Creating Value Together: The Emerging Design Space of Peer-to-Peer Currency and Exchange

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ABSTRACT
Paradigms for the collaborative creation of value through trade and exchange have developed over millennia. Thus, coins emerged in response to a set of challenges in barter and gift exchange. The development of paradigms for trade and exchange continues today, and is accelerating due both to crises in the mainstream global economy, and to new possibilities enabled by information technology. In this discussion paper, we consider alternative and complementary currency and exchange innovations, including local/community currencies, timebanks, crypto-currencies, and person-to-person collaborative economy microenterprises, as a technology design space for currency and exchange. We consider the consequences and trajectories of the rapidly evolving currency ecosystem, particularly with respect to research and development opportunities for CSCW.

Author Keywords
Currency; Exchange; Local/community currencies; Timebanks; Crypto-currency; Collaborative economy microenterprises; P2PX

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - Interaction styles.

General Terms
Human Factors; Design

INTRODUCTION
Exchange of services and commodities is a defining activity among humans, with a long history and diverse consequences [7,8,38]. Trade has facilitated divisions of labor, and eventually mass production, as well as the organization of alliance networks and markets, and the identification and cultivation of comparative advantage in production of tradable commodities [37].

The social and economic arrangements through which humans create value together, for example, incentivizing and recognizing one another, have developed over millennia. Thus, coins and money are a technology invented and adopted to address challenges in economic interactions. New frameworks and supporting technologies for economic interactions are developing today, indeed, the sustained crisis in the mainstream global economy and new possibilities enabled by information technology have accelerated and diversified contemporary developments in currency and exchange.

In this paper, we analyze the historical innovations of barter and gift exchange and of money to characterize a design space for currency and exchange interactions. We then use this analysis to understand contemporary innovations in systems and technologies, including local/community currencies, timebanks, crypto-currencies, and person-to-person collaborative economy microenterprises. Finally, we speculate on the consequences and trajectories of this currency ecosystem, particularly with respect to research and development opportunities for computer-supported cooperative work. With financial markets in turmoil and increasing anger about the ongoing concentration of wealth and power in the hands of a small minority, intense public discourse about what systems might help us better and more fairly manage economies is erupting (e.g. [22,35]. Our paper seeks to focus the attention of the CSCW community on economic innovations that may hold the seeds for positive change with implications for the design of novel technology solutions to support them.

BARTER AND GIFT EXCHANGE
The simplest paradigm for trade is barter, the direct exchange of goods and services. Barter depends on coincidence of wants, and negotiation of relative value between participants. These practical limitations motivated the adoption of commodity money with more generally convertible valuations, such as grains, livestock, and precious metals, which better facilitated the emergence of markets. And commodity money, in turn, eventually led to the minting of standard coins.

CSCW 2015, March 14–18, 2015, Vancouver, BC, Canada.

ACM 978-1-4503-2922-4/15/03…$15.00.
http://dx.doi.org/10.1145/2675133.2675270

Non-market based economies do not necessarily rely exclusively on barter. Indeed, anthropological studies of non-market societies that survived into the modern period have identified complex trading protocols, including trading spheres and gift exchange, which co-occur with barter frameworks. Trading spheres are categories of commodities regarded exchangeable; items in different spheres are normally never exchanged. Trading spheres are seen as a social mechanism that prevents hegemony with respect to subsistence goods. Thus, if goods in the subsistence sphere (for example, vegetables, grains, hand tools, small animals) can only be traded for other goods in that sphere, if it is considered immoral to trade high prestige items for subsistence goods, then individuals who control a disproportionate share of wealth objects nonetheless cannot exert undue influence, for example, by creating artificial scarcities [42].

Gift exchange protocols in non-market societies are community-oriented and political as well as economic [27]. In these contexts, giving is a community service obligation that enhances one's prestige generally, and with respect to the recipient; receiving creates indebtedness, and places one's prestige in jeopardy [17]. If the recipient has relatively low social standing, repayment may be unnecessary. However, among persons with similar social standing, it is typical that even full repayment does not restore balance; the only way forward for reputation and prestige is to continue the relationship, and give more. Ironically, while terms of exchange are normally not explicitly negotiated, and immediate reciprocity is not expected, gifting is an ongoing, and somewhat competitive relationship, maintained by continued gifting. The protocols of spheres of exchange and gift exchange exemplify the evolved sociality of trading interactions in non-market societies.

In social exchange theory [7], traditional gifting is a paradigmatic example of *generalized exchange,* networks of voluntary and non-dyadic exchange that strengthen groups; barter bargaining is a paradigmatic example of dyadic *negotiated exchange*, in which uncertainties about the value of what is exchanged evoke the development of partner trust and norms of fairness, strengthening relational ties.

