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**On the Possibility of a More Stable Financial System: Virtual  
Currency and a Competitive Currency Scheme**

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**ABSTRACT**

The financial crisis of 2008 and subsequent “Great Recession” have called the efficacy of many major U.S. government and financial institutions into question. The US Federal Government and the Federal Reserve have used various monetary policy tools such as interest rate manipulation, liquidity injection, and increased regulation to mend an erratic and fundamentally unstable system. This paper builds from the foundation of a new system envisioned by F.A. Hayek, in which a government monopoly on the production and control of a single, nationwide currency is removed and replaced with a number of competing, private issuers of currency who are subject to some degree of regulatory oversight. It explores the possibility of using virtual currencies in the context of a competing currency scheme in order to enable such a system to function in a stable manner. The author concludes that the advent of virtual currencies does not solve the innately human problems that have manifested themselves in the financial sector, and which will continue to trickle down into the economy if not properly addressed, but that virtual currencies will play an important role in reducing the high barriers of entry to producing and controlling a stable, and thus useful, currency.

## INTRODUCTION

“It has been said that capitalist economies are like drunks—they have trouble moving in a straight line.”<sup>1</sup> Indeed, a review of the past century of economic activity in the U.S. would suggest that the booms and busts of the business cycle are an unavoidable outcome of the policies and institutions that make up our economy. Time and time again the general population faces the jarring destruction of jobs, contraction of wealth, loss of confidence, and increase in poverty and sickness that accompany each new recession.

Most recently, the U.S. economy experienced a serious financial meltdown during the subprime mortgage crisis that caused “The Great Recession” of 2007 to 2009. Six years later, economic growth remains anemic, and the faith of the American public in the efficacy of both monetary and fiscal policy has been strained. The aim of my research is to answer the following question: can the recent advent and popularity of virtual, block chain-based currencies benefit the current financial and economic system within the United States?

The first section provides a brief overview of the financial crisis of 2008 and a review of the subsequent monetary policy actions that were taken to stabilize the economy. The second section introduces the reader to the basic workings of Bitcoin, the largest virtual currency to date with a market cap of over \$3.6 billion as of March 21, 2015.<sup>2</sup> The third section examines Hayek’s argument in favor of a competitive currency market in the context of virtual currencies, exploring how this new technology might enable a competitive currency scheme within the United States.

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<sup>1</sup> Knoop [36], p. xiii.

<sup>2</sup> “Bitcoin Market Capitalization,” [6].

## 1) BACKGROUND: THE FINANCIAL CRISIS

In this section I define the terms needed to discuss the Financial Crisis and subsequent Great Recession, before exploring the failures in the financial system that caused this economic breakdown. I outline the monetary policy implemented by the Federal Reserve and the fiscal policy implemented by Congress and the federal government in an attempt to slow or halt the recession. Finally, I examine the extent to which these policies have achieved their desired outcomes six years after the official end of the Great Recession.

### *1.1. Defining a Recession*

What is a recession? For many, a recession is a period of time where there is suddenly and often inexplicably, a lot less to go around. It is a dark malaise that settles over the entire country, tightening belts, pushing retirement off into the future, reducing pensions, straining budgets, and souring nationalistic and optimistic sentiments.

The National Bureau of Economic Research (NBER) defines a recession as “a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real Gross Domestic Product (GDP), real income, employment, industrial production, and wholesale retail-sales.”<sup>3</sup> The majority of economists, academics, and policy-makers accept this definition as the most useful and accurate way to identify a period of economic trouble. Peaks in GDP growth mark a downward turn towards recession and troughs mark an

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<sup>3</sup> “Business Cycle Dating Committee, National Bureau of Economic Research,” [10].

upward turn towards expansion. The gray shaded area in Figure 1 indicates a recession, and roughly correlates with the local extrema of the Real GDP curve.

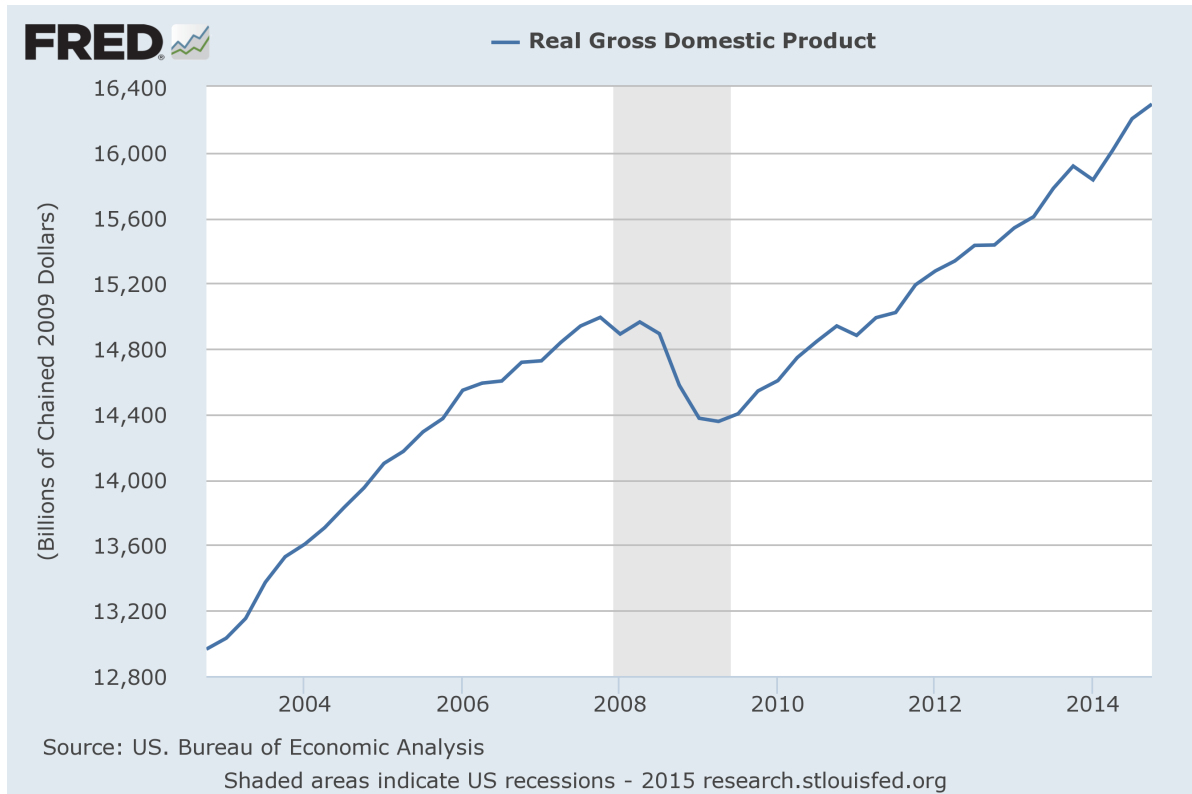


Figure 1. Real GDP as measured quarterly from October 2002 to October 2014. Real GDP differs from nominal GDP in that it is adjusted for inflation.

According to the NBER, the Great Recession began in December 2007 and ended in June 2009. During this time, real US GDP fell 5.1%<sup>4</sup> while the civilian unemployment rate increased from 5.0% to 9.5%, peaking at 10.0% in November 2009.<sup>5</sup> The stock market, as measured by the S&P 500, fell 57% from its peak in October of 2007 to a low in March 2009. Overall, individual

<sup>4</sup> “Changes in U.S. Family Finances,” [11], p. 4.

<sup>5</sup> “Civilian Unemployment Rate,” [12].

median net worth fell 38.8%, while the median net worth of households headed by 35-44 year-old individuals fell 54.4% due to the contraction of the housing market.<sup>6</sup>

### *1.2. Causes of The “Great Recession” of 2008*

The causes of the Great Recession have been studied in great detail. The Financial Crisis Inquiry Commission (FCIC), a 10-person panel of private citizens with extensive political, academic, legal, and business experience, was created under the Fraud Enforcement and Recovery Act, a law designed to examine the causes of the financial crisis and to enhance the criminal enforcement of federal fraud laws.<sup>7</sup> The FCIC conducted a yearlong investigation, auditing millions of documents and interviewing hundreds of individuals, in order to produce a 622 page account of the financial crisis. The FCIC summarized their findings in the following manner:

We conclude that this financial crisis was avoidable. The crisis was the result of human action and inaction, not of Mother Nature or computer models gone haywire. The captains of finance and the public stewards of our financial systems ignored warnings and failed to question, understand, and manage evolving risks within a system essential to the well-being of the American public... The prime example is the Federal Reserve’s pivotal failure to stem the flow of toxic mortgages, which it could have done by setting prudent mortgage-lending standards. The Federal Reserve was the one entity empowered to do so and it did not.<sup>8</sup>

Following from this overarching conclusion, the FCIC highlights the key points of failure within the financial system:

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<sup>6</sup> “Changes in U.S. Family Finances,” [11], pp. 20-21.

<sup>7</sup> “The Financial Crisis Inquiry Report” [56].

<sup>8</sup> “Conclusions of the Financial Crisis Inquiry Commission,” [13], p. xvii.

- We conclude that widespread failures in financial regulation and supervision proved devastating to the stability of the nation's markets.
- We conclude dramatic failures of corporate governance and risk management at many systemically important financial institutions were a key cause of this crisis.
- We conclude a combination of excessive borrowing, risky investments, and lack of transparency put the financial system on a collision course with crisis.
- We conclude the government was ill prepared for the crisis, and its inconsistent response added to the uncertainty and panic in the financial markets.
- We conclude there was a systemic breakdown in accountability and ethics.<sup>9</sup>

The report continually emphasizes the deterioration of *human* factors that directly caused the financial crisis: unsupervised greed, a general lack of ethics and preparation, and dangerously risky behavior are reoccurring themes that are chronicled in an exhaustive manner.

Andrew Lo, a professor at the MIT Sloan School of Management, provides a comprehensive literature review of twenty-one publications (both academic and journalistic in nature) that aim to explore and explain the financial crisis and great recession.

Main themes that emerge from his research expand on the findings of the FCIC:

- Risk was systematically underpriced due to the financial sector's expectation that the government would intervene to support large banks,
- Financial institutions used securitization in order to reduce the transparency of risk, leading to large amounts of asymmetric information in the market,
- Subprime lenders took advantage of borrower ignorance, and savvy borrowers exploited "strategic defaults" (it is unclear which side profited more),

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<sup>9</sup> *Ibid.*, pp. xvii-xxii.



- Financial deregulation under Reagan allowed a large and increasing degree of regulatory capture by an oligarchy of bankers,
- A flawed privatization of Fannie Mae (and later Freddy Mac) allowed the organization to participate in equity markets as a publicly traded company while financial institutions believed that they were implicitly insured by the government. They were mismanaged, presided over huge amounts of assets, and were politically untouchable due to bipartisan policy goals,
- Firms minimized their own risk by transferring it to those members of society least able to interpret and handle that risk.<sup>10</sup>

He concludes that “there is still significant disagreement as to what the underlying causes of the crisis were, and even less agreement as to what to do about it. But what may be more disconcerting for most economists is the fact that we can’t even agree on all the facts.”<sup>11</sup>

It is unrealistic to think human faults such as excess greed and a lack of altruism can be completely removed from any inherently human system, but it is the extreme degree to which these faults were allowed to grow and corrupt some of the most important institutions in the United States that serves as a call to action for reform. As the FCIC states, “the greatest tragedy would be to accept the refrain that no one could have seen this coming and thus nothing could be done. If we accept this notion, it will happen again.”<sup>12</sup> Before we explore how virtual currency may or may not be a viable instrument of financial reform, it is important to examine how the

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<sup>10</sup> Lo [38].

<sup>11</sup> *Ibid.*, p. 173.

<sup>12</sup> “Conclusions of the Financial Crisis Inquiry Commission,” [13], p. xxviii.

Federal Reserve and the US government responded to the crisis, and how the economy is faring as a result of these policies to see whether or not the root causes highlighted by the FCIC have been sufficiently addressed.

### *1.3. Background, and A Timeline of Major Events*

From the 2001-2007 timeframe, low interest rates in the U.S. and Europe following the 2001 recession led investors to demand a new source of high-yield investments. Mortgage rates fell in tandem with interest rates, allowing a surge in home refinancing from \$460 billion in 2000 to \$2.8 trillion in 2003.<sup>13</sup> Home prices “about doubled” in more than 110 metropolitan areas as “low interest rates and then foreign capital” helped fuel the speculative real estate purchasing boom. Overall mortgage indebtedness in the U.S. rose from \$5.3 trillion in 2001 to \$10.5 trillion in 2007, increasing “almost as much in the six years from 2001 to 2007 as it had over the course of the country’s more than 200-year history.”<sup>14</sup>

Meanwhile, large financial institutions created derivative products in order to capture and sell the high returns from the real estate market to investors eager for a source of above-average returns. These products were often tied to the performance of mortgage and home loan payments, but were far removed from the original agreements and/or packaged in with other products, making it difficult to determine the product’s actual risk. While securitization, when done correctly, can be crucial to freeing up and allocating capital correctly, the process was abused in many cases to create complexity in the financial product markets.

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<sup>13</sup> “The Financial Crisis Inquiry Report,” [56], p. 5.

<sup>14</sup> *Ibid.*, p. 7.

The Federal Reserve Bank of St. Louis provides a thorough timeline<sup>15</sup> of key events throughout the crisis, which I will summarize here.

On February 27<sup>th</sup> 2007, The Federal Home Loan Mortgage Corporation (*Freddie Mac*) announces that it will no longer buy the lowest-rated subprime mortgages and mortgage-related securities. On June 1<sup>st</sup>, four months later, Standard and Poor's and Moody's Investor Services downgrades more than 100 sub-prime mortgage backed bonds. One month after the large-scale downgrade, Standard & Poor's places another 612 subprime mortgage-back securities on credit watch. On August 17<sup>th</sup> the Federal Reserve votes to reduce the Federal Funds Rate (FFR) 50 basis points to 5.75 percent, the first of many coming FFR adjustments that are explored in more detail in the next section. On March 24<sup>th</sup> 2008, Bear Stearns, one of the investment banks that was heavily involved in the securitization of sub-prime debt, files for bankruptcy and is liquidated to JP Morgan for \$10 per share, discounted over 92% from its pre-crisis 52-week high price of \$133.30, up from the announced \$2.00 per share agreement with JP Morgan announced on March 17<sup>th</sup>.

On July 30<sup>th</sup> 2008, President George Bush signs the Housing and Economic Recovery Act of 2008 (Public Law 110-289) into law, which “authorizes the Treasury to purchase [Government Sponsored Enterprise (GSE)] obligations and reforms the regulatory supervision of the GSEs under a new Federal Housing Finance Agency.”<sup>16</sup> The Federal Reserve votes to maintain a target FFR of 2.00% in August, 2008. One month later the Federal Housing Finance Agency (FHFA)

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<sup>15</sup> “Full Timeline,” [23].

