EUROPEAN CENTRAL BANK

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VIRTUAL CURRENCY SCHEMES

OCTOBER 2012

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In 2012 all ECB publications feature a motif taken from the €50 banknote.

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CONTENTS

EXECUTIVE SUMMARY

Virtual communities have proliferated in recent years – a phenomenon triggered by technological developments and by the increased use of the internet. In some cases, these communities have created and circulated their own currency for exchanging the goods and services they offer, and thereby provide a medium of exchange and a unit of account for that particular virtual community.

This paper aims to provide some clarity on virtual currencies and tries to address the issue in a structured approach. It is important to take into account that these currencies both resemble money and necessarily come with their own dedicated retail payment systems; these two aspects are covered by the term "virtual currency scheme". Virtual currency schemes are relevant in several areas of the financial system and are therefore of interest to central banks. This, among other things, explains the ECB's interest in carrying out an analysis, especially in view of its role as a catalyst for payment systems and its oversight role.

This report begins by defining and classifying virtual currency schemes based on observed characteristics; these might change in future, which could affect the current definition. A virtual currency can be defined as a type of unregulated, digital money, which is issued and usually controlled by its developers, and used and accepted among the members of a specific virtual community. Depending on their interaction with traditional, "real" money and the real economy, virtual currency schemes can be classified into three types: Type 1, which is used to refer to closed virtual currency schemes, basically used in an online game; Type 2 virtual currency schemes have a unidirectional flow (usually an inflow), i.e. there is a conversion rate for purchasing the virtual currency, which can subsequently be used to buy virtual goods and services, but exceptionally also to buy real goods and services; and Type 3 virtual currency schemes have bidirectional flows, i.e. the virtual currency in this respect acts like any other convertible currency, with two exchange rates (buy and sell), which can subsequently be used to buy virtual goods and services, but also to purchase real goods and services.

Virtual currency schemes differ from electronic money schemes insofar as the currency being used as the unit of account has no physical counterpart with legal tender status. The absence of a distinct legal framework leads to other important differences as well. Firstly, traditional financial actors, including central banks, are not involved. The issuer of the currency and scheme owner is usually a non-financial private company. This implies that typical financial sector regulation and supervision arrangements are not applicable. Secondly, the link between virtual currency and traditional currency (i.e. currency with a legal tender status) is not regulated by law, which might be problematic or costly when redeeming funds, if this is even permitted. Lastly, the fact that the currency is denominated differently (i.e. not euro, US dollar, etc.) means that complete control of the virtual currency is given to its issuer, who governs the scheme and manages the supply of money at will.

There are several business reasons behind the establishment of virtual currency schemes. They may provide a financial incentive for virtual community users to continue to participate, or create lock-in effects. Moreover, schemes are able to generate revenue for their owners, for instance float revenue. In addition, a virtual currency scheme, by allowing the virtual community owner to control its basic elements (e.g. the creation of money and/or how to allocate funds), provides a high level of flexibility regarding the business model and business strategy for the virtual community. Finally, specifically for Type 3 schemes, a virtual currency scheme may also be implemented in order to compete with traditional currencies, such as the euro or the US dollar.

The first case study in this report relates to Bitcoin, a virtual currency scheme based on a peer-to-peer network. It does not have a central authority in charge of money supply, nor a central clearing house, nor are financial institutions involved in the transactions, since users perform all these tasks themselves. Bitcoins can be spent on both virtual and real goods and services. Its exchange rate with respect to other currencies is determined by supply and demand and several exchange platforms exist. The scheme has been surrounded by some controversy, not least because of its potential to become an alternative currency for drug dealing and money laundering as a result of its high degree of anonymity.

The second case study in this report is Second Life's virtual currency scheme, in which Linden Dollars are used. This scheme can only be used within this virtual community for the purchase of virtual goods and services. Linden Lab manages the scheme and acts as issuer and transaction processor and ensures a stable exchange rate against the US dollar. However, the Second Life scheme has been subject to debate, and it has been suggested that this currency is more than simply money for online gaming.

Thereafter, a preliminary assessment is presented of the relevance of virtual currency schemes for central banks, paying attention mostly to schemes which are more open and linked to the real economy (i.e. Type 3 schemes). The assessment covers the stability of prices, of the financial system and of the payment system, looking also at the regulatory perspective. It also addresses reputational risk concerns. It can be concluded that, in the current situation, virtual currency schemes:

- do not pose a risk to price stability, provided that money creation continues to stay at a low level;
- tend to be inherently unstable, but cannot jeopardise financial stability, owing to their limited connection with the real economy, their low volume traded and a lack of wide user acceptance;
- are currently not regulated and not closely supervised or overseen by any public authority, even though participation in these schemes exposes users to credit, liquidity, operational and legal risks;
- could represent a challenge for public authorities, given the legal uncertainty surrounding these schemes, as they can be used by criminals, fraudsters and money launderers to perform their illegal activities;
- could have a negative impact on the reputation of central banks, assuming the use of such systems grows considerably and in the event that an incident attracts press coverage, since the public may perceive the incident as being caused, in part, by a central bank not doing its job properly;
- do indeed fall within central banks' responsibility as a result of characteristics shared with payment systems, which give rise to the need for at least an examination of developments and the provision of an initial assessment.

This report is a first attempt to provide the basis for a discussion on virtual currency schemes. Although these schemes can have positive aspects in terms of financial innovation and the provision

of additional payment alternatives to consumers, it is clear that they also entail risks. Owing to the small size of virtual currency schemes, these risks do not affect anyone other than users of the schemes. This assessment could change if usage increases significantly, for example if it were boosted by innovations which are currently being developed or offered. As a consequence, it is recommended that developments are regularly examined in order to reassess the risks.

1 INTRODUCTION

1.1 PRELIMINARY REMARKS AND MOTIVATION

This report seeks to provide clarity on the topic of virtual currencies and tries to address the issue in a structured approach. Such an approach has been absent, at least to some extent, from the existing literature. Moreover, there have previously been no references to this topic in the publications of central banks, international organisations or public authorities. As a consequence, this report largely relies on information and data gathered from material published on the internet (see the Annex for references and further reading), whose reliability, however, cannot be fully guaranteed. This places serious limitations on the present study.

Virtual currencies resemble money and necessarily come with their own dedicated retail payment systems; these two aspects are covered by the term "virtual currency scheme". Virtual currency schemes are relevant in several areas of the financial system and are therefore of interest to central banks. Virtual currency schemes have been subject to increased press coverage, even being featured in respectable media publications. The ECB has been contacted a number of times in recent months by academics, journalists and concerned citizens, who want to know its view or want to warn the institution about potential problems with virtual currency schemes. In this context, it was considered advisable to strive for a common understanding and, thereafter, to formulate a coordinated response. This explains the ECB's interest in carrying out a more detailed analysis, especially in view of its role as a catalyst for payment systems and its oversight role. The present report is the result of this analysis. It is a first attempt to provide the basis for a discussion on virtual currency schemes.

This report is structured into four parts. After a brief review of the history of money in this chapter, Chapter 2 defines and classifies virtual currency schemes. It also shows how their payment arrangements work and addresses the various business reasons for implementing these schemes. Chapter 3 focuses on two prominent virtual currency schemes, namely Bitcoin and Second Life's Linden Dollars, and describes their basic features, technical elements and monetary aspects. It also addresses the latest issues and security incidents in which these schemes have been involved. Chapter 4 offers an assessment of how central banks could be affected by these schemes, taking into account different aspects, i.e. price stability, financial stability, the smooth operation of payment systems, the regulatory perspective and reputational risk. The report finishes by offering conclusions and proposals for future action.

1.2 A SHORT HISTORICAL REVIEW OF MONEY

It is difficult to establish the precise origins of monetary societies. It seems that payments using some form of money were being made as early as 2200 BC. Nevertheless, the format of money has changed considerably since then. Early money was usually commodity money, that is, an object which had intrinsic value (e.g. cattle, seeds, etc., and later, gold and silver, for instance).

Around the eighteenth century, "commodity-backed" money started to be used, which consisted of items representing the underlying commodity (e.g. gold certificates). These pieces of paper were not intrinsically valuable, but they could be exchanged for a fixed quantity of the underlying commodity. The main advantages of this system were the portability of the money and that larger amounts of money could be transferred.

Modern economies are typically based on "fiat" money, which is similar to commodity-backed money in its appearance, but radically different in concept, as it can no longer be redeemed for a commodity. Fiat money is any legal tender designated and issued by a central authority. People

are willing to accept it in exchange for goods and services simply because they trust this central authority. Trust is therefore a crucial element of any fiat money system.

Regardless of the form of money, it is traditionally associated with three different functions:

- *Medium of exchange*: money is used as an intermediary in trade to avoid the inconveniences of a barter system, i.e. the need for a coincidence of wants between the two parties involved in the transaction.

- *Unit of account*: money acts as a standard numerical unit for the measurement of value and costs of goods, services, assets and liabilities.

- *Store of value*: money can be saved and retrieved in the future.

Money is a social institution: a tool created and marked by society's evolution, which has exhibited a great capacity to evolve and adapt to the character of the times. It is not surprising that money has been affected by recent technological developments and especially by the widespread use of the internet.

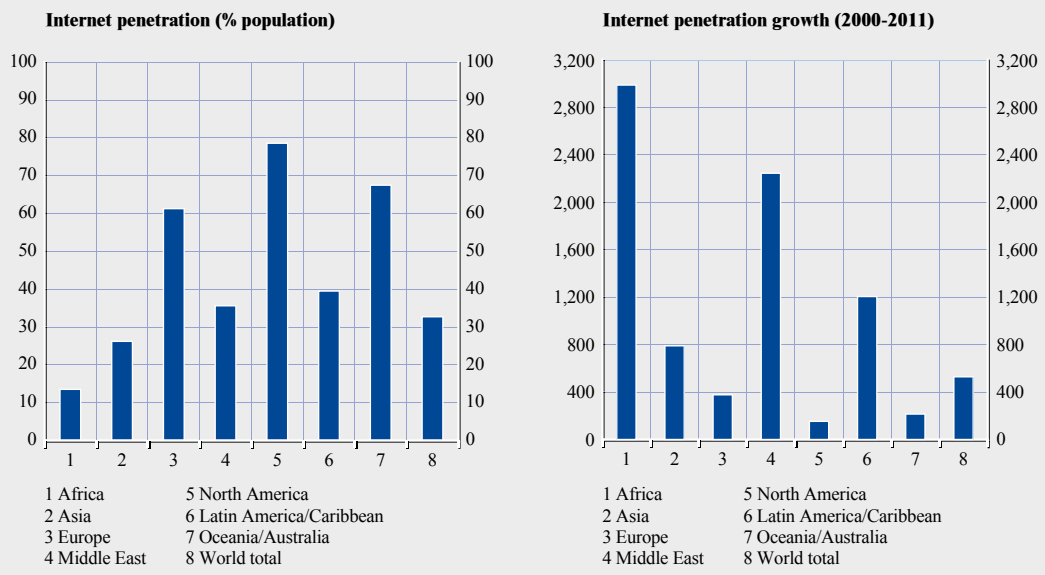
1.3 MONEY IN THE VIRTUAL WORLD

Since its establishment in the 1980s and following the creation of the World Wide Web in the mid-1990s, access to and use of the internet has grown dramatically. According to Internet World Stats,[1] the number of internet users in the world was 361 million at the end of 2000, whereas by the end

1 http://www.internetworldstats.com

Chart 1 Internet penetration and growth by region (December 2011)

(percentage)



Source: Internet World Stats.

of 2011 this figure had reached 2,267 million, or approximately 33% of the global population. The impact has been so significant that it could reasonably be considered a structural change in social behaviour, affecting the way people live, interact with each other, gather information and, of course, the way they pay.

Table 1 A money matrix

Legal status	*Unregulated*	– Certain types of local currencies	**– Virtual currency**
	Regulated	– Banknotes and coins	– E-money
			– Commercial bank money (deposits)
		Physical	*Digital*
		Money format	

Source: ECB.

In connection with the high penetration of the internet, there has also been a proliferation of virtual communities in recent years. A virtual community is to be understood as a place within cyberspace where individuals interact and follow mutual interests or goals. Social networking is probably the most omnipresent type of virtual community (e.g. Facebook, MySpace, Twitter), but there are other prominent communities, such as those that share knowledge (e.g. Wikipedia), those that create a virtual world (e.g. Second Life) or those that aim to create an online environment for gambling (e.g. Online Vegas Casino).

In some cases, these virtual communities have created and circulated their own digital currency for exchanging the goods and services they offer, thereby creating a new form of digital money (see Table 1). The existence of competing currencies is not new, as local, unregulated currency communities existed long before the digital age.[2] These schemes can have positive aspects if they contribute to financial innovation and provide additional payment alternatives to consumers. However, it is clear that they can also pose risks for their users, especially in view of the current lack of regulation.

In essence, virtual currencies act as a medium of exchange and as a unit of account within a particular virtual community. The question then arises as to whether they also fulfil the "store of value" function in terms of being reliable and safe, or whether they pose a risk not only for their users but also the wider economy.

2 See http://en.wikipedia.org/wiki/Local_currency

2 VIRTUAL CURRENCY SCHEMES

2.1 DEFINITION AND CATEGORISATION

Against the background provided in the previous chapter and based on observed characteristics, it is possible to provide the following definition of virtual currency: "a virtual currency is a type of unregulated, digital money, which is issued and usually controlled by its developers, and used and accepted among the members of a specific virtual community". This definition may need to be adapted in future if fundamental characteristics change.

There are typically two ways to obtain virtual currencies. In many virtual currency schemes, the fastest way is to purchase it using "real" money at a conversion rate that has been previously established;[1] the virtual currency itself usually has no commodity-backed value.[2] Secondly, users can often increase their stock by engaging in specific activities, for instance by responding to a promotion or advertisement or by completing an online survey.

There are many different virtual currency schemes and it is not easy to classify them. One possibility is to focus on their interactions with real money and the real economy. This occurs through two channels: a) the monetary flow via currency exchanges; and b) the real flow in the sense of the possibility to purchase real goods and services. Taking this as a basis, three types can be distinguished:

1) *Closed virtual currency schemes*. These schemes have almost no link to the real economy and are sometimes called "in-game only" schemes.[3] Users usually pay a subscription fee and then earn virtual money based on their online performance. The virtual currency can only be spent by purchasing virtual goods and services offered within the virtual community and, at least in theory, it cannot be traded outside the virtual community.

