (T_P) and Sentiment (S)

Reasons for trust in people ratings.. Using a manual open-coding [149] approach to classify respondents' reasons for how and why they rated their trust in other people using Bitcoin identified three broad categories:

1. **Aspects** – something that is part of or facilitated by the technology of Bitcoin, e.g., anonymity.
2. **Behaviors** – a type of another users' behavior, e.g., criminal activity or manipulation.

Model	Coef	2.5%	97.5%	Rej. H_0
$T_U \sim T_P + S$	$\beta(T_P) = 0.037$	-0.033	0.108	FALSE
	$\beta(S) = 0.111$	0.029	0.194	TRUE
$T_U \sim S$	$\beta(S) = 0.112$	0.030	0.194	TRUE
$T_U \sim T_P$	$\beta(T_P) = 0.037$	-0.031	0.106	FALSE
$T_D \sim T_P + S$	$\beta(T_P) = 0.122$	0.051	0.196	TRUE
	$\beta(S) = 0.154$	0.070	0.241	TRUE
$T_D \sim S$	$\beta(S) = 0.143$	0.060	0.229	TRUE
$T_D \sim T_P$	$\beta(T_P) = 0.111$	0.041	0.184	TRUE

Table 3.3: Trust in people - regression outputs

3. **General** – other general comments around trust.

A further 15 responses went un-encoded, mainly through no response being given. A full list of sub-categories is given in table 3.4. From these it is clear that the behavior of other users is a common reason for a trust assessment, particularly behaviors that might be either criminal or in some way manipulative. Arguably the anonymous/pseudonymous aspect also relates to behaviors in so much as it was most commonly given in conjunction with, and as a precursor to, errant behavior. Aside from general comments about trust, 15 respondents were clear to point out that merely using a technology (Bitcoin or otherwise) was not in itself a good yardstick by which to assess trustworthiness.

Of note are two points. Firstly, respondents who cited '*community driven*' as a reason had a markedly higher trust in other users (T_U). Secondly, the majority of other reasons given were used to express mistrust.

3.4.3.2 Trust in people maintaining Bitcoin

The average rating for trust in people maintaining Bitcoin ($\bar{x}T_D = 3.064$, SD = 0.905) was above neutral indicating a slight trust. Unlike trust in users, ordinal logistic regression found that three models $T_D \sim T_P$, $T_D \sim S$ and $T_D \sim T_P + S$ were valid.

Aspects	n	$\bar{x}T_U$	$\bar{x}T_P$	$\bar{x}S$	$\bar{x}E$
Anon / Pseudonymity	7	2.714	26.571	20.571	9.857
Community driven	6	4.000	29.000	23.333	11.667
Technical	6	3.833	26.167	21.167	11.167
Volatility	1	2.000	30.000	16.000	14.000
$\bar{x}(Aspects) =$		3.400	27.350	21.350	11.000

Behaviors	n	$\bar{x}T_U$	$\bar{x}T_P$	$\bar{x}S$	$\bar{x}E$
Criminal / Manipulation	26	2.385	27.962	19.077	9.885
Greed	2	2.500	26.000	23.000	12.000
$\bar{x}(Behaviours) =$		2.393	27.821	19.357	10.036

General	n	$\bar{x}T_U$	$\bar{x}T_P$	$\bar{x}S$	$\bar{x}E$
General common	33	3.121	28.121	22.485	11.121
'Just a tool, nothing to do with trust'	15	2.467	27.133	22.933	11.000
Too context sensitive to be specific	11	2.818	28.000	18.909	10.000
No need for trust	3	3.000	21.333	23.333	14.000
$\bar{x}(General) =$		2.903	27.532	22.000	11.032

Table 3.4: Reasons given for trust in people ratings

Using a backwards selection process with the three valid models, analysis starts with all p variables (T_P & S). Removing either results in a significant decrease in the quality of the model fit, and therefore the model $T_D \sim T_P + S$ is chosen as the best fit - i.e., propensity to trust when combined with sentiment towards Bitcoin has a significant estimated effect of sensitivity upon the trust rating of people maintaining Bitcoin at 95% confidence level.

3.4.3.3 Impacts of loss on trust

Of the respondents who claimed to have or being using Bitcoin ($N = 94$), 62.4% felt they have incurred a loss of Bitcoin (see Table 3.5). Forty-five respondents gave details as to how they had lost bitcoin and rated on a five point Likert scale how this loss had impacted upon their interpersonal trust in Bitcoin users (T_U)

and, in the people maintaining Bitcoin (T_D). The mean impacts of loss ($\bar{x}T_U = 2.689$ & $\bar{x}T_D = 2.911$) both indicated that interpersonal trust was slightly reduced when losing Bitcoin.

Moving slightly away from interpersonal trust briefly; analysis also looked at whether loss impacts upon a general trust in Bitcoin (T_B) and, in Bitcoin exchanges (T_E). Whilst loss had no mean impact upon trust in Bitcoin ($\bar{x}T_B = 3.000$) there was a more marked reduction in trust of the exchanges ($\bar{x}T_E = 2.489$).

Looking at individual types of loss (see Table 3.5) a more nuanced impact with trust being, in the main, negatively impacted by loss is observable. Interpersonal trust (T_U) is most negatively impacted by fraud and theft events. Non-interpersonal trust tends to remain reasonably stable. However, trust in exchanges (T_E) suffers markedly through both technical problems at exchanges (1.600 or *much lower / lower*) and collapse of an exchange (1.889 or *lower*). Interestingly trust in the people maintaining Bitcoin (T_D) was most negatively impacted by loss from technical problems at exchanges, something for which they have no direct, and little (if any) indirect responsibility.

Pearson's Chi-Squared tests of impact of loss (by reason) against these four parties show significant results (see Table 3.5)—the most notable being T_E being pegged to the collapse of exchanges, and T_U being pegged to gambling.

		*Mean Impact on Trust After Loss**				*Significant Impacts Upon Party*			
Reason for Loss	n	T_U	T_D	T_B	T_E	Party	x^2	DF	p
Fraud	18	2.444	3.000	3.056	2.222	-	-	-	-
Exchange Collapse	18	2.778	2.778	2.833	1.889	T_E	24.058	3	0.000
Rate Variations	12	2.583	2.667	2.667	2.167	T_E	7.878	3	0.049
User Error	11	2.727	3.091	3.273	3.000	T_E	12.419	3	0.006
Theft	8	2.375	2.750	2.875	1.875	T_U	7.805	3	0.050
						T_E	7.879	3	0.049
Exchange Problems	5	2.600	2.400	2.400	1.600	T_D	9.056	3	0.029
						T_E	13.715	3	0.003
						T_B	9.562	4	0.048
Other	4	2.750	2.750	3.000	3.000	-	-	-	-
Gambling	2	3.500	3.500	3.500	3.000	T_U	22.213	3	0.000
						T_B	10.334	4	0.035

*(Notes: *where 1="much lower" 2="lower" 3="about same" 4="higher" 5="much higher")*

Table 3.5: Impacts of loss upon trust

3.4.4 Informational trust

3.4.4.1 Mediums of information

Table 3.6 shows analysis of the relationship between trust and use of information mediums. When comparing the ranked order of trust (RT) against respondents' usage (U), all mediums of information have a negative relationship. That is, the more trusted a medium becomes the less respondents tend to use it (see Figure 3.4). With the exception of general news websites (WG), technology websites (WT) and printed newspapers (PN) this is a significant negative relationship.

In addition to these key mediums, 91 respondents also claimed to '*often*' use Bitcoin pricing charts before making investment with 32 asserting they used charts '*all of the time.*'

Medium	Usage* (U)			Ranking of Trust** (RT)			Spearman's Rho (*1-tailed*)		
	Rank	$\bar{x}U$	SD	Rank	$\bar{x}RT$	SD	Model	r	p
Discussion Forums (DF)	1	3.407	1.398	1	7.860	2.552	$U_{DF} \sim RT_{DF}$	-0.540	0.000
Personal Blogs / Vlogs (PB)	6	2.099	1.184	6	4.500	2.465	$U_{PB} \sim RT_{PB}$	-0.237	0.028
Social Networks (SN)	8	1.868	1.204	10	3.202	2.278	$U_{SN} \sim RT_{SN}$	-0.463	0.000
Printed Newspapers (PN)	9	1.648	1.058	9	4.053	2.229	$U_{SN} \sim RT_{SN}$	-0.112	0.303
Friends/Family/Colleagues (FF)	10	1.582	1.023	8	4.202	2.891	$U_{FF} \sim RT_{FF}$	-0.468	0.000
Websites:									
Bitcoin / Cryptocurrency (WB)	2	3.077	1.327	2	7.526	2.601	$U_{WB} \sim RT_{WB}$	-0.354	0.001
Financial News (WF)	4	2.604	1.316	4	6.456	2.377	$U_{WF} \sim RT_{WF}$	-0.322	0.002
Technology (WT)	3	2.637	1.346	3	7.026	1.916	$U_{WT} \sim RT_{WT}$	-0.059	0.590
General News (WG)	5	2.165	1.293	7	4.482	2.203	$U_{WG} \sim RT_{WG}$	-0.030	0.781
Information (WI)	7	1.978	1.211	5	5.693	2.631	$U_{WI} \sim RT_{WI}$	-0.184	0.089

*Notes:(Number of respondents - *Usage 114, **Ranking 91)*

Table 3.6: Relationship between trust of, and use of information mediums

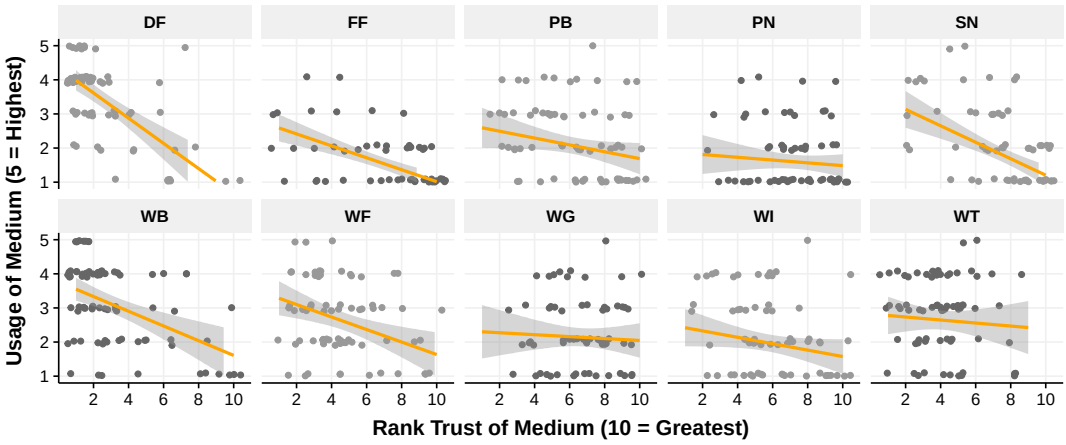


Figure 3.4: Correlation between information mediums and their use

3.4.4.2 The influence of news reporting as a medium

123 respondents provided a rating for agreement with the statement *'I am influenced in bitcoin buy/sell decisions by what I read in newspapers (online or printed).'* The mean response of '*disagree*' ($\bar{x} = 2.390$, SD $= 1.157$) indicated that respondents broadly felt they were not overly influenced by news reports, although this was likely skewed by the inclusion of printed news which ranked 9th for both usage and trust. However, looking at the information mediums (see Table 3.6), only discussion forums (DF) were either used or seen as more trustworthy than the three most obvious Bitcoin-related news websites — Bitcoin/Cryptocurrency (WB), Technology (WT), and Financial (WF), taking second to fourth in both usage and trust.

3.4.4.3 Source credibility in Bitcoin related news websites

In a study analysing discussions of Bitcoin on Twitter [64], it was concluded that "*total shares* [of a story URL] *is a far more accurate measure... for assessing the popularity of a publication.*" The study went on to identify – from the 247,000

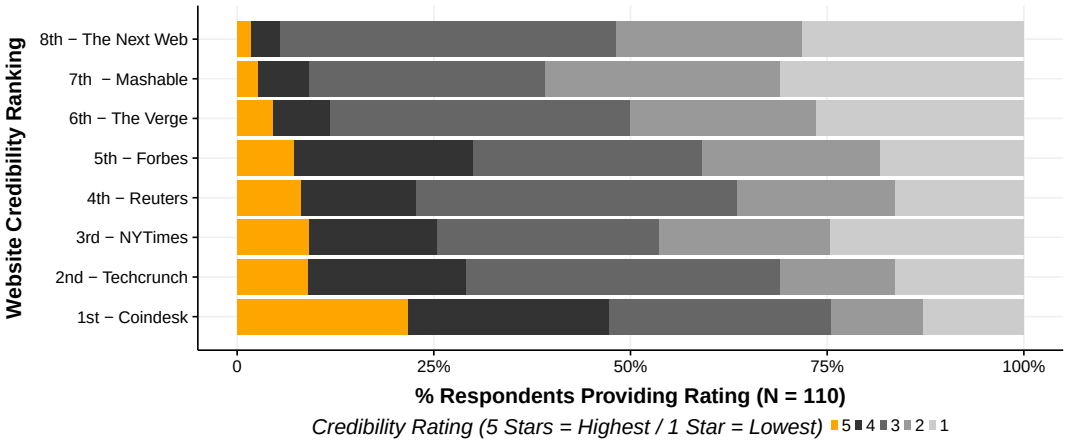


Figure 3.5: Credibility of news websites

unique Bitcoin related URLs shared on Twitter in February 2014 – that Coindesk.com (581 URLs 31,698 shares) was more than twice as popular as its nearest competitor. Following the rationale in [64], respondents were asked to rate 8 of the most popular website sources. Wired and Wall Street Journal were excluded on the basis they did not provide open access at the time of study.

Whilst all eight websites had a modal credibility rating of 3 out of 5, there is a clear hierarchy of trustworthiness in the sources based upon the 110 rankings given by respondents (see Figure 3.5). Unsurprisingly Coindesk – the only cryptocurrency specific website in the list – ranked highest and with 75.45% of respondents giving it a 3 or higher rating. The total of Coindesk's maximum credibility ratings (a score of 5) ($n = 24$) was more than double that of its nearest competitors Techcrunch ($n = 10$) and Reuters ($n = 10$).

3.5 Discussion

This chapter addresses *Objective 1* in seeking to better understand human perspectives of trust within Bitcoin. Not least as colloquial viewpoints on trust tend towards it either being something that is purely based in computation not people or, indeed, that Bitcoin is devoid of trust altogether. Throughout the online study respondents were asked to quantify and discuss notions of trust from their perspective – where, how and why they mattered. This section highlights key findings from those responses and, where appropriate, looks to the literature for support. The implications for this research are also discussed along with limitations. As the often held viewpoint is that trust in people is not necessary when using bitcoin we start with notions of interpersonal trust.

3.5.1 Interpersonal trust

From the generated constructs (see Section 3.3.3), the 125 respondents exhibited a moderate level of propensity to trust others (T_P) based on the NEO-PI-R test – they were neither particularly trusting nor mistrusting of people in general. Throughout the results, respondents were willing to express both trust and mistrust in other people using and maintaining Bitcoin – perhaps unsurprising given the importance of interpersonal trust described by Simpson [145] yet clearly in contradiction to any notion that there is no requirement for trust in people within Bitcoin.

To recap: on average there was a slight mistrust in other users of Bitcoin being significantly determined by the respondent's own sentiment to Bitcoin (S) and not a propensity to trust (T_P). Trust in those people maintaining Bitcoin (the core development team) was found to be very slightly trusting (higher than

that of other users) and dependent upon both sentiment and propensity, more so when combined. This aligns well with Mayer *et al*'s [108] assertion that it is actually these two factors (trust judgement / sentiment and propensity) together are necessary for trust to be established.

3.5.1.1 Trust can be contextual

A number of respondents did allude to interpersonal trust being context specific, something supported by Sitkin and Roth [146] who assert that assessments of trust may not generalize across dissimilar contexts. For example, trusting a 'bricks and mortar' vendor selling books for small amounts of bitcoin might require a different assessment of trust compared to, say, a person peddling drugs on a Dark Web marketplace. Indeed Mayer *et al* stress that a question of '*do you trust them?*' needs to be qualified with context via a reciprocal, '*trust them to do what?*'.

3.5.1.2 Sentiment is critical

The role of sentiment towards Bitcoin appears to be critical in how respondents assess other people (see Sections 3.4.3.1 & 3.4.3.2). It is unclear as to why this might be the case although there is perhaps a key difference in the roles that *'other users'* and *'people maintaining Bitcoin'* play – especially in terms of interaction with respondents.

As respondents (in the majority) were also users of Bitcoin it is likely they had had numerous cyclical interactions [108] in similar contexts (multiple discussions across different forums for example) with *'other users'*—sufficient to generate trust judgements. The same is not necessarily true of interactions with 'people maintaining Bitcoin.' This core development team is generally well known throughout the Bitcoin community with members regularly being called upon by

news agencies and conferences to pass comment or judgement on various cryptocurrency aspects. But these *one-way* interactions (i.e., the respondent is consuming information from a core development person) are different to that of the *two-way* interactions within an active discussion.

So whilst trust in *'other users'* may be linked to those prior interactions, it seems plausible (given the critical role the core development team play in maintaining Bitcoin) that a positive sentiment towards Bitcoin (S) may be acting as some form of proxy for that missing interaction when making judgement on what are a distant non-interacting party. *Objective 2* (see Chapter 4) studying confirmation bias sheds further light on the role of sentiment.

3.5.1.3 Reasons expressed for interpersonal trust

When looking to the reasons given for trustworthiness ratings of other Bitcoin users interesting points of note were as follows:

Financial risk reduces trust.. Three people openly disclosed they had used Bitcoin for illicit purposes and one specifically mentioned that when they transact on the Dark Web that they definitely trust others less. At face value this comment is logical. With no payment reversal mechanism in Bitcoin (something mentioned by a respondent as a reason for not trusting other users) continuing to transact with untrusted third parties would appear to contradict Zarifis *et al*'s [164] assertion that trust is an important factor where financial risk is evident.

In the event of a failed transaction, reversal of funds is not possible and legal action unlikely—at best. This brings in to question why someone would continue to transact in a seemingly untrustworthy and untrustable situation. A plausible rationale lays in another mechanism external to Bitcoin applying pressure to the counter-party to fulfil their obligation. One such mechanism that could be

observed on the Silk Road, whilst still active, was that of party reputation [9, 32] itself being a trust metric common in modern peer-to-peer transactional models online such as eBay.

Mistrust tends to be based on errant behavior.. The behaviors of other users (e.g., fraud, theft or market manipulation) were cited by several respondents as rationale for trust judgements – in the main mistrust. It is unclear from the data collected if these judgements were based on single, perceived, vicarious or repeated (cyclical) experiences. Respondents citing behavior did exhibit slightly below average scores for trust in other users (T_U) and a slightly negative sentiment (S) and it is possible these contribute to the rationale. Without specifically asking for qualification from respondents, this is conjecture. That said, with behavior of others applied as a rationale for trust this reinforces that interpersonal trust is evident in Bitcoin.

Limited expressions of trustless meaning no trust.. Only three people openly declared that there was no need to trust people "*as Bitcoin is trustless.*" No reasoning for this is offered other than from a construct perspective in that all three had very low T_P (between 9-11)—significantly lower than the average respondent (27). All three had sentiment scores (S) within the average categorization of 'moderate' and all three had high or very high levels of self-rated expertise (E).

3.5.1.4 Impacts of loss

With behavior (errant behaviors in particular) being a common reason for trust and mistrust of others, analysis also sought further insight into ways in which respondents had lost bitcoin in the past and how this impacted on four different

parties: in other users (T_U) the people maintaining Bitcoin (T_D), trust in Bitcoin (T_B), and trust in exchanges (T_E).

Over half of respondents (62.4%) had suffered loss. Trust in Bitcoin (T_B)—which was deliberately left as a generic question with no context as Bitcoin *means* different things to differing communities of use—went unaffected by loss. The other three parties were impacted. Notable aspects are as follows:

Gamblers trust more.. Whilst gambling is fully related to T_U, it appears that loss from gambling actually increases trust across all four parties. Some caution is applied to this finding as this context sample size was only two — however it is posited that, as an often repeated behavior, gambling actually fulfils the cyclical pattern of interactions. A key issue in trusting within gambling is fairness. If one player has lost, but s/he does not suspect the game is rigged or the other party is cheating, any loss would not likely reduce their trust, as some loss is an essential element of gambling and thus expected. Further the acceptance of bitcoin as a payment method on gambling websites may demonstrate a desirable level of technical prowess which when combined with a consistency in aspects such as reliable payment of winnings helps to engender or even bolster trust.

Self enacted loss can increase trust.. Where respondents were able to attribute loss to their own failings (user error) it reduced T_U, the reasons for which are unclear. A common theme for 'user error' was lost wallets, keys or passwords. An increase in T_D & T_B might be linked to this personal error reinforcing underpinning concepts of security within Bitcoin wallets.

An equally plausible scenario is based in economic fundamentals which dictates how the relationship between supply and demand will impact upon price. For example as supply in oil decreases, given a stable demand, the price will increase. Conversely a drop in demand and increase in supply will drop prices. For

anyone with a belief in these fundamentals and knowing there is limited supply of bitcoin (the hard limit of 21 million), any loss of bitcoin would actually result in the value of retained bitcoin actually increasing—a process which would reinforce foundational notions of decentralization and (insitutional) trustlessness.

Exchange collapses impact all aspects of trust.. Trust in exchanges (T_E) suffers the most as a result of technical problems or a collapse of the exchange itself. Given the high profile collapse of Mt Gox in early 2014 and the widespread technical problems it and other exchanges endured in the weeks prior, this is not surprising. The more interesting insight is that these technical problems or collapses negatively impact all four measured parties including T_U.

Post study, in August 2016, the bitcoin exchange Bitfinex underwent a security breach in which a ∼US$70M of customer's bitcoin was stolen. Preliminary analysis of this breach in relation to this study's findings and discussions of trust is given in Section 3.6).

Fraud does not reduce trust in Bitcoin, but theft does.. Finally, there are notable differences in impact between fraud and theft events. Both are behaviors undertaken by other parties but it appears respondents view them differently. For example, fraud has negligible impact upon T_D & T_B and its greatest impact upon T_E. For theft the impact is across the board, again with the most pronounced being upon T_E. In both cases it appears that other users might be perceived to be to blame for the loss and that exchanges may in fact shoulder greater blame (again perhaps these reports pertain to the huge losses incurred by many in early 2014). The lack of impact on T_D & T_B through fraud suggests that these parties are not viewed as being at fault, the same is not true in theft events – something that may hint at concerns about underlying security issues in Bitcoin.

3.5.2 Informational trust

Work by Lucassen and Schraagen [103] studies information mediums in terms of 'the Internet', 'printed newspapers' or 'television.' Sources in this context would be the individual websites, newspapers or television programmes. There is a problem with this taxonomy in that it assumes all sources within a medium are in some way analogous with each other from a user's perspective, something alluded to in acknowledging that their study was conducted on a single website's contents. A more realistic taxonomy would likely acknowledge that all websites on the Internet are not alike as neither are all printed newspapers or television channels. This could be achieved by either creating a new layer between medium and source to cater for a further level of categorization or seeing the medium and source layers as more fluid, changing position and influence upon each other depending on context.

Following the concept of medium and source layers, this analysis recognizes that there is a dichotomy in the mediums of information presented to respondents in the study. The first group (social networks, discussion forums, blogs/vlogs and friends/family/colleagues) can be considered as offering bi-directional, often social communication. The second group (printed newspapers and five types of website) can be considered to be uni-directional mediums where social interaction is not the normal modality.