<sup>16</sup> *Ibid.*

places Fannie Mae and Freddie Mac in government conservatorship, increasing the government's net liabilities in order to increase liquidity and ensure GSE solvency. The following week, on September 15<sup>th</sup> 2008, Lehman Brothers files for Chapter 11 bankruptcy protection. The next day, the Federal Reserve board authorizes the Federal Reserve Bank of New York to lend up to \$85 billion to the American International Group (AIG). Shocks to the financial system are coming daily now, and the Federal Reserve is forced to temporarily ban the short selling of financial sector equities. On September 20<sup>th</sup>, the Treasury Department submits draft legislation to Congress that would allow the purchase of troubled assets. This legislation is rejected by the House of Representatives on September 29<sup>th</sup>.

Congress passes and President Bush signs into law the \$700 billion Troubled Assets Relief Program (TARP) on October 3rd, 2008.<sup>17</sup> On October 6th, the Federal Reserve Board announces that the Fed will, for the first time in the history of the institution, “pay interest on depository institutions’ required and excess reserve balances at an average of the federal funds target rate less 10 basis points on required reserves and less 75 basis points on excess reserves.”<sup>18</sup> On October 14th, the Treasury Department announces that \$250 billion in TARP funds have been set aside to purchase preferred stock in financial institutions. Nine large institutions announce their intentions to subscribe to the facility in an aggregate amount of \$125 billion. On October 29th, the FOMC votes to reduce the FFR rate to 1.00%.

On November 12<sup>th</sup> 2008, U.S. Treasury Secretary Paulson formally announces that the Treasury has decided against using TARP funds to purchase illiquid mortgage-related assets

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<sup>17</sup> Formally known as the Emergency Economic Stabilization Act of 2008 (Public Law 110-343).

<sup>18</sup> *Ibid.* This is a major change in monetary policy that was designed, at the time, to reduce risk by incentivizing banks to hold more excess reserves with the Fed and earn the promised risk-free rate of interest.

from financial institutions. On November 17<sup>th</sup>, three large life insurance companies testify before Congress in order to request access to the TARP funds. Executives of Ford, General Motors, and Chrysler testify on the following day. Over the following months, hundreds of billions in TARP funds are disbursed to various institutions. Congress grants President-Elect Obama use of the remaining \$350 billion in TARP funding. The worst of the crisis is now past, and much of the following activity revolves around the government purchase of preferred equity in hundreds of corporations, and actions by Congress, the Treasury Department, and the Federal Reserve to extend lines of credit and increase liquidity within the economy.

#### *1.4. Reaction to the Crisis: Federal Funds Rate*

After the collapse of the mortgage-backed securities market in late 2007, the Federal Reserve quickly lowered its benchmark interest rate, The Federal Funds Rate (FFR), which is the interest rate at which banks can loan reserves to one another. The FFR dropped from 5.25% in June 2007 to 0.4% in November 2008 [Figure 2]. Traditional economic theory posits that lower interest rates stimulate business spending on capital goods (plant, property, equipment) and consumer spending on durable goods, such as homes and cars due to lower levels of interest payments now relative to the future, when the Fed is expected to push interest rates back up.<sup>19</sup>

How did interest rates respond to the low FFR? Short-term interest rates, such as the 6-month treasury bill, are highly correlated with the FFR and responded immediately, moving

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<sup>19</sup> Kliesen [35].

almost in lock step with FFR rates [Figure 2].<sup>20</sup> Long-term interest rates are less correlated with the FFR and have gradually decoupled from movements in the FFR over the past 30 years.<sup>21</sup> The discrepancy in the tightness of the short-term and long-term responses to changes in the FFR is due to the fact that short-term interest rates represent economic reality whereas long-term interest rates represent economic expectations.

Consider an economy where investors believe there are a declining number of lucrative short-term investments available. This pessimism will drive an increasing number of investors to purchase safe, long-term securities, such as 10-Year Treasury Bills, reducing the supply of these investments which in turn increases their price. Price and Yield to Maturity (YTM) are inversely correlated, so an increase in price causes the YTM, or the real interest rate of the bond, to decrease.<sup>22</sup> Figure 2 shows that the YTM on 10-Year Treasury Bills has steadily declined over the past 30 years, reaching a record low of 1.53% in July 2012.

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<sup>20</sup> “Given the Relatively Small Size of the Federal Funds Market, Why Are All Short-term Rates Tied to the Federal Funds Rate?” [25].

<sup>21</sup> Cömert [12], p. 6.

<sup>22</sup> The yield to maturity (YTM) of a bond can be thought of as the real rate of interest paid by the bond each year until the bond expires. Stated formally,  $P = \sum_{t=1}^n \frac{C}{(1+r)^t} + \frac{M}{(1+r)^n}$  where  $P$  is the price of the bond,  $C$  is the coupon rate,  $r$  is the required rate of return (YTM),  $n$  is the number of periods,  $t$  is the time period in which the payment is to be received, and  $M$  is the value of the bond at maturity. The equation is basically an annuity calculation with an extra term for the repayment of the principal (usually \$1,000) at time  $n$ . Price and YTM are inversely related.

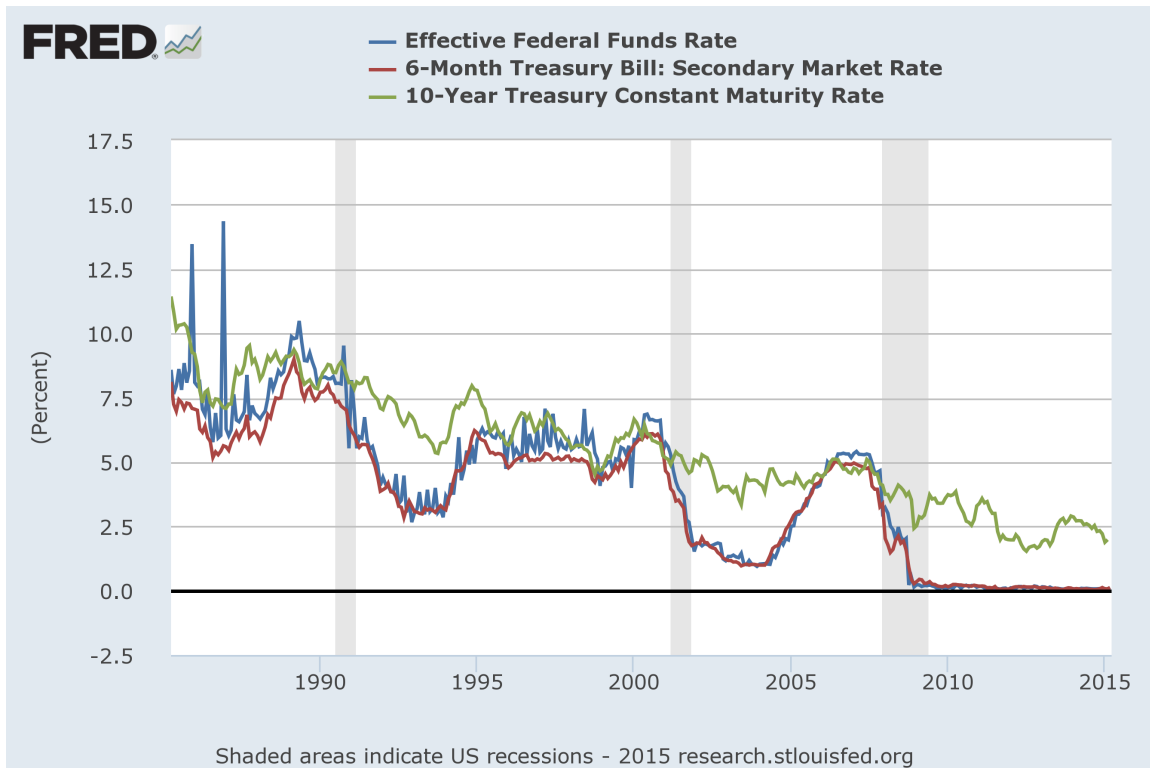


Figure 2. Comparison of the Effective FFR, short-term interest rates, and long-term interest rates on US Treasury Bills.

The problem that the Fed quickly ran into was the “lower bound” of 0% short-term interest rates – if the Fed was to drop the FFR below 0%, effectively taxing banks for holding money, banks would simply exchange any non-mandated<sup>23</sup> Treasury bonds for cash or other securities in order to avoid paying interest on these negative-yield bonds. Once banks have traded their Treasury bond reserves for cash, the FFR loses much of its power because the banks are no longer trading within the Federal Reserve System, making the FFR, the rate at which they can loan reserves to one another, irrelevant.<sup>24</sup>

<sup>23</sup> Banks are forced to hold some minimum fraction of customer deposits and notes in the form of cash or Treasury bonds that are held at the central bank. The fraction, known as a “Reserve requirement”, is determined by the central bank. Increasing the requirement reduces liquidity, as banks consequently have less funds to loan out to consumers and must hold secure each loan against an increased amount of actual currency.

<sup>24</sup> Eggertsson [20], p. 2.

Guidance from the Fed regarding the FFR has become steadily less credible and transparent. Between January 2009 and December 2013, the Federal Reserve had consistently reaffirmed in its quarterly Federal Open Market Committee (FOMC) statements that the “exceptionally low target range for the federal funds rate of 0 to 1/4 percent will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent.”<sup>25</sup> The general unemployment rate fell below 6.5% in April 2013, but the Federal Reserve did not raise the FFR.<sup>26</sup> Instead, the Fed has removed all specific contingency clauses regarding interest rates and made no further mention of any metric that would be tied to a rate hike. The following is an excerpt from the latest FOMC statement (January 2015) which is intended to clarify the Fed’s rationale for continuing to maintain a low FFR rate and provide forward guidance on when investors and the general public can expect to see a rate hike:

Based on its current assessment, the Committee judges that it can be patient in beginning to normalize the stance of monetary policy. However, if incoming information indicates faster progress toward the Committee’s employment and inflation objectives than the Committee now expects, then increases in the target range for the federal funds rate are likely to occur sooner than currently anticipated. Conversely, if progress proves slower than expected, then increases in the target range are likely to occur later than currently anticipated.<sup>27</sup>

This update hardly constitutes guidance. The Fed has broken its commitment to raise interest rates at a certain unemployment threshold, and can no longer offer any more clarity than a simple “wait and see” policy with no discussion of specific contingencies or even the basic rationale behind this decision.

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<sup>25</sup> See the Federal Reserve’s December 18<sup>th</sup>, 2008 Press Release [45].

<sup>26</sup> “Civilian Unemployment Rate,” [11].

<sup>27</sup> See the Federal Reserve’s January 28<sup>th</sup> 2015 Press Release [47].



Federal Reserve Chairwoman Janet Yellen stressed the importance of credibility and transparency in a 2006 speech entitled “Enhancing Fed Credibility.” In the speech, she advocates for greater measures of transparency and credibility:

My personal view is that the steps that we have already taken toward greater transparency have been a good thing, and that we should think seriously about venturing further along this path. As Mae West famously said, “Too much of a good thing can be wonderful.” More seriously, although it is possible to carry transparency too far—I would not, for example, want live television coverage of FOMC meetings—I support the idea of a quantitative objective for price stability. I believe that it enhances both Fed transparency and accountability and that it offers important benefits, as I have discussed. In particular, it could help to anchor the public’s long-term inflation expectations from being pushed too far up or down, and thus help avoid both destabilizing inflation scares and deflations; a credible inflation objective could thereby enhance the flexibility of monetary policy to respond to the real effects of adverse shocks.<sup>28</sup>

Chairwoman Yellen and her fellow economist at the Fed understand the need for accountability and transparency. It is worrying that the institution’s efforts to stabilize the economy with regards to the FFR have necessitated a deterioration of these core values.

We will return to the relationship between interest rates, the FFR, and inflation targeting in more detail later when we discuss Hayek’s argument for the denationalization of currency. For now, it is sufficient to point out that the FFR has hovered just above the zero lower bound for over five years, with the Fed unable to make any upward adjustments for fear of destabilizing an otherwise anemic economic recovery. Guidance that was once specific and contingent upon an external metric (6.5% unemployment) was obfuscated, giving the markets no new information on when to expect an increase in the FFR and short-term interest rates. Ultimately, the Fed’s inability to create a cushion by raising the FFR, and its return to opaque guidance both shed

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<sup>28</sup> Yellen [67].

doubt on the efficacy of its monetary policy, and more fundamentally, its ability to control one of its most important policy tools.

### *1.5. Reaction to the Recession: TARP*

Powerless to reduce the FFR any further, the Fed faced a “problem that was long treated as a mere theoretical curiosity after having been raised by Keynes (1936) — namely, the question of what can be done to stabilize the economy when interest rates have fallen to a level below which they cannot be driven by further monetary expansion, and whether monetary policy can be effective at all under such circumstances.”<sup>29</sup> In order to stimulate the economy through an alternate channel, the Federal Government and the Federal Reserve turned to an unorthodox form of stimulus: the mass purchase of financial instruments.

In Congress, these mass asset were devised under a fiscal policy known as the Troubled Asset Relief Program (TARP), which was signed into law by President George W. Bush on October 14, 2008.<sup>30</sup> As it was originally written, TARP allowed the U.S. Department of the Treasury to purchase or insure up to \$700 billion in assets from banks and other financial institutions in exchange for equity. Moving these complex, illiquid, and difficult-to-value assets would theoretically allow the banks to stabilize their balance sheets and prevent further losses on the devaluation of these assets. Equity stakes in the participating institutions would allow the Treasury to enjoy any gains experienced by the financial institutions that received this aid. Large amounts of treasury funds would be used provide an emergency market for the trade and

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<sup>29</sup> Eggertsson [20], p. 1.

<sup>30</sup> “Troubled Asset Relief Program (TARP) Information,” [59].

deconstruction of these complex securities, cordoning off the economy from the effects of a failing securities market. Once the banks had been nursed back to health, the Treasury would be able to sell its equity positions and realize returns on its \$700 billion loan. The TARP program ended on December 19, 2014 with the Treasury sale of Ally Financial (formerly known as GMAC, the financial arm of US automaker General Motors).<sup>31</sup> The Treasury made \$15.3 billion in profit on a total of \$426 billion in loans for a total nominal return of 3.59% over the 6-year duration of the program.<sup>32</sup>

Economists have argued that the legacy costs of setting a precedent that supports too big to fail (TBTF) banks far outweigh whatever stabilizing effects TARP had on the economy during its “chaotic rollout” in 2008.<sup>33</sup> Essentially, TARP created a moral hazard, signaling that large banks would be rewarded with a bailout rather than punished for risky behavior. As discussed previously, bank failure to manage risk appropriately through the securitization process was one of the prime causes of the 2007 financial crisis. A study conducted by Black in March 2012 concluded that TARP increased risk-taking at large, TARP-assisted banks relative to small, TARP-assisted banks and all non-TARP banks.<sup>34</sup> Fortunately, there is some evidence that the Dodd–Frank Wall Street Reform and Consumer Protection Act<sup>35</sup> has been able to improve the overall market discipline of large banks.<sup>36</sup> Unfortunately, by publicly designating some banks as

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<sup>31</sup> Isidore [31].