Example: World of Warcraft (WoW) Gold is a virtual currency used in this well-known online role-playing game designed by Blizzard Entertainment. Players have different options (with different subscription fees) for opening an account and starting to play. WoW Gold is needed as a means of exchange in the game, for instance in order for players to equip themselves well enough to reach higher levels. Players have several opportunities to earn WoW Gold within the game. Buying and selling WoW Gold in the real world is strictly forbidden under the terms and conditions established by Blizzard Entertainment.[1]

1 However, there seems to be a black market for buying and selling WoW Gold outside the virtual currency scheme. If Blizzard Entertainment discovers any illegal exchange, it can suspend or ban a player's account.

1 For the time being, there seems to be no virtual currency exchange system for transferring and exchanging money between the different virtual communities. This situation could change if initiatives, such as "Currency Connect" (http://www.currencyconnect.com/) succeed.

2 There may be exceptions. For instance, e-gold (http://www.e-gold.com/) is a virtual currency scheme, which was founded in 1996 and is operated by Gold & Silver Reserve Inc. trading as e-gold Ltd. This currency is 100% backed by physical gold (or silver, platinum and palladium) held in locations around the world, such as London or Zurich. Users opening an e-gold account are actually buying a quantity of gold. The value of the account is linked to the price of gold. The system, which also allows the transfer of money to other users, operates with some companies acting as market makers, buying and selling this virtual currency (i.e. the underlying metal) against other currencies. The US authorities have accused this scheme of violating anti-money laundering regulations. In 2008 the company's founder and two senior directors agreed to plead guilty to various charges related to money laundering and the operation of an unlicensed money transfer business. In 2009 the company contacted the US Government in order to reconvert its activity. The dialogue culminated in the development of a Value Access Plan acceptable to both the company and the Government. Once this plan is implemented, the expectation is that users will again have access to the value in their accounts.

3 Strauss (2010).

2) *Virtual currency schemes with unidirectional flow*. The virtual currency can be purchased directly using real currency at a specific exchange rate, but it cannot be exchanged back to the original currency. The conversion conditions are established by the scheme owner. Type 2 schemes allow the currency to be used to purchase virtual goods and services, but some may also allow their currencies to be used to purchase real goods and services.

Example 1: Facebook Credits (FB), Facebook's virtual currency was introduced in 2009 to allow users to buy virtual goods in any application on the Facebook platform. It was possible to buy this currency using a credit card, PayPal account or a variety of other payment methods. A purchase made using any other currency than US dollars would undergo a conversion into US dollars using a daily exchange rate, before being exchanged for Facebook Credits at the rate of FB 1 = USD 0.10. Users were able to gain additional Facebook Credits through special promotions, for instance if they made online purchases. The terms on the website did not provide for a conversion back to US dollars.[1] Surprisingly, in June 2012 the company announced that it would "update the payments product" and that it would convert all prices and balances that were quoted in Facebook Credits into local currency amounts starting in July 2012.[2]

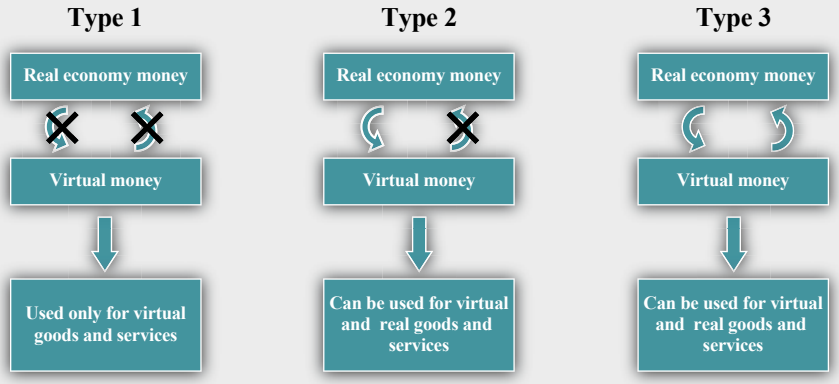
Example 2: The virtual currency scheme set up by Nintendo, called Nintendo Points, can be redeemed in Nintendo's shops and in their games. Consumers can purchase points online by using a credit card or in retail stores by purchasing a Nintendo Points Card. The Points cannot be converted back to real money.

1 See Liu (2010).
2 See http://developers.facebook.com/blog/post/2012/06/19/introducing-subscriptions-and-local-currency-pricing/

3) *Virtual currency schemes with bidirectional flow*. Users can buy and sell virtual money according to the exchange rates with their currency. The virtual currency is similar to any other convertible currency with regard to its interoperability with the real world. These schemes allow for the purchase of both virtual and real goods and services.

Example: Linden Dollars (L$) is the virtual currency issued in Second Life, a virtual world where users create "avatars", i.e. digital characters that can be customised. Second Life has its own economy where users can buy and sell goods and services from and to each other. In order to do so, they need Linden Dollars, which can be purchased with US dollars and other currencies according to the exchange rates established in the currency trading market. A credit card or PayPal account is needed. Users can sell their spare Linden Dollars in return for US dollars.

Chart 2 Types of virtual currency scheme



Source: ECB.
Note: A subscription fee may be required for Type 1.

Box 1

FREQUENT-FLYER PROGRAMMES

Loyalty programmes in the form of vouchers, coupons and bonus points have long existed. Airlines' points/air miles programmes are one of these reward systems implemented to increase frequent flyers' loyalty towards the company. Every time a customer buys a flight or pays with a credit card linked to the frequent-flyer programme, they receive additional air miles that can be exchanged for free flights or for an upgrade to business class.

As highlighted by The Economist (2005), these programmes have reached outstanding values, even surpassing the total amount of dollar notes and coins in circulation (i.e. the M0 supply). Airline companies also sell miles to credit card firms, generating substantial additional revenue for airlines. In addition, these programmes form part of the airlines' marketing and business strategies. By providing the frequent flyer with air miles for buying a flight at a particular time or, on the contrary, by making it harder to spend air miles (e.g. requesting more air miles for a free flight or restricting the number of seats available), the airlines can influence their customers' demand. In practice, this means that the airlines can manage the supply of air miles according to their own strategy.

Based on the definition and concept of virtual currency schemes developed in this section, frequent-flyer programmes can be viewed as a specific type of virtual currency scheme, which exhibits the following features:

– Users usually receive air miles for buying a flight, but they can also earn them in many other ways (e.g. by paying with a linked credit card, by responding to a promotion, etc.). Users can also buy air miles with real money at a specific exchange rate.

– Once the money is in the system, it cannot legally be redeemed into real money. However, as is the case with other virtual currencies, there may also be a black market for air miles.

– Air miles can be used to purchase real goods, i.e. flights. However, it seems that some schemes also allow air miles to be used when buying other real goods and services, but this practice seems to be marginal at this stage.

Taking all these elements into account, it is possible to classify the airlines' frequent-flyer programmes as characteristic of the Type 2 virtual currency schemes.

2.2 VIRTUAL CURRENCY SCHEMES AND ELECTRONIC MONEY

Virtual currency schemes can be considered to be a specific type of electronic money, basically used for transactions in the online world. However, a clear distinction should be made between virtual currency schemes and electronic money (see also Table 2).

According to the Electronic Money Directive (2009/110/EC), "electronic money" is monetary value as represented by a claim on the issuer which is: stored electronically; issued on receipt of funds of an amount not less in value than the monetary value issued; and accepted as a means of payment by undertakings other than the issuer.

Although some of these criteria are also met by virtual currencies, there is one important difference. In electronic money schemes the link between the electronic money and the traditional money format is preserved and has a legal foundation, as the stored funds are expressed in the same unit of account (e.g. US dollars, euro, etc.). In virtual currency schemes the unit of account is changed into a virtual one (e.g. Linden Dollars, Bitcoins). This is not a minor issue, specifically in Type 3 schemes. Firstly, these schemes rely on a specific exchange rate that may fluctuate, since the value of the virtual currency is usually based on its own demand and supply. Secondly, to some extent the conversion blurs the link to traditional currency, which might be problematic when retrieving funds, if this is even permitted. Lastly, the fact that the currency is denominated differently (i.e. not in euro, US dollar, etc.) and that the funds do not need to be redeemed at par value means that complete control of the virtual currency is left to its issuer, which is usually a non-financial company.

Table 2 Differences between electronic money schemes and virtual currency schemes

	Electronic money schemes	Virtual currency schemes
Money format	Digital	Digital
Unit of account	Traditional currency (euro, US dollars, pounds, etc.) with legal tender status	Invented currency (Linden Dollars, Bitcoins, etc.) without legal tender status
Acceptance	By undertakings other than the issuer	Usually within a specific virtual community
Legal status	Regulated	Unregulated
Issuer	Legally established electronic money institution	Non-financial private company
Supply of money	Fixed	Not fixed (depends on issuer's decisions)
Possibility of redeeming funds	Guaranteed (and at par value)	Not guaranteed
Supervision	Yes	No
Type(s) of risk	Mainly operational	Legal, credit, liquidity and operational

Source: ECB.

Moreover, electronic money schemes are regulated and electronic money institutions that issue means of payment in the form of electronic money are subject to prudential supervisory requirements. This is not the case for virtual currency schemes.

Consequently, the risks faced by each type of money are different. Electronic money is primarily subject to the operational risk associated with potential disruptions to the system on which the electronic money is stored. Virtual currencies are not only affected by credit, liquidity and operational risk without any kind of underlying legal framework, these schemes are also subject to legal uncertainty and fraud risk, as a result of their lack of regulation and public oversight.

The definition of virtual currency schemes used in this report excludes an entity like PayPal, the internet-based payment system. Although a virtual account is created, no virtual currency is issued in the PayPal environment. A PayPal account is funded via credit transfer from a bank account or by a credit card payment, i.e. it operates within the banking system. Besides, its European subsidiary is based in Luxembourg and has been operating with an EU banking licence since 2007. As a consequence, PayPal is supervised by the Commission de Surveillance du Secteur Financier of Luxembourg and the electronic money scheme is overseen by the Banque centrale du Luxembourg.

2.3 PAYMENT ARRANGEMENTS IN VIRTUAL CURRENCY SCHEMES

Just like in the real economy, in a virtual economy there are a wide range of economic actors who engage in transactions that have to be settled. These transactions have two settlement components: a) the delivery of (usually virtual, but potentially also real) goods and services; and b) the transfer of funds.

A "payment system" can be defined as a set of instruments, procedures, and rules for the transfer of funds among system participants. It is typically based on an agreement between the participant in the system and the system operator, and the transfer of funds is conducted using an agreed technical infrastructure.[4] In essence, virtual currency schemes work much like retail payment systems, except for the fact that financial intermediaries are not usually involved in the payment process. Virtual currency schemes demonstrate three main elements or processes of a retail payment system:[5]

a) A payment instrument is used as the means of authorising and submitting the payment.

b) Processing and clearing involves a payment instruction being exchanged between the creditor and the debtor concerned.

c) Debits and credits are settled in the user's account.

Although there are different models that may lead to important variations, the following specific features can typically be observed for payment arrangements within virtual currency schemes:

– *Agents involved*: Virtual currencies are held outside the traditional banking channels. A non-financial institution plays the crucial role and there are no other institutions providing payment accounts or payment services, or organisations that operate payment, clearing and settlement services. In this regard, virtual currency schemes work like traditional three-party schemes

4 BIS (2001), p. 14, and ECB Glossary of Terms Related to Payment, Clearing and Settlement Systems.
5 Kokkola (ed.) (2010), p. 25.

with a scheme-owned processor. The accounts to be debited and credited are held within this organisation, which is the virtual community operator. Virtual currency payments are therefore handled "in house" and can be classified as a specific type of "on-us" transaction, that is, a transfer of a claim on the virtual currency issuer.

– *Type of transactions:* From a conceptual perspective, payments can be classified as retail payments, i.e. a large number of payments with small values. The payment instrument is typically a virtual credit transfer.

– *Type of settlement:* Payments are usually settled on a gross basis. Each payment instruction is passed on and settled individually across the accounts of the payer and the payee, resulting in a debit and credit entry for every single payment instruction settled. As a general rule, the settlement is in real time, i.e. on a continuous basis throughout an entire day.

2.4 REASONS FOR IMPLEMENTING VIRTUAL CURRENCY SCHEMES

There are several reasons for a virtual community to issue its own virtual currency. By implementing a virtual currency scheme focused on the online world (basically for virtual goods and services) a company can generate additional revenue. The use of virtual currencies can help motivate users by simplifying transactions and by preventing them from having to enter their personal payment details every time they want to make a purchase. It can also help lock users in if, for instance, it is possible to earn virtual money by logging in periodically. If users are asked to fill out a survey or to answer other questions in order to earn extra virtual money, users reveal their preferences, thereby providing valuable information for commercial use. Virtual currencies can also be used as an important tool for application developers and advertisers when designing a strategy to reap the benefits of the virtual goods market.

At this stage, it is very difficult to come up with a reliable figure for the size of the virtual goods market.[6] On the one hand, there is no universal criterion of what the virtual goods market encompasses. On the other hand, innovations in this field are growing and spreading significantly and, therefore, it is nearly impossible to gather the information necessary to provide a complete picture of the virtual communities and virtual currency schemes that exist. Nevertheless, there are a few estimates circulating on the internet. These show the modest magnitude that this market, which is particularly concentrated in Asia and the United States, may have reached (see Chart 3). Although most of these estimates are not made on a scientific basis, they all indicate that the size of the virtual goods market is far from reaching its potential and that it will grow in the future.