3.5.2.1 Social mediums

Looking at the first group there is a clear break in both usages and trust. The very poor usage and rankings ascribed to social networks and friends/ family/ colleagues would suggest, that for respondents, their own social and familial circles

are either not using or are not well informed about Bitcoin enough to be valuable. Discussion forums, however, are viewed as the most highly trusted and used of all mediums. Looking to statements made by respondents as to why they use and trust discussion forums, there are three clear themes as to why this might be:

Other forum users are perceived as being similar in some way.. "*I think they share my idealism*", "*..compatible levels of intelligence*", "*..their purpose is the same as mine.*"

There is value to be gained from dissimilar (often more experienced or more influential) forum users.. "*..you still can talk with major players, and the most amazing people in the industry*", "*..everyone on Bitcoin Markets knows what they're talking about and are all big investors*", "*..ultimately, it is the people who use Bitcoin that affect Bitcoin the most. As such, knowing what they do trumps most other things.*"

Making credibility assessments on discussions is made easier by the community.. "*..it's easy to spot fud and what isn't obvious fud is easily discredited, often in the very same thread.*"

This reliance upon personal interaction suggests that trust in discussion forums (as a medium) may actually be more based in interpersonal trust of the individuals (a source) being interacted with and would requires examination using methods similar to Lucassen & Schraagen but using these different, more interactive types of mediums and sources. *Objective 3* of this thesis (see Chapter 5) explores this in its creation of a model of informational trust.

3.5.2.2 Non-social mediums

Interpersonal trust of authors increases trust in medium of information.. The non-social group contains Bitcoin, financial and technology news websites, all of which are (not unexpectedly) both highly ranked and used with respondents expressing perceptions of there being a higher level of expertise in these three website types than in others. Respondents also talk to the ability to make credibility assessments upon the authors themselves through understanding the authors own knowledge "*..there's usually a disclaimer for the writer whether they use or have crypto-currencies or not,*" and how biased they might be "*..gauge how partial the writers are by looking at their other articles.*" A desire to correct mistakes in order to "*maintain reputation*" was also cited as a reason for trust.

Mistrust in newspapers is not based on temporality of stories.. The starkest difference was between online websites and their printed contemporaries. It might be presumed that this lack of both use and trust in printed newspapers might be due to temporal issues such as the time taken for a breaking news story to actually be reported. Respondents actually expressed two other clear perceptions of printed news; firstly, bias based upon newspapers being "*institutions.. having no bearing on Bitcoin price or culture*" and secondly, a perceived lack of knowledge of Bitcoin in general. It is noted that respondents did not express these same justifications when assessing the websites of those printed newspapers.

3.5.2.3 Trust in news websites as a source

It is interesting that in the main respondents felt they were not overly influenced by news reporting as demonstrably news reporting is an important medium for information surrounding Bitcoin, second only to discussion forums. The extent to which this may or may not be true is (again) explored in *Obective 3*.

Credibility of websites linked to usage and popularity.. Following the rationale set out by Harris [64], which ostensibly confirmed that crypto-currency, technology and financial websites are the most popular sources of Bitcoin news (on Twitter), this study looked to 8 of the top ten of those websites as sources of information and questioned the respondents directly for their views on website credibility. Whilst there was a slight mismatch in this study's credibility rankings and Harris' popularity assessment, there is agreement on four of the top five websites.

Interestingly ALL of this study's top five websites belong to the four highest ranked and used website mediums — Coindesk (crypto-currency), Techcrunch (technology), Forbes (financial), New York Times and Reuters (general news). There is an apparent linkage between use, trust and popularity of websites as sources of information.

3.6 Post-study Reflection of Bitfinex Hack

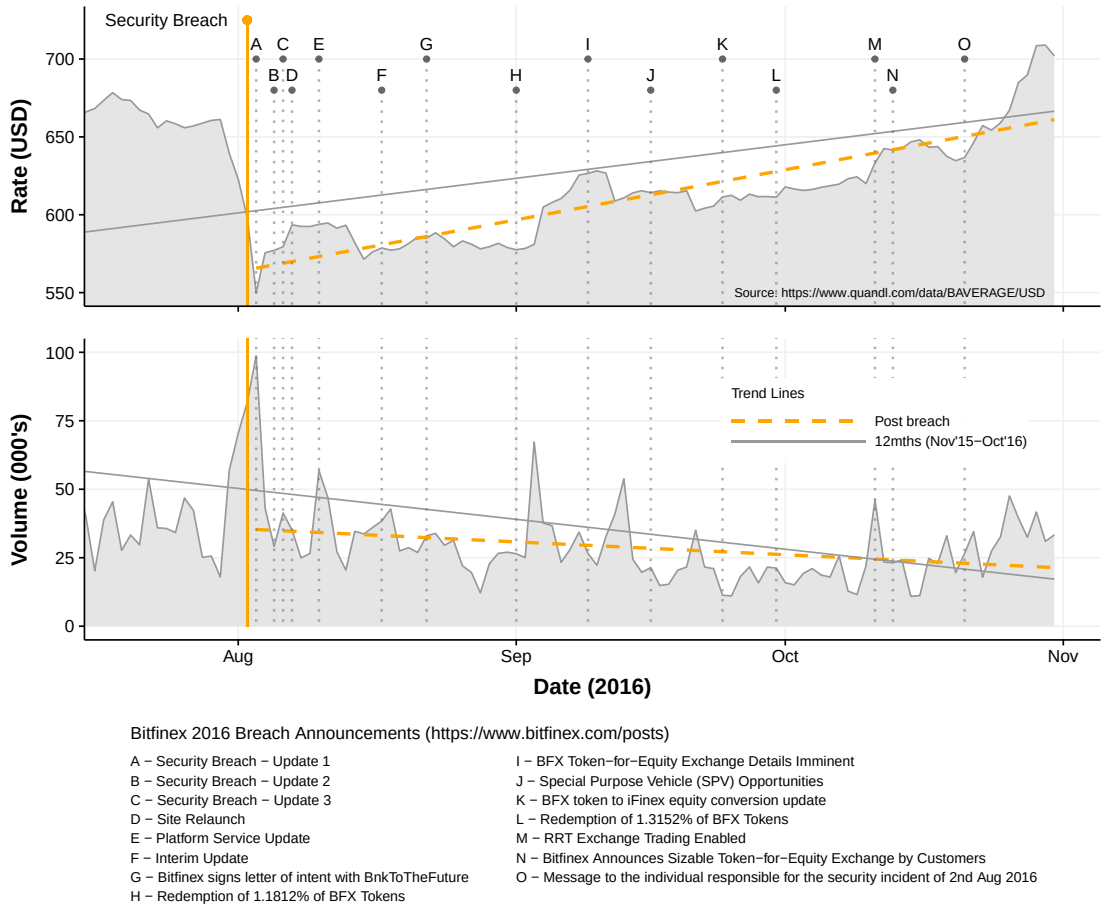


Figure 3.6: Impact of Bitfinex security breach and subsequent recovery efforts on bitcoin markets

The breach. On August, 2nd 2016 Bitfinex — the largest (by volume) exchange at the time — was hacked [15], resulting in a loss of ∼US$70M worth of bitcoin and being the largest single loss since the collapse of MT Gox in 2014. As news broke, the velocity of the already falling price of bitcoin increased, with closing prices having fallen ∼17% to under US$500. In the immediate aftermath press coverage was largely negative with many predicting another full exchange

collapse. However Bitfinex, recognising the potential impact of the negative press in conjunction with significant financial loss, reacted swiftly and released almost daily press announcements about the event.

The response. On August, 6th Bitfinex posted details of a recovery plan in which losses would be generalized (socialized) across all depositors - a 36.067% 'haircut' - by way of a $1 bond-like security ('BFX' token) for later redemption, "*we are crediting a token labelled BFX to record each customer's discrete losses. Tokens will be distributed without release or waiver. The BFX tokens will remain outstanding until redeemed in full by Bitfinex or possibly exchanged upon the creditor's request and Bitfinex's acceptance for shares of iFinex Inc.*" [16]. This was a clear indication by Bitfinex, and their parent company iFinex, that they not only intended to keep trading but also to make good on those losses, and could readily be interpreted as an exercise in re-building customer & market trust.

The announcements updating customers, now creditors, continued over the following weeks, detailing how breach investigations were proceeding, how BFX redemptions were being made and when tokens were being converted at scale into equity as promised.

The 'effect'. Exactly how users viewed this breach is unclear. For some the attack may have been viewed as theft, decreasing interpersonal trust. For others, Bitfinex may have been viewed as institutionally untrustworthy. For some it is possible that as the underlying protocols were not overtly viewed as being at fault and trust in Bitcoin itself might have actually increased. What is likely from this study's findings is that trust will have been impacted across all parties (T_U, T_D, T_B & T_E). In all cases, however, this supports this study's view that the trust model of Bitcoin—as an evolving ecosystem—goes beyond computation alone.

Given this, the efforts by Bitfinex to restore confidence seem well placed. A visual inspection of average bitcoin pricing [131] across multiple exchanges (as this flattens out the more direct impact on Bitfinex-only pricing) shows that post-breach the velocity of price rises actually increased, and the decline in volume eased (see Figure 3.6). Whilst Bitfinex's actions cannot be proven to be causal — without both statistical and user confirmation — when the timings of their announcements are superimposed (with the exception of A,F & H) each was followed within a day by a rise in price, albeit a slight one. Announcements F & H also pre-date similar rises but with greater lag of approximately 2 to 3 days.

3.7 Chapter Summary

This chapter empirically examined the extent to which Bitcoin, as an ecosystem, can really still be referred to as *trustless* – a term which has become semantically loaded by communities of users to infer that Bitcoin is in some way devoid of trust in institutions and users.

Counter to the assertion that the trust model in Bitcoin is based solely in computation [4], this study found that both interpersonal and institutional trust not only exists in Bitcoin, but also that trust is directly impacted by loss — most markedly where that loss is the result of an exchange collapse or gambling. Further analysis found that interpersonal trust can be context specific and that it is dependent upon a respondent's own sentiment towards Bitcoin.

This study also found that trust in information plays a key role in the usage of Bitcoin, with crypto-currency related discussion forums being the most used medium of information and the most trusted. In part this can be attributed to the trust in the most used information mediums actually being based on how *social* that medium is—something which further strengthens the case for interpersonal trust being important in Bitcoin. Looking to news reporting as a medium, analysis found that whilst the average respondent claimed to not be overly influenced by what they read in those reports, news websites still ranked highly for both usage and trust—indicating that they are still widely relied upon, although there is a tendency for usage to actually fall the greater a medium is trusted. Trust in individual websites was found to broadly aligned with other research into website popularity.

The preliminary visual analysis of the Bitfinex hack-recovery lends weight to the distinction between **b**itcoin the currency and **B**itcoin as the wider socio-technical ecosystem and where trust is evident. The positive market movements

post recovery announcements suggest bitcoin users, whilst trusting in the computation, also placed trust in an exchange (an institution) and their messages (information).

Overall this chapter concludes that the term *trustless* is perfectly applicable to bitcoin but that this, i) is a loaded term not well understood and often misinterpreted to mean that there is no notion of trust in the Bitcoin ecosystem, ii) that *trustless* only applies to central banks being intermediaries—as intended in and from the perspective of the foundation paper—and not all organizations / institutions involved in Bitcoin, and iii) that whilst at its core Bitcoin may rely upon computation for trust, the day to day operation is dependent upon interpersonal, institutional and informational trust.

Chapter 4

Evaluation of Potential Confirmation Bias.

This part of the thesis addresses the second objective—*evaluation of potential confirmation bias*—and, through the use of stimulus experimentation, tests whether 57 Bitcoin users overly favor sentiment aligned news information when assessing its credibility.

4.1 Introduction

Whilst bitcoin was initially conceived as a peer-to-peer remittance technology, where a technology affords otherwise unintended opportunity it is likely human nature will re-purpose to take advantage of this utility. In the case of bitcoin, somewhat inevitably, this meant the emergence of firstly trading bitcoin against the very fiat currencies it was designed to *replace* and from there marketplaces (exchanges) upon which speculation more akin to that found elsewhere in financial services could be undertaken. Unlike existing and highly regulated financial services, the advent of bitcoin brought forth an era of investment opportunity to the lay person not previously imagined. No longer were they required to utilise intermediaries replete with training, expertise, real-time / highly costly intelligence and certification. In this new emergent market anyone equipped with access to the Internet, and willing to take on the risk without expert counsel, was able to do so. Bitcoin exchanges were the new, all but lawless wild-west of speculative investment.

For those aligned with the ethos of bitcoin and with a grounding in economic fundamentals, the limited supply of 21 million bitcoins [14] and firm belief that demand would trend upwards meant that no matter where the pricing sat or how short to medium market movements played out, long term returns for holding bitcoin would always be astronomical in comparison to initial investment. Indeed throughout the period leading up to the pricing crash of early 2014 it appeared that such optimistic outlooks would hold true as the price inflated from mere cents on the US dollar to around US$1,000 at its peak. Today, in October 2017, after approximately two years of relatively stable prices, bitcoin is again on a rapid upward march with peak pricing at around US$5,800 per bitcoin. Simple

gains from the price rises, especially through techniques such as arbitrage - the practice of buying assets in a cheaper market and selling in a more expensive one - have been both obvious and tempting.

The finite supply of bitcoin, a rapidly rising price and increasing discussion of Bitcoin in the news press and online forums would have presented an environment in which a wider group of opportunistic speculators would likely succumb to some form of band-wagoning [98] - an effect where the preference for bitcoin would increase purely based upon other people discussing and buying bitcoin. Indeed Becker [13] argues that the band-wagon effect alone could be strong enough to make the "demand curve slope upward" resulting in a feedback loop. In other words the very process of bitcoin being bought and discussed might be enough to drive others to buy and discuss bitcoin—these feedback loops being identified as occurring within Bitcoin by Garcia *et al* [58].

This chapter addresses the second objective of this thesis—*evaluation of potential confirmation bias*. It evaluates the extent to which speculators rely upon confirmation bias - in lieu of more systematic processes - to assess the credibility of news articles upon which they might base their bitcoin investment decisions. This is a position which could render them susceptible to questionable and manipulatable information. It has become apparent to the world during 2016-17, more so than ever before, that the factual accuracy within news reporting is questionable at times and overtly manipulated at other times often to appeal to opinion and belief rather than fact [135]. This paradigm collectively referred to as '*fake-news*' has long been understood in financial market manipulation through techniques such as '*pump-and-dump*' [72] and '*short-and-distort*' [73] whereby the flow and accuracy of information to potential investors is illegally controlled by bad-actors for gain. More broadly such forms of information-based attack have

been long recognized [109] as having the potential to wield incredible destruction upon those structures they are set upon.

Speculation, as a key use and contributing growth factor of Bitcoin [20, 25, 58, 128], has been shown to be as least partially influenced by the information contained within news reporting [58]. Where the quality of that news is questionable it is plausible that speculators might be basing their investment decisions upon factually deficient information. As the ecosystem, and arguably sub-culture, of Bitcoin has emerged it has presented a challenge (by design) to the power structures of sovereign currencies and financial incumbents. In this context it seem reasonable to examine whether bitcoin and its speculators, by relying upon personal belief (confirmation bias), might be vulnerable to a campaign of disinformation.

4.1.1 Contributions

Our key contributions are, as follows:

- The first empirical work that looks to whether Bitcoin speculators are reliant upon confirmation bias when evaluating news reporting upon which they might rely.
- Findings that overall there is no statistical evidence to support the reliance upon confirmation bias.
- Findings that speculators with either positive or negative sentiment towards Bitcoin, when evaluating news which aligns in sentiment, spend significantly less time on that evaluation than those with counter-aligning sentiment, contrary to findings by Knobloch-Westerwick & Meng [86].
- Findings that in approximately 34% of evaluations, credibility evaluation was based upon very minimal stimulus suggesting that in the absence of confirma-

tion bias that other heuristic approaches may be influencing decision making.

Implication of Findings - Given the often polarised and vocal opinions of those discussing Bitcoin online, it had been expected that confirmation bias would be evident. The findings do not support an over reliance, by speculators, on confirmation bias however they do point to other biases being at play to support decision making. Any bias presents a risk to the validity of a decision.

One example of this is the belief in the trust model for Bitcoin laying solely within computation. There is no doubt many proponents of Bitcoin are well versed in both the mathematics and software engineering required to fully understand how trustworthy this computation is. Similarly, there can be little doubt that significant proportions of proponents do not possess those skills and defer their trust to a bias towards other people they believe to possess more expert opinion—this was evident in Chapter 3. The obvious risk in this source bias lays with the trustee not actually being an expert, or holding their own confirmation biases or themselves deferring to others. A situation which would cause something of a trust *house-of-cards*.

Work in Chapter 5 develops a model of informational trust for participants, highlighting further biases.

The rest of this chapter is structured as follows. Firstly, this chapter provides background literature on confirmation bias and its role in seeking and evaluating information with reference to financial speculative decision making and Bitcoin. Secondly, description of the method by which this research examines whether bitcoin speculators are exhibiting potential confirmation bias when evaluating news followed by a presentation and discussion of experimental results. This chapter concludes that confirmation bias is not a statistically significant factor

influencing credibility evaluation, but that there is some evidence to support other biases influencing decision making.

4.2 Related Work

The following section discusses confirmation bias related work with respect to information selection, and financial (bitcoin) decision making.

Humans are pre-programmed to make use of short-cuts in everyday life. Such decision making approaches easing a cognitive load that is simply unsustainable or impractical, especially in times of stress - a process Festinger [51] describes as trying to maintain *cognitive equilibrium*.

Simon [143, 144] suggests that heuristics are necessary as humans we operate in a mode of "*bounded rationality*" within which rational decision making is constrained by the limitations of our mental capacity to process information and solve complex decisions. These heuristic tactics fall back on instinct or '*rule-of-thumbs*' and serve to provide swift & efficient outcome [77]. Tversky & Kahneman acknowledge that these short-cuts might lead to *"severe and systematic errors"* [152], or cognitive biases. Whilst Klayman [83] points out that bias can also refer to merely a tendency or inclination, within this thesis bias is taken to be a rational or logical failure of judgement. In this context cognitive bias serves to help the human achieve cognitive equilibrium by providing shortcuts for one or more of three task-based goals:

- Reducing the complexity and volume of information to enable a decision to be made,
- Forming meaning from seemingly disparate or meaningless information,
- Filtering what information is valuable enough to retain.

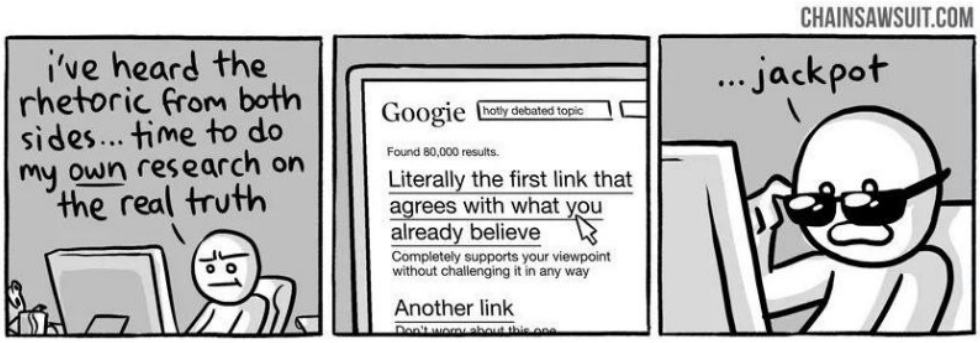


Figure 4.1: Confirmation bias cartoon - source:chainsawsuit.com/comic/2014/09/16/on-research

4.2.1 Confirmation bias.

Wason's seminal selection task experiment [160] was one of the first to demonstrate the difficulty humans have in making counter-positive inference. Simply, the experiment showed that humans tended to seek outcomes in the test which were confirmatory rather that to look for evidence disproving their belief - a behaviour conforming to the need to seek equilibrium. Klayman and Ha [84] argue that the questions posed in the test actually influenced people to think in a more positive way and that confirmation bias is better thought of a positive test strategy - being a default heuristic strategy. Cosmides and Tooby [36] further supported Wason's findings and provided evidence to underpin this default positive heuristic being a context sensitive process borne out of evolutionary *natural selection* - where situations involve threat or risk logical reasonning taking a secondary role to baser fight-flight instinctual heuristics. In other words humans are indeed pre-programmed to take short-cuts, at times.

Nickerson argues that of all the cognitive biases, the one most deserving of attention is that of confirmation bias. It is *"the seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis*

in hand" [122]. From this definition it can be taken that both the searching for and acquisition of information and the interpretation of that information can be subject to confirmation bias. It is important to note that Nickerson takes a view that this preferential attention may be either deliberate or unwitting.

Klayman, in agreement with Festinger, suggests that the conditions that create cognitive dissonance also create powerful enabling mechanisms for systematic judgement failures - confirmation bias being an emergent property of complex decision making systems and the result of the human trying to achieve cognitive equilibrium through one or more of the task based goals of reduction, meaning or filtering.

4.2.2 Sentiment as a predictor of confirmation bias.

Fazio [50] defines an attitude (sentiment) as *"an association in memory, between a given object and a given summary evaluations of the object."* The role of sentiment (sometimes referred to as *attitude* in psychological works) as a predictor of confirmation bias was a key concept in Festinger's work [51] and, arguably, stems as far back as Bacon *"the human understanding when it has once adopted an opinion (either as being the received opinion or as being agreeable to itself) draws all things else to support and agree with it"* [6].

Knobloch-Westerwick and Meng [86] explore attitude as a predictor highlighting that the more extreme the strength of sentiment the greater the possibility for cognitive dissonance to occur. Brannon, Tagler & Eagly [23] explain this position as being one in which *"persons with strong attitudes tend to seek out attitudinally consistent information and thereby avoid the very information that might lead to a change of attitude."*

In works looking at confirmation bias and political sentiment [85, 86], found

that attitude-consistent (sentiment consistent) search results amongst voters were preferred, as were those from *'high credibility'* sources. Further, that people with sentiment consistent with media messages being viewed spent, on average, 36% more time reading those messages [86].

4.2.3 Selection and evaluation of information in financial markets

Traditional neoclassic economics has, in the past, viewed the decisions and actions of investors as being in some way rational and unbiased. More recently behavioural economists - a discipline that assumes financial markets are composed of *'imperfectly rational'* humans in imperfect markets - have questioned this viewpoint, looking to the decision making processes of traders and investors [68, 75, 123].

Following Wason's *selection task* [160] approach, Jones and Sugden [75] looked for positive confirmation bias in how people chose what information to purchase, prior to making a decision - this study taking a very literal stance on the term *acquisition*. Jones and Sugden found evidence of positive confirmation bias in selecting information and that this behavior appeared to persist irrespective of experience. That is, people tended to continue to display bias even though it provided sub-optimal outcomes.

Oberlechner and Hocking [123] found that the sentiments of foreign exchange market traders were tightly coupled with how they valued and assessed financial news. Barber and Odean [8] found that investors were more likely to visit and interact with chatrooms and forums frequented by likeminded investors - an indication of shared sentiment. Park *et al* found that confirmation bias in selecting and evaluating stock tips and news on forums led to an over confidence and increase in trading losses [125].

Hilton [68] discusses confirmation bias in financial decision making as the first of *'seven deadly sins'* citing a U.K. investment fund manager as having said, *"there is a lot of data out there. The data will support almost anything. You have to watch out for confirmation bias in your thinking."* Pouget and Villeneuve [129] found confirmation bias creates excess volatility and that an over-confidence by traders can lead to pricing bubbles - a situation where prices lay beyond those expected by the economic fundamentals of supply and demand [80]. Hilton also points to those who actively follow a disconfirmation strategy (counter-attitudinal position) will profit. This is an interesting position given that this promotes cognitive dissonance as a positive investment behavior.