<sup>32</sup> This simple nominal return calculation does not incorporate a discount rate or take into account returns realized at different times over the 6 year period of the program.

<sup>33</sup> Taylor [52].

<sup>34</sup> Black [8].

<sup>35</sup> “H.R. 4173 — 111th Congress: Dodd-Frank Wall Street Reform and Consumer Protection Act,” [29].

<sup>36</sup> Balasubramnian [2], p. 156.

“systematically important” and requiring that these TBTF banks undergo regular stress testing, the Dodd-Frank Act has strengthened the moral hazard, leading to a simultaneous decrease in the market discipline of these banks.<sup>37</sup> In summary, TARP seems to have been effective in the short run, allowing key companies to survive by temporarily alleviating stressed balance sheets, and returning a profit to the Treasury on issued loans. In the long term, TARP may have constructed a dangerous punishment and reward system for systemically important financial institutions in the United States.

#### *1.6. Reaction to the Recession: Quantitative Easing*

Quantitative Easing (QE) was the Federal Reserve’s monetary policy response to a crisis that it could no longer manage through FRR manipulation. Under QE, the Federal Reserve purchased financial instruments such as bonds, treasury-bills, and mortgage-backed securities from the financial institutions that made up the majority of the market for these instruments. Much like TARP, the Fed’s objective with QE was to absorb risk-bearing assets away from the financial sector and leave these institutions with the liquidity necessary to keep credit lines open, and to keep the economy running smoothly.

There have been three waves of QE thus far, starting with QE1: the purchase of \$600 billion in mortgage-backed securities in November 2008, one month after TARP was enacted. QE1 was designed with the explicit objective of lowering mortgage interest rates in order to “reduce the

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<sup>37</sup> *Ibid.*, p. 165.

cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets and foster improved conditions in financial markets more generally.”<sup>38</sup>

Palley observes that QE1 gathered the support of many Keynesian economists and that it has been criticized by monetarists, new classical macroeconomists, and members of the Austrian school of economics.<sup>39</sup> He goes on to identify five channels of expansionary effect that proponents of QE claim will have a stimulating effect on the economy:

1. A traditional Keynesian interest rate channel whereby the Fed purchases long-term bonds in order to reduce the long-term interest rates as it is unable to further reduce short term rates (zero lower bound on the FFR)
2. The “Tobin’s q” channel whereby some of the newly-generated liquidity is directed to the stock market, increasing equity prices, which would then spur investment
3. A wealth effect of higher equity and asset prices, that allows consumers and businesses to feel financially secure, allowing for increased consumption
4. Expected inflation brings consumption and investment spend forward as households and firms purchase in the present, rather than in the future, when money is expected to lose real purchasing power (i.e. increased velocity of money due to inflation)
5. Increased net exports as some of the liquidity is used to purchase foreign reserves, decreasing the exchange rate and devaluing the dollar

Let us examine each of these in turn to see if the three waves of QE have achieved their goals of stimulating the economy through these 5 channels.

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<sup>38</sup> See the Federal Reserve’s November 25<sup>th</sup> 2008 Press Release [46].

<sup>39</sup> Palley [44], p. 2.

**Channel 1: Long-term Interest Rates.** As we discussed previously, the long-term interest rate has decreased during the 3 waves of QE, but it is unclear whether or not the Federal Reserve has caused this decline in long-term interest rates. Palley observes that one criticism of QE is a Keynesian argument with a long history: “In deep recession some of the channels of QE may be blocked...in deep slumps aggregate demand is insensitive to interest rates.”<sup>40</sup> Jarrow succinctly concludes that QE had “little if any impact on long-term forwards rates. This is in contrast to the Fed’s stated intentions for the QE program.”<sup>41</sup> These observations support Cömert’s thesis that the FFR, and Federal Reserve monetary policy in general, have recently decoupled from long-term interest rates.

Still, the empirical fact remains that long-term interest rates are declining, and this presents an opportunity for debt-issuing entities, such as national governments, to issue cheap debt and raise aggregate demand by increasing spend on infrastructure and R&D. The Federal Reserve may have lost the ability to *tightly* control long-term interest rates through FFR manipulation, but we still observe a weak correlation between the two.

**Channels 2 & 3: Stock Market Wealth Effect.** The Tobin’s q channel has had a strong effect on the stock market. The NASDAQ and the Dow Jones Industrial Average have recovered and continued to surge beyond their pre-recession peaks over the QE period.<sup>42</sup> Theoretically this increase the real wealth of a broad base of consumers and investors as their securities appreciate

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<sup>40</sup> *Ibid.*, p.9.

<sup>41</sup> Jarrow [32], p. 287.

<sup>42</sup> Desilver [17].

in value. The results of an August 2014 survey by Zuckin flatly cast doubt on the efficacy of the surging stock market in improving consumer wealth sentiment:

Despite record gains on Wall Street and the stock market, few Americans say that their own finances are in a good place, and express little optimism that their situation will improve in the next year. When asked to summarize their current financial state, nearly 6 in 10 Americans rate their financial situation negatively: 40 percent say they are in “only fair” shape, and another 19 percent flatly acknowledge they are in poor shape. Only about a third of Americans say their finances are in good shape (34 percent) and just 7 percent currently describe themselves as being in excellent financial shape. Among those who are employed, 58 percent consider themselves in fair or poor shape, compared to 78 percent of those who are unemployed and looking for a job. Among the long-term unemployed, 83 percent rate themselves as being in poor or fair shape.<sup>43</sup>

Figure 3 shows the change in real personal consumption from the year before over a 30-year period. While we do observe an increase in real personal consumption during the post-recessionary, QE period, we also observe that the percentage increase in personal consumption has been stagnant at 2.5% despite the 3 rounds of QE that would have theoretically stimulated consumption at the time of their announcement.

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<sup>43</sup> See the entirety of Zuckin [68] for a comprehensive view of the economy from the average worker’s perspective.

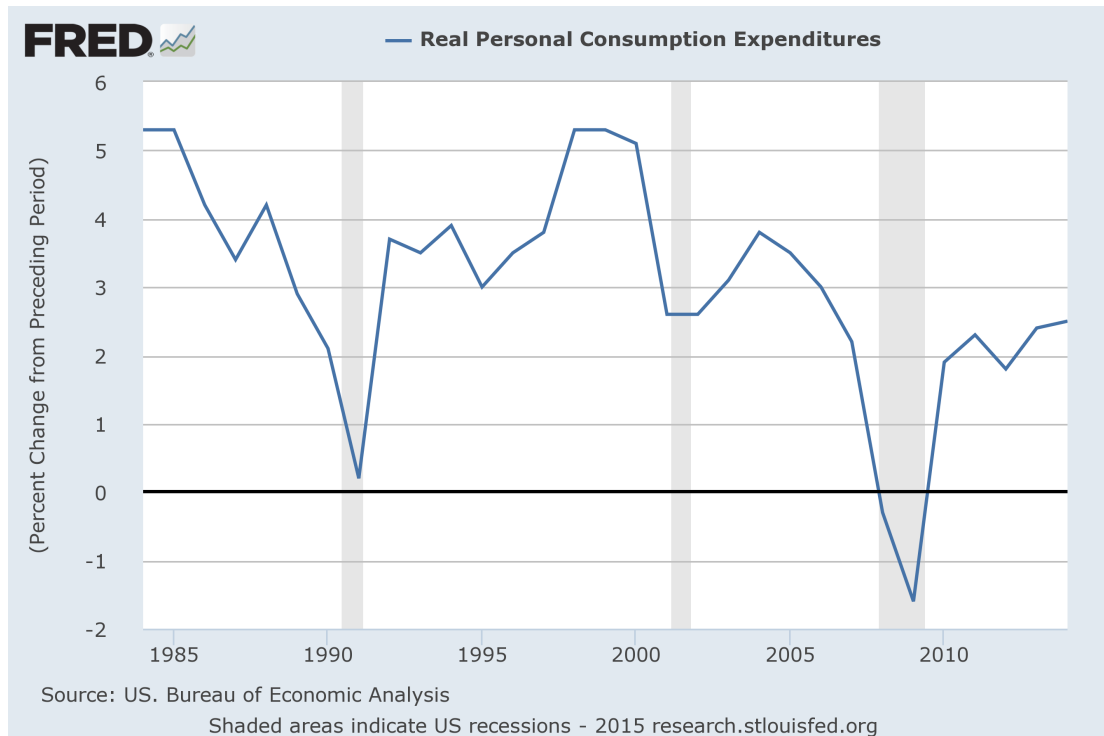


Figure 3. Percentage change in real personal consumption expenditures from previous year. Data taken from the 30-year period starting January 1984 and ending January 2014.

More importantly, we must ask if Americans *feel* that they have become wealthier due to QE, as it is the perceived increase in wealth that is posited to boost consumption. Figure 4 provides us with another view on American's self-perception of the effect of the recession on their income and savings. Over 40% of Americans still feel that they have less than they did 6 years prior. Only 7% of the general population feels that they are earning and saving a lot more relative to their pre-recession selves. In contrast, 70% of the general population feels that they are earning and saving the same or less than they were before the recession. The results are, unsurprisingly, much worse for the segment of the population that is unemployed.



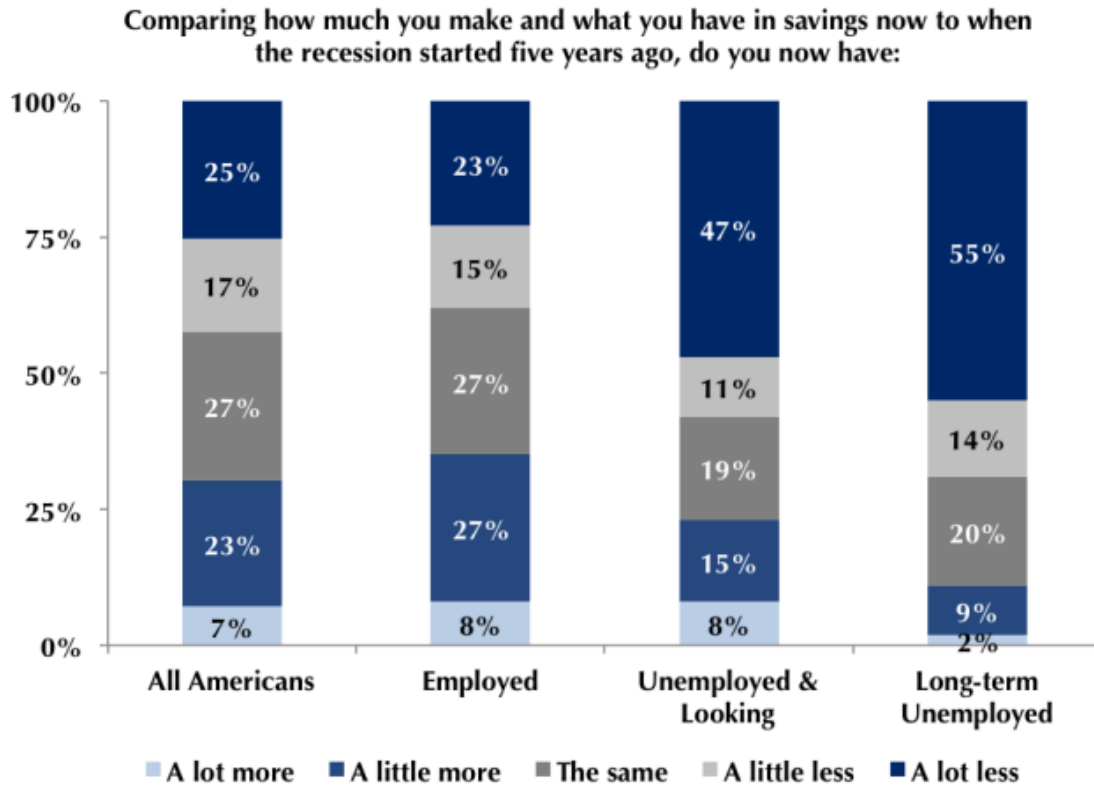


Figure 4. A comparison of how the recession has affected the consumer's self-perception of wages and savings across different employment groups as a result of the recession.<sup>44</sup>

The results of Zukin's study suggest that very few Americans would consider themselves wealthier due to the effects of QE on the stock market, calling into question the synthesis of channels 2 and 3, and the strength of the stock market and wealth effect on consumption.

**Channel 4: Inflation Expectations.** Figure 5 shows the 5-year, 5-year forward inflation expectation rate, or the rate of inflation that is expected on average over the 5-year period that begins 5 years from today. It is calculated using data on the 5-year and 10-year nominal and inflation adjusted Treasury securities. We see that the increased inflation expectations predicted

<sup>44</sup> Source: Zukin [68], Figure 6, p. 9.

under QE are absent. Inflation expectations over the QE period seem to revert to a mean of approximately 2.5%, and that they have actually begun to taper off in recent months.



Figure 5. The 5-year Forward Inflation Expectation Rate. This series is a measure of expected inflation (on average) over the five-year period that begins five years from today.

The trends that we observe in Figure 3 and Figure 5 both refute the idea that inflationary expectations have brought consumption forward from the future into the present.

**Channel 5: Increased Net Exports.** Figure 6 shows the US real Net Exports (NE) since January 1991. Real NE expresses the difference between a country's imports and its exports, adjusted for inflation. We can see an increase in NE during the recession, presumably due to the slowdown in consumption and demand for imported goods, yet we observe little to no increase in NE during the recessionary QE period. Again, the traditional Keynesian theory does not accurately predict market behavior.