MONEY

The first manufactured coins came into use independently between 700 and 500 BC in India, China and the Mediterranean, though commodity money, such as cattle, grains, salt and precious metals, had been in use for more than a thousand years before that in Mesopotamia [13]. One motivation for coinage was to mitigate some of the complications and inefficiencies of barter's coincidence of wants, the cumbersome need to identify particular trading partners who currently had extra quantities of goods one wanted, who wanted goods for which one had current extra quantities, with whom one could successfully negotiate a trade, and to and from whom one could physically transfer traded goods in a timely fashion. Coins also mitigated logistic complications of commodity money, such as securing and assaying metals, feeding cattle, preserving grains, and storage and transport in general. Graeber [13] emphasizes the alternate, or possibly coextensive factor of providing better quantification of obligations in gift exchange, that is, going from "I owe you a gift" to "I owe you some number of units of something".

Money enables new possibilities for exchange. Providing a universal scale for valuing all services and commodities encourages the development of markets. Exchanges are simplified logistically and procedurally. Market-based pricing reduces the need for case-by-case negotiation and for the development of dyadic trust relationships. Obligations to others, including charity, can also be placed on the universal scale of value. Money commodifies trade itself; coincidence of wants is not an issue when trade is mediated by money. In a market economy, everyone always wants money.

Beyond the immediate context of trade, money facilitates the formation and leveraging of capital, permitting the preservation and aggregation of value obtained in exchanges to an extent not feasible in barter or commodity currency frameworks. This in turn expands useful practices such as borrowing, lending, investment, and taxation [43]. Indeed, money enables concentration of capital resources for projects unimaginably ambitious from the perspective of barter and commodity currency; for example, early corporations such as the British East India Company colonized large areas of the world during the 17th century as vast commercial enterprises. These early corporations were the models for modern corporate entities.

Money enables a variety of currency-oriented abstractions and secondary markets including specialty markets, speculation in futures, short selling, and derivative repackaging of investments. It creates the possibility and the ultimately the need to frame and manage monetary policy, nationally and globally, through adjustments to (central bank) interest rates and money supply intended to maintain economic growth and stability [10]. In modern society some job roles involve managing money and abstractions of money, but not with respect to trade or exchange of goods or services per se. Money is no longer merely a medium or measure used in trade; it is as well itself a primary commodity of trade.

The objectification of exchange through money has social and psychological consequences beyond the mechanics of trade. For example, simplifying exchange interactions reduces the need for trading partners to create and strengthen particular social ties and trust relationships, perhaps generalizing identification and trust to the overall economic system [33]. Quantifying debt and obligation also simplifies economic life by clarifying terms of satisfaction. These are both examples of efficiencies within the scope of

	Barter Bargaining	Pre-negotiated Money Exchange
Pre-conditions of exchange	Requires coincidence of wants	Universal exchange motivator; everyone can use money
	Requires participant trust as to what will be exchanged	Pre-negotiated money reduces the need to trust given trading partners
		Money must be earned in advance of exchange
		Money can become an end in itself
Exchange interaction dynamics	Exchanges are concrete social interactions that create and strengthen ties	Exchanges can be efficient, relatively scripted interactions
	Value of goods and exchange terms must be negotiated case by case	Universal scale for valuing, setting reference commodity prices
	Logistics payment involves storage and transport, maintaining animals and grains, assaying metals, etc.	Logistics of payment is simplified to handing over coins
		Exchange interactions create and strengthen social ties less
Consequences of exchange	People feel interdependent	People feel autonomous and self-sufficient [46]
	Cultivates division of labor and bilateral co-dependency relationships	Undermines social sensitivity, reliance on/collaboration with other people; increases social isolation [46]
Disparity and support	Exchange spheres ensure access to subsistence goods	Concentration of capital and thus power marginalizes the poor
	Gifts to persons of low standing are not expected to be reciprocated	Concentration of control in exchange marginalizes smaller enterprises
Reciprocity	Competitive gift exchange regulates prestige and standing through community-based reciprocity	Quantified obligations have clear terms for satisfaction, and rely less on (vague) mores of reciprocity
	Decay of goods encourages dynamism in exchanges	Supports scaling and abstractions for a coordinated global system of systems
Market System	Not scalable	Non-decay of money encourages hoarding
	Key: Positive / Neutral / Negative	Complexity and invisibility of system elements allows market manipulations and profiteering

Table 1: Tradeoff analysis of barter and pre-negotiated money as exchange paradigms, summarizing discussion in the text.

exchange interactions that could nonetheless undermine the formation of social capital through society: Case-by-case negotiation and other trading interactions, and elaborate but underspecified gifting protocols to regulate social standing and prestige are rich social relationships that expand and strengthen social ties [7]. Graeber [13] argued that modern charity and alms emerged in concert with coinage as a way to preserve sociality in money transactions.