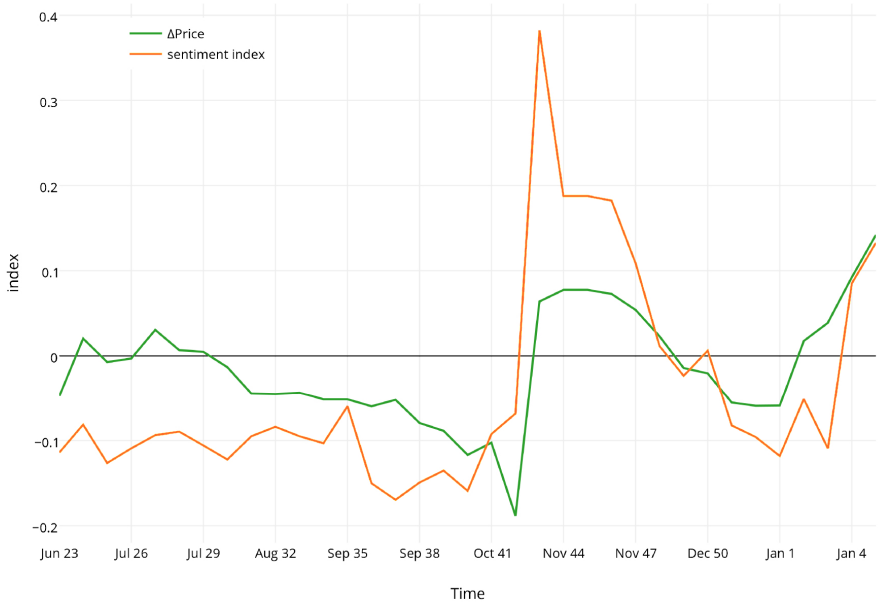


Figure 4.2: Perä's model of biweekly bitcoin price changes and indexed average retweet volumes for positive-negative sentiment news.

4.2.4 Sentiment and confirmation bias in Bitcoin

Within Bitcoin literature discussions of the role of sentiment and confirmation bias are limited. Bukovina and Martiček [25] expressly explore the influence of

speculator sentiment upon the volatility of bitcoin pricing. Within this study sentiment was found to be only a minor driver of volatility, however in periods of *excessive volatility* the influence was far stronger suggesting that the *excessive* nature is driven by speculators with stronger sentiment. Perä [127] found evidence that investors were selectively evaluating information to re-share to others based upon their own sentiment towards that information and that this sharing behavior was aligned to bitcoin pricing (see Figure 4.2). Glaser *et al* [61], whilst not looking for confirmation bias, clearly articulate that Bitcoin is seen as an asset by users but that those same users are *"limited in their level of professionalism and objectivity... highlighted by the bias towards positive news."*

Bitcoin has experienced pricing bubbles [30, 58]. The insight that such bubbles can be associated with confirmation bias [129] which in turn is based with information selection and evaluation fallacy brings into question whether Bitcoin speculators are subject to confirmation bias. This chapter now proceeds to describe how evidence of confirmation bias was tested for.

4.3 Method

This section describes the recruitment process and demographics of the participants. Also described here are the information evaluation task and the stimuli used for testing whether Bitcoin speculators are displaying signs of confirmation bias when seeking and evaluating information.

4.3.1 Participants

The study was advertised on social media, online discussion forums, websites and also through direct email. Whilst remuneration is a common tactic for study recruitment - technical, privacy and ethical considerations meant we requested voluntary participation with no offer of payment.

The study was split into two key parts. Part one was a series of questions looking at (i) discovery and use of the crypto-currency (ii) self perceived levels of knowledge and expertise; and (iii) a general set of questions around technology and news consumption—as described in Chapter 3. Part two was a news article stimuli evaluation task, open to participants who had usage experience of Bitcoin. The normal ethical principles of informed consent, data storage and anonymization were observed, with ethical review and approval given by the relevant body at the authors' institution prior to the study. In total 71 responded to the invitation with fourteen excluded from the analysis for not having fully completed the stimuli evaluation part of the study. Participants were allowed to only take the study once, enforced by client-side cookie and server-side IP registration. We acknowledge such restrictions can be bypassed with effort, however the likelihood of participants engaging in such a deceptive way is unlikely given the lack of reward for participation.

4.3.1.1 Demographics

Of the 57 qualified participants, 75.4% ($n = 43$) were recruited from the online discussion forum Reddit - spread between 9 sub-Reddit forums (r/Bitcoin 17, r/SampleSize 9, r/BTC 6, r/Economics 4, r/BitcoinBeginners 2, r/Mining 2, r/CryptoCurrency 1, r/CryptoMarkets 1, r/Markets 1). The remaining participants were recruited across six other sources: BitcoinTalk (4), Internal (3), Twitter (3), Unknown (2), Facebook (1) and StackExchange (1).

Thirty-eight (66.7%) participants considered themselves as primarily being in paid employment (full or part-time) and a further 21% ($n = 12$) were students. Looking at education backgrounds, 63.1% ($n = 36$) had a college degree or higher with only one participant considering themselves having no education and 5 having gone no further than high-school. All participants were seasoned long-term (over six years) users of the Internet with 89.5% ($n = 51$) claiming more than 11 years of Internet usage.

The majority of participants (86%) were located in either Europe ($n = 32$) or the Americas (North & South) ($n = 17$). Non-native English speaking participants rated their written English on a scale of 1 to 5 (poor to excellent). Mean written English score were: Europeans ($n = 17, \bar{x} = 4.27$) and Eastern Mediterraneans ($n = 1, \bar{x} = 5$) - thusly language was not deemed to be an over-riding challenge for participants.

4.3.1.2 Bitcoin

Exposure to Bitcoin amongst participants peaked in 2012-2013 (as did both the price and press coverage) with 91.2% ($n = 52$) having knowledge of Bitcoin prior to the collapse in pricing in early 2014, (see Figure 4.3). Online discussion forums provided the first point of exposure for 47.4% ($n = 27$) of participants, with news accounting for another 26.3% ($n = 15$).

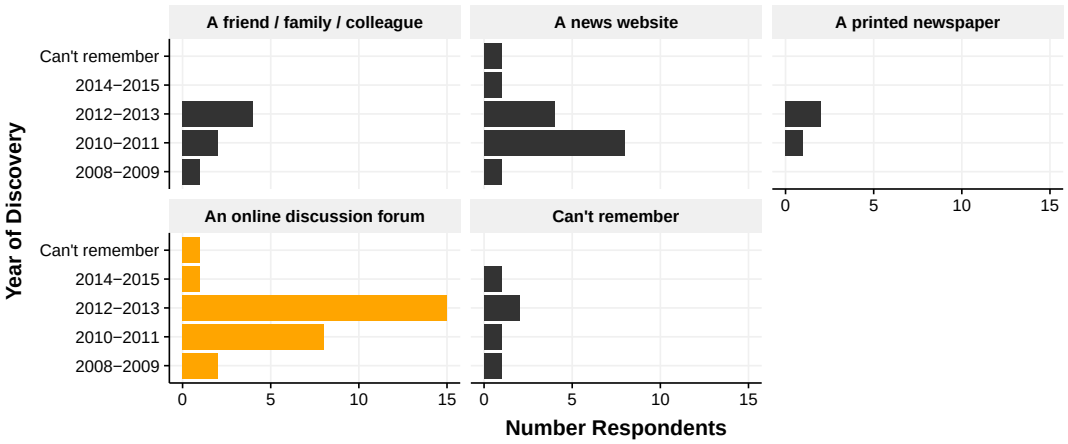


Figure 4.3: When and how experimental participants discovered Bitcoin

	Gen.	Tech.	Finance	Bitcoin	Info.
Never	14	11	10	6	20
Rarely	10	6	12	8	11
Sometimes	8	9	6	8	4
Often	5	12	8	13	6
Always	5	4	6	7	1
n	28	31	32	36	22
Consulted	50%	64.5%	68.8%	83.3%	9.1%

Table 4.1: Use of news when making buy/sell decisions

Looking to the use of news as an information source; 52.6% ($n = 30$) felt they were not influenced by news stories when making buy/sell bitcoin decisions. Sixteen participants admitted being influenced by news but only one strongly agreed.

Where responses were given, it is clear that use of Bitcoin, Finance and Technology websites is prevalent in participant's decision making process (see Table 4.1).

Of the 32 participants who declared owning bitcoin at the time of the study, 71.9% ($n = 23$) had assumed a *'hold'* position neither looking to buy nor sell their bitcoin. The remaining nine participants all took a *'buy'* position looking to actively purchase more bitcoin.

4.3.2 Evaluation task

Post questionnaire; participants who had declared they had or did use Bitcoin were offered the opportunity to evaluate six news articles, one at a time in the order presented in Table 4.2. For each evaluation the participant was first shown a banner similar to that which might be observed on an online search engine (see Appendix B.1) along with five questions:

1. How credible is this story?
2. How much did you already know about this story before determining its credibility?
3. Did you go off to another website to further research this story before determining its credibility?
4. Having read this story, if it were current, what position would you now take in bitcoin?
5. Can you briefly say why?

Whilst within an evaluation task, the participant was able to click the banner to bring up a copy of the full article content, as described in Section 4.3.3.2.

The next sub-section describes the process by which news stories were selected and processed to create the stimulus used in the experimentation.

4.3.3 Stimuli selection

The volume of news about Bitcoin online alone is vast. A search on Google yielded 2.6M website articles for 2016 alone. Social media and forum posts of news likely bringing the total online news articles into the many tens of millions. Harris [64]

Eval	Quality	Words	Sentiment	Website	Published	Title
1	HQ	212	Neg	Reuters	02/09/14	Russian authorities say Bitcoin illegal
2	LQ	237	Neu	Coindesk	02/27/14	New Fed Chair: We Have Authority To Regulate...
3	HQ	467	Neu	Coindesk	12/30/13	The Reserve Bank of India Has No Plans to Reg...
4	LQ	402	Pos	Coindesk	02/23/14	Top UK Payments Body Weighs in on Bitcoins...
5	LQ	375	Neg	Coindesk	07/29/13	Bank of Thailand officially declares bitcoin illegal
6	HQ	378	Pos	Coindesk	12/05/13	Bank of America: Bitcoin Has Clear Potential...

Table 4.2: Stimulus used in evaluation

analysed over 1.3 million tweets mentioning bitcoin (or Satoshi Nakamoto) from February 2014 with the aim of discovering who was interested in the fledgling crypto-currency. Within this study Harris identified over 247,000 unique Bitcoin related URLs being shared and concluded that the number of shares for each URL was indicative of the popularity of the underlying website.

Using the top ten most popular websites identified by Harris as a starting point for news stimulus, we eliminated two (Wired and The Wall Street Journal) as candidates for not providing open access. From the remaining eight—Coindesk, Techcrunch, Reuters, Mashable, The Next Web, New York Times, The Verge and Forbes—we applied a set of criteria to filter potential articles down to the required six for evaluation.

4.3.3.1 Filter criteria

Initial filtering criteria were that articles should: i) have been originally published between April 2013 and March 2014 thus covering the period directly proceeding Harris' study, ii) relate to Bitcoin and be economic or government-policy in nature, and iii) have been broadly factually correct at the time of publication.

Further we determined it was necessary to cater for properties of articles which might render participants overly susceptible to relying upon cognitive biases other than confirmation bias.

Source bias. A pre-test with ten Bitcoin users highlighted that, of the eight possible news sources, there was disparity in how credible each website was viewed with respect to Bitcoin news. This difference in perception can be observed within Thorndike's *Halo Effect* bias [151] whereby an overall impression of the website's credibility could influence disposition to it's contents, i.e., where a website is viewed as credible it is likely that everything upon that website might be viewed as broadly credible. To control for this we chose the two most credibly rated websites from that pre-test (Coindesk and Reuters) as the source for stimuli as they were viewed as being equally credible.

Information bias. The length of the stimulus was considered. Too long and the task becomes not only onerous, but also introduces potential for an effect of illusionary truth [65] whereby repeated exposure to a concept within the stimulus might overly influence the participants belief of credibility. Were the article too short to afford sufficient context and detail for evaluation, this might likely push the participant to evaluate based upon any number of other possible biases. Therefore, as with Lucassen & Schraagen's testing approach [103] we set a bracket of word-length for full articles - in this study 200-600 words.

Confirmation bias. To be able to test for confirmation bias it was critical to measure the sentiment of the article and to choose two of each broad sentiment group - negative, neutral or positive in overall tone. Methodology set out by Breen [24] matches words contained within the target article with pre-rated valence word lists (both positive and negative in sentiment) derived from and maintained by Hu & Liu [70], returning a count of matching terms. This was then converted into a sentiment score on the scale -1 (very negative) to +1 (very positive).

4.3.3.2 Post-filter processing

To enable a further experiment as to whether participants were able to identify fake-news (see Chapter 5) three of the selected six articles (one of each sentiment - negative, neutral and positive) were edited by a professional journalist to be of low quality (LQ) and contain factual errors whilst retaining the same sentiment. The remaining three high quality (HQ) stories were left as published. All six were then converted to Adobe Portable Document Format (PDF) so as be viewable by participants with branding, layout and other surface features consistent with the source web-page.

In addition to the six articles, a simple banner for each was produced with the same sentiment scoring and processing to resemble how the web-page might be located on a popular search engine (see examples in Figure 4.4). All evaluation stimuli (banners and full page articles) along with the original article text can be found in Appendix B.

Russian authorities say Bitcoin illegal
Reuters - 9 Feb 2014
Russia's central bank also **said** on January 27 that **Bitcoin** trade was highly ... in **Russia**, has already come under intense scrutiny as **authorities** ...

(a) Banner 1 - HQ Negative

New Fed Chair: We Have Authority To Regulate Bitcoin
CoinDesk - 27 Feb 2014
f you were worried about the **Federal**Reserve trying to step in to regulate Bitcoin,don't breathe easy: Its leader thinks that the Fed has the authority to..

(b) Banner 2 - LQ Neutral

Figure 4.4: Example of high and low quality banner stimulus

4.3.4 Hypotheses

The background literature highlights two phenomena that are thought to show a evidence of potential confirmation bias. Firstly, from Park *et al* [125] that people showing potential confirmation bias will overly value information whose sentiment aligns with their own. Secondly, from Knobloch-Westerwick & Meng [86] that time spent evaluating information will be significantly greater where there is alignment of a participant's sentiment and the information.

Therefore, it is posited that participants with sentiment alignment to stimulus: will evaluate article credibility more highly $H1$ and, will spend significantly more time on that evaluation $H2$—in both cases, in comparison to participants with counter-sentiment alignment.

4.3.5 Measures and constructs

To test the two given hypotheses it was necessary to be able to determine whether there was sentiment alignment between the participant and the stimulus being evaluated.

Category	Score	n	Rel.%
Very Positive	26-30	11	19.30
Positive	21-25	21	36.84
Neutral	16-20	19	33.33
Negative	11-15	5	8.77
Very Negative	6-10	1	1.75
	$\bar{x}P_S = 20.81$, SD $= 4.85$		

Table 4.3: Summary of participant's sentiment (P_S)

Sentiment towards Bitcoin. Each participant's sentiment towards Bitcoin was measured using six questions (see Section 3.3.3.3) relating to price rises, adoption, regulation, viability as a currency, investment potential and criminal

activity as aspects of Bitcoin. Each question was measured on a five-point Likert scale where 1 = '*strongly disagree*' and 5 = '*strongly agree*'. The total sum of results being used to assign a sentiment score (S_P) to each participant.

To test the internal reliability of this construct a Cronbach's Alpha (α) was used - a common statistical tool in psychometric testing which measures the covariance between item-pairs in a construct and the variance of the total score. As such α can be viewed as the expected correlation that tests measure the same construct. Participant sentiment had an $\alpha = 0.79$ indicating very acceptable reliability thus exceeding the psychometric '*rule-of-thumb*' minimum of 0.7.

Overall the mean sentiment of participants was 20.81 - a neutral to very slightly positive sentiment towards Bitcoin (see Table 4.3).

Sentiment alignment. For each of the six evaluations the participant undertook (see Table 4.2) the alignment was noted as being:

- '*Aligned*' where both the stimulus and participant had the same sentiment. e.g., both were negative towards Bitcoin,
- '*Counter-Aligned*' where the sentiments of stimulus and participant were opposite. e.g., negative:positive or positive:negative,
- '*Neutral*' in all other cases.

As this research is interested in where sentiment exists; evaluations marked as being neutral ($n = 195$) were discarded from the analysis leaving 147 valid sentiment-containing evaluations for analysis.

4.4 Discussion of Findings

This section discusses the main findings of the research looking at whether Bitcoin speculators exhibit signs of confirmation bias when evaluating news based stimulus, such as that they might use when making investment decisions.

To recap; this study asked 57 Bitcoin users to evaluate six news articles. Each participant was asked six questions to determine their personal sentiment towards Bitcoin (S), and each news article was scored for its sentiment (*Negative*, *Neutral* or *Positive*) towards Bitcoin. The alignment of participant to article sentiment was noted and after neutral observations were removed we were left with 147 sentiment-containing evaluations. Two hypotheses were posited - that participants with sentiment alignment to the stimulus would evaluate article credibility more highly ($H1$), and would spend significantly more time on that evaluation ($H2$).

Since the stimulus credibility scores are reported on a five point scale, and the time spent on task is in seconds, these measures are viewed as ordinal and continuous (respectively) and therefore the Mann-Whitney U test is used to determine significance. The Mann-Whitney U test (also known as Wilcoxon-Mann-Whitney) is a non-parametric statistical test for differences between two groups - in this case the groups being sentiment alignment or counter-alignment and the scale being **H1** the credibility score assigned to each evaluation by a participant and **H2** the time taken for that evaluation. The Mann-Whitney U test was applied to the medians of each group (aligned / counter-aligned) with the alternative hypothesis ($H1_A$ & $H2_A$) that the medians of the two groups are not equal - given differences might be expected. All tests were performed using the base 'R' *wilcox.test*.

4.4.1 Support for hypotheses

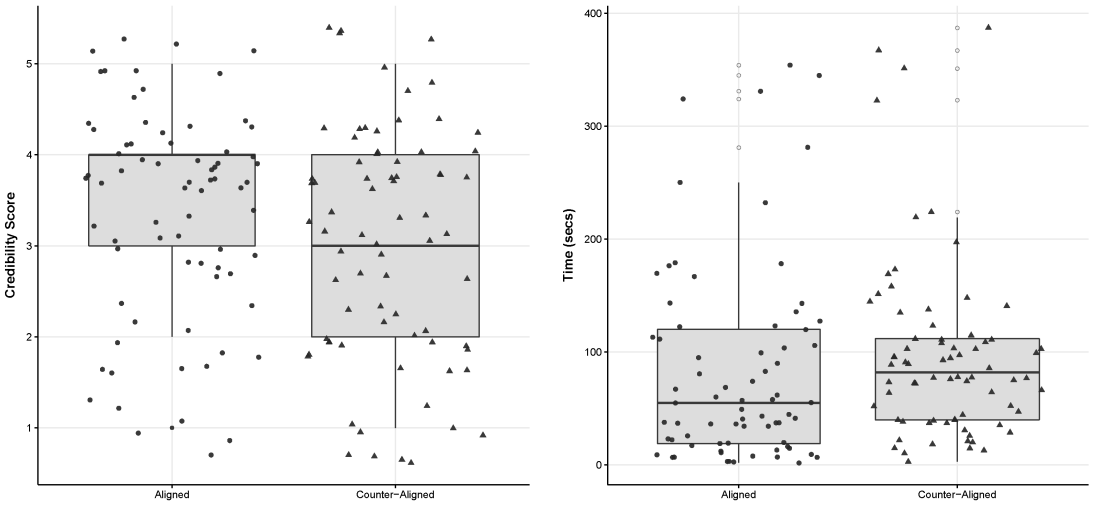
$H1$ Visual inspection of the results (see Figure 4.5a) appears to support the alternative hypothesis ($H1_A$), with an obvious difference in the medians. A Mann-Whitney U test was run to determine if the alternative hypothesis is statistically supported. Median credibility scores for aligned participants (4.0) and counter-aligned participants (3.0) were not significantly different, $U = 3137.0, z = -1.753, p = 0.080$ and therefore cannot accept the alternative hypothesis that the medians are not equal. As such, we can reject the hypothesis ($H1$) as participants do not evaluate sentiment-aligned articles more highly.

$H2$ In this case, visual inspection of the results (see Figure 4.5b) appears to show the completely opposite effect than that expected—based on works by Knobloch-Westerwick & Meng [86]—with the median time on task for aligned participants (55 seconds) being far less than that for counter-aligned participants (82 seconds). Therefore, we reject the initial hypothesis ($H2$) as participants do not spend significantly *more* time evaluating sentiment-aligned articles.

Whilst the original hypothesis is rejected, there still appears to be a marked difference in the median scores suggesting that this marker for confirmation bias may still be valid, albeit in the opposite direction to that first proposed by Knobloch-Westerwick & Meng. This inverted result may, in part, be due to experimental design. In this study, participants were given the ability to evaluate stimulus based upon a banner only without being forced to read the full article. Further, the nature of the subject matter and context—Bitcoin and investment—often necessitates rapid decision making and thus it seems logical that if speculators are relying upon a form of confirmation bias that they skim and accept sentiment-aligned news more quickly.

On this basis the alternate hypothesis can still be tested as this is looking

at the difference in medians only. Applying a Mann-Whitney U test, $U = 2166.5, z = -2.069, p = 0.039$, finds that this difference is significant at the 0.05 level and therefore the alternative hypothesis that there is a difference in the medians is accepted - i.e., participants spend less time evaluating sentiment-aligned stimulus.



(a) $H1$ Credibility Scores **(b)** $H2$ Time on Task

Figure 4.5: Hypotheses Alignment Results

4.4.2 Influence of independent variables

Whilst $H1$ goes unsupported and $H2_A$ is supported—albeit at the 0.05 level and inverse to the actual hypothesis set, it is apparent from the study design that other independent variables may have had influence upon the result. Given the limited number of observations a regression model to test these variables was not able to be successfully fitted in the case of either credibility score or time on task. Taking a more pragmatic approach, the process was broken down into simple pairwise tests between the aligned and counter-aligned participants

for hierarchical groups of independent variables - a process which allows us to explore the data in a similar manner to regression in finding which variables are influential. Our variable groupings were:

- What was evaluated?
  The banner only (**B**) or the full-article (**A**)
- Was more information sought off-study?
  No (**0**) or yes (**1**)
- Was there prior knowledge of story?
  (**None**) or (**Some**)
- What was the quality of the stimulus?
  Low-quality (**LQ**) or high-quality (**HQ**)

For example group *A:0:Some:HQ* ($n = 29$) would be evaluations that were made on the full article, with no off-study research, some prior knowledge of the story and where the stimilus was of high quality (see Section 4.3.3.2). A full list of tests is given in Appendix C. Again Mann-Whitney U tests were applied to the aligned and counter-aligned evaluations within each of these variable groupings. Significant findings are shown in Table 4.4.

4.4.2.1 Judging a book by its cover

Just over a third of evaluations (34.01%) were made solely on viewing the article banner only (group B), that is - the participant did not view the full story article before making their evaluation. Interestingly it is only within group B that significant differences in the median credibility scores / time on task between aligned and counter-aligned participants can be observed.

H1 **Median Credibility Scores**

Grouping	*n*	Aligned	Counter	*U*	*z*	*p*		Conf.Low	Conf.High	Effect.Size
B	50	4.0	3.0	417.0	-2.135	0.033	**	0.000	2.000	58.973
B:0	38	4.0	3.0	239.0	-1.766	0.077	***	0.000	2.000	38.771
B:0:Some	25	4.0	3.0	116.5	-2.135	0.033	**	0.000	2.000	23.300
B:0:Some:HQ	14	4.0	2.5	37.5	-1.734	0.083	***	0.000	3.000	10.022

H2 **Median Time on Task** (secs)

Grouping	*n*	Aligned	Counter	*U*	*z*	*p*		Conf.Low	Conf.High	Effect.Size
B	50	11.0	66.0	110.5	-3.886	0.000	*	-74.000	-20.000	15.627
B:0	38	10.0	69.0	43.5	-3.979	0.000	*	-82.000	-24.000	7.057
B:0:None	13	11.0	89.0	7.0	-1.840	0.066	***	-87.000	1.000	1.941
B:0:Some	25	10.0	64.0	13.0	-3.510	0.000	*	-91.000	-18.000	2.600
B:0:HQ	19	7.0	96.0	0.0	-3.528	0.000	*	-96.000	-57.000	0.000
B:0:Some:HQ	14	8.5	99.5	0.0	-3.041	0.002	*	-101.000	-51.000	0.000

Notes: ** signif at 0.01 level, ** signif at 0.05 level, *** signif at 0.10 level*

Group label key:
B - banner only
0 - no off-study research prior to evaluation
Some - participant had some prior knowledge of the story
HQ - stimulus was of high quality

Table 4.4: Significant group difference Mann-Whitney U test results

Median credibility scores between participants with sentiment alignment (4.0) and those counter-aligned (3.0), $U = 417.0, z = -2.135, p = 0.033$.