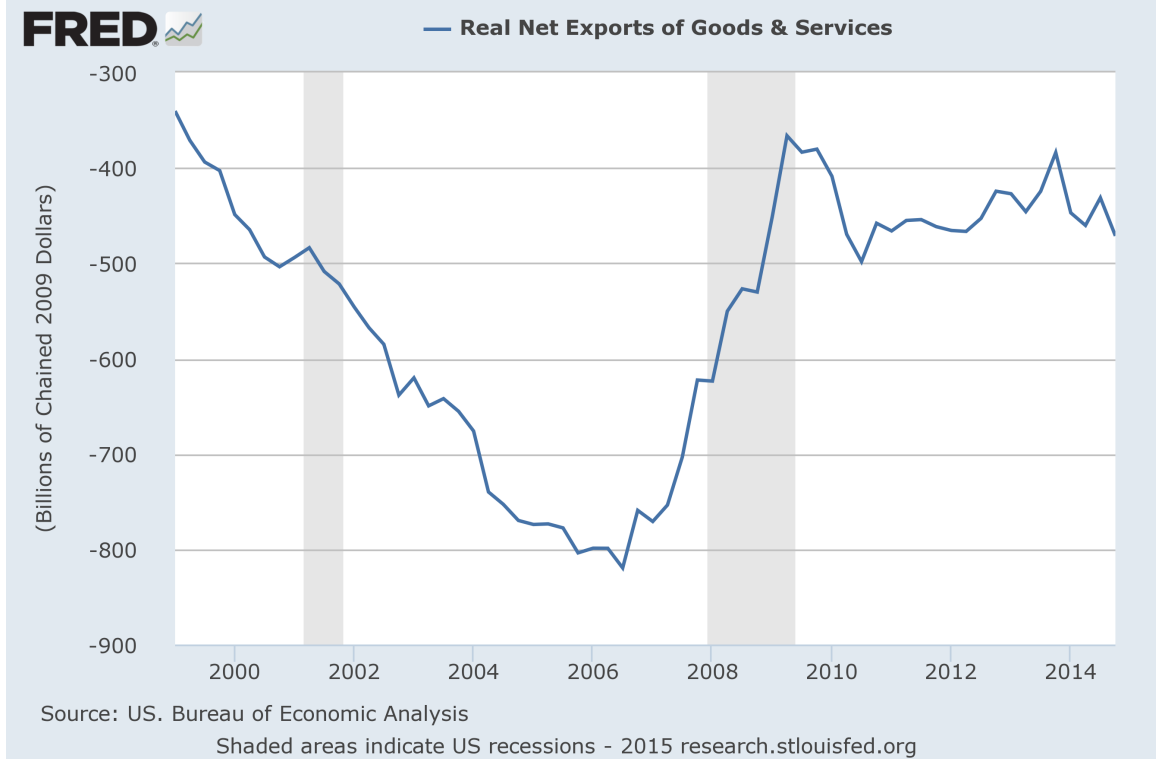


Figure 6. Real Net Exports of Goods and Services from January 1999 to the present.

We will return to the example of the QE and Net Exports in particular in the next session as we examine the “Reserve Trap” that binds the monetary policy of the Federal Reserve. Overall, it is challenging to make a strong case for the efficacy of QE. Of the five channels identified by Palley, we can only make a strong case for QE’s efficacy through the Tobin’s  $q$  channel, as evidenced by the strong recovery of the major stock market indices. Unfortunately, this gain has not translated into a broader wealth effect that would increase consumption and aggregate demand. In the next section we will explore why these injections have not influenced the channels as predicted by classical economic theory.

### 1.7. *QE Trickle-down Ineffective under “Reserve Trap”*

The Federal Reserve has tripled the Monetary Base – the sum of all paper currency, coinage, Federal Reserve notes, and Federal Reserve deposits – since the start of QE in November 2008 in order to inject liquidity into banks with the hope that a stable balance sheet will incentivize banks to lend to consumers, boosting activity within a stagnate economy [Figure 7]. Empirically we observe that the vast majority of the QE liquidity has built up in the form of bank reserves rather than circulating currency.<sup>45</sup>

There are two simple explanations for the failure of QE injections to make their way into circulation. (1) There could be little to no aggregate demand for loans; if there are no investment-worthy projects present in the economy or if consumer preferences are shifting towards saving rather than borrowing, the amount of money available to citizens through banks is irrelevant. (2) Likewise, if banks are unwilling to lend to consumers and businesses due to uncertainty about how the Fed might behave in the future or due to tighter lending laws, then the QE funds cannot be directly passed on to the consumer. In either case, the Fed can only push on the supply side of the equation, which is ultimately mediated by the banks to which it lends. Uncoupled from demand, the efficacy of the liquidity injections has been likened to “pushing on a string.”<sup>46</sup>

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<sup>45</sup> See Williams [66], Figure 2.

<sup>46</sup> Blyth [9].

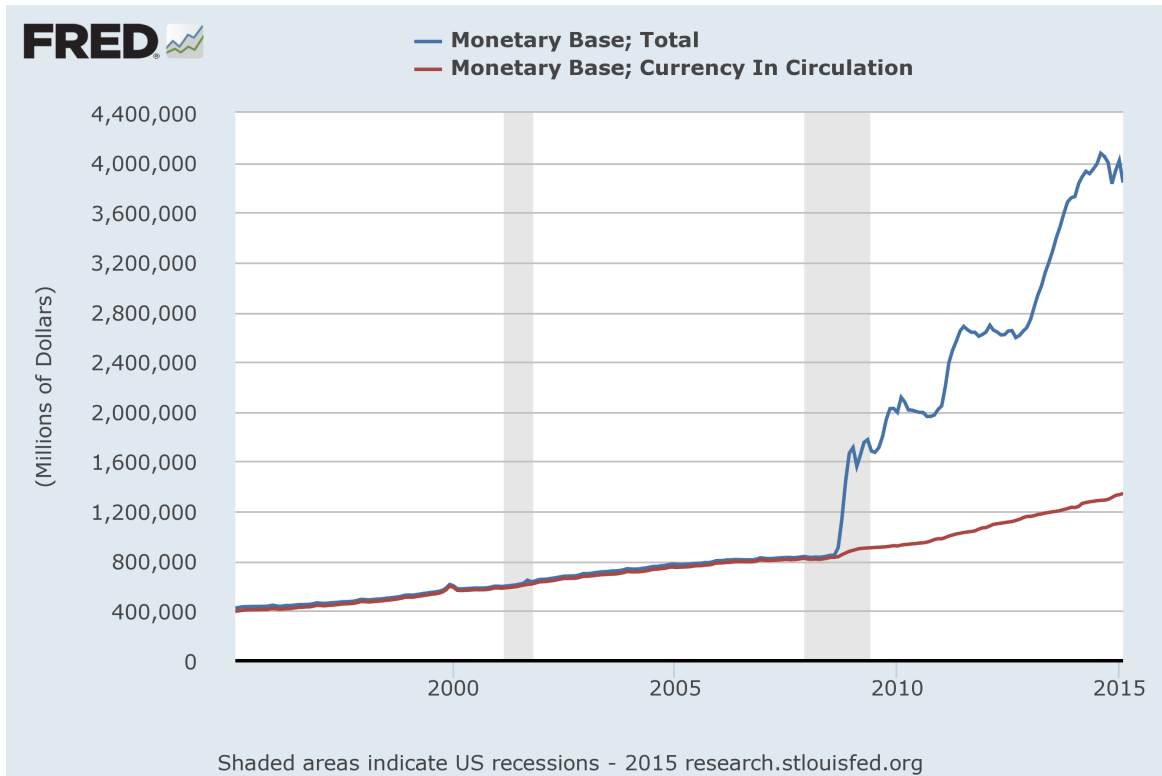


Figure 7. Growth of the Monetary Base under QE. The gap between the total Monetary Base and the currency in circulation represents bank reserves held at the Federal Reserve.

The wide and growing difference between the currency injected into banks and the currency in circulation in Figure 7 clearly demonstrates the uncoupling of currency supply and demand. Bank reserves have rapidly increased at a rapid rate while the amount of “working” currency in circulation shows a marginal increase that closely follows the pre QE trend. There is a clear disconnect between the action – The Federal Reserve drastically inflating the total Monetary Base – and the result – negligible changes in the actual amount of circulating currency. This is a situation that Herbst refers to a “reserve trap” brought on by a “knee-jerk” reaction towards safety that has amplified the unwillingness of banks to lend to businesses and consumers.<sup>47</sup>

<sup>47</sup> Herbst [28], p. 2.

Palley criticizes QE from a similar but slightly more political viewpoint, highlighting points we have touched on before such as the strong stock market, while bringing new data, such as the growth in U.S. income and wealth inequality, to bear on the discussion:

The underlying problem is structurally deficient demand caused by thirty years of neoliberal economic policies that have undermined the income and demand generation process (Palley, 2009). However, rather than fixing this problem, policymakers are again turning to ultra-easy monetary policy in the form of QE. Viewed from this perspective, QE can be interpreted as a form of asset market trickledown whereby supporting asset prices is supposed to jumpstart the macro economy... From a political standpoint, this is an enormous change from the world of forty years ago. The New Deal policy paradigm of wage floors and household income supports has been replaced by one of asset price floors and asset market subsidies. Viewed through a political lens QE therefore represents the triumph of plutonomics, and that makes it an obstruction to the extent it obscures the challenge of repairing the income and demand generation process.<sup>48</sup>

The idea of QE as the easy, quick, and ineffective fix to a severe and continuously deteriorating structural problem is a central theme in this paper and will be echoed by Hayek in his argument for competing currencies.

### *1.8. A Digression on Data*

Finally, we must return to one of the fundamental criticism of the field of macroeconomics that we began to examine during our discussion of definitions: weak data and strong assumptions. Economic data is generally collected through surveys, interviews, self-reported forms that are administered by various government agencies, including the United States Census Bureau and the Bureau of Economic Analysis, among others. The majority of these are collected and

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<sup>48</sup> Palley [44], p. 19.

published on a monthly or quarterly basis.<sup>49</sup> This means that the newest economic indicator data available to policymakers is generally anywhere from a month to a quarter behind where the economy currently stands. Complex systems with time-delayed feedback are notoriously difficult to control, and the U.S. economy is one of the largest and most complex systems in the world.

Near the end of his 8-year tenure as the Director of Statistics and Chief Statistician of the OECD, Giovannini summarized his thoughts on the efficacy of statistical macroeconomics in a somewhat pessimistic fashion:

The main conclusions of the authors are threefold: 1) in forming opinion about the direction of economic policy, ideology seems to play a greater role than accurate information; 2) the key hypothesis underlying economic models (i.e. that economic operators are fully informed, rational and basically selfish) seems to be a long way from reality, because it appears instead that individuals' actions are confused and basically generous; 3) there is still room for hope that increased knowledge might result in a better approach to decision-making, even though results obtained to date from the information society would seem somewhat limited.<sup>50</sup>

No system is without its flaws, but some systems are more broken than others. The economists who serve the United States in positions of power in government and on the Fed are necessarily among the most intelligent and well-informed individuals in the world, especially with regards to monetary policy. Yet we must not ignore the indicators that government policy, where it has not damaged the economy, has left much room for improvement. The constant attempt to manipulate and control an economic system whose complexity places it beyond the comprehension of even the most intelligent economists might very well be a futile exercise that ends up damaging rather than assisting the subjected economy.

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<sup>49</sup> See [<http://www.census.gov/economic-indicators/calendar-listview.html>] for the Census' 2015 schedule of release dates.

<sup>50</sup> Giovannini [24], p. 21.

In light of these shortcomings, what are our options? One alternative to a system dominated by Central Banking could be the introduction of a competing currency scheme, under which the government would play a much less active role in manipulating financial markets. In the next section we will explore a new technology – the virtual currency –that might make such a system possible. We will then apply it to Hayek’s argument for such a system in Section 3, bringing a new technology to bear on an old argument.



## 2) INTRODUCTION TO VIRTUAL CURRENCY

In this section I define the terms needed to discuss the concept of virtual currencies. I will start by describing the properties of Bitcoin, exploring why this form of virtual currency gained popularity in recent years. Throughout this section, I will refer to the general network as “Bitcoin” with a capital “B” and the individual virtual coins themselves as “bitcoin” with a lowercase “b”, as is the common (but not universal) practice in Bitcoin literature.

### 2.1. Definitions

The European Banking Authority defines a Virtual Currency (VC) as “a digital representation of value that is neither issued by a central bank or a public authority, nor necessarily attached to a [Fiat or Commodity-Backed Currency], but is accepted by natural or legal persons as a means of payment and can be transferred, stored or traded electronically.”<sup>51</sup>

Bitcoin was the first manifestation of a VC in that it was *neither issued by a central bank nor a central authority*. Understanding the benefits and drawbacks of decentralization is the key to understanding the large amount of interest in Bitcoin and other blockchain-based VCs.

It is important to note that this definition excludes preceding virtual stores of value such as airline vouchers, virtual coupons, Linden Dollars,<sup>52</sup> Liberty Reserve,<sup>53</sup> and E-gold.<sup>54</sup> While many

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<sup>51</sup> “EBA Opinion on ‘virtual Currencies’,” [19].

<sup>52</sup> “Virtual Currency Schemes,” [61].

<sup>53</sup> See the indictment of a company that created its own currency and attempted to skirt the law: “United States of America v. Liberty Reserve S.A.” [60].

<sup>54</sup> Trautman [57], pp. 4-6.

of these virtual stores of value can be exchanged for other goods or services, they were and continue to be created and issued by a central authority and so we will not consider them in our discussion of blockchain-based VCs.<sup>55</sup>

## *2.2. Reasons for Bitcoin's Creation*

Bitcoin is a decentralized, highly-anonymous VC. It was designed and developed by an unknown individual (or group) known as Satoshi Nakamoto, who created Bitcoin for the following reason: “What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party.”<sup>56</sup>

Nakamoto views two characteristics of the current financial system as “inherent weaknesses”: (1) Banks and other such credit providers must charge relatively high transaction fees to cover a certain unavoidable percentage of fraudulent transactions, and (2) centralizing a network provides one single point of failure or corruption that can bring down the entire network.<sup>57</sup> On the second point, Barber draws a comparison between the decentralized nature of Bitcoin and the distributed design of the internet: “such a purely decentralized system guarantees that no single entity, no matter how initially benevolent, can succumb to the temptation or be coerced by the government into subverting it for its own benefit.”<sup>58</sup>

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<sup>55</sup> “EBA Opinion on ‘virtual Currencies’,” [19], p. 10.

<sup>56</sup> Nakamoto [40], p. 1.

<sup>57</sup> *Ibid.*, p. 1.

<sup>58</sup> Barber [3], p. 400.

### 2.3. Overview of a Bitcoin Transaction

In a centralized network, one agent intermediates every transaction within the network. Take for example a (simplified) credit card transaction with a customer (Alice), a vendor (Bob), and a central authority (Visa): Alice informs Visa of her intention to pay Bob \$5 for a coffee by swiping her Visa credit card. Bob trusts Visa to fulfill Alice's obligation, and so by extension he trusts Alice, allowing her to leave the shop with the coffee. Alice and Bob both trust Visa to transfer the correct amount of credit from Alice's account to Bob's account. Visa updates its internal ledger in order to reflect the updated balances. Visa uses various tools and incentives (late fees, credit score), in order to ensure that the majority of customers fulfill their payment obligations, keeping the network healthy.