A benefit of money is that it provides a universal motivator and scale of value. Thus, where we might naively see two people engaged and working productively, money valuation emphasizes to us that one is receiving twice as much, or perhaps 400 times as much, for his or her efforts. That is, it objectifies the people and their activity as positions on a linear scale of money valuation. Such disparity can be a motivator for people to acquire more valuable skills by working harder, that is, a person can clearly calibrate how she/he is doing (e.g., in dollars per minute) and set concrete goals. However, if the perceived magnitude or immutability of the disparity are too great it could also demoralize and marginalize. Indeed, the introduction of money into non-market economies can disrupt social protocols such as exchange spheres, and thereby reduce access to subsistence goods [42].

The universality of money also entrains downsides. For example, Gesell [11] argued that money ceases to be an effective instrument of exchange whenever it becomes preferable to the goods and services it can purchase. Indeed, coins and notes ineluctably cause such a preference imbalance by being easy to handle relative to goods that can decay and rot, and must be stored and transported. Gesell suggested the remedy of depreciating currency, proposing that money be continuously discounted enough to ensure a poorer return from hoarding and collecting interest than from investing or otherwise circulating money [9].

Money has powerful psychological consequences. Vohs et al. [46] showed that priming the concept of money can cause people to feel self-confident and autonomous, and to be self-focused and relatively insensitive to others. In a series of experiments, participants were incidentally reminded of the concept of large amounts of money while performing various difficult tasks in contrived social situations. Money priming caused people to resist asking for or providing help. Indeed, Vohs et al. found that money priming caused people to pick up fewer pencils after a staged accident in which a box of pencils was spilled, to position their chairs further from interlocutors in a staged discussion, to express a survey preference for individually oriented leisure activities, and even to prefer working alone over working with a partner when working with another person would have allowed them to share workload. In summary, the mere idea of money evokes a sense that one is self-sufficient and that other people ought to be self-sufficient as well.

However, non-market mechanisms like spheres of exchange and gift exchange manifest in market societies in ritualized protocols that sustain and reproduce family structures, such as weddings and birthdays.

Barter and coinage, though ancient systems, are human designs that facilitate specialization, collaboration and economic growth. Analysis of implicit tradeoffs in the barter and money paradigms, as designs for exchange, as presented in Table 1, can help us to understand subsequent and contemporary innovations in currency and exchange, as well as to identify a design agenda for future innovations. But need and opportunity continue to energize design efforts with respect to currency and exchange.

ALTERNATIVE AND COMPLEMENTARY CURRENCIES

Barter and money are conceptual and historical anchors for understanding paradigms for trade and exchange, but are also themselves diverse and evolving. They can help to frame alternative and complementary currency paradigms that have emerged in the past several decades, and that have become impactful in the past decade.

The past three decades have seen an explosion in currencies other than government-backed currencies. The term "alternative currency" is widely employed, but few if any non-government backed currencies actually aspire to provide an alternative. Most currency innovations are complementary currencies, intended to augment the currency ecology with respect to particular needs or possibilities, though it is possible that a truly alternative currency could emerge at some point.

Most complementary currencies address critical analyses of national money, and embody new currency designs that remedy or meliorate identified issues [24]. For example, one critical analysis of national money is that by providing a universal framework for value and exchange, money undermines the sociality and intimacy of exchange interactions. As reviewed above, the universal framework of money may indeed be so powerful as to undermine perceptions of the self as part of a social world. A strong design theme in complementary currencies is the goal of better evoking and strengthening locality and community through transactions. Local/community currencies [23,31] are an example of this sort of design.

Another critique of universal money is that it is socially inertial. People with more money have disproportionately more access to generating money than do people with less money. Over time, this causes income and possession distributions to skew: the rich become the super-rich, but many others are left behind, marginalized in society; they are left ever further behind. This pattern is characteristic of money-based market economies [35]. Another strong design theme in complementary currencies is the goal of enabling marginalized persons to contribute to society, to participate for their own good and for the good of society. A goal of complementary currencies is to facilitate the economic rehabilitation of marginalized people by enabling economic interactions that do not depend on already having accumulated some degree of wealth. Designing interactions for economic co-production is an example of this [4].

Contemporary national currencies are in no sense commodity money; no one is guaranteed conversion of dollars into anything else. Market dynamics set the value of dollars. A third critical analysis of national currencies is that they are grounded ultimately in the confidence citizens have in government. Monetary policies and currency management strategies of central banks mediate this ultimate grounding, and are intended to enhance confidence by regulating swings of inflation and deflation. A complementary design strategy is to ground currencies in something beyond confidence in national government. Time-based currencies and crypto-currencies are an example of this sort of strategy [4,34].