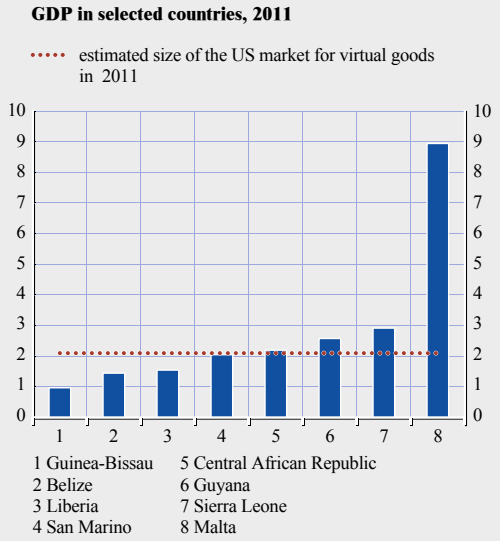
Traditional payment service providers do not want to get left behind either. VISA, for instance, recently acquired PlaySpan Inc. for USD 190 million, with additional considerations for performance milestones. PlaySpan is a privately held company, whose payments platform handles transactions for digital goods in online games, digital media and social networks around the world.[7]

6 A virtual good or resource can be defined as "any virtual-world object/service that increases […] satisfaction, desirability or usefulness, for example, website goodwill, e-books, music files, game equipments, rights to access web, or e-payment services a site provides" (Guo, Chow and Gong, 2009, p. 85). Therefore, an illustration of a flower sent to someone else in a social network or better equipment for a character which is needed to reach higher levels in an online game are two examples of virtual goods that are sold in virtual communities. However, in our view, there should be a clear differentiation between goods that are used only in the virtual environment and those which are used in the real world (e.g. music files or electronic books).

7 See the company's press release (http://corporate.visa.com/media-center/press-releases/press1099.jsp).

Chart 3 Estimates for the size of the virtual goods market

(USD billions)



Source	Estimated size
C. Hudson (2008) *SoftTech VC and Bionic Panda Games*	USD 200 million in 2008
C. C. Miller and B. Stone (2009) *New York Times*	USD 1 billion in the United States in 2008; USD 5 billion worldwide
B. Parr (2009) *Mashable*	USD 1 billion in the US market; USD 7 billion in the Asian market
A. Shukla (2008) *Offerpal Media*	USD 2 billion in the United States in 2008
J. Smith and C. Hudson (2010) *Inside Network*	USD 1.6 billion in the United States in 2010; will reach USD 2.1 billion overall in 2011
M. Shiels (2009) *BBC News*	USD 5 billion in the United States in five years; in Asia this figure has already been reached

Sources: IMF World Economic Outlook database and Smith and Hudson (2010) estimate.

In September 2011, American Express paid USD 30 million for Sometrics, a four-year-old company that helps video game makers establish virtual currencies and virtual currency commerce within their games.[8] Apparently, the company plans to build a virtual currency platform in other industries, taking advantage of its merchant relationships.

An additional reason for implementing a virtual currency scheme is the possibility, in Type 2 and 3 schemes, to obtain new revenue from the float that results from the time difference between the moment at which money is transferred into the system and the moment at which it is taken out from the system again (either – in Type 3 only – via a currency exchange or – for both types – following the purchase of goods and services from third parties). In addition, scheme owners may also make a breakage profit from money which is not spent or exchanged back after its owners stop being active users.

In general, the motivation for setting up Type 3 schemes may differ from the incentives for the other schemes; of particular interest are the schemes designed to compete against real currencies as a medium of exchange. For the time being, the most prominent case is Bitcoin which, according to its creators and supporters, should overcome the limitations of traditional currencies that result from the monopolistic supply and management by central banks.

8 See Button (2011).

3 CASE STUDIES

This chapter focuses on two prominent Type 3 virtual currency schemes; the first is Bitcoin and the second is the scheme established by Linden Lab for Second Life, namely Linden Dollars.

3.1 THE BITCOIN SCHEME

3.1.1 BASIC FEATURES

Bitcoin is probably the most successful – and probably most controversial – virtual currency scheme to date. Designed and implemented by the Japanese programmer Satoshi Nakamoto in 2009,[1] the scheme is based on a peer-to-peer network similar to BitTorrent, the famous protocol for sharing files, such as films, games and music, over the internet. It operates at a global level and can be used as a currency for all kinds of transactions (for both virtual and real goods and services), thereby competing with official currencies like the euro or US dollar. The scheme maintains a database that lists product and service providers which currently accept Bitcoins.[2] These products and services range from internet services and online products to material goods (e.g. clothing and accessories, electronics, books, etc.) and professional or travel/tourism services. Bitcoins are divisible to eight decimal places enabling their use in any kind of transaction, regardless of the value. Although Bitcoin is a virtual currency scheme, it has certain innovations that make its use more similar to conventional money (see Box 3 in Chapter 4).

Bitcoins are not pegged to any real-world currency. The exchange rate is determined by supply and demand in the market. There are several exchange platforms for buying Bitcoins that operate in real time.[3] Mt.Gox is the most widely used currency exchange platform and allows users to trade US dollars for Bitcoins and vice versa. As previously stated, Bitcoin is based on a decentralised, peer-to-peer (P2P) network, i.e. it does not have a central clearing house, nor are there any financial or other institutions involved in the transactions. Bitcoin users perform these tasks themselves. In the same vein, there is no central authority in charge of the money supply. As will be explained later, the money supply is determined by a specific type of "mining" activity. It depends on the amount of resources (electricity and CPU time) that "miners" devote to solving specific mathematical problems.

In order to start using Bitcoins, users need to download the free and open-source software. Purchased Bitcoins are thereafter stored in a digital wallet on the user's computer. Consequently, users face the risk of losing their money if they don't implement adequate antivirus and back-up measures. Users have several incentives to use Bitcoins. Firstly, transactions are anonymous, as accounts are not registered and Bitcoins are sent directly from one computer to another.[4] Also, users have the possibility of generating multiple Bitcoin addresses to differentiate or isolate transactions. Secondly, transactions are carried out faster and more cheaply than with traditional means of payment. Transactions fees, if any, are very low and no bank account fee is charged.

1 However, this is not his/her real name. See the entry on the Bitcoin wiki (https://en.bitcoin.it/wiki/Satoshi_Nakamoto). The content of this chapter partially relies on the information provided by Bitcoin (http://www.bitcoin.org/) and the Bitcoin community (https://en.bitcoin.it/wiki/FAQ). The original paper by Nakamoto (2009) is also used.

2 See https://en.bitcoin.it/wiki/Trade

3 These are Mt.Gox, TradeHill (closed down in 2012), Bitomat, Britcoin, Intersango, ExchangeBitcoin.com, Camp BX, Bitcoin7, VirtEx, VirWox or WM-Center. For smaller amounts, the options are limited due to bank transfer fees, conversion fees and restrictions on transaction size. Options include Bitcoin Market, BitMarket.eu, Bitcoiny.cz, Bit / BTC China, Bitfunnel, #bitcoin-otc, BitcoinExchange Services, Lilion Transfer, Nanaimo Gold, Bitcoin Morpheus, Bitcoin Argentina, Bitcoin.com.es, Bahtcoin, Bitcoin Brasil, BitPiggy, GetBitcoin, Bitcoin 4 Cash, Bitcoin2Cash, bitcoin.local, YouTipIt and Ubitex.

4 However, it seems that all Bitcoin transactions are recorded and can, under certain circumstances (e.g. law enforcement), be traced.

Box 2

ECONOMIC FOUNDATIONS OF BITCOIN

The theoretical roots of Bitcoin can be found in the Austrian school of economics and its criticism of the current fiat money system and interventions undertaken by governments and other agencies, which, in their view, result in exacerbated business cycles and massive inflation.

One of the topics upon which the Austrian School of economics, led by Eugen von Böhm-Bawerk, Ludwig von Mises and Friedrich A. Hayek, has focused is business cycles.[1] In short, according to the Austrian theory, business cycles are the inevitable consequence of monetary interventions in the market, whereby an excessive expansion of bank credit causes an increase in the supply of money through the money creation process in a fractional-reserve banking system, which in turn leads to artificially low interest rates.[2] In this situation, the entrepreneurs, guided by distorted interest rate signals, embark on overly ambitious investment projects that do not match consumers' preferences at that time relating to intertemporal consumption (i.e. their decisions regarding near-term and future consumption). Sooner or later, this widespread imbalance can no longer be sustained and leads to a recession, during which firms need to liquidate any failed investment projects and readapt (restructure) their production structures in line with consumers' intertemporal preferences. As a result, many Austrian School economists call for this process to be abandoned by abolishing the fractional-reserve banking system and returning to money based on the gold standard, which cannot be easily manipulated by any authority.

Another related area in which Austrian economists have been very active is monetary theory. One of the foremost names in this field is Friedrich A. Hayek. He wrote some very influential publications, such as *Denationalisation of Money* (1976), in which he posits that governments should not have a monopoly over the issuance of money. He instead suggests that private banks should be allowed to issue non-interest-bearing certificates based on their own registered trademarks. These certificates (i.e. currencies) should be open to competition and would be traded at variable exchange rates. Any currencies able to guarantee a stable purchasing power would eliminate other less stable currencies from the market.[3] The result of this process of competition and profit maximisation would be a highly efficient monetary system where only stable currencies would coexist.

The following ideas are generally shared by Bitcoin and its supporters:

– They see Bitcoin as a good starting point to end the monopoly central banks have in the issuance of money.

– They strongly criticise the current fractional-reserve banking system whereby banks can extend their credit supply above their actual reserves and, simultaneously, depositors can withdraw their funds in their current accounts at any time.

– The scheme is inspired by the former gold standard.

1 A description of the Austrian Business Cycle Theory can be found, for instance, in Rothbard (2009).
2 Fractional-reserve banking is a form of banking where credit institutions maintain reserves (in cash and coin or in deposits at the central bank) that are only a fraction of their customers' deposits. Funds deposited into a bank are mostly lent out, and banks keep only a fraction (called the reserve ratio) of the quantity of deposits as reserves. Modern banking systems are based on fractional-reserve banking.
3 An interesting speech on this issue can be found in Issing (1999).

Although the theoretical roots of the scheme can be found in the Austrian School of economics, Bitcoin has raised serious concerns among some of today's Austrian economists. Their criticism covers two general aspects:[4] a) Bitcoins have no intrinsic value like gold; they are mere bits stored in a computer; and b) the system fails to satisfy the "Misean Regression Theorem", which explains that money becomes accepted not because of a government decree or social convention, but because it has its roots in a commodity expressing a certain purchasing power.

4 As described in Matonis (2011).

3.1.2 TECHNICAL DESCRIPTION OF A BITCOIN TRANSACTION

The technical aspects of this system are complex and not easy to understand without a sound technical background. Therefore, a comprehensive explanation of the underlying technical mechanism of Bitcoin lies outside the scope of this report. This section aims simply to provide a basic description of the functioning of this virtual currency scheme. According to the founder, Nakamoto (2009), an electronic coin can be defined as a chain of digital signatures. Each owner of the currency (P^i) has a pair of keys, one public and one private. These keys are saved locally in a file and, consequently, a loss or deletion of the file would mean that all Bitcoins associated with it are lost as well.[5]

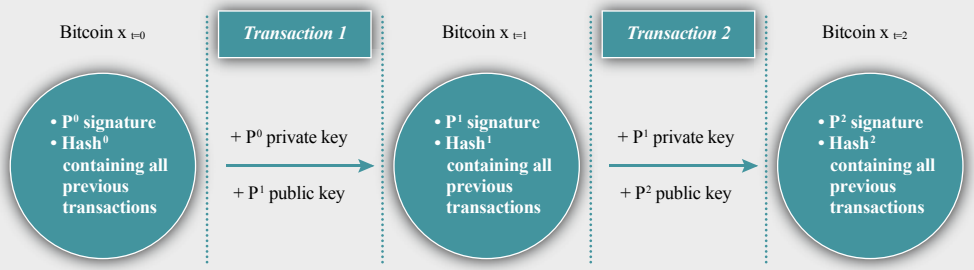
A simplified illustration of a chain of transactions from one node to another can be found in Chart 4. The virtual coin shown in the picture is the same one, but at different points in time. To initiate the transaction, the future owner P^1 has to first send his public key to the original owner P^0. This owner transfers the Bitcoins by digitally signing a hash[6] of the previous transaction and the public key of the future owner. Every single Bitcoin carries the entire history of the transactions it has undergone, and any transfer from one owner to another becomes part of the code. The Bitcoin is stored in such a way that the new owner is the only person allowed to spend it.

All signed transactions are then sent to the network, which means that all transactions are public transactions, although no information is given regarding the involved parties. The key issue to be addressed by the system is the avoidance of double spending, i.e. how to prevent a coin being copied or forged, especially considering there is no intermediary validating the transactions. The solution implemented is based on the concept of a "time stamp", which is an online mechanism

5 Users can also use specific web services to store their money. These services allow people to access their money from everywhere, but also entail risks as users are outsourcing the management of their money to an unknown third party.

6 A hash, or hash value, is the value returned by an algorithm that maps large data sets to smaller data sets of fixed length.

Chart 4 A chain of Bitcoin transactions



Source: ECB.

used to ensure that a series of data have existed and have not been altered since a specific point in time, in order to get into the hash. Each time stamp includes the previous time stamp in its hash, forming a chain of ownership. By broadcasting the new transactions, the network can verify them. The systems that validate the transactions are called "miners" – essentially these are extremely fast computers in the Bitcoin network which are able to perform complex mathematical calculations that aim to verify the validity of transactions. The people who use their systems to undertake this mining activity do so on a voluntary basis, but they are rewarded with 50 newly created Bitcoins every time their system finds a solution.

"Mining" is therefore the process of validating transactions by using computing power to find valid blocks (i.e. to solve complicated mathematical problems) and is the only way to create new money in the Bitcoin scheme.[7]

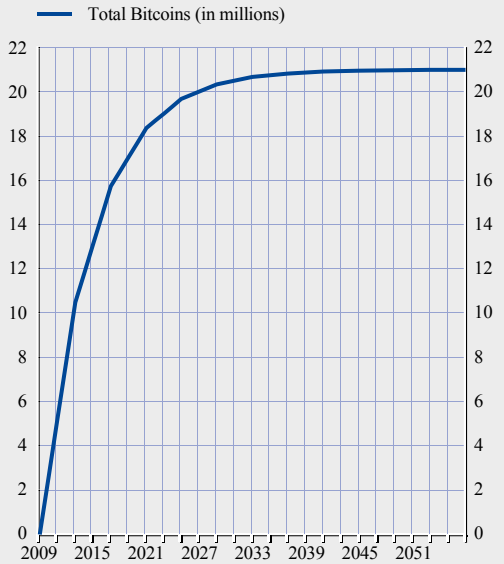
According to Nakamoto (2009), mining is also a very reliable procedure for the security and safety of the system as it provides the incentive to act honestly: "if a greedy attacker is able to assemble more CPU power than all the honest nodes, he would have to choose between using it to defraud people by stealing back his payments, or by using it to generate new coins. He ought to find it more profitable to play by the rules, such rules that favour him with more new coins than everyone else combined, than to undermine the system and the validity of his own wealth". However, as will be explained later, fraudsters may still have non-financial incentives to compromise the system.