In a decentralized network, every fully-participating<sup>59</sup> actor in the network intermediates every transaction within the network. Suppose Alice wishes to purchase a coffee from Bob for one bitcoin. How does she do this? First she creates the message "I, Alice, am giving Bob one bitcoin." She then signs this message with the digital version of her signature: a private cryptographic key. Alice is the only one who knows how to write her own signature, and Bob can digitally verify that it is indeed Alice's unique signature order to ensure that she genuinely

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<sup>59</sup> It is not accurate to state that *every* participant in the network intermediates every transaction. In the Bitcoin network, only clients who run full nodes are actively checking and broadcasting transactions, thereby maintaining the network. Anyone with an address can send and receive bitcoins without running a full Bitcoin node.

intends to transfer one bitcoin to him. As long as Alice keeps her private key secret, it is impossible in practice for an impostor to forge her signature.<sup>60</sup>

Alice takes the signed message and sends it to her peers in the Bitcoin network. Those who receive the message first rebroadcast copies of the message to their peers, quickly informing everyone in the network of Alice's intention to transfer one bitcoin to Bob. The transaction is checked and confirmed, on average, ten minutes after it is announced.<sup>61</sup> Once these ten minutes have elapsed, Bob is publicly designated as the owner of the bitcoin. Everyone records this transaction in their personal ledger; they can refer back to it at any time to check whether or not Bob has the balance needed to make a future transaction.

Bob checks the public ledger to make sure that the network is in agreement about the transaction, and that Alice has indeed transferred ownership to him. Once he sees that the network has published and confirmed the transaction, he can be sure that everyone is in agreement that he now owns Alice's one bitcoin. He gives Alice the coffee and the transaction is settled. With this simple example in hand, we will begin to discuss the more technical components of various aspects of the Bitcoin network.

#### *2.4. Main Components of the Bitcoin Network*

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<sup>60</sup> Credit card companies use a much less secure version of this protocol. Most credit cards are not valid unless signed by their owner. Merchants can compare the signature on the credit card with the signature of the person who is using the card. If they match, then the merchant can be reasonably certain that the card has not been stolen. There are some very obvious and hard to solve issues with this method of verification that are solved cryptographically in the Bitcoin system. [[http://www.mastercard.com/us/merchant/pdf/Unsigned\\_Credit\\_Cards-%28Global%29.pdf](http://www.mastercard.com/us/merchant/pdf/Unsigned_Credit_Cards-%28Global%29.pdf)]

<sup>61</sup> Barber [3], p. 5.

**Wallet Programs, Addresses & Keys.** In order to transact in Bitcoin, Alice must first download a *wallet program*, which she will need to use to generate and store multiple addresses. Each address acts like a separate wallet, storing the individual amounts of bitcoin. When Alice generates an address, she is actually generating a pair of keys that correspond to that address. This security mechanism belongs to the *public key cryptography* family of security techniques. Here, a pair of linked keys, one public and one private, are used to securely transmit and receive information. Her address is simply a hash<sup>62</sup> of her public key, which she can safely broadcast to the world; we will discuss more of the technical details of hashes below, but for now it suffices to note that each unique public key corresponds a unique hash in a deterministic fashion, and so any user on the Bitcoin network could confirm Alice’s identity should they choose.



Figure 8. A Coinbase.com-generated Bitcoin address displaying a QR code and a hash of the address’s public key. A user who wishes to send Bitcoin to this address needs only to scan the QR code or input the hash of the public address, specify the amount of Bitcoin, and execute the transaction.

<sup>62</sup> The reasoning behind Nakamoto’s decision to use the hash of the public key as the address is rather unclear, but it is generally thought to be either security or efficiency driven. See [<http://www.michaelnielsen.org/ddi/how-the-bitcoin-protocol-actually-works/#comment-4258>] for further discussion.

Alice must keep her private key secret; it is the one and only sequence of bits that can “unlock” the address she has just created, giving her access to any bitcoins that might have been sent to that address. If Craig were to learn Alice’s private key, he could access the address associated with that compromised private key and transfer any bitcoins held at that address to another address of his choosing. Ownership of bitcoin depends on the ownership of the address where they are stored, which ultimately depends on the security of that address’s private key.

**Mining.** *Miners* verify Bitcoin transactions and form the backbone of the Bitcoin network. First, they gather a group of unconfirmed transactions. Using historical data, miners verify that each payee has sufficient funds to cover the transaction in question. Once satisfied that each transaction is feasible, a miner collects the transactions together with a digest of previous transactions (more on this later) and a special numeric value called a *nonce*. This entire structure – the transactions, the digest of the previous transactions, the nonce – is bundled together into a *block*.

A block is a record of the most recent transactions that have queued in the system during the time it takes the miners to find a valid nonce. Each block can be thought of as a single page in the Bitcoin ledger, recording ten minutes-worth of transactions on average. Once a miner discovers a valid nonce he broadcasts it, along with the block of transactions he is approving to the entire network. Other miners verify that his nonce produces a valid solution and update their records to include the new block.

**Nonces & the Proof-of-Work.** Let us return to the discussion of the numerical value, or the nonce, that a miner must find in order to create a new block. The nonce is the solution to a

cryptographic puzzle known as a *proof-of-work*. Miners must invest in electricity and specialized equipment in order to solve the proof-of-work. The proof-of-work comes in the form of an equation known as a hash function which produces an output that behaves like a random number [Figure 9].<sup>63</sup> The miner's task is to find some input  $x$  (the nonce) such that the hash function returns an output beginning with a certain number of consecutive zeroes.

What makes this puzzle hard to solve is the fact that the output from a cryptographic hash function behaves like a random number: change the input even a tiny bit and the output from the hash function changes completely, in a way that's hard to predict. So if we want the output hash value to begin with 10 zeroes, say, then [the miner] will need, on average, to try  $16^{10} \approx 10^{12}$  different values for  $x$  before he finds a suitable nonce. That's a pretty challenging task, requiring lots of computational power.<sup>64</sup>

Solving this proof-of-work creates a new block, rewarding the miner with (1) a time-sensitive amount of bitcoin in the form a generation transaction and (2) fees paid on each transaction recorded in this block. In this way, miners expend computational power in order to earn Bitcoin while maintaining the validity of the network.

```
hash(Hello World 1) = da2b7b86282afd991f805f858b70e18e162928e7077af5efcd6def1c6822dd9c
hash(Hello World 2) = 0b4d579933d45ac8e001b52fade270b307bed6ebcec9d7d3ec3c3ad9cdb0e052
hash(Hello World 3) = b977fec294a1a2f22cb0b1e1094c1fed1d90e2873b4a80a9267e29d83b5cf8c4
```

Figure 9. In this example the SHA-256 hash function takes the input “Hello World” and a nonce of value 1, 2, and 3. Even the slightest increment in the nonce outputs a completely different and seemingly random output.

<sup>63</sup>A cryptographic hash function takes in an input and returns some output that is considered practically impossible to revert back to the original input. Bitcoin uses the well-known and extensively applied SHA-256 hash function. See [<http://www.xorbin.com/tools/sha256-hash-calculator>] to test the hash function for yourself.

<sup>64</sup>Nielsen [41].

Currently the network hash rate is 4,332,461 PetaFLOP/s.<sup>65</sup> The total performance of the top 500 supercomputers in the world is 309 PetaFLOP/s.<sup>66</sup> Therefore amount of computing power expended on mining is 140,000 times larger than the potential computing power of the top 500 supercomputers in the world.

**The Block Chain.** Once a miner finds a winning nonce, the solution is distributed to the Bitcoin network. Because a hash function is deterministic, every miner can verify that the proposed solution is indeed valid. Once this solution has been sufficiently examined by the mining community, the transactions in the block are considered verified, and a new block of transactions begins to accumulate. In order to preserve entire historical record of transactions, a hash of the previously verified block is included in the newly accumulating block. In our ledger metaphor, this is akin to writing the final balance at the bottom of one page at the top of the next; while not including every transaction, a dedicated accountant could use these numbers to prove that the transactional record was consistent with the current balance.

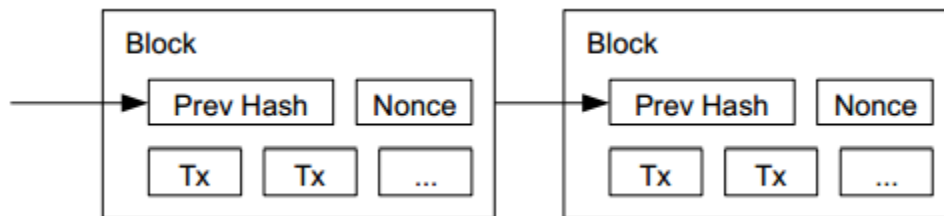


Exhibit 10. Updating the block chain. Each complete block contains a record of the most recent transactions (Tx), the hash of the previous block, and the nonce that validated the creation of the block.

<sup>65</sup> “Bitcoin Watch,” [7].

<sup>66</sup> See the most recent (November 2014) list of the top supercomputers in the world researched and compiled by the Top 500 Organization [42].



This historical sequence of blocks is called the *block chain*; it is the complete collection of every block that has ever been created and verified in the history of the Bitcoin network. If the block is one page of the transactional ledger, the block chain can be thought of as the entire ledger. A full copy of the block chain contains a record of every Bitcoin transaction that was ever executed and thus has *perfect memory* of which address owns which bitcoins. Everyone full participant owns a continually-updated copy of this ledger and can thus use it to track and verify any transaction that has ever occurred. The network's perfect memory makes a Bitcoin transaction practically non-reversible once it has been confirmed multiple times.

**Fees.** Fees are an important mechanism that ensures that miners have an incentive to include every transaction in the block chain. A fee is some non-zero amount of bitcoin that is set aside by the participants of each transaction as a reward for the miner who confirms that transaction. All else equal, miners have an incentive to mine any transaction with a non-zero fee rather than refusing to include the transaction in a block and leaving it for another miner to collect. Fees will become increasingly important in maintaining the incentive structure of the bitcoin network as the number of bitcoin generated through block confirmations halves every 4 years. At the time of writing, miners generate roughly \$850,000 in revenue per 24 hours. 99.6% of total revenue comes from the generation of new bitcoin as each block is confirmed. The remaining \$3,500 is generated in the form of fees.<sup>67</sup>

There is some variance in the time it takes miners to discover a valid solution – one particular nonce might be discovered in five minutes while another might be found in twenty, but the

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<sup>67</sup> “Currency Stats,” [15].

average time between the creation of new blocks is ten minutes.<sup>68</sup> The network monitors the time it takes to mine every 2,016 blocks. If it takes longer than 20,160 minutes, or 10 minutes per block on average, then the network determines that the difficulty is too high relative to the amount of computing power expended. The network adjusts by lowering the difficulty for the next 2,016 blocks. The opposite happens when the difficulty is too low and blocks are generated at a faster-than-desired pace.<sup>69</sup>

### *2.5. Summary of the Bitcoin Protocol*

If Alice wishes to send one bitcoin to Bob she creates and signs a message stating her intent to transfer one Bitcoin from an address under her control to an address that Bob has provided her. She then broadcasts this message to her peers in the Bitcoin network. These peers rebroadcast it along with all of the other known transactions to their peers, flooding the network with known but unconfirmed transactions. Miners compete to verify a block of these transactions in order collect the transaction fees and bitcoin reward that accompanies the discovery of each valid nonce. Once enough subsequent blocks have been confirmed, Alice and Bob's transaction becomes a part of the permanent public record and thus is completely non-reversible. Miners take a hash from the last verified block, bundle it with the newly-announced transactions, and attempt to find the next valid nonce, restarting the cycle.

### *2.6. Characteristics of Bitcoin*

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<sup>68</sup> Barber [3], p. 5.

<sup>69</sup> "Difficulty," [18].

A bit is the most basic form of information that can be read and written by a standard computer. It can only take one of two values: 0 or 1. On or off. Yes or no. True or false. A bit is binary and does not deal in shades of gray along a spectrum of values. This perfect dichotomy can work well within a simple and/or rigidly defined system, such a computer or a mathematical model. Clear delineations often give way to complex interconnections and blurred distinctions when they are applied to a more complex or non-rational system with many variables, such as an economy. This section will attempt to address some of the complexities that emerge when Bitcoin interacts with other systems and ideas; where the charcoal line blurs and the spectrum proves a more useful tool for discussion and measurement.

**Anonymity.** Contrary to popular belief, Bitcoin is not purely anonymous. Every transaction generates information that can be used with varying degrees of success to identify the owner of an account. The balance and transaction history of every Bitcoin address at every point in time is completely transparent and accessible. Users must take many precautions in order to protect their privacy, such as creating a new address for every transaction and laundering large transactions through multiple addresses in order to maintain a high probability of non-detection.<sup>70</sup>

**Deflation.** Bitcoin has been designed with a hard upper limit on the number of bitcoin that can ever enter circulation. Miners are expected to reach this limit of 21 million bitcoins in 2140.<sup>71</sup> Many argue that this limit on the money supply of Bitcoin will lead to an inherently deflationary currency and a system in which users ultimately hoard rather than save, as they

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<sup>70</sup> See Androulaki's study for further information on the security of Bitcoin transactions [1].

<sup>71</sup> "Controlled Supply," [14].

know that their bitcoins will become more valuable relative to goods and services as time passes.<sup>72</sup>

In reality, the act of hoarding is not exclusive to deflation. When a rational consumer is confronted with large amounts of inflation, she will purchase and hoard goods as the currency is losing value relative to the goods, effectively choosing to store value in goods rather than currency. The hyperinflation of the German mark from 1920-1923, as described by Mises, serves as one example of this flight from a rapidly devaluing currency into goods:

When the war inflation came nobody in Germany understood what a change in the value of the money unit meant. The business-man and the worker both believed that a rising income in Marks was a real rise of income. They continued to reckon in Marks without any regard to its falling value...But as they learned that the Government was determined not to stop with the further issue of notes and that the increase of their quantity must lead to a progressive rise of prices their conduct changed. Everybody became anxious not to keep the money in his pocket...At once they handed it over to their wives and these hurried to spend it as quickly as possible by buying at any rate something or other. Nobody wished to retain money, everybody dropped it like a live coal.<sup>73</sup>

Our general floating exchange rate system is governed by competition between central banks. As we will discuss later, most central banks target a 2% rate of inflation in order to give themselves room to manipulate interest rates. This is communicated to the public, to firms, to investors, and to banks. What is important is that the Fed maintains credibility by maneuvering inflation rates to be as close to the target as possible. Hypothetically the Fed could set an inflation target of -2%. As long as it hit that target year over year, without fail, rational actors would be able to consider this information as fact and plan ahead accordingly. Prices would adjust by the same amount and the real value of the currency would remain constant. Eggertsson sums this argument up nicely:

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<sup>72</sup> “Deflationary Spiral,” [16].

<sup>73</sup> Mises [38].