A fourth critique of national money is that the monetary system has become unnecessarily complex, permitting subtle manipulations by incumbents like large banks to effectively tax currency transactions through collection of various fees or unfair high-speed trading that the average investor cannot compete with [27]. As we write this paper, the bank Credit Suisse has just pled guilty to felony conspiracy in tax evasion [36]. Even when banking practices are legal, it is argued, they are not productive except for the very few privileged entities that are able to manipulate the system to their advantage [22]. A strong design theme in complementary currencies is the streamlining of the monetary system, generally through more sophisticated and transparent use of information technology, which would diminish the role of banks, including national central banks. Crypto currencies like Bitcoin are example of this sort of design.

A fifth, related and longstanding critique, one identified as a threat to the United States by President Abraham Lincoln, is that money centralizes and concentrates power and control of exchange relationships in the hands of corporations [25]. In the past this was justified in enabling human projects of unprecedented complexity. However, the case for such concentrated control is weaker in contemporary economics where close collaboration and coordination of means and goals can be enabled by sophisticated information technology, including peer-to-peer endeavors [4] and crowd finance [44]. Collaborative economy microenterprises still depend on the exchange of money, but, unlike crowd financing, they are implemented through direct reciprocal exchange, person-to-person, emphasizing the sociality of exchange.

LOCAL/COMMUNITY CURRENCIES

Local/community currencies are intended to strengthen local economic activity by facilitating exchanges of goods and services within the community. One rationale for local currency is that it increases the money supply; circulating

additional currency in a locale increases the amount of potential local economic activity. A second rationale is that because the local currency is only accepted by local merchants and used by local citizens, the economic activity produced tends to stay centered in the locale, encouraging community members to engage in transactions with one another. Sometimes additional rationales are incorporated, as in the example of the Austrian town of Wörgl; in 1932, the town issued negative interest local scrip in an effort to restart its damaged economy, producing a (successful) test of Gesell's [11] theory that economic recovery can be stimulated by the introduction of 'free money' [9,23].

Contemporary local/community currencies typically bind the value of the local currency to a national currency, but incentivize adoption and use in various ways. For example, BerkShares (www.berkshares.org), in the Bershire region of Massachusetts, offer purchase price discounts. They can be purchased for $US 0.95, but redeemed at parity with the US dollar. OakShares (www.oaklandgrown.org), in Oakland, California, operate like rewards points. They are generated by local purchases made with the Oakland Grown card. Local currencies also employ distinctive graphical designs that vividly evoke the local area, for example, the local scenes and portraits on Salt Spring Island dollars in Canada (www.saltspringdollars.com), or the elaborately witty designs and proud slogan (Our city. Our Money.) of the Bristol Pound in the United Kingdom (bristolpound.org; cf. [26]).

Currently, there are several thousand community currencies; more than a thousand of these are associated with the *transition towns* movement, framing local/community currency as a component of a broader effort to develop community resilience in the context of global economic and ecological crises [31].

TIMEBANKS

Timebanks regulate service exchanges purely on the basis of the time required to perform the services. Everyone has time, and ipso facto can participate in time-based exchange, moreover, valuing services only by the time required to provide them is absolutely equitable; a laborer's time has the same value basis as a boss's time. Timebanks afford new possibilities for social innovation. Thus, time-based exchange helps to integrate economically marginalized members of society, valuing their participation as equal to the most advantaged and central members [40].

Timebanks often coordinate with or are embedded in existing social service institutions (hospitals, schools, churches, food banks, elderly support groups), integrating social service provision, exchange interactions, and opportunities for human development. In the United Kingdom, for example, National Health Service doctors and other healthcare professionals can refer their patients to a timebank as part of treatment for mood disorders. Thus, in the Rushley Green timebank in London, the patients provide services such as accompanying elderly members who are shopping, visiting elderly people in their homes, etc., helping the elderly to live on their own [39]. This innovatively conflates the traditional roles of *recipient* and *provider* in health care services: the participants in these exchange interactions are helped by helping others.

Service exchange interactions in which the roles of provider and recipient are conflated, are called co-productions [19,32]. Co-production interactions are a key mechanism for bringing marginalized persons into the broader economy: Providing services affirms one's ability to contribute something of value. At the same time, it provides an opportunity to learn from working with and helping others. And in a timebank, it also generates time credits, a concrete manifestation of one's contribution [5,12,29].