3.1.3 MONETARY ASPECTS

The Bitcoin scheme is designed as a decentralised system where no central monetary authority is involved. Bitcoins can be bought on different platforms. However, new money is created and introduced into the system only via the above-mentioned mining activity, i.e. by rewarding the "miners" who perform the crucial role of validating all transactions made, with new Bitcoins.

Therefore, the supply of money does not depend on the monetary policy of any virtual central bank, but rather evolves based on interested users performing a specific activity. According to Bitcoin, the scheme has been technically designed in such a way that the money supply will develop at a predictable pace (see Chart 5). The algorithms to be solved (i.e. the new blocks to be discovered) in order to receive newly created Bitcoins become more and more complex (more computing resources are

Chart 5 Total Bitcoins over time



Source: Bitcoin.

7 As stated on the Bitcoin website, from a technical point of view, mining is the calculation of a hash of a block header, which includes, among other things, a reference to the previous block, a hash of a set of transactions and a nonce (a 32-bit/4-byte field whose value is set so that the hash of the block will contain a run of zeros). If the hash value is found to be less than the current target (which is inversely proportional to the difficulty), a new block is formed and the miner gets 50 newly generated Bitcoins. If the hash is not less than the current target, a new nonce is tried, and a new hash is calculated. This is done millions of times per second by each miner.

needed). As explained on its website,[8] the rate of block creation is approximately constant over time: six per hour, one every ten minutes. However, the number of Bitcoins generated per block is set to decrease geometrically, with a 50% reduction every four years. The result is that the number of Bitcoins in existence will reach 21 million in around 2040. From this point onwards, miners are expected to finance themselves via transaction fees. In fact, this kind of fee can already be charged by a miner when creating a block.

The fact that the supply of money is clearly determined implies that, in theory, the issuance of money cannot be altered by any central authority or participant wanting to "print" extra money. According to Bitcoin supporters, the system is supposed to avoid inflation, as well as the business cycles originating from extensive money creation. However, the system has been accused of leading to a deflationary spiral. The total supply of Bitcoins is expected to grow geometrically until it reaches a finite limit of 21 million. If, however, the number of Bitcoin users starts growing exponentially for any reason, and assuming that the velocity of money does not increase proportionally, a long-term appreciation of the currency can be expected or, in other words, a depreciation of the prices of the goods and services quoted in Bitcoins. People would have a great incentive to hold Bitcoins and delay their consumption, thereby exacerbating the deflationary spiral. The extent to which this could be a problem in reality is not clear. Two remarks should be made. Firstly, as highlighted by the Economist (2011a), the deflation hypothesis entails an assumption which is not realistic at this stage, i.e. that many more people will want to receive Bitcoins in return for goods or in exchange for paper money. However, Bitcoin is still quite immature and illiquid (the 6.5 million Bitcoins are shared by 10,000 users) which is a clear disincentive for its use. Secondly, Bitcoin is not the currency of a country or currency area and is therefore not directly linked to the goods and services produced in a specific economy, but linked to the goods and services provided by merchants who accept Bitcoins. These merchants may also accept another currency (e.g. US dollars) and therefore, the fact that deflation is anticipated could give rise to a situation where merchants adapt the prices of their goods and services in Bitcoins.

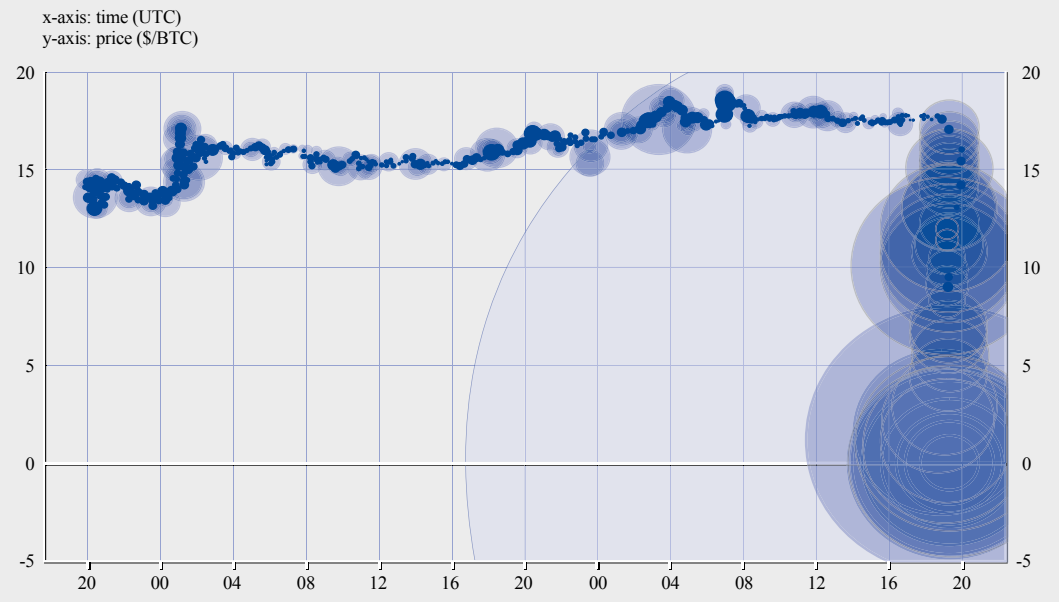
3.1.4 SECURITY INCIDENTS AND NEGATIVE PRESS

From time to time, Bitcoin is surrounded by controversy. Sometimes it is linked to its potential for becoming a suitable monetary alternative for drug dealing and money laundering, as a result of the high degree of anonymity.[9] On other occasions, users have claimed to have suffered a substantial theft of Bitcoins through a Trojan that gained access to their computer.[10] The Electronic Frontier Foundation, which is an organisation that seeks to defend freedom in the digital world, decided not to accept donations in Bitcoins anymore. Among the reasons given, they considered that "Bitcoin raises untested legal concerns related to securities law, the Stamp Payment Act, tax evasion, consumer protection and money laundering, among others".[11]

However, practically identical problems can also occur when using cash, thus Bitcoin can be considered to be another variety of cash, i.e. digital cash. Cash can be used for drug dealing and money laundering too; cash can also be stolen, not from a digital wallet, but from a physical one; and cash can also be used for tax evasion purposes. The question is not so much related to the format of money as such (physical or digital), but rather to the use people make of it. Nevertheless, if the use of digital money in itself complicates investigations and law enforcement, special requirements may be needed. Therefore, the real dimension of all these controversies still needs to be further analysed.

8 See https://en.bitcoin.it/wiki/Controlled_inflation
9 See, for instance, http://gawker.com/5805928/the-underground-website-where-you-can-buy-any-drug-imaginable
10 One user claims to have lost 25,000 Bitcoins worth USD 500,000. See http://forum.bitcoin.org/index.php?topic=16457.0
11 Announced by Cindy Cohn, Legal Director for the Foundation. See http://www.eff.org/deeplinks/2011/06/eff-and-bitcoin

Chart 6 Mt.Gox exchange rate on 20 June 2011



Source: Mt.Gox.

Bitcoin has also featured in the news, in particular following a cyberattack perpetrated on 20 June 2011, which managed to knock the value of the currency down from USD 17.50 to USD 0.01 within minutes. Apparently, around 400,000 Bitcoins (worth almost USD 9 million) were involved. According to currency exchange Mt.Gox, one account with a lot of Bitcoins was compromised and whoever stole it (using a Hong Kong based IP to login) first sold all the Bitcoins in there, only to buy them back again immediately afterwards, with the intention of withdrawing the coins. The USD 1,000/day withdrawal limit was active for this account and the hacker was only able to exchange USD 1,000 worth of Bitcoins. Apart from this, no other accounts were compromised, and nothing was lost.[12]

Chart 6 shows the evolution of Bitcoin's exchange rate on the Mt.Gox exchange platform during the hours of the incident, and is also the expression of how an immature and illiquid currency can almost completely disappear within minutes, causing panic to thousands of users.

In addition, the perpetrator hacked into the Mt.Gox database, gaining access to usernames, e-mail addresses and hashed passwords for thousands of users. Mt.Gox reacted by closing the system for a few days and by promising that the transactions carried out by the hacker would be reversed. Bitcoin defenders claim that the Bitcoin system did not fail. The problem was related to a particular trading platform – Mt.Gox – which did not have strong enough security measures.

In a more recent case (May 2012), the exchange platform Bitcoinica lost 18,547 Bitcoins from its deposits following a cyberattack, in which sensitive customer data might also have been obtained.[13]

12 See Mt.Gox press release https://mtgox.com/press_release_20110630.html
13 See http://www.finextra.com/News/Fullstory.aspx?newsitemid=23713

Another recurrent issue is whether Bitcoin works like a Ponzi scheme or not. Users go into the system by buying Bitcoins against real currencies, but can only leave and retrieve their funds if other users want to buy their Bitcoins, i.e. if new participants want to join the system. For many people, this is characteristic of a Ponzi scheme. The US Securities and Exchange Commission defines a Ponzi scheme in the following terms:

A Ponzi scheme is an investment fraud that involves the payment of purported returns to existing investors from funds contributed by new investors. Ponzi scheme organizers often solicit new investors by promising to invest funds in opportunities claimed to generate high returns with little or no risk. In many Ponzi schemes, the fraudsters focus on attracting new money to make promised payments to earlier-stage investors and to use for personal expenses, instead of engaging in any legitimate investment activity.[14]

On the one hand, the Bitcoin scheme is a decentralised system where – at least in theory – there is no central organiser that can undermine the system and disappear with its funds. Bitcoin users buy and sell the currency among themselves without any kind of intermediation and therefore, it seems that nobody benefits from the system, apart from those who benefit from the exchange rate evolution (just as in any other currency trade) or those who are hard-working "miners" and are therefore rewarded for their contribution to the security and confidence in the system as a whole. Moreover, the scheme does not promise high returns to anybody. Although some Bitcoin users may try to profit from exchange rate fluctuations, Bitcoins are not intended to be an investment vehicle, just a medium of exchange. On the contrary, Gavin Andresen, Lead Developer of the Bitcoin virtual currency project, does not hesitate to say that "Bitcoin is an experiment. Treat it like you would treat a promising internet start-up company: maybe it will change the world, but realise that investing your money or time in new ideas is always risky".[15] In addition, Bitcoin supporters claim that it is an open-source system whose code is available to any interested party.

However, it is also true that the system demonstrates a clear case of information asymmetry. It is complex and therefore not easy for all potential users to understand. At the same time, however, users can easily download the application and start using it even if they do not actually know how the system works and which risks they are actually taking. This fact, in a context where there is clear legal uncertainty and lack of close oversight, leads to a high-risk situation. Therefore, although the current knowledge base does not make it easy to assess whether or not the Bitcoin system actually works like a pyramid or Ponzi scheme, it can justifiably be stated that Bitcoin is a high-risk system for its users from a financial perspective, and that it could collapse if people try to get out of the system and are not able to do so because of its illiquidity. The fact that the founder of Bitcoin uses a pseudonym – Satoshi Nakamoto – and is surrounded by mystery does nothing to help promote transparency and credibility in the scheme.

All these issues raise serious concerns regarding the legal status and security of the system, as well as the finality and irrevocability of the transactions, in a system which is not subject to any kind of public oversight. In June 2011 two US senators, Charles Schumer and Joe Manchin, wrote to the Attorney General and to the Administrator of the Drug Enforcement Administration expressing their worries about Bitcoin and its use for illegal purposes. Mr Andresen was also asked to give a presentation to the CIA about this virtual currency scheme.[16] Further action from other authorities can reasonably be expected in the near future.

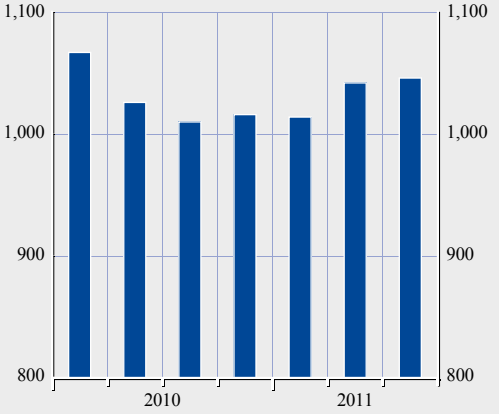
14 See http://www.sec.gov/answers/ponzi.htm
15 See http://gavinthink.blogspot.com/2011/06/that-which-does-not-kill-us-makes-us.html
16 According to Finextra (http://www.finextra.com/news/fullstory.aspx?newsitemid=22644) and Chapman (2011).

3.2 THE SECOND LIFE SCHEME

3.2.1 BASIC FEATURES

Second Life is a virtual community created by Linden Lab (Linden Research, Inc.), a privately held company based in San Francisco. The company, whose CEO is Philip Rosedale, has developed a 'massively multiplayer online role-playing game', which was launched in June 2003. It is based on a three-dimensional modelling tool that allows users to build virtual objects.

Chart 7 Average number of users logging in each month



Source: Reports on Second Life Economy.

The main idea behind Second Life is to create an opportunity for people to change all the things about their life that they dislike. This virtual world mirrors the real world, and its users – called residents – interact with each other and perform their daily tasks and activities just as they do in real life (e.g. meeting friends, playing, writing or organising a party). They can also engage in a business project or buy a house, a car or a yacht. In this virtual world, users do not have to face any kind of restriction.

Users need to install software on their computers and open a free Second Life account to make use of the virtual world. A premium membership option (USD 9.95 per month, USD 22.50 quarterly, or USD 72 per year), which extends access to an increased level of technical support, is also available. Chart 7 shows that the average number of users logging in each month is quite stable at just above one million per month. The number of users registered on 28 November 2011 was more than 26 million. Once they have subscribed, users become residents and they can start using this online world by creating avatars – the residents' digital representation – which may take any form they choose (human, animal, vegetable, mineral, or a combination thereof) or even their own image in real life. A resident account can only have one avatar at a time. Nevertheless, residents are free to change the form of their avatars at any time. Residents can earn money in different ways. They can sell whatever they are able to create; they can also profit from their previous investments (e.g. buying a house and then selling it at a higher price), but they can also win prizes in events. In addition, premium accounts receive a weekly automatic grant of 300 Linden Dollars paid into the member's avatar account.