We have argued that the key to dealing with a situation in which monetary policy is constrained by the zero lower bound on short-term nominal interest rates is the skillful management of expectations regarding the future conduct of policy. By “management of expectations” we do not mean that the central bank should imagine that with sufficient guile it can lead the private sector to believe whatever it wishes it to, independently of what it actually does; we have instead assumed that there is no point in trying to get the private sector to expect something that it does not itself intend to bring about. But we do contend that it is highly desirable for a central bank to be able to commit itself in advantage to a course of action that is desirable due to the benefits that flow from its being anticipated, and then to work to make this commitment credible to the private sector.<sup>74</sup>

In summary: it is not the nominal target of inflation that is important, but that the target remains stable. If an authority is to guarantee a certain rate of inflation, it must deliver upon its promises and maintain transparency and credibility. Ultimately, this allows actors within an economy to accurately plan the most efficient allocation of their resources. Accurate information is of the utmost importance when making decisions regarding the future which can be more or less certain given the efficacy and credibility of the central authority. Thus worries of the extreme harm of a mildly deflationary currency are unfounded given the enforced credibility of the governance of Bitcoin which will we discuss in the next paragraph.

**Governance.** Contrary to what many have claimed, Bitcoin is not completely without governance. The Core Developers serve as the de facto administrators of the system, updating the source code as necessary to keep the system running smoothly.<sup>75</sup> Anyone who desires to contribute to the project can submit code to the Core Developers who will review the changes and then make the decision of whether or not to include them in the next update of the Bitcoin client.

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<sup>74</sup> Eggertsson [20], p. 67.

<sup>75</sup> “Bitcoin Development,” [5].

The system differs from a standard democracy in that the government has no legal or executive arms and thus no ability to make and enforce laws upon the user.<sup>76</sup> The developers can implement any changes they want to Bitcoin's source code and release a completely different or broken version of the software as a new "update." The miners and participants then get to choose whether or not to download and run the new version of the Bitcoin software. It is in the best interest of miners and participants who are invested in the network to ensure the health of the network if they wish to protect the value of their earnings and holdings. Therefore miners and participants have the option to eschew any potentially damaging changes imposed by the *de facto* government without consequence or fear of legal and/or executive repercussions.

For example let us consider what would happen if the Core Developers decided to release an update, Version 10.0 (V10), in which they simultaneously sharply decreased the mining difficulty, decreased the reward for discovering a new block, and removed the upper bound that constrains the creation of bitcoin past 21 million units. The new "monetary policy" under V10 would effectively result in an unexpected hyperinflationary shock that would devalue every existing bitcoin and decrease the incentive for miners to participate. Miners and network participants who generate wealth from the strength of Bitcoin relative to other currencies would be opposed to this sudden and severe decrease in the real value of their wealth. They would simply ignore V10 and continue to transact and mine under the previous, stable version, thereby avoiding the harmful monetary policies of the government. Ultimately the miners and participants would elect a few members from within their own ranks to replace the previous Core

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<sup>76</sup> Rules such as the mining difficulty and maximum number of bitcoins that can ever be created are considered to be among the fundamental "laws" that define Bitcoin. See [[https://en.bitcoin.it/wiki/Prohibited\\_changes](https://en.bitcoin.it/wiki/Prohibited_changes)] for a list of changes that cannot be implemented without diverging from the fundamental "spirit of Bitcoin," and that, if implemented, would lead to the creation of a new and separate currency.

Developers who had proven themselves to be untrustworthy. This new group of Core Developers could transition relatively seamlessly into the new role due to the open source nature of Bitcoin's framework.

Under a national currency, participants do not have the option to simply ignore harmful monetary policy. Time and time again, corrupt or unstable governments have destroyed economies and ruined the lives of their constituents through monetary policy that is forced upon the users through both (1) powerful executive and judicial enforcement mechanisms (2) and the monopoly it enjoys over the control of the money supply.<sup>77</sup> The most extreme example is the 1946 hyperinflation of the Hungarian pengő, in which prices doubled approximately every 15 hours.<sup>78</sup> We can reasonably expect users of Bitcoin and similarly structured VCs to avoid these economic calamities by updating their client software in an intelligent and discretionary manner.

**Open-Source.** Bitcoin is an open-source software, meaning that anyone with the proper technical knowledge can view and duplicated the source code that runs the network. Many developers did just that, adjusting the properties of Bitcoin as they saw fit to create new VC's with different visions, goals, and purposes. Some notable examples include Litecoin,<sup>79</sup> Dogecoin,<sup>80</sup> Auroracoin,<sup>81</sup> and Ripple.<sup>82</sup> The ability to create a working and adoptable currency with little more than a computer represents a large lowering of the technological barriers to entry

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<sup>77</sup> See Hanke [26] for a survey of recent hyperinflations.

<sup>78</sup> *Ibid.*, p. 12.

<sup>79</sup> "What Is Litecoin?" [64].

<sup>80</sup> "What Is Dogecoin?" [63].

<sup>81</sup> "Getting Started with Auroracoin," [23].

<sup>82</sup> "Opening Access to Finance," [43].

of the currency market. Creating a paper currency that might effectively compete with a government-issued currency is both impractical and explicitly illegal. The legal status of VCs is in continuous flux, but the technical implications are quite clear: VCs present a new, efficient way for private parties to transact in their own currencies.

With this new understanding of Bitcoin and other block chain-based virtual currencies, let us now move on to Section 3 in which we will apply VCs to Hayek's theory.

### **3) DENATIONALIZATION THROUGH DIGITIZATION**

In this section I will start by summarizing the key points of Hayek's argument. I will then provide a brief history of the government monopoly of currency, as told by Hayek and informed from outside sources, before considering some of the key assumptions and premises that form the foundation of Hayek's theory. Next, I will apply the new tool of virtual currency to the relevant parts of Hayek's argument, where technical obstacles might have weakened his original argument in 1978. Finally, I will conclude with my own thoughts on the merits and shortcomings of this scheme, as well as a commentary on realistic it might be to implement a competitive currency scheme to address the multitude of issues raised in Section 1.

#### *3.1. Hayek's Argument Summarized*

Hayek challenges the assumption that governments must command monetary policy, proposing instead that the countries of Europe as well as North America remove themselves



completely from the duties of creating and issuing money. He argues that the current government monopoly on currency bears the defects of all monopolies: one must use the product even if it unsatisfactory, and that a monopolist has no incentive to devise a better product.

Instead, Hayek argues, currency creation should be left to private enterprise in a competitive market, which will cull unstable and dishonest currencies, leaving only the best currencies viable. This requires that participating countries abolish the controls and regulations that govern the inter-country movement of money and that they must allow all contracts and accounting to be conducted in any of the freely-traded, privatized currencies. The purpose of this scheme is “to impose upon existing monetary and financial agencies a very much needed discipline by making it impossible for any of them, or for any length of time, to issue a kind of money substantially less reliable and useful than the money of any other.”<sup>83</sup>

### *3.2. Origins of Government Monopoly on Currency*

Currency developed in response to society’s need for an efficient way to exchange goods and services. Communities began to replace pure barter with a system in which a standard set of ornamental goods, such as cowries (shells) and wampums (white beads), were used to conduct transactions in a more efficient manner.<sup>84</sup> As societies and markets grew in size, metallic coins of gold and silver replaced these region-specific tokens.

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<sup>83</sup> Hayek [27], p. 23.

<sup>84</sup> Pryor, [49] p. 395.

Hayek argues that the government played a key role in assaying currency, or guaranteeing its fineness, as well as granting the coins authenticity by stamping them with the likeness of some generally recognized authority: “The task the government was understood to assume was of course initially not so much to make money as to certify the weight and fineness of the materials that universally served as money.”<sup>85</sup> He compares this responsibility to the task of establishing and setting a uniform system of weights and measures. Both of these tasks required a central authority with a large amount of resources so naturally this responsibility fell to the government. The Roman government was the first to consolidate enough power to firmly establish the minting prerogative, setting a precedent for many governments to come.

During the Middle Ages, feudal lords and princes began to view the responsibility of maintaining their regional currency as a right and a tool that could be used for profit. Rulers set the value of money by decree through the doctrine of the *valor impositus*, imposing value on the coins that many writers and philosophers argued derived their value through *bonitas intrinsica* – the amount of precious metal contained within each coin.<sup>86</sup> Seen another way, the *valor impositus* represents the sale price of a coin and the *bonitas intrinsica* represents its manufacturing cost.

The difference between the cost to mint a coin and its sale price is pure profit for the mints and government, known as seigniorage. It is worth noting that seigniorage, “most of the time a trivial source of revenue, becomes significant after debasements.”<sup>87</sup> A debasement, the government act of recalling current coinage only to melt it down and reissue coinage with a lower

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<sup>85</sup> Hayek [27], p. 29.

<sup>86</sup> Monroe [39], p. 20.

<sup>87</sup> Rolnick [50], p. 7.

gold or silver content, was used extensively by the rulers of England, France, Spain, and Italy during the middle ages to generate “unusually large revenues for the sovereign.”<sup>88</sup> Governments took full advantage of this newfound revenue stream, perhaps none so much as Henry VIII who in 1542 began what is now known as the Great Debasement, reducing the amount of silver in the pound sterling by 83% over a 10 year period.<sup>89</sup> These debasements occurred with such frequency that Hayek is forced to conclude that “nobody has yet written a full history of these [debasements]...it would indeed be all too monotonous and depressing a story.”<sup>90</sup>

Paradoxically, during the period **x to x**, Rolnick observes a statically significant *increase* in the amount of coins brought to the mint following a debasement. Actors within the economy did not lack information; Rolnick is confident that the majority of the populace was made aware of the debasement within a few weeks. Rather, they lacked “the ability to use [this] information in every day transactions” which “created profit opportunities from converting old coins to new coins.”<sup>91</sup> After dismissing several different models that have been constructed to explain this phenomenon, Rolnick concludes that this counterintuitive behavior might be best explained by a model with a relaxed “rational agent” assumption. In this model we would assume that the peasants and other common folk were informed by the government that exchanging currency after a debasement somehow increased their real wealth, and that they lacked the ability to deduce that this might not be true. Whatever the case, governments and traders were clearly able

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<sup>88</sup> *Ibid.*, p. 2.

<sup>89</sup> *Ibid.*, p. 7.

<sup>90</sup> Hayek [27], p. 33.

<sup>91</sup> Rolnick [50], p. 27.

to use the general public's lack of financial sophistication in order to profit at the expense of the common user of the currency.

Inflation engineered through an increase in the money supply is the modern, paper version of the metal debasement. Paper currency has little to no intrinsic value, so even if it were possible for a central bank to recall a majority of its issued currency, it would be impossible for it to reissue another paper currency with even less intrinsic value. Instead, the government engineers inflation by simply printing and circulating more paper currency.

It is clear that the government has become accustomed to using inflation as a tool for monetary policy, but is this necessarily a bad thing? We have come to one of the central themes of Hayek's argument: government-engineered inflation is easy to achieve and politically attractive, but it corrupts the healthy functioning of prices, wages, profits, and all other prices that are meant to signal economic health within an economy, directing the allocation of scarce resources. Let us examine this argument in more detail in the next section.

### *3.3. The First Premise: Evils of Inflation*

Hayek's argument for competing private currencies is based upon the premise that any form of inflation, "even mild inflations, ultimately produce the recurring depressions and unemployment which have been a justified grievance against the free enterprise system and must be prevented if a free society is to survive".<sup>92</sup> Hayek's anti-inflationary belief stands in direct opposition to the US Federal Reserve's current method of promoting economic stability.

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<sup>92</sup> *Ibid.*, p. 13.

Although the Fed does not explicitly refer to it as “inflation targeting”, its current policy regarding inflation is to target a long-term 2% rate of inflation, which is justified through the following rationale:

The Committee judges that inflation at the rate of 2 percent, as measured by the annual change in the price index for personal consumption expenditures, is most consistent over the longer run with the Federal Reserve's statutory mandate. Communicating this inflation goal clearly to the public helps keep longer-term inflation expectations firmly anchored, thereby fostering price stability and moderate long-term interest rates and enhancing the Committee's ability to promote maximum employment in the face of significant economic disturbances.<sup>93</sup>

The origins of inflation targeting are somewhat hazy. Bernanke posits that the practice first emerged after the disintegration of the Bretton Woods Treaty in the early 1970s.<sup>94</sup> In the nascent monetarist style, the German Bundesbank and the Swiss National Bank began setting yearly goals for money supply growth. They calculated the desired amount of inflation to be 2%, then used the amount of money created as a quantitative indicator and lever that they could directly influence in order to indirectly control the rate of inflation.<sup>95</sup> Kahn, Vice-president of the Kansas City Federal Reserve, succinctly summarizes why most central banks have decided on a similar route of action, targeting a small, positive rate of inflation:

While there is agreement that inflation is costly and should therefore be minimized, for a number of reasons policymakers nevertheless aim for an inflation rate above zero. First, available measures of inflation are imperfect and tend to overstate “true” inflation. Second, a little inflation may make it easier for firms to reduce real wages—without

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<sup>93</sup> “The Federal Reserve's Dual Mandate,” [55].

<sup>94</sup> Bernanke [4].

<sup>95</sup> *Ibid.*

cutting nominal wages—when necessary to maintain employment in an economic downturn. Third, a negative inflation rate—deflation— could be even more costly than a similar rate of inflation, suggesting that a low rate of inflation might be desirable to insure against falling prices. Finally, at very low levels of inflation, nominal short-term interest rates may be very close to zero, limiting a central bank’s ability to ease policy in response to economic weakness. Because nominal rates cannot fall below zero, policymakers cannot cut short-term interest rates any further once they have lowered these rates to zero.<sup>96</sup>

In the early 1990’s a collection of progressive banks adopted similar methods after seeing the success of the German and Swiss Central banks under this new system. Since then inflation targeting has become a staple of the modern central bank. At the time of writing at least 27 central banks have adopted inflation targeting.<sup>97</sup>

Hayek argues that inflation is dangerous because it distorts signals such as price and profit. This leads to the misallocation of resources to firms that look good on paper, but that could actually be failing to produce meaningful and sustainable economic returns:

The initial general stimulus which an increase of the quantity of money provides is chiefly due to the fact that prices and therefore profits turn out to be higher than expected. Every venture succeeds, including even some which ought to fail. But this can last only so long as the continuous rise of prices is not generally expected. Once people learn to count on it, even a continued rise of prices at the same rate will no longer exert the stimulus that it gave at first.<sup>98</sup>

In order to maintain the degree of economic activity it has generated by the initial shock of mild inflation, monetary policy must increase the rate of inflation at an accelerating rate as the current level of inflation comes to be expected. If monetary policy fails to continue this artificial support,

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<sup>96</sup> Kahn [34], p. 37.

<sup>97</sup> “Inflation Targets,” [30].