Timebanks are not a universal framework for exchange; they are better suited to regulating service exchanges than commodity exchanges. For example, it is not obvious how to extend principles of accessibility and equity to valuing a sandwich, a lawnmower, or your house in units of time, nor does the principle of voluntary exchange seem compelling for exchanges involving commodities. Even within the realm of service exchanges, timebanking raises valuation issues; for example, could the equity principle impede exchanges that are inherently inequitable, removing valuable services (e.g., dentistry, software development) from timebanking systems? And the "banking" metaphor is somewhat misleading in implicitly emphasizing the financial economic framing of accretion [2].

Timebanking can be seen as an innovation in generalized exchange [7]. From this standpoint, the uncertainties inherent in its principles of equitable value, voluntary participation, and co-production are social resources that potentially strengthen commitment and trust throughout communities. Because contributions are valued purely on the basis of time, and because the exchanges are voluntary, timebank activity has been granted tax exemption in the United States and in many other countries [4,23]. Timebanks transparently address issues of currency supply and inflation/deflation; members can always generate more or fewer hours, and time is literally a physical constant.

VIRTUAL/DIGITAL/CRYPTO-CURRENCY

Where community currencies and timebanks are examples of currency and exchange innovations that now incorporate information technology, such as database systems, innovation has also flowed the other way round, from new ideas about digital currency applications and infrastructures toward appropriation by society.

	Community Currency Systems (e.g., BerkShares)	Timebanks (e.g., Rushley Green timebank)	Crypto-currency Systems (e.g., Bitcoin)	Collaborative Microenterprises (e.g., an airbnb host)
Pre-conditions of exchange	Encourages local exchange interactions	Everyone always has time to exchange	Universal exchange motivator; everyone can use	Enables utilization of resources that might otherwise go unused
		Requires trust among participants	Low need for trust among partners	Requires trust among participants
			Must be earned in advance of exchange	Money must be earned in advance of exchange
Exchange interaction dynamics	Exchanges are social interactions that create and strengthen ties and community identity	Exchanges are social interactions that create and strengthen ties and community identity	Exchanges are socially direct but private and encrypted	Exchanges are social interactions that introduce people
		Everyone's time is valued equally	Transactions and logistics are simple and efficient	
	Can only be used within the local community	Time is a universal scale valuing services	Universal scale for valuing	Leverages money economy
		Service exchanges often co-productions	Adoption is not universal	
		Can only be used within the timebank		
Consequences of exchange	Participants feel locally interdependent	Participants feel interdependent; that every member can contribute, and knows this	Participants feel autonomous and self-sufficient	Participants feel interdependent, and more able to benefit from interdependence
	Resources/capacities are developed and invested locally	Uncertainties of generalized exchange build social capital		
Disparity and support	Exchange spheres ensure access to subsistence goods	Concentration of capital and thus power marginalizes the poor	Direct peer-to-peer exchange undermines central concentration and control of capital	Direct peer-to-peer exchange undermines central concentration and control of capital
	Gifts to persons of low standing are not expected to be reciprocated	Concentration of control in exchange marginalizes smaller enterprises		
Reciprocity	Integrate quantified terms for satisfaction with community-based reciprocity	Integrate quantified terms for satisfaction with community-based reciprocity	Integrate quantified terms for satisfaction with public reciprocity	Integrate quantified terms for satisfaction with direct social interaction
Market System	Backed by the value of the community itself	Equitable/voluntary time-based exchanges can be tax exempt	Supports scaling for a coordinated global system	Enterprises can be very narrow
	Comprehensiveness and potential for growth limited by locality of exchange	Robust with respect to inflation/deflation; intrinsically adjust "money-supply" (hours exchanged)	Bitcoin supply limitations encourages hoarding	Federated exchange can be comprehensive
		Applies much better to services than commodities	Complexity and novelty may limit adoption	
Key	**Positive**	**Neutral**	**Negative**	

Table 2: Tradeoff analysis of alternate/complementary currency and exchange paradigms, summarizing discussion in text.

Much has been made of currency that is used within virtual worlds, such as Second Life's Linden and World of Warcraft's Bloody Coin. Originally designed to facilitate exchange between players in these worlds, the currencies quickly came to achieve real world value in that some individuals were willing to buy the currency in exchange for national currency. This has led to problems with 'farming' in which organizations, often in China, employ or force players to earn currency through their game efforts in order to be able to buy real currency with their earnings [18]. Another issue is that personal gains can be very high in some cases, raising the problem of how to tax virtual currency income [28].