3.2.2 SECOND LIFE ECONOMY

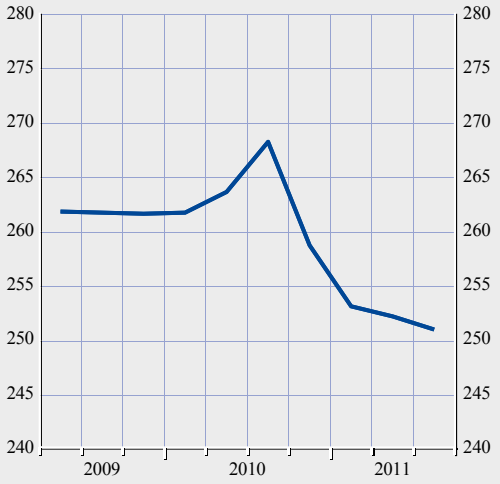
In the Second Life economy, people create items, such as clothes, games or spacecraft, and then sell them within the community. Most of the money earned comes from the virtual equivalent of land speculation, as people lease islands or erect buildings and then rent them out to others at a premium.[17] The economy within Second Life works in a similar way to any other economy in the world, but exhibits three specific features. Firstly, it is a self-sufficient economy, i.e. a closed economy where no activity is conducted with the outside; secondly, it is only focused on virtual goods and services; and thirdly, it is generated and takes place entirely within Linden Lab's infrastructure. Everything else is quite similar to a normal economy. Second Life has its own

17 The Economist (2006).

economic agents (buyers, sellers and even an online-community regulator) interacting in its economic system and conducting commerce; the factors of production are the same as in a real economy (labour, capital and land); and the price system is the mechanism in charge of resource allocation. As a consequence, Second Life's output can be measured and, according to one estimate, the value of transactions increased by 94% on a year-on-year basis in 2009. Residents exchange goods and services worth around USD 600 million each year and the Second Life economy is estimated to be bigger in terms of GDP than 19 countries, including Samoa.[18] Although Second Life seems to have the largest output among the virtual communities, it is obvious that it is still far from reaching a significant volume. Second Life has its own financial system and exchange market. In 2006 this virtual community also started issuing its own virtual currency, called Linden Dollars (L$). The Linden Dollar is a virtual currency that has to be purchased (e.g. by credit card or PayPal) before being used to buy virtual goods and services inside the Second Life community. In principle, real-world goods and services cannot be purchased with Linden Dollars.

Chart 8 Average exchange rate

(Linden Dollar/US dollar)



Source: Reports on Second Life Economy.

This currency can be bought through Linden Lab's currency brokerage, the LindeX Currency Exchange, or other third-party currency exchanges. It can also be converted back into real money. As can be seen in Chart 8, the exchange rate has been quite stable, at around L$ 260 = USD 1. This is because Linden Lab tries to keep volatility low by injecting new Linden Dollars as demand increases. Therefore, it can be said that the Linden Dollar is, to some extent, pegged to the US dollar. According to the Second Life Economy in Q4 2010 report, the total LindeX volume traded in 2010 was nearly USD 119 million, 2.8% higher than in 2009.

Although Second Life's economy exists online, companies selling virtual goods and services can make real profits. Moreover, as reported by Elliot (2008), some companies are also starting to use the online world for merchandising their products. Companies, such as Cisco, Reuters, Dell, Sun Microsystems, Adidas, Starwood Hotels and Toyota have made use of the Second Life environment for marketing and brand-building purposes. In addition, some universities (e.g. Chicago Law School, the University of Idaho and New York University) and politicians (e.g. Hillary Clinton) have a presence in Second Life.

3.2.3 MONETARY ASPECTS

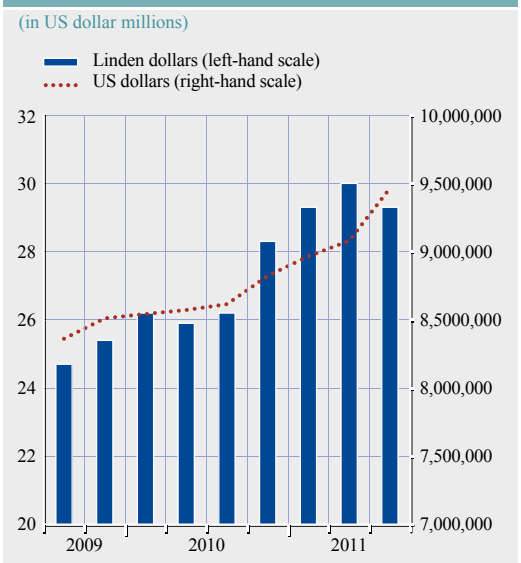
Second Life also has its own monetary policy, based on the supply of Linden Dollars by Linden Lab. As explained by Peng and Sun (2009), the total amount of this virtual currency in circulation depends on three elements: a) the net selling amount of Linden Dollars traded by Linden Lab on LindeX with users, which is similar to the open market operations conducted by central banks in the real world; b) Linden Lab's revenue in Linden Dollars from island sales and land rental to

18 Fleming (2010).

residents; and c) the Linden Dollar grant paid by Linden Lab to premium members. Only in the first and last cases is new money created. In its terms of service, the company clearly states that "Linden Dollars are available for purchase or distribution at Linden Lab's discretion, and are not redeemable for monetary value from Linden Lab". Furthermore, "Linden Lab has the right to manage, regulate, control, and/or modify the license rights underlying such Linden Dollars (…)". In practice, it can be said that Linden Lab acts as the issuing bank in the Second Life environment. It can change the quantity of money in circulation as it wants and decide how to allocate these resources.

Chart 9 shows the evolution of the supply of Linden Dollars and, in order to provide an overview of the dimension of this virtual money supply, it is compared with the supply of US dollars. So far money supply is negligible and cannot therefore influence any state's economy.

Chart 9 Supply of Linden Dollars and US dollars



Sources: Second Life and Federal Reserve.
Notes: The US money stock is measured by M2 (not seasonally adjusted). The figures refer to the last month of every quarter.

Linden Lab's money issuing policy within the virtual community has not escaped criticism. For example, Beller (2007) suggests that they may be creating an endogenous shock since Linden Lab finances its deficit by creating new Linden Dollars. A deficit in Second Life occurs when the weekly Linden Dollar grants that Linden Lab pays to premium account holders exceed its revenue from land rentals and other administrative services it provides to residents. Every time Linden Lab runs a deficit, the supply of money instantly increases by an equivalent amount. As a consequence, to finance its deficit, Linden Lab is "printing" Linden Dollars, rather than borrowing them from the market, i.e. it is not increasing its stock of public debt, instead creating new money which is not supported by real money.

This money creation process, which artificially inflates the money supply, could be creating a boom within Second Life's economy that could lead to a recession if Linden Lab is forced to tighten its money supply. In this situation, a loss of confidence and a sudden deprecation of the Linden Dollar would be expected, causing all users that are involved in the virtual community to suffer some losses. In any case, it is important to highlight that this would only have a negative impact within the virtual community and for its users. Its effects would not spread to the real economy.

3.2.4 ISSUES WITH SECOND LIFE

Second Life is focused on the virtual world, but this does not mean that everything is virtual in this community. There are real economic transactions behind Second Life and there are also real issues and problems that arise. Within Second Life, Linden Lab is the only authority and regulator. To some extent they also oversee the system, but without the involvement of any public authority. It is not even clear if any authority even needs to be involved. In fact, in the current situation, any potential issue within this virtual marketplace can perhaps be regarded in the context of consumer protection rights.

Second Life goes beyond a regular online game. From an economic and financial point of view, Second Life exhibits specific features that link this virtual world with the real world. Firstly, as stressed above, some companies are starting to use the online world for merchandising their products. Also, virtual businesses have been set up and obtain real profits in Second Life. Secondly, it seems that some residents have been able to earn significant amounts of real money with their financial transactions, but in the process have assumed high levels of risk. In the past, some Second Life banks started offering very high interest rates on deposits, which motivated many users to change real money to buy Linden Dollars and deposit them in these banks. Such a high yield in a non-regulated environment raised some concerns with regard to the possibility that Second Life, or some users of Second Life, might actually be working like Ponzi schemes.[19] One case even appears to confirm this: Ginko Financial, a bank that used to pay very high interest rates to depositors (they could ostensibly reach up to 69.7% per year), went bankrupt in August 2007, causing losses of around USD 750,000 to some Second Life residents. After the collapse, Linden Lab introduced a rule prohibiting users from offering interest or any direct return on investment (whether in Linden Dollars or any other currency) from any object, such as an ATM, located in Second Life, without proof of an applicable government registration statement or financial institution charter.[20]

Second Life's real estate market has also developed quite quickly, basically fuelled by land speculation. In 2006, Businessweek magazine highlighted the case of Anshe Chung, a resident whose real name is Ailin Graef. Apparently, this woman (who lives in Frankfurt) has become the first online figure to achieve a net worth of more than one million US dollars; this has been achieved from profits entirely earned inside Second Life. This fortune is especially remarkable because she developed it over a period of two and a half years from her initial investment of USD 9.95, the amount required to open a premium account.[21] Her business is based on the purchase of virtual land and the construction of resorts (houses, mansions, beaches, etc.) that she sells or rents on to other residents.

In its role as unique authority and regulator, Linden Lab can control every single aspect within the community which, in turn, could have real economic consequences for its users. It could, for instance, make new rules, implement a new tax or eliminate a particular business without any kind of limitation, which gives this company near complete access to the funds circulating in the Second Life environment. For the time being, Linden Lab has used this power to ban specific businesses from Second Life, for instance internet gambling companies (in July 2007), but it could be used at any time for other purposes.

This is just one area in which uncertainty exists about Second Life, partially as a result of a lack of proper legal basis and oversight, but there are other situations in which this legal risk might materialise:

– Although Second Life has developed Digital Rights Management technology, there have been some claims related to the infringement of intellectual property rights. Moreover, a number of paying users have filed a class-action lawsuit against the company and its founder. Apparently, the terms of virtual property ownership were changed, and residents were forced to agree to new terms of service that eroded their ownership rights to virtual property and goods.[22]

19 For a critical assessment of Second Life, see Harrison (2007a,b).

20 For more information on this particular case, see http://alphavilleherald.com/2007/08/ginko-financial-2.html For more information on the Linden Lab Official Policy regarding in-world banks, see http://wiki.secondlife.com/wiki/Linden_Lab_Official:New_Policy_Regarding_Inworld_Banks

21 See Businessweek (2006) and http://www.anshechung.com/include/press/press_release251106.html

22 See http://news.cnet.com/8301-13577_3-20004004-36.html

– According to Second Life's terms of service, Linden Lab is not required to pay any compensation if Linden Dollars are lost from the database. They are completely exonerated from any operational disruption that could happen in Second Life. As the system is not properly overseen, it is difficult to assess whether the operational risk and business continuity measures in place are enough to mitigate all potential risks.

– In the same vein, Linden Lab is not liable for its users' actions, and is released from any claims relating to other users. Its liability is also limited in the event of security incidents. Linden Lab is trying to gather information on all incidents reported and is implementing different policies to avoid them. However, although there seems to be a decreasing trend, incidents have continued to be reported in recent years.

Special attention also needs to be paid to counterparty risk and fraud risk. Users are not protected against either, but both are real risks that exist in this virtual environment. Users generally do not know the reliability of the counterparty with which they are doing business. In this context, the lack of regulation and information required to open an account might create the adequate conditions for criminals, terrorists, fraudsters and money launderers.[23] The extent to which any money flows can be traced back to a particular user is unknown.

To sum up, every criminal act which takes place in the real world might also be reproduced and adapted to Second Life and probably also to other virtual communities; but the likelihood is even stronger as a result of the lack of proper regulation and oversight and owing to the high degree of anonymity that exists in these online worlds.

23 Elliot (2008).

4 THE RELEVANCE OF VIRTUAL CURRENCY SCHEMES FOR CENTRAL BANKS

As shown in the previous chapters, virtual currency schemes have become relevant in several areas that traditionally fall within the scope of the financial system and especially so in relation to the tasks of central banks. Consequently, it seems appropriate to consider the extent to which they might affect a central bank's tasks in the areas of payment systems, regulation, financial stability, monetary policy and price stability.[1]

A closed virtual currency scheme (Type 1) which focuses on a specific virtual community (e.g. an online game) is not relevant from a central bank's perspective. This kind of scheme is a simple adaptation of traditional games to suit the online world and, therefore, can be quickly disregarded in this context. For schemes that are more open and/or linked to the real economy (Types 2 and 3) the situation is different, especially if bilateral exchange rates are involved, creating the opportunity for speculative behaviour, and/or if the virtual currency can be used to buy real goods and services, thereby competing with traditional currencies.

This chapter focuses on the potential impact that virtual currency schemes may have in relation to the following central bank tasks: a) price stability, b) financial stability, and c) payment system stability. A final section is also included that examines the potential for central banks to face reputational risks arising from security incidents involving virtual currency schemes.

It is important to stress that this chapter is not intended to be a fully-fledged analysis; rather it is a first attempt at providing a basis for discussion on this issue. Largely, this is a result of the uncertainty surrounding virtual currency schemes and the lack of reliable information and data. From the analysis of the existing information it is already possible to draw an initial conclusion: it is very complicated to obtain a clear overview of the situation regarding virtual currency schemes at this stage. Almost all of the information that can be found is on the internet, written in blogs or on web pages where personal bias cannot be excluded (see, for instance, the references listed in the Annex). With the exception of a few articles from respectable media sources or economics journals, it is almost impossible to find any comprehensive papers on this issue, since no international organisations have published statements. A similar problem exists with regard to the quantitative information and statistics that would be needed in order to assess the speed at which these virtual currency schemes are growing and the point at which they could become a real threat. The quantitative information that is available is not extensive and is usually provided by the respective scheme owner.

4.1 RISKS TO PRICE STABILITY

The ways in which innovations to payment systems might have an impact on price stability and monetary policy has been extensively discussed in the context of electronic money.[2] The most important challenges identified were (i) the preservation of the unit of account, (ii) the risks to the effectiveness of monetary policy and its implementation, and (iii) the possible distortions to the information content of monetary aggregates. Conceptually, virtual currency schemes could have an impact on price stability and monetary policy if they affect the demand for the central bank's

1 The issuance of new forms of digital money and their impact on central banks' roles has been intensively debated since the early years of the European Monetary Institute (see, for instance, EMI, 1994). More recently, these issues have also been discussed in the context of the Electronic Money Directive.