Median time on task aligned participants (11 seconds) and counter-aligned (66 seconds), $U = 110.5, z = -3.886, p =< 0.01$.

For these 50 banner-only evaluations the higher credibility score and substantially shortened time on task would seem to suggest that some form of bias may be guiding the participants and that they might have been pre-judging the credibility at face value. Given that our two tests for possible confirmation are not fully supported this also suggests that this bias might might lay elsewhere. This bias potential is statistically supported by the subgroup $B : 0$ ($n = 38$) who made the assessment without researching the story more widely on the Internet before scoring (see Table 4.4).

4.4.2.2 A little knowledge goes a long way

Further support for bias can be found in when a participant's prior knowledge of the story is added to the mix. The subgroup $B : 0 : Some$ ($n = 25$) is significant again for credibility score and time on task.

4.4.2.3 Accuracy matters

Within the sub-group $B : 0 : Some : HQ$ ($n = 14$) there is evidence that bias might be influencing the decision making process, but only when the stimuli is of high quality. This suggests that participants are discriminating in evaluations towards the high quality banners. However, with very little content to accurately assess the quality of the banner (there simply are is not enough detail), it seems plausible that they are deferring to other information based decision making processes such as those described by Lucassen and Schraagen [103], and explored through *Objective 3* (see Chapter 5).

4.5 Chapter Summary

This chapter presented an empirical study of Bitcoin users and how they evaluated Bitcoin-related news articles, with a view to determining if those evaluations might be influenced by a confirmation bias. This work determined the sentiment alignment of participants and the stimulus they were evaluating. For potential confirmation bias it had been expected to observe sentiment aligned participants both scoring articles more favorably and taking longer to do so. It was found that there was no statistical support for favourable article scoring, but that those with sentiment alignment spent significantly less time undertaking the evaluation than those counter-aligned - a position completely the opposite to that expected.

This chapter concludes that statistical support for potential confirmation bias was very weak for social online forum Bitcoin investors and that in all likelihood another form of bias was being exhibited but only within a subgroup of evaluations, namely those that made decisions without viewing the full news article.

In the next part of this thesis, participant biases towards the source and medium of news information is tested along with how they utilize self-claimed expertise when evaluating the credibility of the stimulus. This knowledge is used to build a model of informational trust for Bitcoin speculators.

Chapter 5

Development of a Model of Informational Trust

This part of the thesis addresses the third and final objective—*development of a model of informational trust*. Through the use of stimulus experimentation this objective tests whether 57 Bitcoin users can correctly identify factually correct news information from incorrect information, and models how users base their credibility decisions upon differing biases.

5.1 Introduction

As Bitcoin has grown, users have evolved new uses for it, beyond merely a payments mechanism. One such use is speculative investment [25] and a number of works [20, 58, 128] have highlighted such speculation as being not only a key use of Bitcoin but also a contributing factor for its growth. Speculative investment, by its very definition, is risky. The need for sound information has long been viewed by investors as critical in mitigating such risk. Prior work [58] has shown that when making decisions as to whether to adopt and use Bitcoin, investors discussed, searched for and utilized information in the form of social media and news.

For investors the supply of *"credible information is limited"* [25]. Information quality issues can be readily observed within Bitcoin news reporting with positive pro-Bitcoin stories in the mainstream press being counter-balanced with those of a negative and often misleading tone. A good example is the widespread reporting that China had "*banned Bitcoin*" in early December 2013 when in reality the People's Bank of China had explicitly stated that "*the public is free to participate in Internet transactions* [with bitcoin] *provided they take on the risk themselves*," [18] which was far from a ban.

5.1.1 Contributions

This part of the thesis questions whether investors, in a post-truth era, possess the skills and abilities necessary to separate factual from non-factual information in order to mitigate the inherent financial risk in speculative Bitcoin speculation.

Fifty-seven participants took part in this study's online experiment in which they asked them questions around their news consumption and Bitcoin behaviors. Participants then undertook a news article evaluation task in which they were

asked to read and rate the credibility of six articles to determine which they believed to be the most credible and how this might impact their investment behavior. Our key contributions are, as follows—we present:

- The first empirical work that explores how Bitcoin investors are making decisions based upon information credibility evaluations, prior to speculative investment moves.
- A summary of the types of news-based information being used by these investors.
- Findings, that significant percentages of these investors, i) are unable to identify and discount information that is of low quality, and ii) would act upon their poor evaluations.
- Findings, that expertise based credibility evaluation strategies are not significantly being used by these investors and that trust is not being placed in the fundamentals of the information itself.
- Findings, that Bitcoin investors are making credibility evaluations based upon un-mediated biases for either the source or medium of the information. For those making correct evaluations there is a trust in the source of the information, otherwise trust is deferred to a more general trust of information based on the Internet.

Implication of Findings - *Fake-news* is where the boundaries between truth and fiction are blurred [81] and fact is traded for appealing to opinion or belief [135]. In 2017, it is apparent that such *fake-news* is the new normal, from online blog posts to mainstream broadsheet press. Sifting through news for truth is already being widely recognised as a challenge to consumers world-wide. For

investors reliant upon not only the timeliness but also the accuracy of news it is critical they are equipped with the skills and where-with-all to filter as needed.

Whilst Chapter 4 found no meaningful evidence of confirmation bias, this study has shown that overly reliance upon those sources and mediums is being made. In Chapter 3, an investor's use and trust in mediums and sources of news was shown to be important (see Section 3.5.2). More importantly participant's claimed their trust were, at least in part, based upon some personal assessment of the author's expertise or ideology.

In a world where *fake-news* is readily created, published and shared, without truly understanding the truthfulness of the news information being relied upon, and by deferring that trust to a third party, investors are actually generating greater risk for themselves. Within Bitcoin in particular—where there is still a relatively limited community of users and trusted news sources (compared to traditional finance)—there is also potential for significant risk to the stability of bitcoin. Given the links between news, discussion and pricing [58, 57], were concerted effort made to subvert bitcoin-related news it is plausable that whole markets could readily be shifted, based upon investor's overly trusting news sources not fact.

The rest of this chapter is structured as follows: *Firstly*, related literature is provided for information credibility and informational trust (Section 5.2). *Secondly*, the method by which questions surrounding how Bitcoin users make decisions about trust in information are examined (Section 5.3). *Thirdly*, this is followed by a presentation of findings from the experimentation in which participants were asked to assess the credibility of a number of high and low quality news stories. *Fourthly*, a discussion of the key findings of the study with reference to literature. *Finally*, this chapter concludes that, given apparent biases

towards source and Internet based information and with nearly half of those making poor evaluations being willing to act upon their evaluation, there is potential for increased risk to Bitcoin speculators.

5.2 Related Work

In this section related works for information credibility and informational trust are presented.

5.2.1 Information credibility

Definitions of information credibility online vary slightly, but collectively are determined to be the extent to which a user finds information to be believable or true [1, 54].

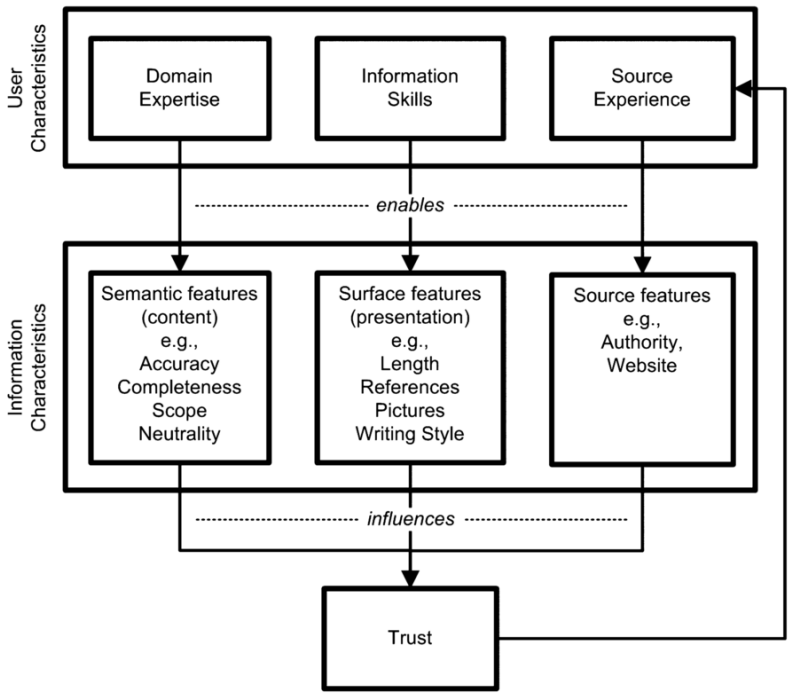


Figure 5.1: Lucassen *et al*'s 3S model

Chaiken [29] argues that credibility assessment can be thought of as both a heuristic and systematic process, with Metzger *et al* [115] expressing that decisions as to which process to use are dependent upon user motivation at the time.

Following this argument, Lucassen *et al* [99, 102] claim that evaluating credibility is always in part heuristic and proposed their *'3S'* model of three differing strategies a user might utilize (see Figure 5.1).

The first strategy is based upon the *semantic* features of the information such as accuracy or neutrality, requiring a level of domain expertise from the user — domain expertise having been shown to have positive impact upon a user's capacity for credibility evaluation [31, 79, 102].

The second strategy looks to *surface* features such as the way in which information is presented or number of references, for which sound information skills are necessary — information skills are seen to improve with education [22, 67].

The third strategy focusses on the *source* features of the information, namely not the actual information but considering only the website from where the information came — Hovland and Weiss [69] first identified perceptions of trustworthiness of a source as a key factor in evaluating credibility. More commonly accepted is Whitehead's duality of trustworthiness being the perceived goodness or morality and perceived expertise of the source [162].

5.2.2 Informational trust

McKnight & Kacmar [112] assert that information credibility differs from trust in so much as credibility is focussed not upon the website or organization but rather the information artefact itself. They do concede that *"credibility and trust are probably closely related"* as *"the more credible they (the user) believe that information to be, the more likely they are to act upon it."*

Lucassen and Schraagen [99] argue that credibility evaluation is always at least partly heuristic, and that a *"dichotomous choice between heuristic and sys-*

tematic processing is somewhat simplistic in the [psychological] domain of trust." They illustrate this simply with *"if a user would consider all aspects of credibility systematically, she or he would be certain of the credibility of the information. This means that the concept of trust is eliminated. Hence, absolute systematic processing is not possible in credibility evaluation."*

As information normally flows from one party to another (for example: person to person or organization to person) Lucassen and Schraagen therefore promote trust in information as a valid concept, defined as *"the expectation that the information is correct."* Credibility being a property of information upon which trust is based.

To explore informational trust, Lucassen and Schraagen [103] view trust in information decisions as being based upon *"rules-of-thumb"* (cognitive biases). They offer a clear model for trust in information which takes account of these biases by partitioning trust into four key layers (see Figure. 3.1):

- Propensity to trust (personality type)
- Trust in the information *medium* (e.g., the Internet)
- Trust in the information *source* (e.g., a particular website)
- Trust in the fundamentals of the information itself.

Whilst for many the base trust model in Bitcoin is *"based in computation rather than people"* [4], the need for trust in the Bitcoin ecosystem is critical, from adoption [164] to its everyday use.

Next follows a brief discussion of the sub-objectives for this study of Bitcoin investors, along with where the methods used differ from those used in Chapter 4.

5.3 Method

This section describes: i) the sub-objectives for addressing *Objective 3*, our recruitment process and demographics of the participants, ii) the information evaluation task and procedure along with the stimuli used, and iii) the measures and constructs used to explore a participant's trust in information.

5.3.1 Sub-objectives

This study has three sub-objectives:

1. *Firstly*, to ascertain whether or not Bitcoin users can make valid information credibility evaluations when assessing news articles upon which they might base speculative investment decisions.
2. *Secondly*, to identify and subsequently understand the influence of expertise in Bitcoin upon that decision making — congruent with Lucassen *et al*'s '3S' model [99].
3. *Thirdly*, to explore other dimensions of informational trust that may influence an investor's decision as to whether to trust information – congruent with, and through application of Lucassen and Schraagen's model of informational trust [103].
4. *Thirdly*, to explore other dimensions of informational trust that may influence an investor's decision as to whether to trust information – congruent with, and through application of Lucassen and Schraagen's model of informational trust [103].

5.3.2 Participants

To recap, the study (see section 4.3.1) was widely advertised to a number of online forums, websites, social media and also through direct email asking for voluntary participation with no offer of payment. The study was split into two key parts. Part one was a series of questions looking at (i) discovery and use of the cryptocurrency (ii) self perceived levels of knowledge and expertise; and (iii) a general set of questions around technology and news consumption. Part two was a news article stimulus evaluation task, open to participants who had usage experience of Bitcoin. After incomplete evaluations were removed, 57 people completed the experiment. A summary of their demographics can be seen in Section 4.3.1.1.

5.3.3 Evaluation task: procedure and stimuli

The experimentation for *Objective 3* followed the same task procedure and used the same stimuli as *Objective 2* (see Sections 4.3.2 & 4.3.3). The key difference being that rather than focussing upon the sentiment of the stimulus, this experiment is based around the quality of the stimulus: high quality factually accurate (HQ) and low quality innaccurate (LQ). Details of this process are given in Chapter 4 (see Section 4.3.3.2).

5.3.4 Measures and Constructs

Moving beyond the simple evaluation task (*sub-objective 1*) and to explore the second and third sub-objectives of this study, four constructs were built for each participant.

5.3.4.1 Influence of expertise

Construct 1 - Self-rated expertise: To meet the *sub-objective 2* of this study in understanding the influence of expertise upon credibility evaluation, a participant's self-rated expertise (as perceived knowledge) was determined to be a suitable proxy for actual expertise and calculated as in Section 3.3.3.3.

5.3.4.2 Influence of informational trust

To meet *sub-objective 3* of this study in examining other facets of informational trust, this experiment borrowed from Lucassen and Schraagen's model of informational trust [103] (see section 5.2).

Construct 2 - Propensity to trust: Each participant's propensity towards having a trusting personality was calculated using the NEO-PI-R questions as in Section 3.3.3.1.

The construct T_P allows to determine as to whether this underlying personality trait is having significant influence upon the participant's credibility assessment of the stimuli.

Construct 3 - Trust in the medium: Respondent's general trust in the Internet (as a medium of information) was measured with six questions, the total sum being used to assign a score to the participant (T_M). The construct T_M allows for determination of whether this more general trust of things online is having a significant influence on credibility evaluation.

Trust in the (Information) Medium (T_M)

Trust in the medium of information is based upon a selection of the sub-questions in *'Q4.4 Without spending too much time thinking about the statement; how much do you agree with the following statements?'*, being:

- I find much of the information on the Internet credible.
- In general I trust the companies and people running the Internet.
- I trust people I interact with on the Internet.
- Information in Internet forums tends to be credible and trustworthy.

Construct 4 - Trust in the source: Respondent's trust in the source of the information (T_S) was directly extracted from the participant's own credibility rating of the website from which they chose the most credible story and allows for determination of whether a reliance upon a pre-held opinion of the source website significantly influences credibility evaluation.

For the constructs E, T_P & T_M all questions used a five-point Likert scale where 1 = 'strongly disagree' and 5 = 'strongly agree'. Internal reliability of each of these three constructs is tested using Cronbach's Alpha (α) (see Section 5.4.2). Reliability tests for T_S are not needed as this was a directly extracted score rather than being composed of a number of questions around a topic.

5.4 Findings

In this section, the findings of this study are presented in relation to the sub-objectives (see Section 5.3.1), being: i) the outcome of the basic evaluation task, ii) an assessment and summary of the constructs used to explore the second & third sub-objectives of the study, iii) the influence of expertise upon credibility evaluation, and finally iv) the influence of informational trust.

5.4.1 Credibility evaluations

Of the 57 participants who undertook the evaluation, on average participants rated their chosen most credible stimulus 4.37 out of 5 (see Table 5.1)—this score being henceforth referred to as the participants' trust in the information (T_I). Very little difference was observed between the group correctly identifying high quality (HQ) stimulus ($f = 37$, $\bar{x}(T_I) = 4.37$) and those choosing low quality (LQ) stimulus ($n = 20$, $\bar{x}(T_I) = 4.25$).

		ALL	HQ	LQ
Respondents	(n)	57	37	20
Credibility Score (T_I) [1]	($\bar{x}$)	4.37 (0.67)	4.43 (0.65)	4.25 (0.72)
Prior knowledge [2]	($\bar{x}$)	2.78 (1.05)	2.24 (1.04)	2.35 (1.09)
Off-study research	(n)	10	7	3
Full story pop-ups	($\bar{x}$)	0.74	0.74	0.85
Zero full-story views	(n)	20	15	5
Evaluation time	($\bar{x}$)	60.5s	42.7s	90.9s

Standard deviations shown in brackets
[1] Story credibility rated 1 (lowest) to 5 (highest)
[2] Prior knowledge of story 1 (none), 2 (little), 3 (some), 4 (a lot)

Table 5.1: Summary of stimulus evaluation results

5.4.1.1 Post evaluation investment position

Post evaluation task, participants were asked what bitcoin investment position they would take based upon the story they rated most highly (see Table 5.2).

	ALL	HQ	LQ
Buy	5 (8.8%)	5 (13.5%)	0 (0.0%)
Hold	36 (63.2%)	25 (67.6%)	11 (55%)
Sell	16 (28.1%)	7 (18.9%)	9 (45%)

Table 5.2: Post evaluation investment position

Forty-five percent of LQ participants declared they would make a change in position based upon that incorrect story—in all 9 cases this was to sell any bitcoin they possessed.

5.4.2 Validity of constructs

Self-rated expertise (E) had a Cronbach's α of 0.93 indicating excellent reliability. Respondent's propensity to trust (T_P) is derived from the NEO-PI-R questionnaire [37] and had a Cronbach's α of 0.84 indicating good reliability in the questions as an indicator of trust. Trust in the information medium (T_M) had a Cronbach's α of 0.75 being an acceptable indication of trust.

5.4.3 Construct summary

Across all constructs (T_P, T_M, T_S & E) the mean scores by evaluation group (HQ/LQ) varies little with both groups seeing their means in the same category (see Table 5.3). For example, both groups ($\bar{x}(HQ) = 27.973$, $\bar{x}(LQ) = 28.600$) displayed a *moderate* propensity for trust. Within constructs, interesting points are:

E - Both evaluation groups on average shared a *'high'* level of self-rated expertise in Bitcoin, however the LQ group had a pronounced skew towards viewing their own expertise as being very high.

T_P - Both evaluation groups on average shared a *'moderate'* propensity for trust

Self-rated expertise (E)

Category	Score	n	Rel.%	HQ	Rel.%	LQ	Rel.%
5) Very High	13-15	21	36.84	10	27.03	11	55.00
4) High	10-12	21	36.84	17	45.95	4	20.00
3) Middling	9-9	3	5.26	1	2.70	2	10.00
2) Low	6-8	9	15.79	6	16.22	3	15.00
1) Very Low	3-5	3	5.26	3	8.11	0	0.00
$\bar{x}$(Score)	All = 11.035			HQ = 10.514		LQ = 12.000	

Propensity to trust (T_P)

Category	Score	n	Rel.%	HQ	Rel.%	LQ	Rel.%
5) Very High	36-40	4	7.02	3	8.11	1	5.00
4) High	31-35	15	26.32	7	18.92	8	40.00
3) Moderate	20-30	36	63.16	26	70.27	10	50.00
2) Low	13-19	2	3.51	1	2.70	1	5.00
1) Very Low	8-12	0	0	-	-	-	-
$\bar{x}$(Score)	All = 28.193			HQ = 27.973		LQ = 28.600	

Trust in the medium (T_M)

Category	Score	n	Rel.%	HQ	Rel.%	LQ	Rel.%
5) Very High	18-20	1	1.75	-	-	1	5.00
4) High	15-17	8	14.04	6	16.22	2	10.00
3) Middling	10-14	33	57.89	19	51.35	14	70.00
2) Low	7-9	12	21.05	11	29.73	1	5.00
1) Very Low	4-6	3	5.26	1	2.70	2	10.00
$\bar{x}$(Score)	All = 11.439			HQ = 11.108		LQ = 12.050	

Trust in the source (T_S)

Category	Score	n	Rel.%	HQ	Rel.%	LQ	Rel.%
5) Very High	5	12	21.05	7	18.92	5	25.00
4) High	4	14	24.56	11	29.73	3	15.00
3) Middling	3	18	31.58	11	29.73	7	35.00
2) Low	2	4	7.02	2	5.41	2	10.00
1) Very Low	1	9	15.79	6	16.22	3	15.00
$\bar{x}$(Score)	All = 3.281			HQ = 3.297		LQ = 3.250	

Table 5.3: Construct summaries by evaluation group

with a slight skew towards being more trusting than not.

T_M - Both evaluation groups shared a *'middling'* trust in the information medium (the Internet) but the HQ group were skewed towards being less trusting than those in the LQ group.

T_S - Both evaluation groups shared a *'middling'* trust in the information source (the website of the chosen story). Both groups were skewed to being more trusting in the source, more so HQ group.

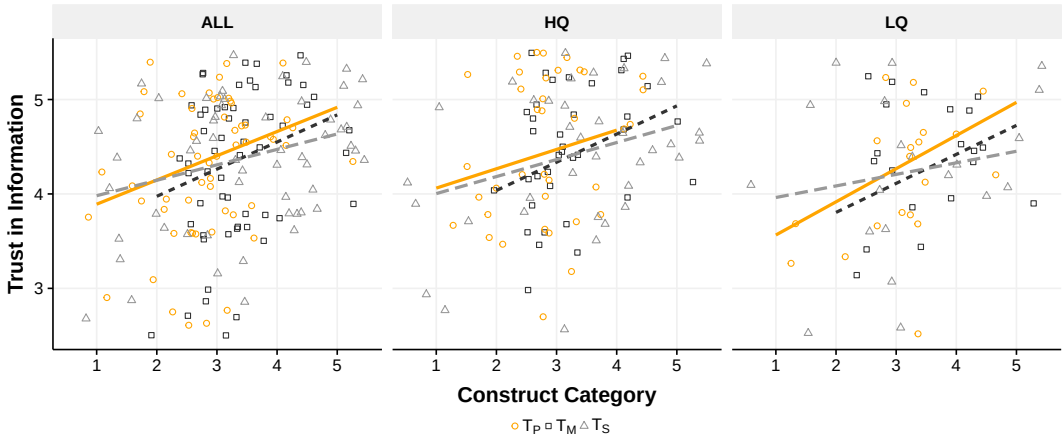


Figure 5.2: Construct (T_P, T_M & T_S) influence upon trust in information (T_I)

5.4.4 The influence of expertise

Following Lucassen *et al*'s '3S' model [99], expertise facets that support semantic and surface feature strategies for credibility assessment were tested.

Firstly, statistical dependence between E and demographic markers was assessed using Pearson's Chi Squared (x^2) tests. This determines the statistical likelihood of any observed difference between two categorical sets being based upon chance. No significant relationship between E and when a participant discovered Bitcoin was found, $x^2(12, N = 57) = 12.00, p > 0.05$. The relationship was greater with the HQ group ($x^2(12, N = 37) = 14.55, p = 0.27$) than the LQ group ($x^2(9, N = 20) = 6.92, p = 0.65$), but still insignificant.

Similarly, no significant relationship was found between E and educational background, $x^2(24, N = 57) = 19.77, p > 0.05$. Again the strength of the relationship was greater in the HQ group than the LQ group but still insignificant.

As such neither a participant's self-rated expertise was not influenced by either their educational background or how long they had known about Bitcoin and, therefore, these demographic differences are discounted.

5.4.4.1 Semantic evaluation

Semantic evaluation strategies, requiring domain expertise, were evaluated using a one-way ANOVA test ($T_I \sim E$). No significant relationship was found between a participant's self-rated expertise and their trust in the information, $F(1, 55) = 1.113, p = 0.296$. Using Chi Squared ($x^2$), the participant's choice of either a HQ or LQ article as being most credible was not found to be dependent upon E, $x^2(11, N = 57) = 11.59, p > 0.05$.