During the 1990s, many initiatives explored digital currency concepts, including secure cash distributions from banks to personal electronic devices, anonymous crowdfunding for assassinations, voluntary online economies that could defy taxation, and solving cryptographic equations to generate digital coins [34]. An imperative that emerged from this early work was to protect privacy and minimize transaction costs through peer-to-peer exchange, that is, to eliminate central mediation of transactions by banks and other financial institutions, but at the same time, to ensure the integrity of currency exchanges, specifically to prohibit double-spending.

Bitcoin, the first successful crypto-currency, was defined in 2008 [30]. Many others exist (310 are listed on coinmarketcap.com at the time of writing) but we will focus our discussion on Bitcoin, which is currently worth more than all the rest combined. Peer-to-peer Bitcoin transactions are verified by public-key encryption, in effect, carried out in public without revealing personal identities. Transactions are bundled and then encrypted, by Bitcoin miners, who compete to provide cryptographic hash equations in order to earn Bitcoin. The bundled and encrypted transactions are then added to the block chain of time-stamped/digitally signed Bitcoin transactions.

Bitcoin has attracted attention as a serious alternative to contemporary national fiat money. It is important to note that the underlying computational mechanisms for a crypto-currency need to be sound, and need to be regarded as sound, but do not need to be explicitly understood or directly used by individuals. Indeed, user testimonials often refer specifically to reduced transaction costs, created by eliminating the role of banks and credit card companies, and reduced risks, entrained by the security and real time finality of transactions [34].

Bitcoin's reputation has been undermined somewhat from its reported appropriation by criminal enterprises, security breaches of Bitcoin online exchanges, such as Mt. Gox, and the great volatility in its valuation One concept that accelerated the early adoption of Bitcoin was the limitation to create no more than 21 million Bitcoins. Not surprisingly, this policy has led to hoarding [21], which has occasionally caused the value of Bitcoin to soar, but more generally undermined it as an effective currency (recall [11]).

COLLABORATIVE ECONOMY MICROENTERPRISES

Collaborative consumption [3], also called the sharing economy [16], has emerged and grown meteorically through the past couple years. It consists of person-to-person exchanges of commodities and services, for example, a meal (cookening.com), the loan of a garden tool (yerdle.com), use of a parking space (parkatmyhouse.com), a ride to work (carpooling.com), a place to sleep (airbnb.com), and so forth. There are hundreds of such services catered to by investment funds, professional associations and networking and advocacy groups (e.g., collaborativefund.com, ouishare.net, shareable.net, peers.org).

In general, collaborative consumption exchanges are arranged through social media interactions, and are executed through face-to-face interactions. They utilize money, but, similar to crypto-currency, they eliminate the institutional mediation entailed in the standard economic paradigm (usually in the form of companies that provide products and services). We call these service exchanges collaborative economy *microenterprises* because the providers operate as tiny independent businesses; they use social websites, like Airbnb, to identify themselves to potential service recipients, for which they pay a fee.

Collaborative economy entrepreneurs provide access to resources (lawnmowers, cars, parking spaces, beds) and experiences (yachts, beach houses, gourmet food) that people might otherwise not be able to arrange or afford, and which otherwise might go unused, and, in that sense, be wasted. Reciprocally, these transactions are opportunities for the entrepreneur to earn money and make social contacts. Collaborative economy microenterprises tend to be quite narrow with respect to the services and commodities exchanged; each is somewhat of a boutique. However, the spectrum of the new microenterprises is quite broad; thus, in aggregate they seem more like a paradigm change.

Collaborative economy microenterprises use national money as currency, thus one has to have money in order to obtain any resource or service at all. The role of money may thereby entrain social isolation [46], diminished connection to others, and reinforce seeing money as end in itself. Of course, the microenterprises also inherit the upsides of money, such as its universal exchange utility. Moreover, this paradigm confronts some downsides of money-based exchange, such as concentration of capital, power, and control of economic activity in small elites (Table 1).

Like the other emerging currency and exchange paradigms, the microenterprises replace hegemonic scale with direct peer-to-peer responsiveness. All of the paradigms rest upon direct peer-to-peer interactions among people, and diminish or eliminate the role of large institutional mediators such as national and global corporations and banks. Thus, as crypto-currency attenuates bank-based transaction costs, collaborative economy microenterprises reduce corporate overheads.

All of the complementary currency and exchange paradigms create new opportunities for people to generate value through working together, and thereby forge social ties that enable greater access to a variety of resources [14]. All of the new paradigms increase the range of economic opportunities available to individuals, and thus to some extent address the inertial incumbency challenge of the conventional money economy that the rich get richer and the poor get marginalized. In various ways, they restore sociality to economic exchange.

DISCUSSION

The history of trade and exchange is not a simple matter of innovation and improvement. For example, the spice trade between Europe and Asia initially entrained unprecedented interaction among civilizations, but eventually led to the colonization and domination of much of the world by European powers. Indeed, contemporary geo-politics includes many debates about trade policy. The present and future of exchange is likewise not a simple matter, and is of course susceptible also to untoward consequence.