2 See, for instance, ECB (1998).

liabilities and interfere in the control of the supply of money through open market operations. Overall, these schemes could affect price stability if:

a) they substantially modify the quantity of money;

b) they have an impact on the velocity of money, the use of cash, and/or influence the measurement of monetary aggregates;

c) there is an interaction between the virtual currencies and the real economy.

Regarding the first aspect – the impact on the quantity of money – it is difficult to assess, owing to the lack of reliable information, the extent to which virtual currency schemes are creating new money. However, in principle, most of these schemes work on a prepaid basis, i.e. the issuance of virtual currency takes place when real money is exchanged and, in the same vein, virtual currency is absorbed (withdrawn from circulation) when exchanged back to real money. Consequently, the net effect should, in theory, be limited.

The supply of money in the most prominent schemes seems to be quite stable and does not reach significant figures, at least not yet (see sections 3.1.3 and 3.2.3). However, two comments should be made:

– It is assumed that the money supply will remain more or less stable over time; however, there is actually no way of ensuring this.

– The impact of the money supply on a real currency has to be assessed in terms of the latter, i.e. there could be a certain impact as a result of the exchange rate, even if the money supply remains stable. In the case of Linden Dollars, this is not a serious issue, as – for the time being – Linden Lab uses several instruments to keep the exchange rate in Second Life relatively stable. However, in the event of high exchange rate volatility this picture could change quite substantially. Bitcoin is a clear example of this.[3]

The second aspect to consider is how virtual currencies could have an impact on the velocity of money, the use of cash, and/or influence the measurement of monetary aggregates. The velocity of money is a measure of how often a unit of currency is spent to purchase goods and services produced in the economy.[4] A textbook assumption is to consider that the velocity of money is constant in the short term, as it relies on the institutional and technological features of the economy and these are assumed not to change in the short run. However, it is not clear at this stage how the technological innovations presented by virtual currency schemes might affect the velocity of money. As this is a network industry, it will largely depend on the number of active virtual currency scheme users (consumers willing to pay with these virtual currencies and merchants willing to accept their payments).

3 The number of Bitcoins in circulation as of 26 July 2011 was 6,905,450. Taking the market exchange rate for Bitcoins on 1 April 2011 (USD 0.785), this means that the money supply was around USD 5.4 million. If, however, the exchange rate of 8 June 2011 (USD 30.99) is used, then the total amount of Bitcoins in circulation would be around USD 214 million. On 3 May 2012, the exchange rate was around USD 5.099. With around eight million Bitcoins in circulation, the value of this currency was around USD 41 million.

4 In the classical equation of exchange, the velocity of money (V) is represented in the following terms: $V = P \times Y / M$, where $P \times Y$ is the nominal GDP and M is the money supply.

In an extreme case, virtual currencies could have a substitution effect on central bank money if they become widely accepted. The increase in the use of virtual money might lead to a decrease in the use of "real" money, thereby also reducing the cash needed to conduct the transactions generated by nominal income. In this regard, a widespread substitution of central bank money by privately-issued virtual currency could significantly reduce the size of central banks' balance sheets, and thus also their ability to influence the short-term interest rates. Central banks would need to look at their existing tools to deal with this risk (for instance, trying to impose minimum reserve requirements on virtual currency schemes).

The substitution effect would also make it more difficult to measure monetary aggregates and, as a consequence, would affect the relationship between the monetary aggregates as measured and inflation, which is used to gauge risks to price stability in the medium to longer term.

Lastly, on this second aspect, when virtual money is created outside the realm of the central bank and virtual credit can be extended, this may have implications for the way interest rate decisions by the central bank are transmitted through the economy and the central bank's control over money and credit developments could become less effective.

The third aspect to examine is the interaction between the virtual currencies and the real economy. Second Life and Bitcoin users are spread around the globe and therefore their impact should also be interpreted globally. However, if a virtual currency scheme was to be focused on one specific country, it could indeed have an impact on the money supply of this country. This is what happened in China with the Chinese virtual currency scheme Q-coin, introduced by the company Tencent, one of the leading telecom operators in the country. QQ is an instant messaging service provided by this company that also allows virtual payments to be made with Q-coins. This currency can be purchased by credit card or by using the remaining balance on a prepaid telephone card. The exchange rate is fixed against the renminbi. Originally, this currency was implemented only for the purchase of goods and services provided by Tencent. However, users started using it for person to person (P2P) payments and some merchants also started accepting Q-coins as a means of payment. In addition, several online games rewarded users with points that could be exchanged against Q-coins and ultimately also against yuan in the black market. The virtual currency had evolved into an illegal money scheme. Chinese authorities saw the amount of Q-coins traded reach several billion yuan in one year, after rising around 20% annually. In June 2009, the Chinese authorities decided to ban this currency for trading in real goods in order to "limit its possible impact on the real financial system".[5] They also provided a definition of a virtual currency and stressed that they would only allowed it to be used for purchasing the virtual goods and services provided by its issuer and not for real goods and services.

Box 3 shows a few examples of innovations based on Bitcoin. Apart from fraud concerns, two possible effects can be expected if these kinds of innovation proliferate and succeed. On the one hand, they could have an impact on the velocity of money existing in the economy. On the other, the interaction between virtual currencies and the real economy could also increase if widely used. In both cases, there would be a need to monitor these innovations.

5 Ministry of Commerce, People's Republic of China: (http://english.mofcom.gov.cn/aarticle/newsrelease/commonnews/200906/20090606364208.html).

Box 3

INNOVATION AND VIRTUAL CURRENCY SCHEMES – BITCOIN EXAMPLES

Innovations in the retail payment markets are progressing very quickly, triggered by technological developments. Virtual currency schemes are no exception. In the context of Bitcoin, for instance, a new payment instrument is being developed called Bitbills (http://bitbills.com/index.html). Bitbills are prepaid cards for storing Bitcoins or for conducting point of sale payment transactions in regular shops. There are several denominations (1, 5, 10 and 20 Bitcoins). They can be viewed as a substitute for cash based on the Bitcoin system without requiring an internet connection. Each Bitbill contains a special security hologram where a QR code is stored. This encodes a cryptographic single-use private key linked to the money stored on the card. Users can either exchange the cards at face value (for instance at a retailer) or redeem the funds and spend them in the Bitcoin network by cutting the card and extracting the private key. According to the creator of this innovation, since their launch on 9 May 2011, the demand for Bitbills has been substantial.

This is not, however, the only payment innovation linked to Bitcoin. Another example links Bitcoins to payment cards from regular, international card schemes. For instance, Bitcoin 2 Credit Card (https://www.bitcoin2cc.com/) was a virtual credit card offered in exchange for Bitcoins that could be used for purchases where a physical plastic card was not required, such as for online and telephone purchases. Buyers of these cards received the necessary details to perform a transaction (card number, expiry date and other relevant details). According to the provider, these cards worked with PayPal and the banks used for handling the transactions were located in Canada and the United States. Another way to link Bitcoins to a regular payment card is to increase the balance of an existing payment card by selling Bitcoins. This service, called Withdraw2Card, is currently being offered by AurumXchange. Customers sell their Bitcoins on one of the major exchange platforms and receive a redeemable coupon which is used to transfer the payment to the payment card (card number and expiry date are required). This part of the service is based on an extension of the existing card scheme option to credit a card in the event of a refund.

On 21 October 2011, another innovation related to Bitcoin was made public: the development of a Bitcoin point of sale system (https://en.bitcoin.it/wiki/Casascius_Bitcoin_POS_system). Its main function is to enable retailers to accept Bitcoins at the point of sale.

The economics literature has not yet addressed the effect of virtual currencies on real money and monetary policy. One exception to this is a paper written by Peng and Sun (2009). These authors argue that virtual currency schemes act as a medium of exchange in the real goods trade and, therefore, that real GDP is affected and should be taken into account when assessing the effects of virtual currency schemes on the real money supply. According to the authors, the impact of virtual currencies on the real money supply depends on two aspects:

a) the substitution effect of the virtual economy on the real economy. Based on a survey, they infer that in China the total income of the real economy tends to decrease because of virtual economic activities (e.g. people spending a lot of time in virtual games spend less time working in the real world), thereby also affecting the volume of the monetary base.

b) the crowding-out effect of virtual currencies on real cash. As the volume of virtual currencies increases, people hold less cash in real life. This causes a decrease in the cash/deposit ratio and, consequently, an increase in the money multiplier.[6]

The authors argue that as the real money supply is affected by virtual currency schemes, central banks should incorporate virtual currencies into monetary statistics in order to monitor their volume.

The challenge that virtual currency schemes might eventually pose for the conduct of monetary policy, in the event that these schemes manage to substantially diminish the use of central bank sponsored currencies (replacing its roles in providing liquidity and a store of value), has also been highlighted in a recent BIS document.[7]

Finally, it is important to safeguard a currency's role as a unit of account, as society reaps benefits from a well-defined and stable monetary unit for its economic transactions, irrespective of the issuer or the format in which money is issued. Virtual currency schemes could lead to the emergence of multiple units of account in the real economy. Virtual currency scheme owners could then be tempted to issue excessive amounts in order to profit from the placement of these funds. A change in views about the creditworthiness of these issuers (and the associated virtual exchange rate variability) would threaten to undermine the role of money in providing a single unit of account as a common financial denominator for the whole economy.

CONCLUSIONS ON PRICE STABILITY

While subject to a lack of reliable information, we can conclude that virtual currency schemes do not pose a risk for price stability at this stage, provided that the issuance of money continues to be as stable as it seems to be at present. In the short to medium term, no significant impact can be expected on the velocity of money. However, it is probably worth monitoring the interaction between virtual currencies and the real world.

4.2 RISKS TO FINANCIAL STABILITY

The ECB defines financial stability as the condition in which the financial system – comprising financial intermediaries, markets and market infrastructures – is capable of withstanding shocks, thereby mitigating the likelihood of disruptions in the financial intermediation process which are severe enough to significantly impair the allocation of savings to profitable investment opportunities. The safeguarding of financial stability requires an identification of the main sources of risk and vulnerability, such as inefficiencies in the allocation of financial resources from savers to investors and the mispricing or mismanagement of financial risks.

In the context of virtual currency schemes, as they work outside the banking system, the main (and also, unlikely) source of potential financial instability would be the link between virtual

6 Peng and Sun (2009) also examine what they call the "behaviour effect of issuers". This effect has the opposite impact on the multiplier, compared with the crowding-out effect. However, the authors conclude that the crowding-out effect is greater and, therefore, that the money multiplier increases.

7 See BIS (2012).

currencies and the real economy, i.e. the exchange rates and the exchange markets.[8] Obviously, Type 1 and 2 schemes are not affected by this, meaning special attention should be paid to Type 3 schemes, where two exchange rates (buy and sell) are involved. The value of Type 3 virtual currencies is determined by the demand and supply of money in the foreign exchange market. The big difference from real money is that there is no country or currency area behind the virtual currency scheme and therefore the exchange rate is not affected as seriously by the strength of the (virtual) economy, its trade imbalances or its productivity. The price of the virtual currency and its volatility depend on five main factors:

1) The supply of money and other issuer actions, such as the decision to intervene in the market in order to maintain a fixed or semi-fixed exchange rate. Typically, the exchange rate is set in a bid/ask spread, although, for instance, Linden Lab also implements its own type of "monetary policy" measures to stabilise it. Linden Lab can print and sell Linden Dollars against real money, thereby acting as a virtual issuing bank and benefiting from a form of income from seigniorage.

2) The dimension of the network. Virtual currency schemes exhibit network externalities, i.e. the value of the currency will also depend on how many users and merchants use and accept it. Therefore, it can be expected that, as the size of the network (consumers and merchants) grows, the currency's value will increase accordingly. Moreover, virtual currency schemes with low trading volumes are expected to suffer more volatility in their exchange rates, as the exchange transaction of only a few users could alter the value of the currency.

3) Institutional conditions governing the virtual community. The virtual communities that have clear and transparent policies and state-of-the-art security measures are more likely to generate confidence and have stronger currencies.

4) The virtual currency issuer's reputation for meeting its commitments. Since virtual currency payments are not settled in central bank money or commercial bank money, nor is there any lender of last resort, a crucial element affecting the virtual exchange rate is the trust gained by the virtual currency issuer.

5) Speculations regarding the future value of the currency and history of cyberattacks suffered in the virtual community.

Type 3 virtual currency schemes may tend to be inherently unstable for several reasons, such as the scheme's lack of maturity, a lack of confidence on the part of users of an incipient system, low volumes traded, lack of legal certainty, speculation and cyberattacks, etc.

One example of this instability is Bitcoin. Its value in terms of US dollars has increased dramatically. On 1 April 2011, one Bitcoins was worth USD 0.785. The closing price on 8 June 2011 was USD 30.99, but it went down to USD 0.10 on 20 June 2011, following a security incident (see section 3.1.4). On 13 December 2011, the closing price was USD 3.24 (see Chart 11). Considering the short time frame during which the currency appreciated, and the fact that it appears no significant changes had taken place as far as the factors listed above were concerned, the exchange rate evolution should probably be attributed entirely to speculation. Therefore, this evolution resembles a bubble, especially if it is considered that between the system being established in 2009

8 A second source of financial instability could arise if these schemes jeopardise the smooth functioning of payment systems. This issue is discussed in the next section.

Chart 10 Bitcoin exchange rate in Mt.Gox

Source: Bitcoin charts (http://bitcoincharts.com/charts/)

and April 2011, the exchange rate was quite stable at less than USD 1. Similar speculative situations can also be expected in the future.

For the time being, the low volume traded in these virtual currency schemes and the fact that there is no substantial connection with the real economy (relatively few users who are spread across the world) means that the stability of the financial system cannot be negatively affected by any of these schemes. However, the situation could change in the future if these schemes become an alternative to traditional currencies, thereby introducing instability in the system as a result of their substantial volatility, even with the potential to distort the relative prices of goods and services. Here again, the true impact of virtual currency schemes will largely depend on the number of active users, as well as the number of merchants willing to accept the virtual currency for real transactions. In addition, the fact that these currencies have only exchange value and no use value may also pose a problem. Users of the system actually exchange real currency for computing bits. There is normally no asset with intrinsic value underlying the virtual currency, nor is there any central bank backing the currency and acting as lender of last resort. At the same time, these markets are illiquid and rely on others wanting to join the scheme. As a consequence, users face a substantial liquidity risk and could end up owning bits that no one wants to buy.