5.4.4.2 Surface evaluation

Surface evaluation strategies, requiring information processing skills, were also evaluated using a one-way ANOVA ($T_I \sim Education$). No significant relationship was found between a participant's education and their trust in information, $F(1, 55) = 0.075, p = 0.786$. Again no dependency was found for the article choice based on education, $x^2(6, N = 57) = 6.07, p > 0.05$.

5.4.5 Resulting informational trust model

With no significant relationship between self-rated expertise (either in education or domain expertise) and evaluation, it was necessary to look to further constructs for significant influence.

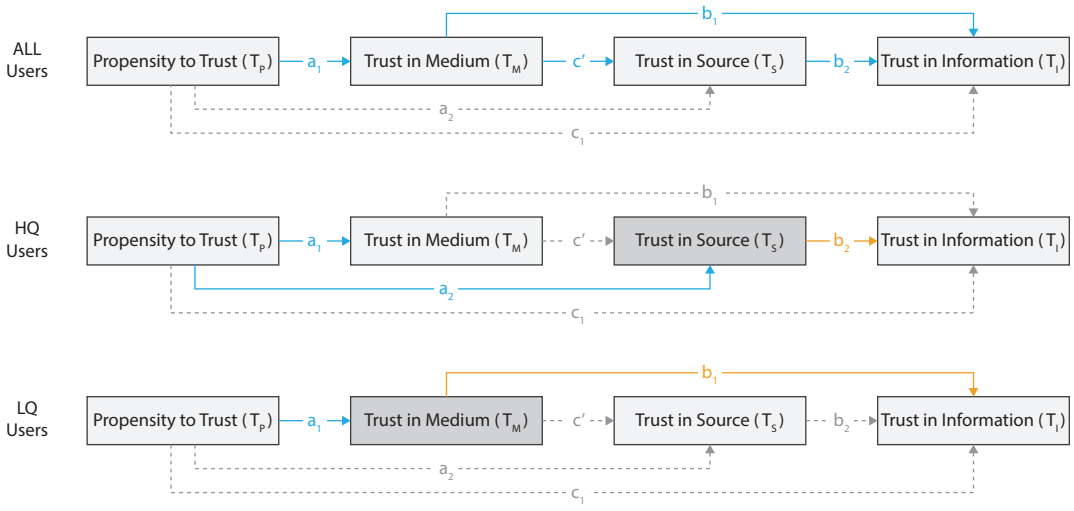


Figure 5.3: Cross-section of applied Lucassen and Schraagen informational trust layer model

Group	Coef	p	Interval	Rej.H_0	Coef	p	Interval	Rej.H_0
	a_1 $(T_M \sim T_P)$				a_2 $(T_S \sim T_P)$			
ALL	0.285	0.000	0.166, 0.404	yes	0.068	0.077	-0.007, 0.142	no
HQ	0.267	0.000	0.127, 0.407	yes	0.110	0.012	0.024, 0.197	yes
LQ	0.308	0.005	0.093, 0.523	yes	-0.015	0.823	-0.149, 0.118	no
	b_1 $(T_I \sim T_M)$				b_2 $(T_I \sim T_S)$			
ALL	0.074	0.023	0.010, 0.139	yes	0.158	0.010	0.038, 0.279	yes
HQ	0.068	0.095	-0.012, 0.148	no	0.217	0.004	0.068, 0.367	**yes**
LQ	0.116	0.029	0.012, 0.220	**yes**	0.063	0.529	-0.133, 0.258	no
	c_1 $(T_I \sim T_P)$				c' $(T_S \sim T_M)$			
All	0.000	0.990	-0.036, 0.036	no	-0.017	0.814	-0.155, 0.122	yes
HQ	-0.009	0.674	-0.053, 0.034	no	-0.076	0.382	-0.246, 0.094	no
LQ	0.004	0.901	-0.056, 0.063	no	0.087	0.460	-0.144, 0.317	no

Table 5.4: Mediated regression analysis

To test the null hypothesis that a construct has no influence upon a participant's trust in the information (T_I), 6 regression models were fitted to the cross-section of Lucassen and Schraagen's trust in information layer model. To validate the models, mediation analysis was conducted using the *lavaan* package

in R [136]. Models between constructs are shown in Table 5.4 and where zero lays within the confidence interval $< 2.5\%, 97.5\% >$ the model cannot reject the null hypothesis and therefore no significant influence is found.
Applying the analysis to the graphical representation of the model (see Figure 5.3), the pathways for construct influence can be readily observed:

- Pathways with no significant influence between constructs are represented by dotted-gray notation - - - - -
- Pathways with significant influence are shown in solid-blue ——
- Primary influences are highlighted in solid-gold ——

ALL Users No direct influence (pathway c_1 on Figure 5.3) was found and $TI \sim T_P$ is rejected, meaning that neither T_M or T_S mediate this relationship even though T_M is influenced by T_P itself.
There are subtle differences between the HQ and LQ groups, however.

HQ evaluations For the participants correctly identifying a high quality article as most credible, there is a significant influence from the source of the information pathway $b_2 : T_I \sim T_S$ $(0.217, p = 0.004)$. i.e., For users who correctly identified factually correct stimulus as being the most credible, there was a significant influence of the source of the information upon the decision.

LQ evaluations For those who made an incorrect evaluation there is a significant influence from the medium of the information pathway $b_1 : T_I \sim T_M$ $(0.116, p = 0.029)$ and this is not mediated by T_S. i.e., For users who identified factually incorrect stimulus as being the most credible, there was a significant influence of the medium of the information upon the decision.

5.5 Discussion

This section discusses the major findings of this study, being:

1. A lack of reliance on expertise in Bitcoin to evaluate related news,
2. A significant source bias by participants who were able to make correct credibility evaluations only,
3. A significant bias towards a general trust in Internet based information by participants making erroneous credibility evaluations, and
4. A concerning declaration by 45% of erroneous participants that they would act upon their evaluations prior to making investment decisions.

To recap; this study asked 57 Bitcoin users to evaluate six news articles and identify the one they believed to be the most credible. For each participant four constructs were created, based upon a reference model of informational trust which takes into account underlying biases in information credibility decision making. In conjunction with how each participant evaluated the article it was possible to observe the influence of these constructs, and derive an understanding of how decisions were being made. In summary, 37 participants identified factually correct (HQ) news articles as being most credible, and 20 incorrectly chose low quality (LQ) articles.

5.5.1 A lack of reliance upon expertise

Sub-objective 2 was to identify the role of expertise in making credibility evaluations within our participants. Following the rationale set out in Lucassen *et al*'s '3S' model [99], expertise plays a role in using either a semantic or surface feature based evaluation strategy.

5.5.1.1 Semantic evaluation through domain expertise

A participant's domain expertise in Bitcoin was based upon a self-reported level of expertise (see Section 5.3.4). This domain expertise is important when evaluating the semantic features of information. No significant influence of this expertise upon the credibility evaluation ($T_I \sim E$) was found in this study ($F = 1.113, p = 0.296$).

At a glance, it might be presumed that this lack of influence may be a result of mis-reporting or over-estimation of domain expertise on the part of the participant—this being a well understood phenomena [42, 93, 118]—something that could be controlled for with a specific domain knowledge test.

Support for this presumption could be inferred if significant differences in the expertise scores of those in the HQ and LQ response groups were observed. Whilst there was a slightly greater skew towards higher levels of self-rated expertise in the LQ group this was not overly so and median scores for both groups were both within the *'high'* category of expertise (see Table 5.3). Further there is no statistical support for the participant's choice of either HQ or LQ stimuli being based upon domain expertise or length of time using Bitcoin.

It is therefore unlikely, but not impossible, that participants were subject to a *Kruger-Dunning* effect [93]. More likely is that participant's were not utilizing a semantic strategy—deferring evaluation to other approaches.

5.5.1.2 Surface evaluation through information skills

Information skills are shown to be directly related to the education a participant has attained [22, 67]. With over 60% of participants having a college degree or higher (see Section 5.3) it would be expected for participants to possess good information skills and, in the absence of semantic evaluation (above), be bringing

these to bear in the credibility assessment by looking at the surface features of the news story—such as the number or type of references within the story, related author stories etc.

As with semantic evaluation, the participant's choice of a HQ or LQ article as being the most credible was not seen to be dependent upon an under-pinning factor—in this case their education. Again, no evidence was found of participants significantly using surface strategies ($T_I \sim Education$). The strength of this influence($F = 0.075, p = 0.786$) was less than that of semantic strategies (above) indicating this was even less likely to be the credibility evaluation approach being used.

As neither expertise based strategy for credibility evaluation has been shown to be significant in this study, the implication is that the third possible strategy—based upon source evaluation—is likely at play.

This study has already found that, i) participants making correct evaluations do employ source trust and those making erroneous evaluations do not, deferring to a more general trust of the Internet, and ii) significant percentages of those making erroneous evaluations would act upon their assessments. Next is a discussion of these findings of informational trust.

5.5.2 Source trust only used in correct evaluations

Lucassen *et al*'s '3S' model [99] presented a third strategy for credibility evaluation based upon how credible (trustworthy) a participant perceives the source to be. This bias towards a trust in the source is illustrated in Lucassen and Schraagen's model of informational trust (see Figure **??**). In this study participants were asked to rate the credibility of eight different websites (as sources) prior to taking the stimulus task.

Looking to this model of informational trust and in particular the mediated aspects as shown in Figure 5.3: A very strong relationship between source trust and a participant's trust in information ($T_I \sim T_S$) was found, however this was only the case where participants correctly identified an HQ article as most credible ($coef = 0.217, p = 0.010$). This indicates that for these participants, and again as there was no evidence of significant expert strategies in effect, they were basing their credibility evaluations in a bias for the source of the information in-line with common theories on source credibility [54, 69, 150, 162].

The same was not true of those making erroneous evaluations. For these participants we found that credibility was not being assessed based upon a trust in the source. This, obviously, does not concur with source credibility theories. Rationale for a similar finding made by Lucassen and Schraagen [103] looks to either i) participants being able to compare multiple articles from the same source, or the nature of their stimuli source. Neither of these hold true for this study as multiple sources were used and source credibility (the prior rating of the sources by participants) was approximate for the sources used.

Thusly for the erroneous group (LQ), trust was found to be placed in a more general trust in Internet ($T_I \sim T_M$, $coef = 0.116, p = 0.029$). As expected this was a weaker level of trust than for those trusting the source—as T_M is more distant from T_I in Lucassen and Schraagen's mediated informational trust model (see Figure 5.3).

5.5.3 A little knowledge can also be dangerous

Evidence clearly links a user being willing to act upon information the more they believe it to be credible [112] so it should not really come as a surprise that 37% ($n = 21$) of all participants expressed a willingness to make *'buy'* or *'sell'* decision based on their credibility evaluation. For those making correct evaluations, this

willingness is perfectly understandable—the decision about which position to hold being one based on investment motivations not explored in this study.

For the 9 participants willing to *'sell'* their bitcoin holdings based upon their erroneous credibility evaluation this axiom also appears to hold true. Kruger and Dunning, controversially, offer one plausible explanation that moves away from credibility evaluation in that *"people tend to hold overly favorable views of their abilities... this over-estimation occur[ing], in part, because people who are unskilled in these domains suffer a dual burden: Not only do these people reach erroneous conclusions and make unfortunate choices, but their incompetence robs them of the meta-cognitive ability to realize it"* [93].

Simply, in this study, participants making erroneous credibility evaluations may just not be able to recognize they are not very well informed about Bitcoin and are over-confident in their abilities. Statistical support for over-estimation of domain expertise was not observed, however it has already been noted that for those in the *LQ* group there was a more pronounced skew towards higher levels of self-reported expertise.

5.6 Chapter Summary

This chapter presented an empirical study of Bitcoin users and how they evaluated credibility in Bitcoin related news prior to making speculative investment decisions. The study found that just over a third of participants (35%) identified low quality, inaccurate news articles as being most credible. Counter to expectation no significant evidence of a participant's (self-rated) expertise in Bitcoin influencing this evaluation was found. It is noted that incorrect participants did tend to claim a higher level of expertise than who were correct in their evaluation. It was also found that for those who made a correct evaluation, their trust in the information was influenced by a trust in the source (website) of the story.

This chapter concludes that for social online forum Bitcoin investors, there is enhanced potential for financial risk resulting from speculative decisions made not on an expert evaluation of Bitcoin related news but rather a bias for trusting more generally in content from the Internet.

Chapter 6

Conclusions

6.1 Thesis Summary

The principle question asked by this thesis is: *to what extent are people able to select and correctly evaluate information they might rely upon to make decisions* within the sub-community of Bitcoin users for whom speculative investment is an important use of the crypto-currency. This thesis sought to answer this by addressing three key research objectives:

1. *Investigation* and exploration of disclosed human notions of trust within the Bitcoin ecosystem,
2. *Evaluation* of bitcoin speculator's reliance upon confirmation bias when selecting news reporting used to support investment decisions and,
3. *Development* of an informational trust model for speculators which highlights the role of expertise in assessing relevant information prior to decision making.

6.1.1 Objective summary

The *investigation* objective serves to build a foundation of knowledge around how information quality issues in the Bitcoin community create a potential risk to speculators whom rely upon this information when making investment decisions.

Chapter 1 highlights the motivation for investment and information quality concerns. *Chapter 2* briefly summarizes the inception of bitcoin and where community expressions of trustlessness stem from. *Chapter 2* also points to where the majority of existing research lays and highlights the gap for human aspects trust research within the Bitcoin space. *Chapter 3* breaks through the community adherence to trust in bitcoin being based solely in computation by empirically studying human notions of interpersonal, informational, institutional and technological trust in and around Bitcoin.

Having established in *Chapter 3* that human notions of trust extend far beyond computation alone, and that trust in information is indeed an applicable concept in the Bitcoin community, the *evaluation* objective addresses the first part of the overall research question, *'to what extent are speculators able to select relevant information.'* *Chapter 4* empirically evaluates, using stimulus experimentation, whether or not confirmation bias might be in some way influencing speculators to select information as *relevant* by overly favoring that which had a sentiment towards Bitcoin aligning with their own.

Whilst bitcoin speculators did spend less time evaluating stimulus with which their own sentiment aligned—a marker for confirmation bias—no significant evidence of confirmation was observed. However approximately 1/3 of stimulus evaluations did exhibit potential source bias.

In *Chapter 5* the *development* objective builds on the experimental work of *Chapter 4* to address the second part of the overall research question, '*to what extent are speculators able to correctly evaluate information*'. Within *Chapter 5*, further stimulus experimentation establishes to what extent domain expertise in Bitcoin may or may not be being brought to bear on this evaluation task along with other potential biases Bitcoin speculators might be exhibiting when trying evaluate the credibility of the information.

The development of a model of informational trust highlights that speculators do not appear to rely upon their own domain expertise but rather place their trust as to the quality of news information in its source, or even a more general trust of online media. This is a position which sits hand-in-hand with findings from Chapter 3 that interpersonal trust is critical when forming opinions of trust on sources and mediums of news.

6.2 Contributions

This thesis makes two key contribution to both the crypto-currency and security communities.

Firstly, in investigating where human trust is evident in the Bitcoin ecosystem—as it transitions towards mainstream adoption—this study sheds light on the potential barriers to that adoption, not only Bitcoin but also other blockchain-based technologies. In particular this study highlights the consequences of design choices such as the impact of loss or media exposure upon a user's trust and sentiment towards and within the ecosystem.

Secondly, through answering the research question of *are people able to select and correctly evaluate information they might rely upon to make decisions?*—exposes a model of informational trust for a sub-community of users whom claim expertise yet exhibit a number of biases which suggests that they do not actually utilise that expertise when making risky investment decisions. Such deference to bias, rather than true understanding of information, presents a challenge to the rational and systematic process of evaluating risk normally found in security frameworks. Whilst these frameworks are traditionally employed at an organisational level for evaluating risk, this model suggests the same rationality and systematization is not necessarily true of users themselves.

These two key contributions are supported by the findings (see Section 1.5) from each of the three primary research objectives, which build a hitherto unexplored picture of the Bitcoin ecosystem; not only that trust exists beyond computation but where that trust is placed and, by whom.

6.3 Application to Research Question

The methodological approach used to guide this thesis has addressed the objectives and allowed for the exploration of the principle research question: *to what extent are Bitcoin speculators able to select and correctly evaluate news based information upon which they might be making investment decisions in a way which reduces risk to themselves?*

Objective 1 - Investigation Prior research has suggested that aspects of trust within the broader ecosystem of Bitcon exist (see Section 2.3.3). Given the degree of assertive discussion around Bitcoin within online forums, it had been expected that bitcoin speculators were adhering to the colloquial notions of trustlessness. Consequently it was important to have been able to empirically show not only that trust beyond computation does exist, but also where it is placed and how it can be impacted by both loss and media coverage.

In terms of the investigation, one of the most revealing aspects was just how important interpersonal trust was when looking at information sources. Rationale discussing information sources / mediums clearly articulated that the level of social interaction was a key element for trust, and where that didn't exist evidence of expertise on the part of the author could be deferred to.

As regards expertise, outwardly many speculators present as being '*knowledgeable*' about aspects of Bitcoin. However, the reliance upon trust of information sources based upon interpersonal facets suggests that some speculators may have been basing their decisions upon their own and others' belief in Bitcoin - potentially more so than they might be relying upon their own expertise in evaluating factual information.

Objective 2 - Evaluation The potential that speculators might be basing decisions upon belief in the future of Bitcoin directly aligns with the *'ability to select new information'* aspect of the research question. Selecting information (news) based upon belief is a form of confirmation bias and would have the ability to hugely distort the view on Bitcoin to one which aligned only with that of the speculator. Confirmation bias has been shown to impact upon the risk to investors [125]. Some limited support for confirmation bias was found - however limitations encountered (see Section 6.4.1) meant that it was not possible to observe statistical support for both key markers of confirmation bias; time on task and overly favouring sentiment aligned news.

The other key finding from *Objective 2* was that the time spent on task was far less for those with sentiment (attitudinal) alignment, directly the opposite of the findings by Knobloch-Westerwick & Meng [86]. The tendency for people to spend more time reading information that conforms to their own sentiment is a well understood phenomenon and critical for the spread of fake-news - by only reading sentiment-affirming information the discomfort of cognitive dissonance is mitigated. So for Bitcoin speculators to buck this tendency is surprising. As noted, the limitation from sample size meant that this was not a significant result and lends itself to future study.

Objective 3 - Development Basing method upon information credibility assessment works within the psychology community [99, 101, 102], the final objective of this thesis built upon previous two objectives and sought to address the second part of the research question, the *'ability to correctly evaluate information... in a way which reduces risk.'* Within this process a model of information trust was constructed which highlighted two key points:

Firstly, that rather than applying expert knowledge of Bitcoin, speculators

tended to evaluate credibility based upon the source or medium of the news information. This sits well with the findings of *objective 1* - in so much as these sources were also previously rated as highly credible based upon their social interaction or transparency of author's related writing. This also follows from *objective 2* as the lack of overt confirmation bias also suggested that other forms of bias might have been relied upon.

Secondly, that a notable percentage (35%) of credibility evaluations were incorrect (where factually inaccurate news stories were identified as being most credible) with nearly half of those erroneous evaluations being viewed as sound enough to base an investment change upon.

6.4 Reflection

The process of developing the model of informational trust for Bitcoin speculators has led to a number of observations which fall outside the main body of analysis yet are worthy of consideration.

6.4.1 Limitations of the study

The breadth and depth of usage around Bitcoin is significant and, as succinctly put by Bohr & Bashir [20], "*due to the decentralized and relatively anonymous nature of Bitcoin, it is impossible to draw a random sample and confidently generalize to the global or English-speaking Bitcoin community.*" More simply, the culture of Bitcoin effectively makes it impossible to access all potential communities of users and thus to overly generalize any study findings is problematic.

This thesis, in addressing its three key objectives, acknowledges these issues with wider generalizability and in doing so is focussed solely upon those utilizing bitcoin as a speculative investment vehicle. Moreover the objectives are targeted

at the use of online news reporting (as a source of information) as this thesis (see Chapter 3) and other works have shown such sources of information are of great importance to Bitcoin users.

As such it seems reasonable to have recruited participants online and acknowledge that respondents were drawn primarily from Bitcoin related sources. The 125 survey respondents and 57 experimental participants, who expended significant periods of time within the study, displayed demographic diversity (with the exception of language) and would be considered representative of this online speculative user base.

Had an incentive mechanism (such as bitcoin or voucher reward) been employed to entice participation it is possible that a greater number of respondents might have been recruited. However, this would have introduced an additional layer of complexity to the administration of the study as well as potentially encouraging investment in bitcoin - which would have presented as an ethical constraint. Tighter controls of independent variables—such as the ability to undertake off-site research in study—combined with greater observation numbers might have allowed for a regression model to have been fitted.

With these caveats, the findings of this thesis still not only afford an important insight into how Bitcoin users really perceive trust but also opens a door into studying how Bitcoin users select and evaluation information prior to investment decision making.

6.4.2 Alternative approaches

It is accepted that this work is predominantly quantitative in nature—excepting rationales for loss contained in Chapter 3. These quantitative methods are borrowed from disciplines within which such methods are considered *normal*. It is becoming more common in cyber security fields to see such fully quantitative

work applied only to formal proofs and for human aspects work to be predominantly qualitatively based.

Qualitative works by Sas and Khairuddin [138, 82, 139] lean to interviews and case studies with limited numbers of participants, however they do more clearly seek to address questions of *why* people trust. This thesis affords a more in depth quantitative look at the *how* side of trust and as such each set of works complements each other.

6.5 Future Work

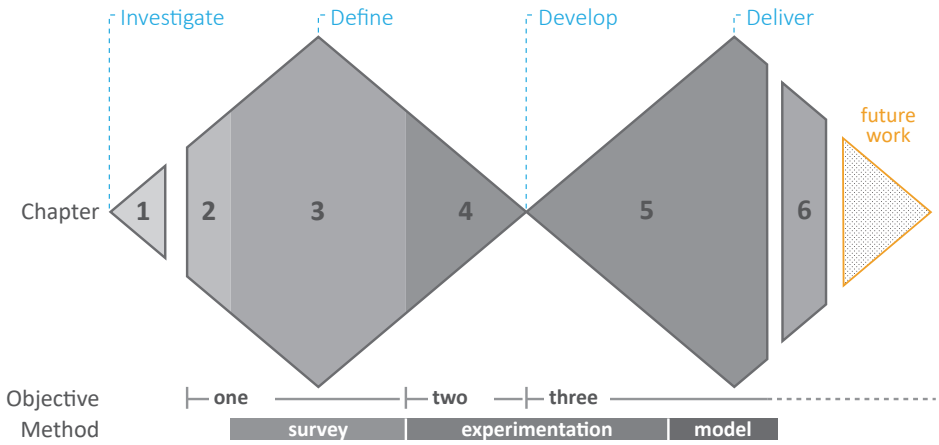


Figure 6.1: Overview of the design process methodology used for this thesis highlighting where future work lays in completing the delivery phase.