<sup>98</sup> Hayek [27], p. 97.

the economy will enter a recession brought on by the misdirection of production, labor, and resources under the bubble of the increasingly-inflationary economy.<sup>99</sup> Whoever controls the money supply, and therefore inflation, has the power to “give in most situations almost instantaneous relief to unemployment, even of only at the price of much unemployment later,” which, Hayek concludes, must make the political pressure on such an entity “irresistible”.<sup>100</sup>

It is hard to say whether or not Hayek’s theory is correct, but much of the research cited in Section 1 tends to support Hayek. The Fed has pursued a traditionally Keynesian monetary policy regimen over the past 6 years, using interest rate and inflation targeting until it could no longer push interest rates any lower. The results of QE have been tepid, but there have been some improvements with regards to unemployment and the stock market nonetheless. Readers will have their own thoughts on the matter, but for now let us proceed with Hayek’s argument under the assumption that the buildup and inevitable abandonment of runaway inflation is the main cause of volatile expansionary and recessionary cycles. Let us explore how a system of competing virtual currencies would obviate the need to set an arbitrary external inflation target, and would allow the markets to respond naturally to external shocks.

### *3.4. Issuing Banks*

Hayek’s first step in envisioning a denationalized, privatized, and competitive system of money is to consider who should create and maintain the new competing currencies:

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<sup>99</sup> *Ibid.*, p. 97.

<sup>100</sup> *Ibid.*, p. 97.

I shall assume for the rest of this discussion that it will be possible to establish a number of institutions in various parts of the world which are free to issue notes in competition and similarly to carry cheque account in their individual denominations. I shall call these institutions simply ‘banks’, or ‘issue banks’ when necessary to distinguish them from other banks that do not choose to issue notes. I shall further assume that the name or denomination a bank chooses for its issue will be protected like a brand name or trade mark against unauthorized use, and that there will be the same protection against forgery as against that of any other document. These banks will then be vying for the use of their issue by the public by making them as convenient to use as possible.<sup>101</sup>

What Hayek describes as an *issue bank* closely resembles any developer who wishes to create her own currency. The developer can choose any mechanism by which to issue the notes. Generating Bitcoin through block verification is one example; some currencies such as Auroracoin come “premined” meaning each user receives a certain amount of coins in the beginning simply for downloading and running the software.<sup>102</sup> Addresses can send and receive value, functioning exactly like checking accounts. There can be no unauthorized use of bitcoins because they can only be used through the Bitcoin protocol, and any transaction that is not included in the public ledger simply does not exist. Proof-of-work, digital signatures, and the block chain ensure that there are no fraudulent transactions. Thus, a virtual currency functions exactly as Hayek envisioned a private currency might, with the added bonuses of low barriers to entry relative to the production of paper currency and enhanced security against fraudulent transactions.

### 3.5. *The End Goal: Achieving Stability*

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<sup>101</sup> *Ibid.*, p. 46.

<sup>102</sup> “The Airdrop,” [54].



Hayek argues that “the chief attraction the issuer of a competitive currency has to offer to his customers is the assurance that its value will be kept stable (or otherwise be made to behave in a predictable manner).”<sup>103</sup> He goes on to admit that there is little empirical knowledge on the process and the criteria by which most people would choose among a group of competing currencies, and that it would probably be useless to conduct a poll as most people having never been in such a position have yet to form an opinion on what they would do. He is careful to avoid the assumption that people will all act rationally when confronted with such a radically new situation, but that they would soon decide which currency best fulfills their needs through observation and experience.<sup>104</sup> He begins his deduction by first identifying the four uses of money that he considers important and distinct enough to list: its use (1) for cash purchases of commodities and services, (2) for holding reserves for future needs, (3) in contracts for deferred payments, (4) as a unit of account, especially in keeping books.<sup>105</sup> We will explore each of these functions in turn through the lens of competing VCs in order to assess how each might be impacted by a new VC system.

### *3.6. Function 1: Common Purchases*

In response to (1) Hayek posits that the chief concern of the average consumer is to be able to make “any necessary daily purchases” in the currency in which they are paid as a matter of convenience. This requires that shopkeepers post multiple prices based on the different values of

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<sup>103</sup> Hayek [27], p. 59.

<sup>104</sup> *Ibid.*, p. 66.

<sup>105</sup> *Ibid.*, p. 67.

different currencies, putting the burden of exchange on the vendor. Hayek argues that vendors would be willing to accept any type of currency as long as they can instantaneously exchange it for any other at a known rate,<sup>106</sup> presumably to convert any sales into the currency that suits their own needs best. For the remainder of the discussion we will take “cash purchases” to mean reoccurring purchases of normal, non-durable goods (food, clothing, utilities, etc.) in the spirit of Hayek’s description: “any necessary daily purchases”. I will refer to these as “common purchases” to avoid confusion, as they might not necessarily be carried out with cash.

Common purchases are usually conducted with either cash or credit card. Under a competing currency system, common purchases in cash would require vendors to hold large reserves of multiple currencies in order to eschew the time and money spent exchanging one currency for another at a physical foreign exchange broker. Credit cards provide a more convenient exchange mechanism, but they can be expensive to acquire and use. Users must pay interest on any outstanding credit card balances and must build up a creditworthy reputation in order to keep their line of credit open. Furthermore, credit card companies tend to charge anywhere from 1-3% foreign transaction fees when users purchase goods that are marked in a different currency than the one tied to their account, as would occur under a multiple-currency system.<sup>107</sup> Credit cards fulfill Hayek’s requirement of being able to exchange any one currency for another instantaneously, but they do so in a relatively expensive manner.

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<sup>106</sup> *Ibid.*, p. 69.

<sup>107</sup> “Foreign Transaction Fee Credit Card Chart,” [21].

VCs can provide this foreign exchange service (1) immediately, with instant settlement<sup>108</sup> through a third party exchange and (2) for a fixed fee of 0.0001 BTC, or approximately 3 cents USD per transaction, regardless of size.<sup>109</sup> This means that the vendor has the option of instantly converting Bitcoin or any other virtual currency into a more stable store of value if she chooses at a fraction of the cost of what a credit card company would charge to handle the same transaction.<sup>110</sup> Thus, assuming vendors (1) use some type of instant settlement, Bitcoin enterprise-solution, (2) have the necessary infrastructure to accept Bitcoin payments, and (3) transact in an economy where it is convenient to use their preferred VC, they have every incentive to conduct common purchases in Bitcoin (or a similar VC) rather than cash or credit. Assumptions 2 and 3 are quite strong, and do not reflect the current situation of virtual currencies within the economy. Yet for the purposes of Hayek's argument, VCs address the requirement of an instant method of exchange in a more efficient manner than cash or credit.

### 3.7. *Increased Menu Costs Under Multiple Currencies*

The cost of setting and updating the prices of goods and services would increase under a multiple currency regime. This cost is known in economic literature as a *menu cost*.<sup>111</sup> As of now the majority of stores use physical labels which must be reprinted and changed by hand. As online

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<sup>108</sup> See Bitpay's FAQ: "What Are My Options for Settlement?" [62].

<sup>109</sup> "Transaction Fees," [58].

<sup>110</sup> Assuming a foreign transaction fee of 1%, any fee-covered transaction above \$3.00 USD would be more expensive than any size Bitcoin transaction at the current price. The average value of a credit card transaction in 2012 was \$94 according to research sponsored by the Federal Reserve System.  
<[https://www.frb services.org/files/communications/pdf/research/2013\\_payments\\_study\\_summary.pdf](https://www.frb services.org/files/communications/pdf/research/2013_payments_study_summary.pdf)>

<sup>111</sup> The menu cost derives its name from the example of a restaurant that decides to change its prices and replace its old menus. It needs to pay for the printing and binding of new menus.

shopping continues to grow and nascent technologies such as digital price tags<sup>112</sup> are adopted, the menu cost of setting prices in multiple currencies will decrease. Setting and displaying a price virtually is quite evidently less time and resource-consuming than changing price tags and menus by hand. The transition in the securities markets from paper ticker tape to the currently-used electronic display system serves as an example of how the digital setting and display of prices is more efficient than its physical counterpart.<sup>113</sup>

Hayek suggests that vendors mark their wares with different colored price tags to distinguish between different currencies,<sup>114</sup> but a more efficient merchant might make use of digital price tags to display prices denominated in the top 2-3 currencies that circulate in her region. She could also automatically update the different prices relative to one another by implementing an API that constantly fetches the latest exchange rate from a large currency board and recalculates prices based on any movements in the exchange rate. While there are possible solutions to problem of the increased menu price under competing currencies, the reality is that unless there is the proper economic incentive, as was the case with the stock exchange ticker transition, then there will be no move towards the adoption of digital signage. This cost is not of critical concern – a large system of competing currencies would force vendors to post their prices in multiple currencies. Hayek has included these costs in his analysis: The technology exists but is not necessary at the moment under a primarily monopolistic currency market.

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<sup>112</sup> Pricer is one of the only companies on the market that is currently actively developing products for the digital price tag space [48].

<sup>113</sup> Gallagher [22].

<sup>114</sup> Hayek [27], p. 69.

### *3.8. Functions 2 & 3: Borrowing & Lending*

We can think of “Holding Reserves for Future Needs,” and “A Standard of Deferred Payments” as two sides of the same coin: saving (in order to lend), and borrowing.

Hayek identifies the contradictory forces at work in these currency functions; lenders prefer an appreciating currency, and debtors prefer a depreciating currency. Under a competing currency scheme, both types of money could be made available to any interested parties. An appreciating currency (Upcoin) could be developed for lenders and a depreciating currency (Downcoin) could be developed for borrowers. Hayek predicts that these pressures would largely cancel each other out, leaving stability as the chief concern of a user of a competing currency. Let us test this hypothesis by introducing a third currency, Stablecoin, whose value is kept stable relative to Upcoin and Downcoin. Consider Lenny, a lender, who wishes to lend 1000 Stablecoin to a Bill, a borrower, over the period of 1 year. Let us assume that the core developers of Upcoin have made a credible commitment to a 2% yearly increase in value relative to Stablecoin while the core developers of Downcoin have made a credible commitment to a 2% yearly decrease in value relative to Stablecoin, and that both currencies have a healthy amount of participants and miners who will transact in and maintain the system over the coming year. Lenny knows he can earn a rate of return of 2% by investing his 1,000 Stablecoin in Upcoin. Therefore he will not be willing to accept any amount less than 1,020 Stablecoin at the end of the year. Billy sees this, and accepts the loan at 2% interest, promising to pay Lenny 1,025 Stablecoin in 1 year. He then creates his own currency, Uppercoin, which he pegs to appreciate 3% relative to Stablecoin. If he gathers enough support for Uppercoin and users begin to mine and transact in his currency, creating a

viable ecosystem, then he could invest his 1,000 Stablecoin in Uppercoin and generate a profit of 5 Stablecoin over 1 year period of the loan.

Here we see how important market forces are under a competitive currency scheme. Users are required to be proactive in finding the currency that best suits their needs. The currencies that are not used due to bad design or lack of faith will simply fail. Say Eddie, an entrepreneur, creates a currency, Bubblecoin, that he guarantees will appreciate 100% per year relative to Stablecoin. If enough users and business (1) vet the source code and determine that it will achieve the stated goal and (2) believe that others will adopt Bubblecoin with them, then the currency will be successful. A \$100 USD bill has no intrinsic value – it is only valuable because it is widely used and accepted. This is known in economic literature as a network effect.

It is likely in the case of Bubblecoin that vendors would see Bubblecoin as a risky asset, especially if Eddie had no credibility in the virtual currency world. They would either (1) not accept Bubblecoin, or (2) accept Bubblecoin and immediately convert it into Stablecoin to hedge against the risk of holding such an asset. Without vendor adoption, a VC cannot survive, as its users will move towards currencies with actual purchasing power. A weak ecosystem would cripple Bubblecoin, and we could expect to see it fall out of use, following the same path of the useless, hyperinflated currencies that lost popularity due to poor design or erratic monetary policy. Hayek predicts that “such a displacement of most bad money by good would, I believe, come about fairly soon, but occasional disturbances of the whole price structure and in

consequence of general economic activity cannot be wholly excluded until the public has learnt rapidly to reject tempting offers of cheap money.”<sup>115</sup>

It is clear that Stablecoin would be used extensively in this economy, and would most likely be one of the currencies in which citizens would be able to pay their taxes, companies would keep their accounts and pay their employees, and vendors would set prices. The network effect would most likely limit the number of these large, stable, competing currencies, but it is unlikely that a single variant of Stablecoin would dominate the global market for currency given the differences in governance, culture, language, and law of each sovereign nation.

Therefore, in a (1) competitive market with (2) the groups of lenders and debtors composed of a healthy mix of individuals and corporations from all sectors, we could expect to see a preference for at least one static currency that neither appreciates nor depreciates in purchasing power. Hayek does allow room for short run gains and losses in wealth from changes in the value of a static currency relative to other currencies in the market, but he predicts somewhat vaguely that the general populace “would probably all soon discover that these losses and gains were merely temporary and tended to disappear as soon as interest rates adapted themselves to expected price movements.” Assumption 1 would be reasonable under a competitive currency scheme, but assumption 2 might not hold true, at least in the early phases of a VCs deployment.

Bitcoin serves as an interesting use-case: the early adopters have been heavily skewed towards libertarian/anarcho-capitalists,<sup>116</sup> small businesses, black market users, and speculators. Due to Bitcoin’s nearly-anonymous nature, the actual composition of the user base remains unclear, but

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<sup>115</sup> *Ibid.*, p. 89.

<sup>116</sup> See the somewhat informal survey by Lui for a better sense of the demographics of the Bitcoin early adopter [37].

a 2014 survey of the US population's attitude towards Bitcoin confirms the select nature of its early adopters and continued users.<sup>117</sup> It also highlights that approximately 50% of respondents are still unaware that virtual currencies such as Bitcoin exist. Bitcoin and VCs in general are still quite far from attaining the mainstream acceptance and knowledge that would be required to create a healthy pool of lenders, borrowers, savers, and consumers.

We can conclude that the current population and infrastructure have created a marketplace that has carved out a niche for Bitcoin in relation to the still-dominant global currencies, but that VCs face a steep uphill battle in terms of (1) the necessary adoption of payment infrastructure and (2) the education of the general populace on virtual currencies. Both of these issues could be solved if VCs could provide a compelling economic case for adoption. Could stability under a competing currency scheme be the incentive Bitcoin needs to overcome the hurdles of early adoption?

### *3.9. Function 4: Designing Stablecoin, a Reliable Unit of Account*

Here we come to the function of money that “rules the roost” according to Hayek -- stability.<sup>118</sup> But how do we define a stable value of money? Hayek argues that technically speaking, there is no such thing as a perfectly stable value of money, or a constant value of anything else for that matter. Value is, by definition, relative. It expresses the ratio by which two commodities exchange which is subject to an unlimited number of exogenous factors that could cause this ratio

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<sup>117</sup> “The 2014 Consumer Survey: Consumer Attitudes on Bitcoin and Other Virtual Currencies,” [53].