It seems that, at the moment, these schemes do not allow borrowing or lending. But this may change in the future. There is even speculation on how Bitcoin could evolve.[9] Banks could, for instance, act as a depository for the wallet files that contain users' Bitcoins; these users would then rely on the banks' technical and security knowledge. The banks could then pay interest to those who hold the virtual currency with them. Alternatively the Bitcoin system could even start working as a fractional-reserve system, extending credit over and above its actual reserves; however, the scheme's supporters are clearly opposed to this. These developments, if they came to pass, could indeed have a certain impact on financial stability in the future.

CONCLUSIONS ON FINANCIAL STABILITY

Virtual currency schemes may be inherently unstable. Nevertheless, for the time being they do not jeopardise financial stability, given their limited connection to the real economy, the low volumes traded and the lack of wide user acceptance. However, developments should be carefully monitored, as the situation could change substantially in the future.

9 See, for instance, http://www.webisteme.com/blog/?p=192

4.3 RISKS TO PAYMENT SYSTEM STABILITY

As stressed earlier, in general, a payment made within a virtual currency scheme is handled "in-house" and can therefore be classified as a specific type of "on-us" transaction. Payments are usually low value payments and are settled on a gross and real-time basis. The settlement institution (i.e. the issuer) is a non-regulated institution. A significant concentration of payment activities and associated exposures within this single institution could ensue if values processed in these virtual currency schemes were to grow significantly in the future.

Virtual currency payment arrangements have evolved into "real" payment systems within the specific virtual community. As a consequence, they face the typical risks linked to payment systems:

– Credit risk. Users are exposed to credit risk in relation to any funds held on the virtual accounts, as it cannot be guaranteed that the settlement institution is able to fully meet its financial obligations when these are due or at any time in the future.

– Liquidity risk. Users are also exposed to liquidity risks if the settlement institution fails to meet any commitments it has made to provide liquidity to the participants as and when expected. In this regard, virtual currency schemes are very illiquid as a result of the low volumes traded. In the event of security incidents, the conversion of users' funds into real money would probably not occur quickly without a significant material loss in value.

– Operational risk. Both payer and payee need to have accounts with the settlement institution and are therefore reliant on the soundness of its operational and business continuity.

– Legal risk. There are many legal uncertainties regarding virtual currency schemes. In virtual currency schemes, the lack of a proper legal framework substantially exacerbates the other risks.

The nature, size and duration of these exposures depend very much on factors such as the design of the system or its degree of illiquidity. However, as a rule of thumb, it can be assumed that these risks are very difficult to avoid or to control in a virtual currency scheme.

In these schemes, the settlement asset is the virtual currency, and therefore the finality and irrevocability of payments cannot be ensured. Only central bank money can do so, because central banks present no default risk and act as lender of last resort to the member of the system in order to stop any possible chain reaction resulting from payment incidents or unforeseeable liquidity shortages.[10] Virtual currencies cannot therefore be considered to be safe money, since the likelihood of the asset retaining its value for the holder, and hence its acceptability to others as a means of payment cannot be ensured. It simply relies on the creditworthiness of the issuer of the settlement asset. The level of safety is clearly below that of commercial bank money, as commercial banks are subject to prudential requirements and are supervised in order to reduce the likelihood of default, thereby improving the safety of claims on these institutions.

This is a fundamental risk relating to virtual currency schemes, which do not involve any kind of supervision of the settlement institution or oversight of the system, and therefore no one is accountable for their acts. Nor is there any kind of investor/depositor protection scheme in place. As a consequence, users bear all of these risks themselves.

10 OECD (2002), p. 66.

Central banks' oversight activities aim to achieve safe and efficient payment and settlement systems, and contribute to financial stability and the proper functioning of the economy as a whole. The "Core Principles" are usually accepted as a basic reference for implementing central banks' oversight activities; even for non-systemically important payment systems (see Box 4).[11]

11 As acknowledged by the ECB (2003), the systems having a lesser impact on the financial infrastructure and the real economy (including virtual currency schemes) do not necessarily have to comply with the relevant oversight standards: "Such systems have to comply with the relevant oversight standards, as and if defined for them". Since there are no oversight standards for virtual currency schemes, this report uses as its starting point the Principles for Systemically Important Payment Systems.

Box 4

CORE PRINCIPLES FOR SYSTEMICALLY IMPORTANT PAYMENT SYSTEMS (BIS, 2001)

I. The system should have a well-founded legal basis under all relevant jurisdictions.

II. The system's rules and procedures should enable participants to have a clear understanding of the system's impact on each of the financial risks they incur through participation in it.

III. The system should have clearly defined procedures for the management of credit risks and liquidity risks, which specify the respective responsibilities of the system operator and the participants and which provide appropriate incentives to manage and contain those risks.

IV.[1] The system should provide prompt final settlement on the day of value, preferably during the day and at a minimum at the end of the day.

V.[1] A system in which multilateral netting takes place should, at a minimum, be capable of ensuring the timely completion of daily settlements in the event of an inability to settle by the participant with the largest single settlement obligation.

VI. Assets used for settlement should preferably be a claim on the central bank; where other assets are used, they should carry little or no credit risk.

VII. The system should ensure a high degree of security and operational reliability and should have contingency arrangements for timely completion of daily processing.

VIII. The system should provide a means of making payments which is practical for its users and efficient for the economy.

IX. The system should have objective and publicly disclosed criteria for participation, which permit fair and open access.

X. The system's governance arrangements should be effective, accountable and transparent.

1 Systems should seek to exceed the minima included in these two principles.

It is quite clear that virtual currency schemes do not comply with most of the Core Principles, especially in relation to their legal basis (CP I); the rules and procedures in place in order to enable participants to have a clear understanding of the risks they are taking (CP II); the procedures for the management of credit and liquidity risks (CP III); the asset used for the settlement, i.e. the virtual currency (CP VI); the degree of security and operational reliability (CP VII); and the governance arrangements (CP X).

That being said, the Core Principles also provide three criteria in order to assess the criticality of a payment system: i) it is the only payment system in a country, or the principal system in terms of the aggregate value of payments; ii) it handles mainly payments of high individual value; and iii) it is used for the settlement of financial market transactions or for the settlement of the other payment systems. From a global perspective, none of these criteria are met by virtual currency schemes, and therefore they cannot be considered systemically important payment systems. Consequently, it is absolutely clear that they would not be capable of triggering disruptions or transmitting shocks across the financial system. However, they could cause a significant environment of instability within the virtual community in which they operate. In this regard, virtual currency schemes can indeed be critical, but only for their users within the virtual community. This issue might be of interest for other authorities (e.g. in the context of market conduct regulation and supervision).

CONCLUSIONS ON PAYMENT SYSTEM STABILITY

Virtual currency schemes seem to work like retail payment systems within the virtual community they operate. However, in contrast to traditional payment systems, they are not regulated or closely overseen by any public authority. Participation in these schemes exposes their users to credit, liquidity, operational and legal risks within the virtual communities; no systemic risk outside these communities can be expected to materialise in the current situation.

4.4 LACK OF REGULATION

The instability of virtual currency schemes can be explained by one of the most critical aspects mentioned earlier, i.e. the lack of a proper legal basis for virtual currency schemes.[12] The legal basis of a payment system consists of framework legislation, as well as specific laws, regulations, and agreements governing both payments and the operation of the system.[13] Virtual currency schemes visibly lack a proper legal framework, as well as a clear definition of rights and obligations for the different parties. Key payment system concepts such as the finality of the settlement do not seem to be clearly specified.

Furthermore, the global scope that most of these virtual communities enjoy not only hinders the identification of the jurisdiction under which the system's rules and procedures should eventually be interpreted, it also means the location of the participants and the scheme owner are hard to establish. As a consequence, governments and central banks would face serious difficulties if they tried to control or ban any virtual currency scheme, and it is not even clear to what extent they are

12 The non-existence of a clear legal basis for virtual currency schemes is an illustration of the overall existing lack of understanding about virtual economies and their impact on the real economy. For instance, it is not clear to what extent virtual production should be considered when estimating the production of wealth per capita. The current national income and product accounts do not assign any value to online assets (see Castronova, 2001). Moreover, two related aspects that could be considered are how to tax individual income earned through virtual currency transactions and how to define and protect virtual properties (see Chu, 2008 and The Economist, 2011b).

13 BIS (2001), p. 16.

permitted to obtain information from them.[14] In the particular case of Bitcoin, which is a decentralised peer-to-peer virtual currency scheme, there is not even a central point of access, i.e. there is no server that could be shut down if the authorities deemed it necessary.

14 One possible way to overcome this situation and obtain some quantitative information on the magnitude of the funds moved through these virtual currency schemes could be to focus on the link between the virtual economy and the real economy, i.e. the transfer of money from the banking environment to the virtual environment. Virtual accounts need to be funded either via credit transfer, payment card or PayPal and therefore a possibility would be to request this information from credit institutions, card schemes and PayPal.

Box 5

BITCOIN AND THE EU LEGAL FRAMEWORK

Bitcoin's legal framework is very unclear. In the EU, there are some who suggest that Bitcoin could fall under the Electronic Money Directive (2009/110/EC). This Directive uses three criteria to define electronic money: (i) it should be stored electronically; (ii) issued on receipt of funds of an amount not less in value than the monetary value issued; and (iii) accepted as a means of payment by undertakings other than the issuer.

Can Bitcoin be considered an electronic money institution? Bitcoin probably complies with the first and the third criteria, but not with the second. Moreover, it is important to consider the conversion into another currency, which was clearly not envisaged in the Directive. In fact, Art. 11 explicitly says that "Member States shall ensure that, upon request by the electronic money holder, electronic money issuers redeem, at any moment and at par value, the monetary value of the electronic money held". This cannot be ensured in a virtual currency scheme like Bitcoin (or in any other Type 3 scheme). A last key aspect that should be taken into account is the "mining" activity, which leads to money creation without the receipt of funds.[1] It is difficult to assess how this could be interpreted within the scope of the Directive.

Another European law that might have some relevance to virtual currency schemes like Bitcoin is the Payment Services Directive (2007/64/EC). This Directive lays down rules on the execution of payment transactions where the funds are electronic money, yet it does not regulate the issuance of electronic money, nor does it amend the prudential regulation of electronic money institutions as provided for in the Electronic Money Directive. Therefore, the new category of payment service provider it introduces – payment institutions – should not be allowed to issue electronic money. As a consequence, Bitcoin clearly falls outside the scope of the Payment Services Directive.

In the meantime, some initial attempts to define the legal status of Bitcoin are already happening in Europe. The French law courts are looking into the issue after local banks shut down the currency exchange facility for accounts handling the currency, on the presumption that Bitcoin should conform to electronic money regulations.[2]

Finally, the issue of Bitcoin's legal framework has been raised in the European Commission's Payments Committee.

1 See Jacobs (2011).
2 Finextra (http://www.finextra.com/news/fullstory.aspx?newsitemid=22921).

Usually regulation lags behind technological developments by some years. This is also the case in virtual currency schemes (at least in their current form), which were already being established as early as the late 1990s. It was only in 2006 that a number of US government agencies started considering these schemes. The following year, some of these companies were charged with operating unlicensed money transmitting businesses. Since then, a number of other legal actions have been taken and many of these schemes operating in the United States have been closed.[15] Subsequently, China has also taken a stance against the use of virtual currency schemes for the purchase of real goods and services. Recently, in the context of a survey on innovation in payment systems carried out by the Reserve Bank of Australia (RBA), Microsoft asked the Australian central bank to consider adjustments to the domestic payments market to help consumers conduct transactions in virtual currencies.[16]

Authorities need to consider whether they intend to formalise or acknowledge and regulate these schemes. In this regard, a likely suggestion could sooner or later involve virtual currency scheme owners registering as financial institutions with their local regulating authorities. This is a similar trajectory to the one PayPal has undergone, as it was granted a banking licence in Luxembourg in 2007 after its service became popular.[17] This is not an easy step, but it looks like the only possible way to strike a proper balance between money and payment innovations on the one hand, and consumer protection and financial stability, on the other.

Registering these companies as financial institutions would at least reduce the incentive for terrorists, criminals and money launderers to make use of these virtual currency schemes for illegal purposes. As explained, Type 3 schemes allow users to convert virtual currency into real currency and vice versa, using different channels and accounts. Villasenor et al. (2011) provide a good overview of how these virtual currency schemes might be used by criminals and money launderers. A number of elements from this paper are worth examining. On the one hand, technology-facilitated transactions can be designed to be invisible or to be visible but anonymous. On the other, these transactions are very difficult to trace back. There are basically two difficulties:

– Technological hurdles: a movement of USD 900,000 conducted in 100 different electronic transfers of USD 9,000 might be easy to spot, but the power of a large, widely-dispersed online network that enables this money to be moved in 100,000 transactions with randomised amounts, generally in the USD 6 to USD 15 range, might not be so easy to pinpoint.

– Legal hurdles: a variety of entities and intermediaries, each located in a different country, could be involved in the transaction, without any of them really having all the information on the transaction.

A final aspect worthy of further investigation is the extent to which transactions carried out in these virtual communities are or should be covered by consumer protection measures. Transactions within virtual communities could be regarded as a special kind of electronic commerce, as they look quite similar to other online transactions. However, neither Directive 2011/83, on consumer rights, nor

15 DGC Magazine (2010), p. 28.
16 See the feedback provided by Microsoft to the Reserve Bank of Australia (http://www.rba.gov.au/payments-system/reforms/strategic-review-innovation/submissions/201106-strategic-review-innovation/microsoft.doc).
17 Korolov (2010). Prior to this they were a regulated electronic money institution in the UK.

Directive 2000/31, on electronic commerce, seems to refer to the transactions performed in a virtual community or with Bitcoin.[18]

CONCLUSIONS ON THE LACK OF REGULATION

Virtual currency schemes, in contrast to traditional payment systems, are not regulated. The legal uncertainty surrounding these schemes might constitute a challenge for public authorities, as these schemes can be used by criminals, fraudsters and money launderers to perform their illegal activities.

4.5 REPUTATIONAL RISK

The reputation of central banks is a key element determining the effectiveness of their various policies, especially monetary policy. A reputation is hard to earn, but very easy to lose.