Nevertheless, the innovations currently underway can change, and perhaps are now changing paradigms for currency and exchange in contemporary society.

The history of currency and exchange can be viewed as evolutionary design. In a social context without even barter, direct exchange, negotiated case by case, is incredibly innovative. But in leveraging the dynamics of comparative advantage and divisions of labor, barter also helps to manifest its own downsides, for example, the coincidence of wants and unscalably cumbersome negotiations and logistics. Standard exchange values and commodity currencies entrain coins, relieving problems of case-by-case negotiation and logistics, and raising many new affordances for lending/borrowing, taxation, and a wide range of investment paradigms. But money-based exchange also raises new challenges such as objectifying people and activity on an over-simple scale of value, complicating transactions, over-concentrating wealth and economic activity, creating diverse and arcane opportunities for criminal activity, and more generally evoking social isolation and undermining trust and empathy [7,46].

We suggest that the downsides of money are addressed by emerging alternate/complementary currency and exchange paradigms of community currencies, timebanks, crypto-currency, and collaborative economy microenterprises. Indeed, the core rationales for these newer designs address salient features of the money economy that the designers regarded as problematic: community currencies anchor exchange interactions and benefits in local communities; timebanks facilitate equity in access to currency and exchange, and thereby in opportunities to contribute, learn and benefit; crypto-currency increases individual privacy and control, and eliminates the supervision of governments and banks through direct peer-to-peer transactions; collaborative economy microenterprises reduce mediation and transaction costs, while enhancing the direct social consequences of exchange interactions.

The variety of complementary currencies can be analyzed as an emerging ecosystem, that is, as more than a collection of reactions to hegemonic money. This currency ecosystem can be seen as embodying design propositions about future trajectories of economic exchange. Thus, all four examples we discussed favor direct peer-to-peer exchanges over exchanges mediated by national and global institutions. More specifically, these paradigms protect individual privacy relative to centrally-supervised trade and exchange (local/community currencies, timebanks, crypto-currencies), strengthen and encourage strongly social trade and exchange relationships, that is relationships among people who live and/or work in proximity (community currencies, timebanks, many collaborative economy microenterprises), and indeed, between them ensure that every member of society can always participate equitably in at least some economic interactions (timebanks). The trading spheres for the four paradigms are complementary, raising the potential for future integration in a peer-to-peer economy.

Perhaps most importantly, the emerging design space of peer-to-peer currency and exchange is still emerging; each of the four paradigms we analyzed is a work-in-progress. They are developing and changing. We are also aware of ongoing innovations that do not fit well into our four types, for example, modern barter schemes, like www.u-exchange.com, use the web to vastly expand the sphere of users transaction possibilities and credits to overcome the coincidence of wants problem, gift exchanges, like yerdle.com, use the web to expand the sphere of possible transactions. These further examples do fit well into our overall analysis of contemporary peer-to-peer currency and exchange innovations as less centrally supervised and more social and equitable than the long-running paradigm of national money.

IMPLICATIONS FOR DESIGN

Our review and conceptual analysis of contemporary complementary currency and exchange innovations suggests many further design directions. The notion that socio-technologists should or can redesign systems and technologies for currency and exchange may seem over-ambitious, if one focuses on redesigning established systems like the US Federal Reserve. But the alternative and complementary paradigms we have reviewed and analyzed are still emerging, and are relatively plastic with respect to their ability to incorporate new ideas. They are still developing and rapidly growing.

Crypto-currency is a good example for information technologists, as it is literally a data exchange protocol. The Bitcoin experience has evoked many ideas and directions for successive crypto-currencies. Krugman [21] noted that Bitcoin's design, which incorporated a money supply cap of 21 million Bitcoin, encourages speculative hoarding, which, in turn, has limited the impact of Bitcoin. As discussed earlier, hoarding is common whenever financial incumbents believe they can earn more from holding money than they can from investing it. This problem is not likely to ever be directly addressed by national banks, indeed the few (successful) historical cases of implementing Gesell's [11] concept of negative interest (or a tax on wealth, not just income) were stopped by national banks [9]. Crypto-currencies easily afford implementation of negative interest in their underlying algorithms. This is a case where implications for design seem obvious and the consequences could be dramatic.

Negative interest could also be incorporated into timebank designs. It is known that timebanks also evoke hoarding behaviors [40]. The issue is not the same one Gesell identified, since time-based currencies do not accrue interest, and cannot be invested, though they can be shared. The reluctance to circulate time credits appears to be due to preference on the part of some participants for contributing

time over consuming services [40]. Still, the negative interest mechanism might serve to loosen inhibitions about requesting services, and in any event, would diminish hoarded time balances and renew motivation to earn time credits.