It can be noticed, in the illustrative map of methodology (see Figure 6.1), that the final quarter (delivery) of the Design Council's *Double Diamond* model is left incomplete. This is deliberate for two key reasons. Firstly, it is incredibly difficult, and arguably impossible, to accurately model out human decision making in such a way as to be truly generalizable. Secondly, and as a result of this, any model

is only ever as complete as the data behind it, and the every changing contexts within which people make trust decisions

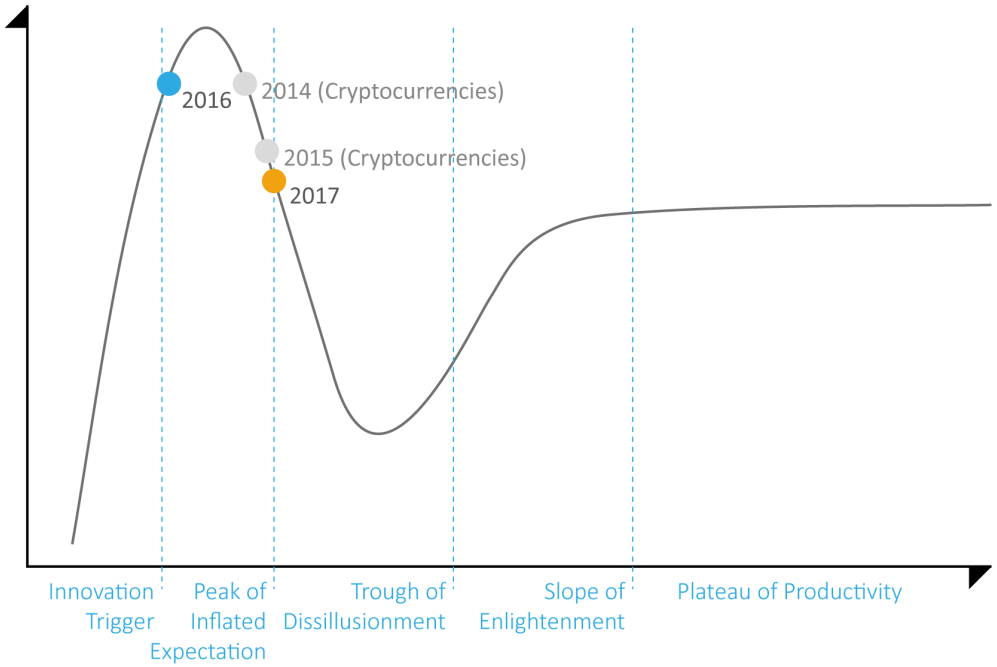


Figure 6.2: Blockchain as viewed on Gartner Hype Cycle for Emerging Technologies

Three key areas of future research, stemming directly from this thesis have been identified:

6.5.1 Trust in blockchain-based technologies

Whilst a generalizable model of information trust may be something unobtainable, it is apparent that the blockchain underpinning bitcoin presents an interesting context for further study. The Gartner 'Hype Cycle' for Emerging Technologies (see Figure 6.2) clearly views blockchains as having passed its *peak of inflated expectation* and heading towards the *trough of disillusionment* - the point where people realize the hyped promise may not be as realizable as at first suggested. Anecdotally, it is not uncommon to hear discussions of how blockchains will rev-

olutionize everything from banking to security in the Internet of Things (IoT) from the press to government, often with the presumption that the transparency of an accessible ledger will promote, engender or increase trust in the applicable industry. With blockchains expected to reach mainstream adoption within 5 years, this slip into disillusionment is expected and rapidly being approached.

Contemporary research in blockchain looks to domain application for distributed ledgers. Underwood [154] and Hawlitschek *et al* [66] both point to the necessity for trust in the wider application of blockchains. In contrast, Beck *et al* [12] and Weber *et al* [161] assert the application of blockchains is reliant upon them being *trustless* or *trust-free* in much the same manner of early Bitcoin research.

There is significant potential to move the information trust model into understanding where trust exists or is absent within these use cases for blockchain and how those promoting blockchains are forming their opinions of trust. If the *hype* is based upon an abstracted trust to, for example, their own sources of information as opposed to a fundamental understanding of how blockchains work, then it seems plausible that the *trough of disillusionment* will be reached more quickly and potentially be much deeper than expected.

6.5.2 Informational trust in alternative domains

Leading on from looking at trust in blockchain-based technology, there is also scope to examine how the *shape* of informational trust differs, from Bitcoin, within other blockchain-based domains. Thesis insights into how users defer trust to sources of information, rather than leveraging expert method/knowledge, have been taken forward into a funded research project (HoSEM [47]) within the context of a blockchain-based peer-to-peer energy trading market.

Using a mixed-methods approach the study will employ both stimulus ex-

perimentation (using methods evolved from this thesis) and more qualitative approaches, including semi-structured interviews and stakeholder workshops, to understand how renewable energy prosumers form trust in third parties, information and user interfaces.

Findings from this study will be used to inform software engineering design decisions for the marketplace platform, and how best to drive and sustain adoption by such prosumers.

6.5.3 User-Susceptibility to fake-news

As discussed in this thesis, by deferring informational trust to either the source or medium of the information, users potentially renders themselves susceptible to not only receiving but also being influenced by *fake-news*. Simply, they rely upon others' credibility assessment rather than their own expert assessment. Insights from this thesis as to the susceptibility of bitcoin speculators to *fake-news* have been published [39], however further work is required.

Firstly, future work is needed to understand how generalizable this susceptibility may be, i.e., does it extend, and to what extent, to other domains, and in particular those which profess user expertise?

Secondly, whilst technological approaches to automatically identifying and removing *fake-news* may be considered the desirable option for many social networks, news publishers and governments alike, it is not without issue. Such technology is still in its infancy, often resulting in false-positive or uncertain selection of news as being *fake*. Through being able to reliably identify user-susceptability, it might be possible to mitigate this technological limitation by alerting more susceptible users to potentially *fake* content. This approach not only provides a complimentary approach to automated removal, but arguably might also improve user behavior and resilience through the process of alerting them.

6.6 Conclusion

Bitcoin has become far more than its intended payments mechanism roots in 2008/9 could have envisaged. Whilst it initially sought to remove the need for trust in third party intermediaries, such as banks and governments, the reality of Bitcoin as a socio-technical ecosystem is that not only does trust exist but that it is utterly essential to its adoption, maintenance and ongoing usage. Simply this is due to trust being pervasive in human society [35, 104]. At its most elemental level, trust in Bitcoin is based in the validity of the computation - a technological or algorithmical trust - that underpins the whole system, although in practice this is equally an interpersonal trust in those maintaining that computation. Interpersonal trust also underpins transactions. Whilst the bitcoin protocol does indeed allow for assurance of payment it does nothing to enforce the reciprocity of exchange. For example, bitcoin itself does not require, enforce or trace a counter-party actually sending the thing being paid for.

Trust also extends to institutions around the ecosystem from exchanges to the core-development team and further into information, its sources and mediums of delivery. In all cases, though, this is all underpinned by that very human need for interpersonal trust not least as humans are so very intrinsically involved at every level of Bitcoin.

But this very reliance upon interpersonal trust, in a predominantly digital online community, does appear to present a challenge to speculative investors. In traditional financial services much reliance is placed upon the accurate assimilation and interpretation of information to reduce risk, and this in most markets is undertaken by trained and (often) licensed professional services upon whom rests a duty of care to protect investors.

In Bitcoin anyone can quickly and simply create accounts, transfer funds and start trading. There is no regulatory requirement currently for professional intermediation and as such speculators are left to their own wits. It appears that significant proportions of Bitcoin speculators do not possess the requisite expert skill, relying upon that interpersonal trust for third party selection and interpretation of information. In a world where *fake-news*, appealing to belief rather than fact, is a pertinent and rapidly pervasive problem it is somewhat worrisome that bitcoin speculators are left to their own devices.

Huge pricing volatility over the period 2011-2017 has no doubt made many very wealthy. Many others, through their own poor decision making or criminal activity, have incurred significant loss. The future for Bitcoin is not yet clear, however as we transition through towards mainstream adoption of foundation technologies and alternative currency this thesis is presented to both the nascent crypto-currencies and security research communities to help shape understanding of where the main barriers to mass adoption of blockchain based technologies may lay. In particular this thesis is a stepping stone for studying trust in Bitcoin to allow these communities to understand the consequences of design choices such as the impact of loss or media exposure on a user's sentiment towards the system.

Appendix A

Survey Questionnaire

This appendix contains a copy of the questions presented to our study participants using the University's own hosted implementation of Qualtrics. The formatting of the questions may vary from those presented due to the nature of online web based interfaces and text layout within this thesis, however the content remains the same. The appendix is split into two parts; firstly the questions asked and used within the analysis of this thesis and its constituent papers. The second part of questions asked in the survey but not used in this analysis.

Conventions: Where numeric codes were assigned to responses these are given in brackets beside each option. Where the order of available responses was randomized this is indicated with an asterisk after the question title. Where question or section logic was used to display options or questions this is given at the foot of each question in curly braces { }. For multiple choice type questions, single answer only are in round brackets ( ), and multiple answers are in square brackets [ ]

A.1 Questions used in Analysis

Introduction

Welcome. Thanks for dropping by to help out with this piece of academic research into how people use information when using bitcoin. The study is open until the end of February, and is split into three sections;

1. Some simple questions about how you get news information and use the internet.
2. A more in depth look at your understanding and use of bitcoin.
3. A task where we ask you to read a few news stories and tell us how you felt about them.

Participation is voluntary and ideally we would love you to complete all three sections, but if you've had enough by the end of section 2 (about 10-15 minutes) that's fine just click the "skip experiment button" when it appears and we part ways with our thanks.

The whole study takes about 35 minutes (depending on how fast you read). Again, thanks for volunteering your help and we would suggest doing this on a desktop or laptop computer for ease.

Barney Craggs, Security Lancaster / Highwire DTC, Lancaster University

What We Collect Just to make it clear & simple we don't collect ANY personal / contact information but the survey software does use simple cookies to track your progress through the study. The only thing we do automatically collect is a random unique participant number and your responses to the questions.
Data Usage It is Lancaster University's policy to retain collected data for a minimum of 10 years, and we may well use it for later academic works including publication of research findings. We will NOT pass or sell this data on to anyone outside of Lancaster University.
Removing Your Data from the Survey If you wish to withdraw from the study at any point before 31 March 2016 please make a note of your unique participant number given at the end of the study - write this down as without this number we have no way of removing your data if you wish so. To remove yourself from the study please just drop an email with your participant number and a message to the address below. After 31 March 2016 all data will be locked having

been anonymised where necessary & analysed to ensure integrity of the study and removal will NOT be possible.

Contacting Us If you would like more information about this study, its findings or to remove yourself from the study (if you have remembered to keep your participant number) please contact Barney Craggs,
by email: b.craggs [@] lancaster.ac.uk, or
in writing: School of Computing and Communications, Lancaster University, LA1 4WA, UK

Q1.1 Consent

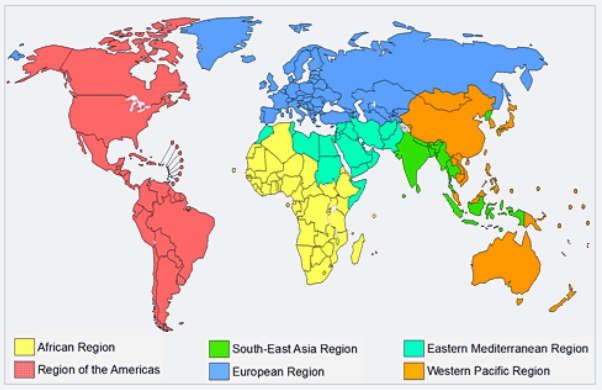
Consent: Please indicate that you understand the task being set and that you are willing to undertake this study.

[ ] Yes, I will participate in the study
[ ] No I WILL NOT participate and I want to leave now

Demographics

Q2.2 Where in the world do you Live?

( ) Africa (1)
( ) The Americas (2)
( ) Europe (3)
( ) Eastern Mediterranean (4)
( ) South-East Asia (5)
( ) Western Pacific (6)



Q2.3 Is English your primary language?

( ) Yes
( ) No
{If 'Yes' skip to Q2.5}

Q2.4 What is your primary language?*

( ) Spanish (1)
( ) Chinese (2)
( ) French (3)
( ) Hindi (4)
( ) Russian (5)
( ) Japanese (6)
( ) Hebrew (7)
( ) Arabic (8)
( ) Other..... (9)

Q2.5 How good do you consider your English to be?

Written English ★★★★★
Spoken English ★★★★★

Q2.6 How old are you?

( ) Under 13 (1)
( ) 13 - 17 (2)
( ) 18 - 25 (3)
( ) 26 - 35 (4)
( ) 35-54 (5)
( ) 55-64 (6)
( ) 65 or over (7)

Q2.7 Which gender do you most identify yourself with?

( ) Female (1)

( ) Male (2)

( ) Other..... (3)

( ) Prefer not to say (4)

Q2.8 Is this the same gender you had at birth?

( ) Yes (1)

( ) No (2)

( ) Prefer not to say (3)

Q2.9 Please indicate the highest level of education completed.

( ) High school or equivalent (1)

( ) Vocational/Technical school, 2yrs (2)

( ) Some college (3)

( ) College graduate, 4yrs (4)

( ) Master's degree (MS, MA...) (5)

( ) Doctoral degree (PhD) (6)

( ) Professional degree (MD, JD...) (7)

( ) Other..... (8)

Q2.10 Do you see yourself primarily as...

( ) Still in education (1)

( ) Home-maker (2)

( ) Full time employed (3)

( ) Self employed (4)

( ) Part time employed (5)

( ) Temp employed (e.g., holiday cover) (6)

( ) Retired (7)

( ) Unemployed (8)

{If 1,2,7 or 8 skip to Q2.13}

Q2.14 Without spending too much time thinking about each question; how much do the following statements apply to you?

	Strongly disagree (1)	Disagree (2)	Neither agree or disagree (3)	Agree (4)	Strongly agree (5)
Regarding the intentions of others I am rather cynical and sceptical.	( )	( )	( )	( )	( )
I believe that you will be used by most people if you allow them to.	( )	( )	( )	( )	( )
I believe that most people have good intentions.	( )	( )	( )	( )	( )
I believe that most people, with whom I have dealings, are honest and trustworthy.	( )	( )	( )	( )	( )
I become distrustful when someone does me a favour.	( )	( )	( )	( )	( )
My first reaction is to trust people.	( )	( )	( )	( )	( )
I tend to assume the best of others.	( )	( )	( )	( )	( )
I have a good deal of trust in human nature.	( )	( )	( )	( )	( )

Internet Use

Q4.1 How long have you been using the Internet (including using e-mail, social networks, websites, etc...)?

( ) Less than 1 year (1)

( ) 1 to 5 years (2)

( ) 6 to 10 years (3)

( ) 11 years or more (4)

Q4.2 Which of the following types of website do you use?*

	Never (1)	Less than once a month (2)	Once a month (3)	2-3 Times a month (4)	Once a week (5)	2-3 Times a month (6)	Daily (7)
Social networks	( )	( )	( )	( )	( )	( )	( )
Discussion forums	( )	( )	( )	( )	( )	( )	( )
General news	( )	( )	( )	( )	( )	( )	( )
Technology news	( )	( )	( )	( )	( )	( )	( )
Leisure/hobby	( )	( )	( )	( )	( )	( )	( )
Financial news	( )	( )	( )	( )	( )	( )	( )
Internet banking	( )	( )	( )	( )	( )	( )	( )
Personal blogs/vlogs	( )	( )	( )	( )	( )	( )	( )
Video sharing sites	( )	( )	( )	( )	( )	( )	( )
Information/Wiki's	( )	( )	( )	( )	( )	( )	( )

Q4.4 Without spending too much time thinking about the statement; how much do you agree with the following statements?*

	Strongly disagree (1)	Disagree (2)	Neither agree or disagree (3)	Agree (4)	Strongly agree (5)
I tend to use the Internet for information rather than off-line sources.	( )	( )	( )	( )	( )
I find much of the information on the Internet credible.	( )	( )	( )	( )	( )
In general I trust the companies and people running the Internet.	( )	( )	( )	( )	( )
I trust people I interact with on the Internet.	( )	( )	( )	( )	( )
Information in Internet forums tends to be credible and trustworthy.	( )	( )	( )	( )	( )
I am confident I can find information on the Internet, when I need it.	( )	( )	( )	( )	( )
I find it easy to filter out inaccurate or incorrect information I find online.	( )	( )	( )	( )	( )

Bitcoin Use

Q5.1 Roughly, when did you first hear about Bitcoin?

( ) 2016 (6)

( ) 2014 - 2015 (1)

( ) 2012 - 2013 (2)

( ) 2010 - 2011 (3)

( ) 2008 - 2009 (4)

( ) Cannot remember (5)

Q5.2 Can you remember from where you first heard about Bitcoin?

( ) A friend / family member / colleague (1)

( ) An online discussion forum (2)

( ) A printed newspaper, magazine or periodical (3)

( ) An academic paper (4)

( ) A news website (5)

( ) Cannot remember (6)

Q5.3 How much do you agree with the following statements about Bitcoin?*

	Strongly disagree (1)	Disagree (2)	Neither agree or disagree (3)	Agree (4)	Strongly agree (5)
Short term (1-3 years) bitcoin prices will be very volatile.	( )	( )	( )	( )	( )
Long term (3 years +) bitcoin prices will always rise.	( )	( )	( )	( )	( )
Long term adoption by retailers will be good for Bitcoin.	( )	( )	( )	( )	( )
Theft of bitcoin is currently hampering adoption.	( )	( )	( )	( )	( )
Governments will regulate Bitcoin.	( )	( )	( )	( )	( )
Bitcoin provides a viable alternative to traditional fiat (currency).	( )	( )	( )	( )	( )
Speculation has driven price rises & falls in the last 5 years.	( )	( )	( )	( )	( )
The people maintaining Bitcoin are trustworthy.	( )	( )	( )	( )	( )
The real value of Bitcoin is not as a currency.	( )	( )	( )	( )	( )
Long term bitcoin offers a better financial return (as an investment) than stocks.	( )	( )	( )	( )	( )
Bitcoin is primarily a tool for criminal activity.	( )	( )	( )	( )	( )
People using bitcoin are trustworthy.	( )	( )	( )	( )	( )

Q5.4 You said you ${Q5.3 Response 12} that "people using bitcoin are trustworthy." Can you briefly explain why?

Q5.5 Can you explain why you ${Q5.3 Response 2} that long term (3 years +) prices for bitcoin will always rise?

Q5.6 How well do these statements describe you?*

	Strongly disagree (1)	Disagree (2)	Neither agree or disagree (3)	Agree (4)	Strongly agree (5)
I am influenced in bitcoin buy/sell decisions by what I read in newspapers (online or printed).	( )	( )	( )	( )	( )
I am well informed about bitcoin technologies.	( )	( )	( )	( )	( )
I am well informed about bitcoin markets.	( )	( )	( )	( )	( )
I am well informed about non-Bitcoin news that might impact the bitcoin markets.	( )	( )	( )	( )	( )

Q5.7 Can you tell us five (5) words you feel describe bitcoin? [use a new line for each word]

Q5.8 Have you ever actually used bitcoin?

( ) Yes (1)

( ) No (2)

{If No skip to Q5.25}

Q5.9 What have you used bitcoin for? [tick all that apply]

[ ] Purchase something (1)

[ ] Transfer funds to someone (2)

[ ] Launder money (3)

[ ] For investment / speculation (4)

[ ] To drive adoption / disrupt current monetary system (5)

[ ] Other..... (6)

Q5.10 Can you rank your uses of bitcoin in order of importance to you?

[1 = most important]

_____ Purchase something (1)

_____ Transfer funds to someone (2)

_____ Launder money (3)

_____ For investment / speculation (4)

_____ To drive adoption / disrupt current monetary system (5)

_____ Other..... (6)

Q5.11 You said you have used bitcoin for investment / speculation; what position do you currently have?

{Display if investment use selected}

( ) Sell (1)

( ) Hold (2)

( ) Buy (3)

Q5.12 Can you briefly explain why you have this position?

Q5.19 Have you ever lost bitcoin? How? [tick all that apply]

[ ] Never (1)

[ ] Fraud (2)

[ ] Theft (3)

[ ] Collapse of an exchange (4)

[ ] Variations in exchange rates (5)

[ ] Technical problems with exchange (6)

[ ] Other..... (7)

Note: post study analysis found that 'other' led to two further loss categories... 'User error' (8), and 'Gambling' (9)

Q5.20 Thinking about when you lost bitcoin, did this affect your trust?

	Much lower (1)	Lower (2)	About the same (3)	Higher (4)	Much higher (5)
Trust in Bitcoin in general.	( )	( )	( )	( )	( )
Trust in exchanges.	( )	( )	( )	( )	( )
Trust in people using bitcoin.	( )	( )	( )	( )	( )
Trust in people maintaining bitcoin.	( )	( )	( )	( )	( )

Q5.21 Thinking about when you buy or sell bitcoin, do you look at / read / consult any of the following before making your decision?*

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	All the time (5)
Bitcoin market charts/data.	( )	( )	( )	( )	( )
General news websites.	( )	( )	( )	( )	( )
Technology news websites.	( )	( )	( )	( )	( )
Financial news websites.	( )	( )	( )	( )	( )
Bitcoin / Cryptocurrency news websites.	( )	( )	( )	( )	( )
Printed newspapers / magazines / periodicals.	( )	( )	( )	( )	( )
Social networks.	( )	( )	( )	( )	( )
Friends / family / colleagues.	( )	( )	( )	( )	( )
Information websites (e.g. Wikipedia).	( )	( )	( )	( )	( )
Discussion forums (e.g. Reddit, Stack Exchange, Bitcointalk).	( )	( )	( )	( )	( )
Personal blogs / vlogs / podcasts.	( )	( )	( )	( )	( )

Q5.25 Can you rank these sources of information about bitcoin in the order you would likely trust before making any decision on using / trading?*

[1 = Most trusted — 10 = Least trusted]

_____ Bitcoin market charts/data.

_____ General news websites.

_____ Technology news websites.

_____ Financial news websites.

_____ Bitcoin / Cryptocurrency news websites.

_____ Printed newspapers or magazines/periodicals.

_____ Social networks.

_____ Friends / family / colleagues.

_____ Information websites (e.g. Wikipedia).

_____ Discussion forums (e.g. Reddit, Stack Exchange or Bitcointalk).

_____ Personal blogs / vlogs / podcasts.

Q5.28 Can you tell us how credible you think the following websites are for bitcoin news & information?*

[1 Star = NOT Credible, 5 Stars = Very Credible]

Coindesk ☆☆☆☆☆

New York Times ☆☆☆☆☆

Mashable ☆☆☆☆☆

The Verge ☆☆☆☆☆

The Next Web ☆☆☆☆☆

Forbes ☆☆☆☆☆

Reuters ☆☆☆☆☆

Techcrunch ☆☆☆☆☆

A.2 Questions NOT used in analysis

Demographics (Unused)

Q2.11 Which of the following categories best describes the industry you primarily work in?

( )	Agriculture, Forestry, Fishing and Hunting (1)	( )	Retail (17)
( )	Utilities (2)	( )	Publishing (18)
( )	Computer and Electronics Manufacturing (3)	( )	Telecommunications (19)
( )	Wholesale (4)	( )	Information Services and Data Processing (20)
( )	Transportation and Warehousing (5)	( )	Finance and Insurance (21)
( )	Software (6)	( )	College, University, and Adult Education (22)
( )	Broadcasting (7)	( )	Arts, Entertainment, and Recreation (23)
( )	Real Estate, Rental and Leasing (8)	( )	Government and Public Administration (24)
( )	Primary/Secondary (K-12) Education (9)	( )	Scientific or Technical Services (25)
( )	Health Care and Social Assistance (10)	( )	Military (26)
( )	Hotel and Food Services (11)	( )	Trained Professional (27)
( )	Legal Services (12)	( )	Skilled Laborer (28)
( )	Religious (14)	( )	Consultant (29)
( )	Mining (15)	( )	Researcher (31)
( )	Construction (16)	( )	Other..... (specify) (33)

Q2.12 Thinking about your income; can you answer the following?

	Much lower (1)	Slightly lower (2)	About the same (3)	Slightly higher (4)	Much higher (5)
Compared to other people in my country, I earn...	( )	( )	( )	( )	( )
Compared to my friends, I earn...	( )	( )	( )	( )	( )

Q2.13 If your income was greater than it is now, would you feel...

( ) Much less content happy (1)

( ) A bit less content happy (2)

( ) About the same (3)

( ) a bit more content happy (4)

( ) A lot more content happy (5)

News Consumption (Unused)

Q3.1 Do you read newspapers and/or magazines/periodicals (printed or on the Web)? [tick all that apply]

[ ] Newspapers (1)

[ ] Magazines / Periodicals (2)

[ ] Neither (3)

Q3.2 How well do the following statements about newspaper reading describe you?