<sup>118</sup> Hayek [27], p. 67.



to change. Fortunately, Hayek gives us a simple definition of stability to work with: “When we apply the term ‘value’ to money itself what is meant is that the price of most commodities will not tend to change predominantly in one direction, or will change only little, over short periods.”<sup>119</sup> In other words, a stable money is one that exerts a reasonably constant command over some basket of commodities with respect to time. Hayek posits that a basket of raw materials, agricultural foodstuffs, and standardized semi-finished industrial products would be the most effective basket to peg against as these goods are the inputs to every industry, are widely traded on regular markets, and their prices are readily available and quite sensitive to supply or demand shocks. According to Hayek, “a currency stable in terms of raw material prices is probably also the nearest approach we can hope to achieve to one conducive to [*sic*] stability of general economic activity.”<sup>120</sup>

This is completely different from the way that current VCs are designed. Bitcoin has no peg – as discussed before, it simply has a cap on the maximum number of bitcoins that can ever be created. Bitcoin has seen a large amount of volatility since its inception, peaking at \$1,124.76 on November 29, 2013. Figure 10 shows the numerous and severe fluctuations in Bitcoin’s price that have made it quite an unstable store of value over its 6-year lifespan.

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<sup>119</sup> *Ibid.*, p. 70.

<sup>120</sup> *Ibid.*, p. 75.



Figure 10. The BTC/USD exchange rate from March 2012 to the present.<sup>121</sup>

Would it be possible to peg a block chain-based VC to a diversified portfolio of goods? This could be achieved in the same manner as one would peg any physical currency – through the manipulation of the money supply in response to shocks in the supply and demand of the goods within the portfolio. For example, let us imagine that we create a new VC called Stablecoin, which is identical to Bitcoin with 2 exceptions: (1) the price of the currency is tied to a carefully constructed portfolio of pegged goods and (2) the supply of stablecoin is directly controlled by the core developers. In order to peg the price of Stablecoin against the pegged portfolio, the core developers of the currency could create an algorithm that multiplies any change in the price of commodity  $x$  by the weight of commodity  $x$  in the portfolio. The corresponding change in the value of the portfolio is accounted for by a change in the supply of stablecoin such that consumers “will not reduce or increase their outlay for the purpose of adapting their balances to their altered

<sup>121</sup> Google Finance. (2015). “CURRENCY:BTC [Chart].” Retrieved from <https://www.google.com/finance?q=CURRENCY:BTC>.

liquidity preferences.”<sup>122</sup> In other words, changes in the supply or demand of any good in the portfolio are matched by changes in the supply of Stablecoin such that the circulation of currency remains unchanged – rational economic agents will not save or consume any more due to nominal changes to the money supply.

Given that we can easily create a VC that is pegged to a portfolio of goods, can we now manipulate the currency to adjust for shocks in the supply and demand of the portfolio goods? Let us assume that we start with a money supply of 21,000,000 Stablecoin. The price of 1 portfolio is 1,000 Stablecoin. Wheat is weighted at 10% of the overall portfolio. An unexpected event destroys 5% of the world’s total quantity of wheat overnight. Wheat’s price must increase due to this decreased supply, but by how much? What is the optimal adjustment to the money supply that will keep prices relatively stable?

At first glance, it might seem like a simple problem. Assuming that a decrease in quantity of 5% leads to a 5% increase in the price of wheat, the portfolio has become 0.5%<sup>123</sup> more expensive, holding all else equal. The price of the same portfolio of goods is now 1,005 Stablecoin. Thus the value of one stablecoin must appreciate by 0.5% to match the increase in the price of our pegged portfolio. The core developers would achieve this by decreasing the money supply by 0.5%. They would remove 105,000 Stablecoin from circulation, and with a new supply of 20,895,000 Stablecoin the price of 1 pegged portfolio would return to 1,000 Stablecoin. Purchasing power would remain constant (to the portfolio, not to its individual assets) and users of the currency

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<sup>122</sup> Hayek [27], p. 81.

<sup>123</sup> The weight of wheat in the portfolio (10%) multiplied by the change in the price of wheat (5%) equals a 0.5% change in the overall portfolio price.

might not even notice that the price of wheat had increased incrementally with respect to all other assets in the portfolio.

There are a few critical problems with this calculation. Firstly, we assumed that price and supply are perfectly inversely correlated. In reality, there are many factors that relate the quantity of a good and its price, such as the elasticity of demand for the good and number of close substitutes. We can approximate what effect a supply shock might have on price, but ultimately our calculation will not be perfectly accurate. Secondly, in order for this change in the monetary supply to have the correct effect, every single unit of Stablecoin must always be available for instantaneous circulation within the economy. If Alice has a savings account of 10,000 Stablecoin which she is planning to use 3 years from now for her college tuition, then these 10,000 Stablecoin have effectively been removed from the money supply for 3 years. We could approximate the daily transaction volume of Stablecoin as Blockchain.info does for Bitcoin, and use this as a *de facto* daily money supply, but it would still be a rough estimate at best.<sup>124</sup> Thirdly, we did not take the number of new coins generated by miners into account. We could approximate this using the difficulty and the average blocks mined per day, and then adjust the money supply to take these new blocks into account, but if users and vendors came to expect this daily decrease in the money supply, prices would adjust accordingly. Lastly, we assumed that people are completely rational actors, and that they would not change their consumption preferences due to purely nominal changes in the money supply. As we have noted previously, this assumption rarely holds.

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<sup>124</sup> See “Currency Stats,” [15].

The emerging theme is clear: the economy is complex, and we cannot control for all the variables that influence supply and demand. Given this complexity, Hayek argues that it is impossible for the architects of Stablecoin, or any monetary authority for that matter, to manipulate the money supply effectively: “No authority can beforehand ascertain, and only the market can discover, the ‘optimal quantity of money.’ It can be provided only by selling and buying at a fixed price the collection of commodities the aggregate price of which we wish to keep stable.”<sup>125</sup>

Again, we return to Hayek’s central thesis: competition is bound to provide a more stable form of currency than a monopolistic central authority. He argues that all economists and Central Banks are in agreement that stability is the end goal, but that they have “become somewhat over-ambitious concerning the degree of stability that is either achievable or even desirable under and conceivable economic order, and that they have unfortunately encouraged political demands concerning the certainty of employment at a hoped-for wage which in the long run no government can satisfy.”<sup>126</sup> Under a competitive system, there can never be a general increase nor a general decrease of prices as there will always be at least one Stablecoin that will profit from keeping its money supply in step with the price of a portfolio of widely used commodities. Thus, competition will effectively rid the currency market of long-term inflation for good, putting an end to the government’s temptation to use inflation as an addictive political tool that is abused for short-term gain.

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<sup>125</sup> Hayek [27], p. 81.

<sup>126</sup> *Ibid.*, p. 87.

Let us reconvene to summarize what we have learned before we digress from this central argument towards the theoretical enforcement of such a system. Block chain-based VCs would allow for a more seamless version of a competitive market to exist than physical cash or credit cards due to the following properties: (1) VCs can be exchanged for any other currency immediately (2) with instant settlement through a third party client, and (3) for a fraction of the cost of the average credit card transaction. The governance of a VC is incentivized to make only “good” or “necessary” changes to the currency, and the users and participants of that VC can ignore any unwanted, “bad” monetary policy that the governance of that VC might try to force upon its users. Competition would drive bad money out of the market, leaving behind a small collection of stable currencies that the public could pick from in order to best suit its needs. Provided that the participants agreed, the government could push updates on the currency immediately by updating the source code. Block chain-based currencies necessarily create a fuller and more granular set of data with regards to their usage, leading to better monetary policy decisions. Ultimately, competition would enforce discipline upon the

On the other hand, the overall measure of convenience in the marketplace would decrease. Users would be forced to educate themselves about the different currencies and their relative advantages and disadvantages. The menu cost under a multiple currency scheme would increase. The infrastructure and general knowledge required for such a scheme would be expensive to implement. A competitive currency scheme is far from a reality.

### 3.10. *Press & Credit Rating Agencies as Enforcement Mechanisms*

One of the main advantages of competition is that it tends to enforce honesty. While a competitive market will undoubtedly force a higher degree of honesty on its participants than a monopolistic market, we have predicted that a few main, stable currencies would develop and come to own a large share of the total market due to constraints of economies of scale and convenience. Hayek proposes that the press would play a critical role in such a currency market, acting as an enforcement mechanism by making a full set of information available to each consumer so that she might choose the most honest currency “in time of any dereliction of duty”<sup>127</sup>:

The competition between the issuing banks would be made very acute by the close scrutiny of their conduct by the press and at the currency exchange. For a decision so important for business as which currency to use in contracts and accounts, all possible information would be supplied daily in the financial press, and have to be provided by the issuing banks themselves for the information of the public. Indeed, a thousand hounds would be after the unfortunate banker who failed in the prompt responses required to ensure the safeguarding of the value of the currency he issues.<sup>128</sup>

Figure 10 is an example of what he considers to be an effective table that would be printed daily in some sort of financial publication. Applying Hayek’s idea into the 21<sup>st</sup> century, these tables could be published online and updated in real time. A fear of any exposure of wrongdoing would keep currency providers honest.

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<sup>127</sup> *Ibid.*, p. 128.

<sup>128</sup> *Ibid.*, p. 53.

TABLE I  
ILLUSTRATION OF POSSIBLE CURRENCY PRICE  
DEVIATIONS

<i>Currency</i>	<i>Deviation from</i>	
	<i>Announced Standard</i>	<i>Our Test Standard</i>
	%	%
Ducats (SGB)	−0·04	−0·04
Florins (FNB)	+0·02	+0·03
Mengers (WK)	+0·10	+0·10
Piasters (DBS)	−0·06	−0·12
<b>Reals (CNB)</b>	<b>−1·02</b>	<b>−1·01</b>
Shekels (ORT)	−0·45	−0·45
Talents (ATBC)	+0·26	+0·02

Figure 10. Table comparing the deviation of each currency from the announced standard of value in terms of a basket of commodities. Simply put, the table exposes banks that fail to keep their commitments. Issuing bank names are given in parentheses after the name of the currency that it issues. Bold type indicates that the real value of the currency has fallen below the standard set by the publishing paper or agency.

Credit Rating Agencies (CRAs) play a similar role in that they audit different types of financial instruments and make their findings available to investors who might not otherwise have the time or resources to conduct their own research. They provide this information in the form of “ratings”, or judgments on the creditworthiness of securities and their issuers.<sup>129</sup> This information is useful to investors provided that it is accurate and timely. As previously mentioned in Section 2, a breakdown in the reliability of CRAs played a key role in the lead up to the most recent financial crisis. One striking example of the CRA’s inability to perform their duty is exemplified by the fact that every single one of the 3 major agencies held “investment grade” ratings on Lehman Brothers on the morning of its bankruptcy.<sup>130</sup> As detailed by Jollineau, many

<sup>129</sup> White [65], p.43.

<sup>130</sup> *Ibid.*, p. 43.



have continuously pointed out the perverse incentive structure between bond CRAs and their customers, the bond issuers:

Critics of the current credit rating system claim that CRAs act favorably toward debt issuers largely because issuers of debt securities pay CRAs for rating their securities. The “issuer pays” model provides an incentive for unconscious bias and perhaps even conscious corruption. William Harrington, a former senior vice-president at Moody’s, claims that “this salient conflict of interest permeates all levels of employment, from entry-level analyst to the chairman and chief executive officer of Moody’s corporation” (Neate 2011). The issuer’s incentive is to shop for ratings and choose the most favorable one (Story 2011). Relatively favorable ratings arguably increase the likelihood of continued business from the issuer. Furthermore, CRAs also provide fee-based advisory services to debt issuers regarding how to structure their security offerings, which exacerbates the conflict of interest between CRAs and debt issuers.<sup>131</sup>

White, as Hayek, advocates for an obvious solution: Introduce competition in order to increase the quality of information. The three major credit rating agencies - Moody’s, Fitch, and Standard & Poor’s – enjoy an oligopoly under which they alone determine which securities banks can and cannot invest in. White observes that this oligopoly is protected by the weight of the law, which has disallowed banks from investing in speculative or “junk” bonds, as determined by the credit rating agencies, since 1936.<sup>132</sup> Deregulation of the bond market, White argues, would not hurt the average investor that the regulation was designed to protect because the bond market is now primarily an institutional market.<sup>133</sup> Market forces can be expected to perform as they should, encouraging honesty and innovation by making it possible for new CRAs to join the market for the first time in over 70 years.

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<sup>131</sup> Jollineau [33].

<sup>132</sup> White [65], p. 44.

<sup>133</sup> *Ibid.*, p. 44.

Credit ratings and news agencies should produce unbiased, accurate information. Any monetary scheme would benefit greatly from this increase in competition. A competitive CRA and financial news market would provide an important enforcement mechanism that could keep competing currencies honest, regardless of the number of issuing companies in the market.

## CONCLUSION

The financial crisis of 2007 and subsequent “Great Recession” of 2008-2009 have exposed some of the systematic flaws of the U.S. financial system. The Federal Reserve’s largely-Keynesian response to the crisis of lowering the FFR and engaging in QE brought about negligible effects in the channels that they were intended to influence. It is altogether quite doubtful that the Federal Reserve can intentionally stabilize and control a system as complex as the United States economy with the data and tools that it currently finds at its disposal.

One alternative to the ineffective central banking system would be a competing currency scheme where the market determines the optimal qualities and quantity of several different forms of currency. This is preferable to the current system as the most popular currencies would only be able to attract and retain customers by keeping the value of their currency stable. Users would be free to choose the currency that best suited their needs, rather than be forced to use a currency that is regularly subjected to potentially damaging monetary policy, such as QE and inflation targeting.

A competing currency system is not feasible with the prevailing technology of paper currency. VCs provide efficiency gains over existing technologies (physical currency and credit cards) that would help to make this system possible at the expense of long-term infrastructure investments, technological education, and increased menu costs which would be relatively less convenient than the current system. A competitive market of credit rating agencies and news sources could be used as an enforcement mechanism to keep the market honest. Time, experience, and good governance from a set of experienced core developers, tempered by the invisible hand of the

market would produce the stability Hayek envisions. Nakamoto's conception of a block chain-based virtual currency, such as our theoretical Stablecoin, is a huge step forward in realizing Hayek's dream.

The argument presented here is largely qualitative. Future papers might explore the possibility of quantifying the social welfare gains (or losses) of an economy with a competitive currency scheme. There is also much work to be done in exploring Hayek's premise that pegging a currency to a basket of goods is the best way to create a stable currency.

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