Since central banks are the institutions to which people look in order to establish how much trust to place in money, they are very much concerned about their reputation. For the ECB, reputational risk is defined as the risk of deterioration of the reputation, credibility or public image of the ECB towards different external stakeholders (e.g. general public, financial sector, etc.). It is included as it has a specific impact on operational risk, which is defined as the risk of negative financial, business or reputational impacts resulting from inadequate or failed internal governance and business processes, people, systems or from external events. A reputational impact may occur even when business objectives are being met, i.e. even if central banks are not responsible. Virtual currency schemes are able to have a reputational impact. They are about money and about payments and therefore, for the general public, they clearly fall under the responsibility of central banks, even though this might not be the case from a statutory and legal point of view. Therefore, the possibility of a reputational impact in the event of a security incident should be taken into account. Although the impact of a failure of a virtual currency scheme would be limited, assuming they do not significantly grow in size, the likelihood is considerable as a result of the high volatility and instability of virtual currency schemes and the broad media coverage they receive from time to time (for instance, Bitcoin).

CONCLUSIONS ON REPUTATIONAL RISK

If the use of virtual currency schemes grows considerably, incidents which attract press coverage could have negative impacts on the reputations of central banks, if the public perceives the incidents as being caused, in part, by central banks not doing their jobs properly. As a consequence, this risk should be considered when assessing the overall risk situation of central banks.

18 Directive 2011/83/EU, on consumer rights, alludes to "digital content" and defines it as data which are produced and supplied in digital form. From a purely conceptual point of view, there are few differences between buying an image to use as a screen saver on a mobile phone and buying clothes for an avatar in Second Life.

5 CONCLUSION

Although in practical terms virtual currency schemes are only an evolution, from a conceptual point of view they do present substantial changes when compared to real currencies and payment systems. Firstly, conventional actors like financial institutions, clearing houses and central banks are absent from these schemes. Also, they proliferate more easily, against the background of the huge growth in access to and use of the internet and as a result of the technical innovations behind these schemes. Moreover, they are not often bound to a specific country or currency area, which complicates law making, regulating and law enforcing.

From the preliminary analysis in this report it can be concluded that, in the current situation, virtual currency schemes:

– do not pose a risk to price stability, provided that money creation continues to stay at a low level;

– tend to be inherently unstable, but cannot jeopardise financial stability owing to their limited connection with the real economy, their low volume traded and a lack of wide user acceptance;

– are currently not regulated and are not closely supervised or overseen by any public authority, even though participation in these schemes exposes users to credit, liquidity, operational and legal risks;

– could represent a challenge for public authorities, given the legal uncertainty surrounding these schemes, as they can be used by criminals, fraudsters and money launderers to perform their illegal activities;

– could have a negative impact on the reputation of central banks, assuming the use of such systems grows considerably and in the event that an incident attracts press coverage, since the public may perceive the incident as being caused, in part, by a central bank not doing its job properly;

– do indeed fall within central banks' responsibility as a result of characteristics shared with payment systems, which give rise to the need for at least an examination of developments and the provision of an initial assessment.

Although these schemes can have positive aspects in terms of financial innovation and the provision of additional payment alternatives for consumers, it is clear that they also entail risks. Owing to the small size of virtual currency schemes, these risks do not affect anyone other than the users of the schemes. However, it can reasonably be expected that the growth of virtual currencies will most likely continue, triggered by several factors: a) the growing access to and use of the internet and the growing number of virtual community users, b) the increase of electronic commerce and in particular digital goods, which is the ideal platform for virtual currency schemes; c) the higher degree of anonymity compared to other electronic payment instruments that can be achieved by paying with virtual currencies; d) the lower transaction costs, compared with traditional payment systems; and e) the more direct and faster clearing and settlement of transactions, which is needed and desired in virtual communities.

Given that the current assessment of risks is highly dependent on relatively small-sized virtual currency schemes, the assumption that virtual currency schemes will continue to grow means that a periodical examination of the developments is needed in order to reassess the risks.

ANNEX: REFERENCES AND FURTHER INFORMATION ON VIRTUAL CURRENCY SCHEMES

Further information on the virtual currency schemes mentioned in this report can be found at the following websites:

- WoW Gold: http://www.wowgoldeuro.com/
- Facebook credits: http://www.facebook.com/credits/
- Linden Dollars: http://wiki.secondlife.com/wiki/Linden_Dollar / http://wiki.secondlife.com/wiki/Getting_Linden_Dollars_FAQ
- Bitcoin: http://www.bitcoin.org/ and https://en.bitcoin.it/wiki/FAQ
- E-gold: http://www.e-gold.com/ and http://www.e-gold.com/unsecure/contact.html
- Tencent_QQ: http://en.wikipedia.org/wiki/Tencent_QQ
- Nintendo Points: http://www.nintendo.co.uk/NOE/en_GB/systems/nintendo_points_1489.html

The Webpage "Virtual currency platforms" (http://www.virtualcurrencyplatforms.com/virtual-currency-platforms/) provides some examples and information on Type 1 virtual currency schemes.

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In addition, the following references have either been cited in this report or provide an interesting overview of the topic.

BALL, James (2011), "Bitcoins: What are they, and how do they work?", *The Guardian*, 22 June.

BBC (2009), "Sales of virtual goods boom in US", available at http://news.bbc.co.uk/2/hi/technology/8320184.stm, *BBC News*, October.

BELLER, Matthew (2007), "The Coming Second Life Business Cycle", *Ludwig von Mises Institute*, 2 August.

BIS (2001), "Core Principles for Systemically Important Payment Systems", *CPSS Publications*, No 43, January.

BIS (2003), "The role of central bank money in payment systems", *CPSS Publications*, No 55, August.

BIS (2012), "Innovations in retail payments", Report of the Working Group on Innovations in Retail Payments, May.

BRODBECK, Simon (2007), "Virtual money – A new form of privately issued money in the money market", *European School of Management*, Paris, May.

BUSINESSWEEK (2006), "Virtual World, Real Money", 1 May.

BUTTON, Keith (2011), "Virtual Currencies, Real Potential", *American Banker*, 1 November.

CASTRONOVA, Edward (2002), "On virtual economies", *CESifo Working Paper Series*, No 752

CHAPMAN, Stephen (2011), "Bitcoin: A guide to the future of currency", *ZDNet*, 15 June.

CHU, Ping (2008), "Virtual currency: regulation and taxation issues", *E-commerce law and policy*, November.

CORWIN, Peg (2009a), "Virtual Goods in Social Networks: Alternative business models", *How To Start A Social Network*, December.

CORWIN, Peg (2009b), "Virtual Goods in Social Networks: Examples of Facebook, Twitter and More", *How To Start A Social Network*, December.

DELGADO, Antonio (2011), "La expansión del dinero virtual", *Eroski Consumer*, March.

DGC MAGAZINE (2010), "Bitcoin", August.

DOURADO, Eli (2011), "The Economics of Cryptocurrency", available at http://elidourado.com/blog/economics-cryptocurrency, 12 March.

DUFFY AGENCY (2010), "Facebook Credits could be our new universal currency", *Duffy Agency*, July.

ECONOMIST, The (2002), "Airline miles. Frequent-flyer economics", 2 May.

ECONOMIST, The (2005), "Frequent-flyer miles. In terminal decline?" 6 January.

ECONOMIST, The (2006), "Living a Second Life", 28 September.

ECONOMIST, The (2011a), "Virtual currency: Bits and Bob", 16 June.

ECONOMIST, The (2011b), "Paying for pixels. Virtual goods are worth real money – and cause real dilemmas", 10 December.

ELLIOT, James (2008), "Help – Somebody Robbed my Second Life Avatar!", *Journal of Virtual World Research*, Vol. 1, No 1, July.

ERNSTBERGER, Philip (2009), "Linden Dollar and Virtual Monetary Policy", *Working Paper "Forschungsstelle für Bankrecht und Bankpolitik"*, 23 January.

EUROPEAN CENTRAL BANK (1998), *Report on Electronic Money*, August.

EUROPEAN CENTRAL BANK (2003), "Oversight standards for euro retail payment systems", June.

EUROPEAN MONETARY INSTITUTE (1994), "Report to the Council of the European Monetary Institute on Prepaid Cards", *Working Group on EU Payment Systems*, May.

FLEMING, Nic (2010), "Virtual world disputes heading for meatware courtrooms", *AccessIndia*, 1 January.

GRINBERG, Reuben (2011), "Bitcoin: An Innovative Alternative Digital Currency", *Yale Law School Working Paper Series*, April.

GUO, Jingzhi and CHOW Angelina (2008), "Virtual Money Systems: A Phenomenal Analysis", *Proceedings of the 2008 10th IEEE Conference on E-Commerce Technology and the Fifth IEEE Conference on Enterprise Computing, E-Commerce and E-Services*, 21-24 July, pp. 267-272.

GUO, Jingzhi; CHOW, Angelina & GONG, Zhinguo (2009), "Virtual Wealth Realization in Virtual and Real Worlds", *IEEE International Conference on e-Business Engineering*, 21-23 October, pp. 85-94.

HARRISON, Randolf (2007a), "SecondLife: Revolutionary Virtual Market or Ponzi Scheme?", *Capitalism 2.0.*, 23 January

HARRISON, Randolf (2007b), "The Linden Dollar Game", *Capitalism 2.0.*, 20 February.

HAYEK, Friedrich A. (1976), *Denationalisation of Money*, 3rd edn., The Institute for Economic Affairs, London.

HUDSON, Charles (2008), "My Best Estimate for the Size of the Virtual Goods Market in the United States", available at http://www.charleshudson.net/my-best-estimate-for-the-size-of-the-virtual-goods-market-in-the-united-states

ISSING, Otmar (1999), "Hayek – Currency Competition and European Monetary Union", *Annual Hayek Memorial Lecture*, Institute of Economic Affairs, London, 27 May.

JACOBS, Edwin (2011), "Bitcoin: a bit too far?", *Time.lex*, 25 June.

JEFFERIES, Duncan (2009), "Virtual money of the future", *Digital Life*, 22 October.

JEFFRIES, Adrianne (2011), "Bit O'Money: Who's Behind the Bitcoin Bubble?" *Betabeat*, 15 June.

KOKKOLA, Tom (ed.) (2010), *The payment system: Payments, securities and derivatives, and the role of the Eurosystem*. European Central Bank, Frankfurt am Main.

KORMAN, Avril (2011), "What Price, Gold? Virtual Currency Can Mean Real Crime", *Search Engine Watch*, 28 May.

KOROLOV, Maria (2010), "Does your grid needs its own currency?", *Hypergrid Business*, 31 August.

LEHDONVIRTA, Vili & ERNKVIST, Mirko (2011), *Knowledge Map of the Virtual Economy*, World Bank, Washington D.C.

LIU, Deborah (2010), "Expanding Our Commitment to Facebook Credits", *Facebook Developer Blog*, February.

MATONIS, Jon (2011), "Why Are Libertarians Against Bitcoin?", *The Monetary Future*, 16 June.

MILLER, Claire Cain & STONE, Brad (2009), "Virtual Goods Start Bringing Real Paydays", *New York Times*, 6 November.

MILLER, Max (2010), "The Rise of Virtual Economies", *Big Think*, 16 November.

MILLS, Elinor (2008), "Rising fraud threats in virtual worlds", *cnet News*, August.

MISHKIN, Frederic S. (2010), *The Economics of Money, Banking and Financial Markets*, 2nd edn., Pearson Education, Boston.

NAKAMOTO, Satoshi (2009), "Bitcoin: A Peer-to-Peer Electronic Cash System", available at http://bitcoin.org/bitcoin.pdf

OECD (2002), *The Future of Money*, OECD, Paris.

ORMAN, Levent V. (2010), "Virtual Money in Electronic Markets and Communities", *Johnson School Research Paper Series*, No 27.

PARR, Ben (2009), "The Future of Gaming: 5 Social Predictions", *Mashable*, November.

REKHI, Ada Chen (2010), "How to price your virtual currency", *Hypergrid Business*, 9 December.

PENG, Hui & SUN, Yanli (2009), "The theoretic and empirical analysis on the impact of network virtual money on real money supply", *International Conference on Future Computer and Communication*, Kuala Lumpar, 3-5 April.

ROTHBARD, Murray N. (2009), *Economic Depressions: Their Cause and Cure*, Ludwig von Mises Institute, Alabama.

SHIELS, Maggie (2009), "The US virtual economy is set to make billions" *BBC News*, 29 December.

SHUKLA, Anu (2008), "Beyond Facebook Gifts: Virtual Currencies 101", *Mashable*, December.

SEN, Ved (2010), "Virtual Currency - Money for Nothing & Clicks for Fee?", *Thinkplank*, May.

SMITH, Justin & HUDSON, Charles (2010), "The US Virtual Goods Market 2010 – 2011", *Inside Virtual Goods*.

STÖCKER, Christian (2011), "Geld aus der Steckdose", *Der Spiegel*, 31 May.

STRAUSS, Michael (2010), "A comparison of virtual currency systems", *Helium*, May.

SUTTER, John D. (2009), "Virtual currencies power social networks, online games", *CNN*, 19 May.

TICE, Brock M. (2011), "Why Bitcoin is Smart, and Not a Scam", *Virtuallyshocking*, 22 May.

TRIALPAY (2009), "Virtual Currency Monetization Platforms: Five Ways to Increase Revenue with Direct Payment Options", April.

VILLASENOR, John, MONK, Cody and BRONK, Christopher (2011), "Shadowy Figures: Tracking Illicit Financial Transactions in the Murky World of Digital Currencies, Peer-to-Peer Networks, and Mobile Device Payments", *James A. Baker III Institute for Public Policy*, August.

WALSH, Ivan (2009), "Why a virtual currency is not a currency?" available at http://www.ivanwalsh.com/technical-writing-tips-tools/why-a-virtual-currency-is-not-a-currency

WILLIAMSON, Stephen (2011), "Bitcoin", *New Monetarism*, 24 June.

WILLIS, Nathan (2010), "Bitcoin: Virtual money created by CPU cycles", *LWN.net*, November 10.

WIRTSCHAFTSWOCHE (2011), "Der Traum vom freien Geld", *WirtschaftsWoche*, No 028, 11 July.

WORTHEN, Ben (2010), "Fraudsters Like Virtual Goods", *The Wall Street Journal*, 21 July.