	Strongly disagree (1)	Disagree (2)	Neither agree disagree (3)	Agree (4)	Strongly agree (5)
I tend to read more than one newspaper daily	( )	( )	( )	( )	( )
I tend to purchase my own newspapers	( )	( )	( )	( )	( )
I tend to read newspapers in printed form more than online	( )	( )	( )	( )	( )
The newspapers I read often challenge or disagree with my own opinions	( )	( )	( )	( )	( )
In general I trust the content I read in newspapers	( )	( )	( )	( )	( )
I find the content in newspapers that I read accurate	( )	( )	( )	( )	( )
I often go away and find more information about things I read in newspapers	( )	( )	( )	( )	( )

Q3.3 How well do the following statements about magazine periodical reading describe you?

	Strongly disagree (1)	Disagree (2)	Neither agree disagree (3)	Agree (4)	Strongly agree (5)
I tend to read more than one magazine a month	( )	( )	( )	( )	( )
I tend to purchase my own magazines	( )	( )	( )	( )	( )
I tend to read magazines in printed form more than online	( )	( )	( )	( )	( )
The magazines I read often challenge or disagree with my own opinions	( )	( )	( )	( )	( )
In general I trust the content I read in magazines	( )	( )	( )	( )	( )
I find the content in magazines that I read accurate	( )	( )	( )	( )	( )
I often go away and find more information about things I read in magazines	( )	( )	( )	( )	( )

Q3.4 You said you don't trust newspapers; can you briefly explain why?

Q3.5 You said you don't trust magazines/periodicals; can you briefly explain why?

Q3.6 You said you tend to read newspapers in printed form; can you briefly explain why you don't read them online?

Internet Use (Unused)

Q4.3 How do you access Internet services?

	Never (1)	Less than once a month (2)	Once a month (3)	2-3 Times a month (4)	Once a week (5)	2-3 Times a week (6)	Daily (7)
Mobile telephone / smartphone	( )	( )	( )	( )	( )	( )	( )
Tablet	( )	( )	( )	( )	( )	( )	( )
Laptop computer	( )	( )	( )	( )	( )	( )	( )
Desktop computer	( )	( )	( )	( )	( )	( )	( )

Bitcoin (Unused)

Q5.13 Thinking about when you speculate; do you prefer to...

( ) Use automated tools (bots, algorithmic trading) (1)

( ) Manually place orders (2)

Q5.14 Can you briefly explain why you prefer to ${Q5.13/Response}?

Q5.15 What type of Bitcoin wallet do you use? [tick all that apply]

[ ] Online - Exchange based (1)

[ ] Online - Third Party (e.g. blockchain.info) (2)

[ ] Offline - Mental or Paper (3)

[ ] Offline - Digital (4)

	Have you used the exchange?			How much do you trust the exchange?		
	Never used (1)	Used in past (2)	Currently using (3)	Not Trusted (1)	A Bit Trusted (2)	Trusted (3)
MT Gox	( )	( )	( )	( )	( )	( )
Bitstamp	( )	( )	( )	( )	( )	( )
Bitfinex	( )	( )	( )	( )	( )	( )
BTC-e	( )	( )	( )	( )	( )	( )
itBit	( )	( )	( )	( )	( )	( )
Coinbase	( )	( )	( )	( )	( )	( )
Kraken	( )	( )	( )	( )	( )	( )
OKCoin	( )	( )	( )	( )	( )	( )
Huobi	( )	( )	( )	( )	( )	( )
Localbitcoins	( )	( )	( )	( )	( )	( )
LakeBTC	( )	( )	( )	( )	( )	( )
Other....	( )	( )	( )	( )	( )	( )

Q5.16 Have you ever used any of the following exchanges for bitcoin?

Q5.17 Which methods for adding funds to your exchange account(s) have you used?

[ ] Direct funds transfer from your bank account (1)

[ ] Wire transfer (2)

[ ] Cash purchase (say through Localbitcoins) (3)

[ ] Inter-exchange transfer (4)

[ ] Other..... (5)

Q5.18 Have you mined your own Bitcoin?

( ) Yes (1)

( ) No (2)

Q5.22 As you use websites to obtain information before making bitcoin trading decisions; can you name the website you trust the most for that information?

Q5.23 When searching for bitcoin news; do you search within your trusted news source website(s) OR use a search engine?

	I always use a search engine (1)	I tend to use a search engine (2)	I use both equally (3)	I tend to search directly on website (4)	I always search directly on website (5)
Please select statement that most applies	( )	( )	( )	( )	( )

Q5.24 You said you look at bitcoin market charts / data; can you place the following in order of importance to you when making buy / sell decisions?

[1 = Most important — 3 = Least important]

_____ Price chart on a single single exchange (1)

_____ Price charts on multiple exchanges (2)

_____ Third party price charts or indicies (3)

Q5.26 You said you trusted ${Q5.24/ChoiceWithLowestValue} the most; can you briefly explain why?

Q5.27 You said you trusted ${Q5.24/ChoiceWithHighestValue} the least; can you briefly explain why?

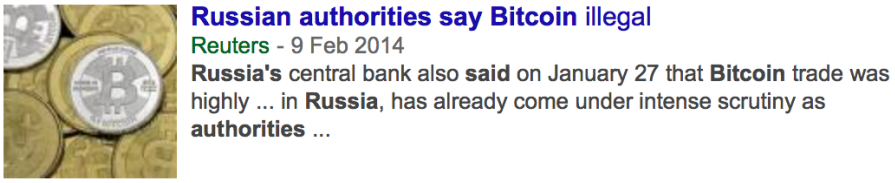
Appendix B

Experimental Stimulus

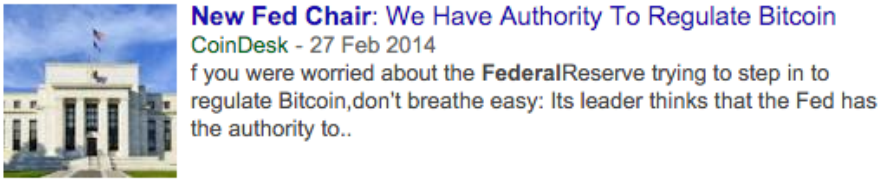
This appendix contains a copies of the stimulus used within the experimental parts of this thesis. To recap, six news stories were presented both as a banner and a full article to participants. Three stories were presented left as is, being deemed broadly accurate. Three stories were edited to be of low quality (*LQ*) by including factual errors. A summary is presented below.

Eval	Quality	Words	Sentiment	Website	Published	Title
1	HQ	212	Neg	Reuters	02/09/14	Russian authorities say Bitcoin illegal
2	LQ	237	Neu	Coindesk	02/27/14	New Fed Chair: We Have Authority To Regulate...
3	HQ	467	Neu	Coindesk	12/30/13	The Reserve Bank of India Has No Plans to Reg...
4	LQ	402	Pos	Coindesk	02/23/14	Top UK Payments Body Weighs in on Bitcoins...
5	LQ	375	Neg	Coindesk	07/29/13	Bank of Thailand officially declares bitcoin illegal
6	HQ	378	Pos	Coindesk	12/05/13	Bank of America: Bitcoin Has Clear Potential...

B.1 Article Banners Presented



(a) Banner 1 - HQ Negative



(b) Banner 2 - LQ Neutral

The **Reserve Bank of India Has No Plans to Regulate B**...
CoinDesk - 30 Dec 2013
According to the Times of **India**, the **RBI** does **not** even **plan** to develop ... He was keen to point out that **bitcoin regulation has not** been enacted ...

(c) Banner 3 - HQ Neutral

Top UK Payments Body Weighs in on Bitcoin's Future
CoinDesk - Feb 21, 2014
The **Payments** Council is the governing **body** for **UK payments** systems and services. As such, its task is to lead the development of future ...

(d) Banner 4 - LQ Positive

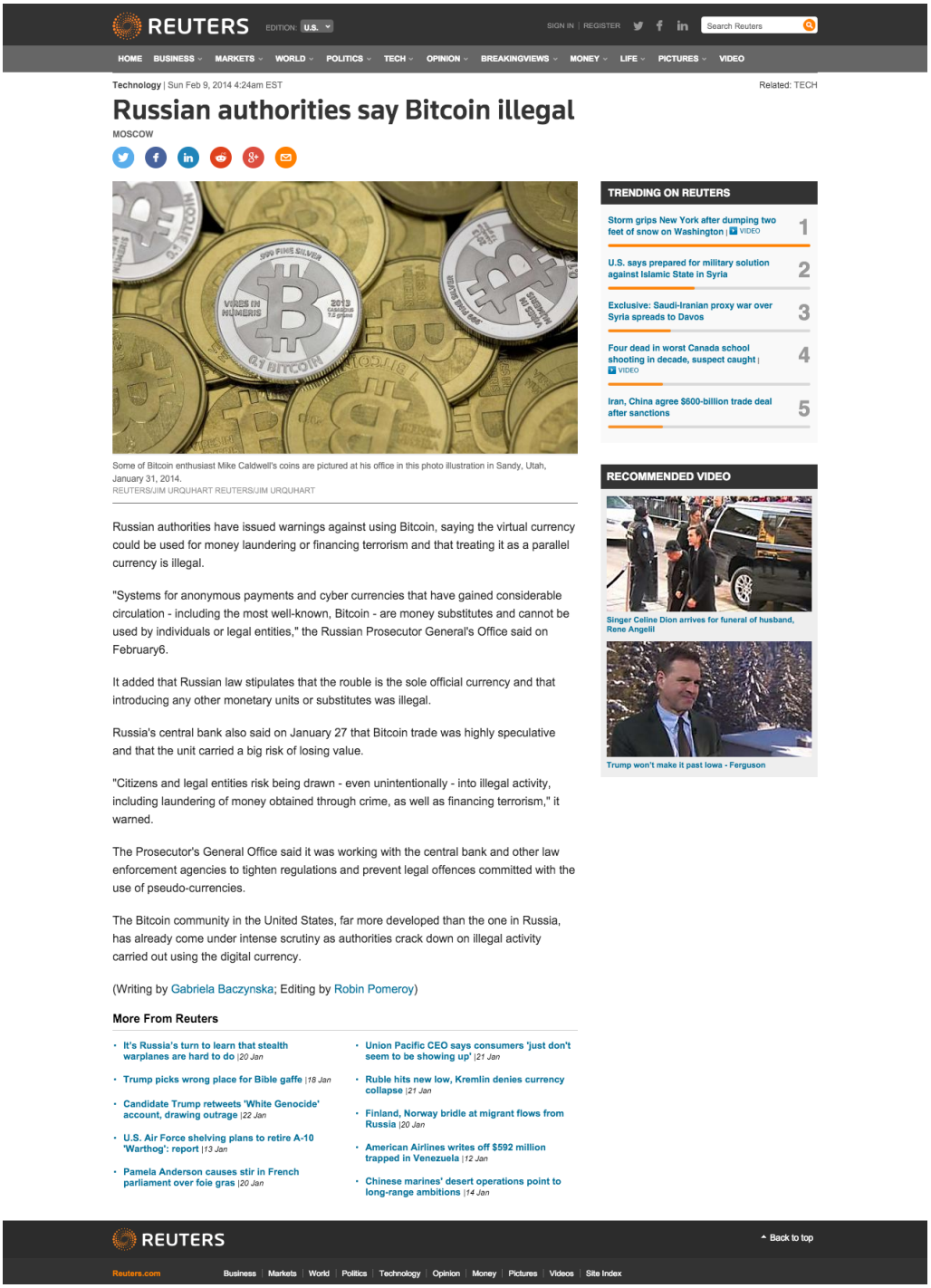
Bank of Thailand officially declares bitcoin illegal, **Thai** ...
CoinDesk - Jul 29, 2013
A **Thai** bitcoin exchange has suspended trading after the **Bank of Thailand** declared the cryptocurrency illegal, throwing the ...

(e) Banner 5 - LQ Negative

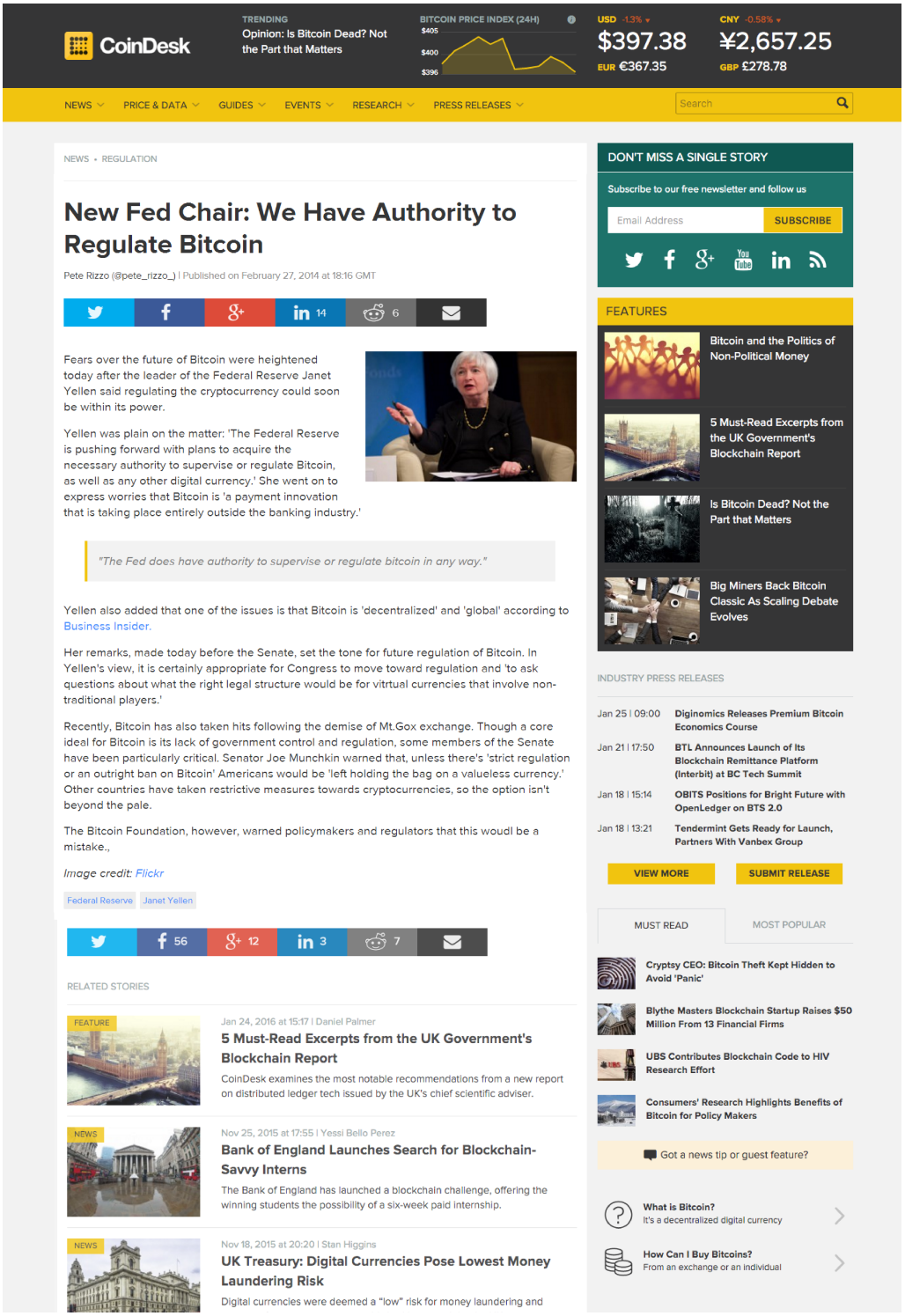
Bank of America: **Bitcoin Has Clear Potential for Growth**
CoinDesk - 5 Dec 2013
Bank of America **has** become the first US bank to talk openly about **bitcoin**, having issued a client note stating that the digital currency **has "clear** ...

(f) Banner 6 - HQ Positive

B.2 Fullpage Articles Presented



(a) Article 1 - HQ Negative (footer clipped to fit page)

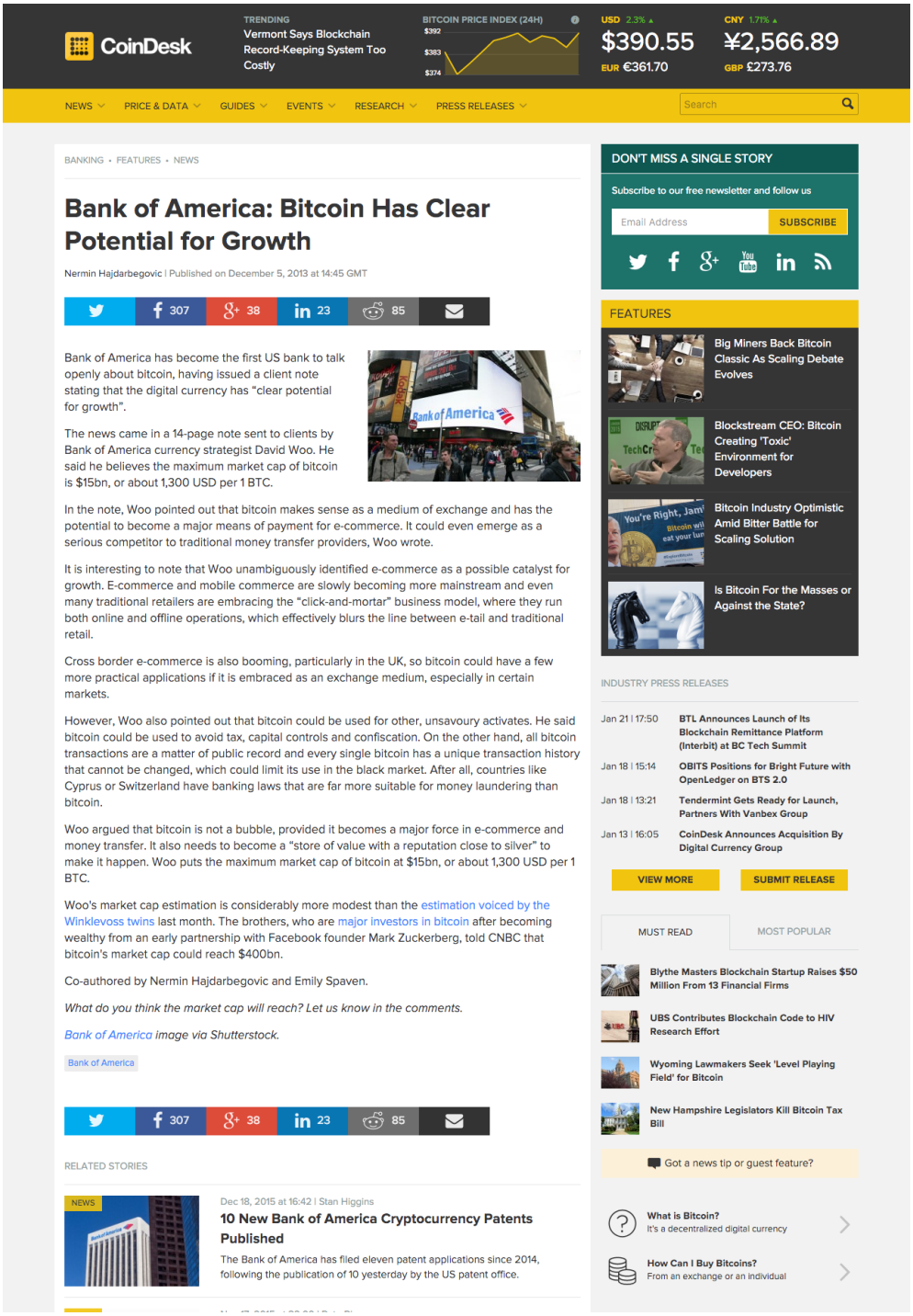


(b) Article 2 - LQ Neutral (footer clipped to fit page)

(c) Article 3 - HQ Neutral (footer clipped to fit page)

(d) Article 4 - LQ Positive (footer clipped to fit page)

(e) Article 5 - LQ Negative (footer clipped to fit page)



(f) Article 6 - HQ Positive (footer clipped to fit page)

B.3 Article Transcripts

Story 1 - HQ Negative (Unedited)

<article>
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<title>Russian authorities say Bitcoin illegal</title>
<description>Russia's central bank also said on January 27 that Bitcoin trade was highly ... in Russia, has already come under intense scrutiny as authorities ...</description>
<body>Russian authorities have issued warnings against using Bitcoin, saying the virtual currency could be used for money laundering or financing terrorism and that treating it as a parallel currency is illegal. ''Systems for anonymous payments and cyber currencies that have gained considerable circulation − including the most well−known, Bitcoin − are money substitutes and cannot be used by individuals or legal entities,'' the Russian Prosecutor General's Office said on February 6. It added that Russian law stipulates that the rouble is the sole official currency and that introducing any other monetary units or substitutes was illegal. Russia's central bank also said on January 27 that Bitcoin trade was highly speculative and that the unit carried a big risk of losing value. ''Citizens and legal entities risk being drawn − even unintentionally − into illegal activity, including laundering of money obtained through crime, as well as financing terrorism,'' it warned. The Prosecutor's General Office said it was working with the central bank and other law enforcement agencies to tighten regulations and prevent legal offences committed with the use of pseudo−currencies. The Bitcoin community in the United States, far more developed than the one in Russia, has already come under intense scrutiny as authorities crack down on illegal activity carried out using the digital currency.</body>
<url>http://www.reuters.com/article/us−russia−bitcoin−idUSBREA1806620140209</url>
</article>

Story 2 - LQ Neutral (EDITED)

<article>
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<used>TRUE</used>
<title>New Fed Chair: We Have Authority To Regulate Bitcoin</title>
<description>If you were worried about the Federal Reserve trying to step in to regulate Bitcoin, don't breathe easy: Its leader thinks that the Fed has the authority to..</description>
<body>Fears over the future of Bitcoin were heightened today after the leader of the Federal Reserve Janet Yellen said regulating the cryptocurrency could soon be within its power. Yellen was plain on the matter: ''The Federal Reserve is pushing forward with plans to acquire the necessary authority to supervise or regulate Bitcoin, as well as any other digital currency.'' She went on to express worries that Bitcoin is ''a payment innovation that is taking place entirely outside the banking industry.'' Yellen also added that one of the issues is that Bitcoin is ''decentralized'' and ''global,'' according toBusiness Insider. Her remarks, made today before the Senate, set the tone for future regulation of Bitcoin. In Yellen's view, it is certainly appropriate for Congress to move toward regulation and ''to ask questions about what the right legal structure would be for virtual currencies that involve nontraditional players.'' Recently, Bitcoin has also taken hits following the demise of the Mt.Gox exchange. Though a core ideal for Bitcoin is its lack of government control and regulation, some members of the Senate have been particularly critical. Senator Joe Munchkin warned that, unless there's ''strict regulation or an outright ban'' on Bitcoin ''Americans will be left holding the bag on a valueless currency.'' Other countries have taken restrictive measures towards cryptocurrencies, so the option isn't beyond the pale. The Bitcoin Foundation, however, warned policymakers and regulators that this would be a mistake.</body>
<url>http://www.coindesk.com/federal-reserve-chair-us-central-bank-cant-regulate-bitcoin/</url>
</article>

Story 2 - LQ Neutral (Unedited)

<article>
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<edited>no</edited>
<title>Federal Reserve Chair: US Central Bank Can't Regulate Bitcoin</title>
<description>In an address to the Senate Banking Committee, the US central bank head discussed bitcoin regulation.</description>
<body>After months of silence on the matter, Federal Reserve chairwoman Janet Yellen has stated that the US central bank does not have the authority to regulate bitcoin. Yellen was appointed as chair of the Federal Reserve last October after she was nominated to replace Ben Bernanke. During an address to the Senate Banking Committee on 27th February, the top US banking official, said: ''The Fed doesn't have authority to supervise or regulate bitcoin in any way.'' In her response, Yellen commented broadly on a score of issues including the impact of recent weather on US economic output, ongoing turmoil in the Ukraine and the new technologies that are more broadly impacting payments. It was on the latter subject that the topic of bitcoin was introduced, with Yellen noting that such developments are ''taking place outside the banking industry.'' Notably, the remarks came in response to a question about bitcoin regulation by US Senator Joe Manchin, a noted critic of bitcoin. The news follows Manchin's 26th February letter to the Federal Reserve chairwoman, which called for her to take aggressive action against bitcoin due to its involvement in criminal activity. The Bitcoin Foundation has also since responded to the letter. Yellen continued, saying that FinCEN has indicated that current money laundering statutes are ''adequate to meet enforcement needs.'' Manchin later asked whether Yellen believed the US to be ''behind the curve'' in regards to regulation, a nod to his previously stated belief that the US should follow the lead of countries like China and Thailand in banning bitcoin. Yellen said: ''Certainly it would be appropriate for Congress to ask questions about what the right legal structure would be for digital currencies [...] My understanding is Bitcoin doesn't touch [US] banks.'' She ended her response by stating that the Federal Reserve is looking into the matter. The statement notably comes at a time when many US state regulators are looking for guidance on how to put controls or safeguards on the bitcoin industry. Though the most notable example would be New York, which held detailed

hearings on the matter in January, Alabama and Texas have joined the conversation following the ongoing troubles at major Japan−based bitcoin exchange Mt. Gox.
</body>
<url>http://www.coindesk.com/federal−reserve−chair−us−central−bank−cant−regulate−bitcoin/</url>
</article>

Story 3 - HQ Neutral (Unedited)

<article>
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<title>The Reserve Bank of India Has No Plans to Regulate B...</title>
<description>According to the Times of India, the RBI does not even plan to develop ...He was keen to point out that bitcoin regulation has not been enacted ...</description>
<body>Last week the Reserve Bank of India (RBI) issued a public notice warning users to stay away from digital currencies. It made it clear that Indian bitcoin exchanges lack the regulatory approval needed to exchange digital currencies for rupees and other national currencies. Local exchanges were quick to suspend operations, but that was not enough. Within 48 hours of the RBI notice, India's Enforcement Directorate (ED) raided at least two bitcoin exchanges, buysellbitco.in and rbi.rbit.co.in, owned by Nilam Doctor. Investigators questioned the owners of both sites in an effort to ascertain whether any transactions carried out on their platforms violated the Prevention of Money Laundering Act and the Foreign Exchange Management Act. For the time being, the owners of the platforms are not in custody and they do not appear to be facing any criminal charges. This may be indicative of another problem even Indian regulators do not know what to do and even if they do, they lack a clear regulatory framework for digital currencies. According to the Times of India, the RBI does not even plan to develop a regulatory framework for digital currencies. Therefore, at this moment in time, bitcoin platforms based in India simply cannot get regulatory approval. Additionally, it seems that this situation is not set to change anytime soon. ''Regulation comes only when people are doing certain business and we come to understand that something wrong is happening,'' RBI deputy governor KC Chakrabarty told a gathering of Indian entrepreneurs on Saturday. ''First of all, we don't understand this subject.'' Chakrabarty stressed that the RBI does not regulate nor support digital currencies. He was keen to point out that bitcoin regulation has not been enacted anywhere else in the world, and that people who understand the risks are free to do whatever they like with their money. ''Whether it is ... legal or illegal, we don't know,'' he said bluntly. ''If it crosses the limit of legality then people may face a problem. So people should be

cautious.'' Chakrabarty's statements are unusually candid, and illustrate a wider problem for financial authorities. Regulators simply cannot deal with digital currencies as they have to operate within the existing legal framework, which does not contain the provisions needed to regulate such currencies. Furthermore, he seems to imply that regulating digital currencies is not RBI's job to begin with. Hence, it is understandable why the RBI does not plan to assist in the development of a new regulatory framework for digital currencies. In essence, the executive branch and national regulators have their hands tied, they cannot take any meaningful, constructive action without new legislation and there is simply no political will to deal with the issue. They can, however, try to apply existing foreign currency legislation to bitcoin operators, which effectively renders their activities illegal.</body>
<url>http://www.coindesk.com/the-reserve-bank-of-india-regulate-bitcoin/</url>
</article>

Story 4 - LQ Postive (EDITED)

<article>
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<edited>yes</edited>
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<title>Top UK Payments Body Weighs in on Bitcoin's Future</title>
<description>The Payments Council is the governing body for UK payments systems and services. As such, its task is to lead the development of future...</description>
<body>The Payments Council, the organisation that sets strategy for payment mechanisms in the UK, has issued a statement saying that it is generally positive on Bitcoin, and sees numerous ''fantastic opportunities'' for digital currencies. In response to questions from CoinDesk, the Payments Council said that it had been tracking the progress of digital currencies 'with interest', and that Bitcoin is only one of many ''competitive offerings'' that are emerging in the UK. The organisation appeared to be concerned but positive over the future of digital currencies: As shopping habits are increasingly moving across borders and continents, it seems certain that there will be increased possibility of issues arising with virtual currency providers, most of whom will remain unregulated and outside of traditional domestic banking systems and laws. The council's statement also noted that digital currencies, like other payment services, would be driven by consumer demand. The council appeared to be using the terms ''digital currency'' and ''virtual currency'' interchangeably in its statement. CoinDesk refers to Bitcoin as a ''crypto currency.'' The Payments Council is the governing body for UK payments systems and services. As such, its task is to lead the development of future payment systems and regulate the accountability and transparency of existing systems. It is an organisation with a compulsory membership comprising banks and building societies, including HSBC, Nationwide Building Society, Citibank and others. Among the schemes that the Procurement Council operates is the LINK ATM scheme, which ensures cash cards issued by banks, building societies and other institutions can be used across different ATMs. Around 30% of the UKs ATMs are connected to the LINK network. The council sets rules on the security of transactions, customer data and fees charged. The council has an interest in promoting speedier Internet transactions. Under the Speedier Payments Scheme, launched in 2004, Internet and phone payments for

individuals and businesses in the UK saw transaction times improved from three working days to around 24 hours. The system was designed to allow quick transactions for amounts of less than 1,000 (US$1,680). The council is now working on a UK−wide mobile Bitcoin payments scheme that will allow consumers to send secure payments to mobile phone numbers instead of a bank account number. The council promises that this process will be ‘as easy as texting.’ Some 9% of UK current accounts will be able to do this when the scheme is launched this spring next year.</body>
<url>http://www.coindesk.com/top−uk−payments−body−weighs−bitcoins−future/</url>
</article>

Story 4 - LQ Positive (Unedited)

<article>
<storyType>LQPos</storyType>
<edited>no</edited>
<title>Top UK Payments Body Weighs in on Bitcoin's Future</title>
<description>The Payments Council is the governing body for UK payments systems and services. As such, its task is to lead the development of future...</description>
<body>The Payments Council, the organisation that sets strategy for payment mechanisms in the UK, has issued a statement saying that it is ''neutral'' on bitcoin, though it sees ''opportunities'' for digital currencies. In response to questions from CoinDesk, the Payments Council said that it had been tracking the progress of digital currencies 'with interest', and that bitcoin was one of many ''competitive offerings'' that are emerging in the UK. The organisation appeared to be relatively positive on the future of digital currencies: ''As shopping habits are increasingly moving across borders and continents, it seems certain that there will be real opportunities for virtual currency providers who are outside of traditional domestic banking systems.'' The council's statement also noted that digital currencies, like other payment services, would be driven by consumer demand. The council appeared to be using the terms 'digital currency' and 'virtual currency' interchangeably in its statement. CoinDesk refers to bitcoin as a 'digital currency'. The Payments Council is the governing body for UK payments systems and services. As such, its task is to lead the development of future payment systems and regulate the accountability and transparency of existing systems. It is a voluntary organisation with a membership comprising banks and building societies, including HSBC, Nationwide Building Society, Citibank and others. Among the schemes that the Payment Council operates is the LINK ATM scheme, which ensures cash cards issued by banks, building societies and other institutions can be used across different ATMs. Almost all of the UK's ATMs are connected to the LINK network. The council sets rules on the security of transactions, customer data and fees charged. The council has an interest in promoting speedier Internet transactions. Under the Faster Payments Scheme, launched in 2008, Internet and phone payments for individuals and businesses in the UK saw transaction times reduced from three working days to several hours. The system was designed to allow quick transactions for amounts of less than 100,000

(US$166,680). The council is now working on a UK−wide mobile payments scheme that will allow consumers to send secure payments to mobile phone numbers instead of a bank account number. The council promises that this process will be ‘‘as easy as texting”. Some 90% of UK current accounts will be able to do this when the scheme is launched this spring.</body>
<url>http://www.coindesk.com/top−uk−payments−body−weighs−bitcoins−future/</url>
</article>

Story 5 - LQ Negative (EDITED)

<article>
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<used>TRUE</used>
<title>Bank of Thailand officially declares bitcoin illegal</title>
<description>A Thai bitcoin exchange suspends trading, after the Bank of Thailand declared the cryptocurrency illegal</description>
<body>A Thai bitcoin exchange has suspended trading after the Bank of Thailand declared the cryptocurrency illegal, throwing the community into heated debate. Bitcoin Co Ltd, a Thai exchange, posted a note on its website saying that the Bank of Thailand held a conference earlier today to discuss the exchange's business operations. ‘‘At the conclusion of the meeting senior members of the Foreign Exchange Administration and Policing Department advised that due to lack of existing applicable laws, capital controls and the fact that Bitcoin straddles multiple financial facets the following Bitcoin activities are illegal in Thailand,” says the post. It outlined the purchase or sale of bitcoins themselves as illegal, alongside the buying and selling of goods or services in exchange for bitcoins. Sending or receiving bitcoins to or from anyone outside Thailand would also be illegal. ‘‘Based on such a broad and encompassing advisement, Bitcoin Co. Ltd. therefore has no choice but to suspend operations until such as time that the laws in Thailand are updated to account for the existance of Bitcoin,” the exchange said. Debate heated up on the online forums, with some agreeing with the statement, and some arguing that senior officials at a bank agreeing on something doesn't make it law. ‘‘Bitcoin was not ruled illegal in Thailand. There is poor reporting and interpretation going on. The Bank of Thailand has no legal power,” said one commenter. Another commenter claimed ”a senior official at the central bank told us at point−blank, ‘buying or selling Bitcoins is illegal', so unless you have a seriously large legal fund and are willing to fight all the way to the constitutional courts if necessary, you take this seriously... But despite the official saying laws will be enforced, I would assume the blackmarket will still operate business−as−usual.” What is known is that the Bank of Thailand, a non−government agency under the Bank of Thailand Act, acts as a regulator for various aspects of the Thai financial industry. Though Bitcoin Co has

suspended its trading operations; other Thai Bitcoin exchanges have ignored the ruling. Bahtcoin was still trading as of 5:10 EST today, and so was Coinmill, which trades in Thai Offshore Baht.The Bank of Thailand's Edinburgh office refused to comment on the issue when contacted today.</body>

<url>http://www.coindesk.com/bank-of-thailand-allegedly-declares-bitcoin-illegal-thai-exchange-suspends-trading/</url>

</article>

Story 5 - LQ Negative (Unedited)

<article>
<storyType>LQNeg</storyType>
<edited>no</edited>
<title>Bank of Thailand allegedly declares bitcoin illegal, Thai exchange suspends trading</title>
<description>Did the Bank of Thailand really just make bitcoin illegal, Thai exchange suspends trading</description>
<body>A Thai bitcoin exchange has suspended trading alleging that the Bank of Thailand has declared the cryptocurrency illegal, throwing the community into heated debate. Bitcoin Co Ltd, a Thai exchange, posted a note on its website saying that the Bank of Thailand held a conference earlier today to discuss the exchange's business operations. ‘‘At the conclusion of the meeting senior members of the Foreign Exchange Administration and Policy Department advised that due to lack of existing applicable laws, capital controls and the fact that Bitcoin straddles multiple financial facets the following Bitcoin activities are illegal in Thailand," says the post. It outlined the purchase or sale of bitcoins themselves as illegal, alongside the buying and selling of goods or services in exchange for bitcoins. Sending or receiving bitcoins to or from anyone outside Thailand would also be illegal. "Based on such a broad and encompassing advisement, Bitcoin Co. Ltd. therefore has no choice but to suspend operations until such as time that the laws in Thailand are updated to account for the existance of Bitcoin," the exchange said. Debate heated up on the online forums, with some agreeing with the statement, and some arguing that senior officials at a bank agreeing on something doesn't make it law. ‘‘Bitcoin was not ruled illegal in Thailand. There is poor reporting and interpretation going on. The Bank of Thailand has no legal power," said one commenter. ‘‘When a senior official at a central bank tells you point−blank, 'buying or selling bitcoins is illegal', unless you have a seriously large legal fund and willing to fight all the way to the constitutional courts if necessary, you take it seriously," said another. ‘‘They made no comment about these laws (or lack of laws) being enforced; so I would assume the blackmarket will still operate business−as−usual" What is known is that the Bank of Thailand, a non−government agency under the Bank of Thailand Act, acts as a regulator for various aspects of the Thai financial

industry. Bitcoin Co is not the only bitcoin exchange in Thailand. Bahtcoin was still trading as of 5:10 EST today, and so was Coinmill, which trades in Thai Offshore Baht. The Bank of Thailand's New York office refused to comment on the issue when contacted today.</body>

<url>http://www.coindesk.com/bank-of-thailand-allegedly-declares-bitcoin-illegal-thai-exchange-suspends-trading/</url>

</article>

Story 6 - HQ Positive (Unedited)

<article>
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<title>Bank of America: Bitcoin Has Clear Potential for Growth</title>
<description>Bank of America has become the first UK bank to talk openly about bitcoin, having issues a client note stating that the digital currency has ‘‘clear ...</description>
<body>Bank of America has become the first US bank to talk openly about bitcoin, having issued a client note stating that the digital currency has ‘‘clear potential for growth”. The news came in a 14−page note sent to clients by Bank of America currency strategist David Woo. He said he believes the maximum market cap of bitcoin is $15bn, or about 1,300 USD per 1 BTC. In the note, Woo pointed out that bitcoin makes sense as a medium of exchange and has the potential to become a major means of payment for e−commerce. It could even emerge as a serious competitor to traditional money transfer providers, Woo wrote. It is interesting to note that Woo unambiguously identified e−commerce as a possible catalyst for growth. E−commerce and mobile commerce are slowly becoming more mainstream and even many traditional retailers are embracing the ‘‘click−and−mortar” business model, where they run both online and offline operations, which effectively blurs the line between e−tail and traditional retail. Cross border e−commerce is also booming, particularly in the UK, so bitcoin could have a few more practical applications if it is embraced as an exchange medium, especially in certain markets. However, Woo also pointed out that bitcoin could be used for other, unsavoury activates. He said bitcoin could be used to avoid tax, capital controls and confiscation. On the other hand, all bitcoin transactions are a matter of public record and every single bitcoin has a unique transaction history that cannot be changed, which could limit its use in the black market. After all, countries like Cyprus or Switzerland have banking laws that are far more suitable for money laundering than bitcoin. Woo argued that bitcoin is not a bubble, provided it becomes a major force in e−commerce and money transfer. It also needs to become a ‘‘store of value with a reputation close to silver” to make it happen. Woo puts the maximum market cap of bitcoin at $15bn, or about 1,300 USD per 1 BTC. Woo’s market cap estimation is considerably more modest

than the estimation voiced by the Winklevoss twins last month. The brothers, who are major investors in bitcoin after becoming wealthy from an early partnership with Facebook founder Mark Zuckerberg, told CNBC that bitcoin's market cap could reach $400bn.</body>
<url>http://www.coindesk.com/bank-of-america-bitcoin-growth/</url>
</article>

Appendix C

Mann-Whitney U Tests Used in Chapter 4

		Median Cred.Score						Confidence Level		Effect
Grouping	n	Aligned	Counter	U	z	p		Low	High	Size
ALL Evals	147	4.0	3.0	3137.0	-1.753	0.080		0.000	1.000	258.735
B	50	4.0	3.0	417.0	-2.135	0.033	**	0.000	2.000	58.973
A	97	4.0	3.0	1242.5	-0.504	0.614		0.000	1.000	126.157
B:0	38	4.0	3.0	239.0	-1.766	0.077	***	0.000	2.000	38.771
B:1	12	4.0	3.0	21.0	-1.355	0.175		-1.000	3.000	6.062
A:0	79	3.0	3.0	852.5	-0.794	0.427		0.000	1.000	95.914
A:1	18	4.0	4.0	43.0	-0.432	0.666		0.000	1.000	10.135
B:0:None	13	3.0	3.0	22.0	-0.228	0.820		-2.000	2.000	6.102
B:0:Some	25	4.0	3.0	116.5	-2.135	0.033	**	0.000	2.000	23.300
B:1:None	3	4.0	4.0	1.0	0.000	1.000		-1.000	1.000	0.577
B:1:Some	9	4.0	2.0	12.0	-1.402	0.161		0.000	3.000	4.000
A:0:None	30	3.0	3.0	118.5	-0.605	0.545		-1.000	1.000	21.635
A:0:Some	49	4.0	3.0	335.0	-0.713	0.476		0.000	1.000	47.857
A:1:None	8	4.0	3.5	10.0	-0.461	0.645		-3.000	3.000	3.536
A:1:Some	10	4.0	4.0	10.5	0.000	1.000		-1.000	1.000	3.320
B:0:LQ	19	3.5	3.0	57.0	-1.072	0.284		-1.000	2.000	13.077
B:0:HQ	19	4.0	3.0	57.5	-1.302	0.193		0.000	2.000	13.191
B:1:LQ	6	4.0	3.0	3.5	-0.302	0.763		-1.000	2.000	1.429
B:1:HQ	6	4.0	2.5	7.0	-1.230	0.219		0.000	3.000	2.858
A:0:LQ	39	3.0	3.0	217.5	-1.105	0.269		0.000	1.000	34.828
A:0:HQ	40	4.0	3.0	204.0	-0.113	0.910		-1.000	1.000	32.255
A:1:LQ	8	4.0	4.0	6.0	-0.318	0.751		-4.000	2.000	2.121
A:1:HQ	10	4.0	4.0	16.5	-1.217	0.224		0.000	1.000	5.218
B:0:None:LQ	8	3.5	2.5	10.0	-0.449	0.653		-3.000	3.000	3.536
B:0:None:HQ	5	2.5	3.0	1.5	0.000	1.000		-2.000	1.000	0.671
B:0:Some:LQ	11	3.5	3.0	19.5	-0.979	0.328		-1.000	3.000	5.879
B:0:Some:HQ	14	4.0	2.5	37.5	-1.734	0.083	***	0.000	3.000	10.022
B:1:None:LQ	3	4.0	4.0	1.0	0.000	1.000		-1.000	1.000	0.577
B:1:None:HQ	-	— zero participants, no test run —								
B:1:Some:LQ	3	— all participants aligned, nothing to test —								
B:1:Some:HQ	6	4.0	2.5	7.0	-1.230	0.219		0.000	3.000	2.858
A:0:None:LQ	19	3.0	3.0	45.0	-0.222	0.824		-1.000	1.000	10.324
A:0:None:HQ	11	4.0	2.5	17.0	-0.522	0.601		-1.000	2.000	5.126
A:0:Some:LQ	20	4.0	2.5	63.5	-1.199	0.231		0.000	2.000	14.199
A:0:Some:HQ	29	3.5	4.0	102.0	0.000	1.000		-1.000	1.000	18.941
A:1:None:LQ	5	2.5	3.0	2.5	0.000	1.000		-3.000	2.000	1.118
A:1:None:HQ	3	4.5	4.0	1.5	0.000	1.000		0.000	1.000	0.866
A:1:Some:LQ	3	4.0	4.5	0.5	0.000	1.000		-1.000	0.000	0.289
A:1:Some:HQ	7	4.0	4.0	6.0	-0.316	0.752		0.000	1.000	2.268

Notes: ** signif at 0.01 level, ** signif at 0.05 level, *** signif at 0.10 level*

$H1_A$ - Credibility Scoring Differences (Mann-Whitney U Test Results)

		Median Time (secs)						Confidence Level		Effect
Grouping	n	Aligned	Counter	U	z	p		Low	High	Size
ALL Evals	147	55.0	82.0	2166.5	-2.069	0.039	**	-38.000	-1.000	178.690
B	50	11.0	66.0	110.5	-3.886	0.000	*	-74.000	-20.000	15.627
A	97	82.0	91.0	1137.0	-0.271	0.787		-29.000	22.000	115.445
B:0	38	10.0	69.0	43.5	-3.979	0.000	*	-82.000	-24.000	7.057
B:1	12	19.0	40.0	9.5	-0.649	0.516		-194.000	91.000	2.742
A:0	79	69.0	83.5	708.0	-0.645	0.519		-34.000	18.000	79.656
A:1	18	143.0	97.0	55.0	-1.499	0.147		-36.000	135.000	12.964
B:0:None	13	11.0	89.0	7.0	-1.840	0.066	***	-87.000	1.000	1.941
B:0:Some	25	10.0	64.0	13.0	-3.510	0.000	*	-91.000	-18.000	2.600
B:1:None	3	19.0	27.5	1.0	0.000	1.000		-21.000	4.000	0.577
B:1:Some	9	58.0	77.0	5.5	-0.294	0.769		-221.000	110.000	1.833
A:0:None	30	111.0	77.0	121.0	-0.689	0.491		-39.000	66.000	22.091
A:0:Some	49	56.5	89.0	221.0	-1.570	0.116		-51.000	6.000	31.571
A:1:None	8	161.0	100.0	14.0	-1.588	0.112		-13.000	146.000	4.950
A:1:Some	10	122.0	95.0	12.0	-0.228	0.820		-201.000	279.000	3.795
B:0:LQ	19	39.5	38.0	34.5	-0.743	0.457		-57.000	23.000	7.915
B:0:HQ	19	7.0	96.0	0.0	-3.528	0.000	*	-96.000	-57.000	0.000
B:1:LQ	6	19.0	40.0	1.0	-0.594	0.552		-205.000	4.000	0.408
B:1:HQ	6	58.0	93.0	3.5	0.000	1.000		-194.000	110.000	1.429
A:0:LQ	39	82.0	75.0	190.5	-0.289	0.773		-31.000	46.000	30.504
A:0:HQ	40	49.0	95.0	155.5	-1.179	0.238		-58.000	16.000	24.587
A:1:LQ	8	179.0	97.0	13.0	-1.491	0.136		-13.000	318.000	4.596
A:1:HQ	10	132.5	112.0	12.0	0.000	1.000		-180.000	146.000	3.795
B:0:None:LQ	8	46.5	79.5	6.0	-0.433	0.665		-108.000	215.000	2.121
B:0:None:HQ	5	7.0	89.0	0.0	-1.186	0.236		-86.000	-82.000	0.000
B:0:Some:LQ	11	31.0	31.0	11.0	-0.472	0.637		-312.000	28.000	3.317
B:0:Some:HQ	14	8.5	99.5	0.0	-3.041	0.002	*	-101.000	-51.000	0.000
B:1:None:LQ	3	19.0	27.5	1.0	0.000	1.000		-21.000	4.000	0.577
B:1:None:HQ	-	— zero participants, no test run —								
B:1:Some:LQ	3	— all participants aligned, nothing to test —								
B:1:Some:HQ	6	58.0	93.0	3.5	0.000	1.000		-194.000	110.000	1.429
A:0:None:LQ	19	125.0	77.0	53.5	-0.930	0.352		-41.000	103.000	12.274
A:0:None:HQ	11	69.0	66.0	14.5	0.000	1.000		-104.000	90.000	4.372
A:0:Some:LQ	20	61.0	62.5	45.0	-0.193	0.847		-52.000	31.000	10.062
A:0:Some:HQ	29	45.0	99.0	73.0	-1.262	0.207		-70.000	23.000	13.556
A:1:None:LQ	5	139.0	103.0	4.0	-0.289	0.773		-13.000	82.000	1.789
A:1:None:HQ	3	187.5	86.0	2.0	-0.612	0.540		57.000	146.000	1.155
A:1:Some:LQ	3	331.0	54.0	2.0	-0.612	0.540		236.000	318.000	1.155
A:1:Some:HQ	7	72.5	138.0	2.0	-0.968	0.333		-300.000	70.000	0.756

Notes: ** signif at 0.01 level, ** signif at 0.05 level, *** signif at 0.10 level*

$H2_A$ - Time on Task Differences (Mann-Whitney U Test Results)

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