We described the co-production principle above, the notion that many exchanges depend upon strongly reciprocal interactions in which the roles of provider and recipient are conflated. Thus, when a patient provides a timebank service as part of treatment for a mood disorder, all parties to the exchange are *both* providers and recipients of services [4,12]. Although co-production is cited as a core value and practice of timebanking [4,40] no timebanking software explicitly supports crediting co-production [6]. Instead, co-production is recognized in timebank communities through work-arounds, such as sending messages, awarding ad hoc time credits, and under-reporting (and various other improvisations). It could be that recognizing co-production non-explicitly is a feature, not a bug, in timebanking. Or, it could be that allowing co-production interactions to remain invisible depresses the extent to which co-production exchanges occur. This could be investigated directly through supporting and studying recognition mechanisms such as recommendations, badges, testimonials, and reciprocal donations of time [2,6].

A key goal of local/community currencies is to strengthen local economic activity by encouraging trade and exchange among local community members. Standard approaches of implementing community currencies through commodity money or local currency involve the logistical overheads of managing, or even producing, physical money. Recently, Knowles et al. [20] proposed integrating local sensing technologies into a community currency system; in this design, people employ national currencies, but allow their located transactions to be sensed or declared as they occur, and thus participate transparently in a community currency through their meta-data. This concept has not yet been empirically evaluated. An even more transparent implementation would be to include location information in the profiles and/or transactions of crypto-currency users, thus allowing everyone in the world to participate in a community currency without physical/logistical overheads.

A further implication of using context awareness is that it should be possible to recommend exchange possibilities to potential participants, based on context. Context could be relatively static information such as someone's interests, social connections and history of activities or it could be highly dynamic such as current location, availability or ongoing activity. For example, if a timebank knew that a person enjoys working with the elderly and discussing local politics, and that the person was currently located near an elderly person interested in local politics, the timebank could push a suggestion for a service exchange, instead of merely managing a database of manually submitted service offers and requests [2].

Pushing the use of context-awareness even further, a more sophisticated system might be able to recommend transactions based on personal goals or societal ideals. For example, a person who wants to but isn't getting much exercise (as sensed by a personal mobile device) might receive a recommendation to walk a neighbor's dog each morning. Or a youngster interested in learning about citrus growing, might receive a recommendation to help out on a nearby local fruit farm at harvest time. In a situation where rifts exist in a community (for example in Oakland, California, African American and Spanish-speaking populations that live side-by-side are not well integrated and experience a high degree of inter-racial tension) a system could detect the lack of social connections and interactions between two such groups. It could then recommend transactions between community leaders on each side of the cultural divide who are highly connected in their respective networks and have common interests. In discovering common interests, such individuals are likely to form bonds and help to bring their communities closer together.

Context awareness and automated transaction partner matching offer intriguing design possibilities for increasing the timeliness, convenience, attractiveness and benefits of peer-to-peer exchanges across all four emerging currency paradigms. The collaborative economy microenterprise TaskRabbit has already made a first move in this direction, announcing their use of a matching algorithm in the past few weeks at the time of writing, albeit their algorithm is not yet context-aware.

Alternative currency designs emphasize possibilities for social and economic exchange that mitigate downsides of the established paradigm of pre-negotiated money-based exchange. Especially in the past decade, relatively simple and robust empirical methods, such as the money priming method used by Vohs et al. [46], have been widely applied in psychological studies of the meaning and behavioral impacts of money. These methods could be directly extended to investigate *differences* between the established concept of money and emerging complementary currency concepts, such as those we discussed above.

Alternate/complementary currency and exchange paradigms are growing rapidly. This makes them a natural laboratory for relatively large-scale investigation. For example, the timebank collective hOurWorld (www.hourworld.org) has over 20,000 members and a very high rate of growth for a non-profit, more than doubling in the last two years, according to its website; the collaborative economy enterprise airbnb.com, grew more than tenfold, in guest nights booked, between June 2010 and June 2012, when they reported 10 million rooms booked. Indeed bitcoin and timebanks are great examples of why CSCW research and design innovation is needed; people designing radical p2p technology without economic and collaboration theories may have gotten it wrong (or at least only partially right).

CONCLUSION

The observation that global banking and finance is in crisis has become a worrying commonplace. As we finish this paper, major new economic powers like Brazil, China and Russia are in crisis, while the old economic powers of Europe and North America are barely recovering from the economic crisis of 2007. Engaging and addressing the challenges of creating value together, and of how new designs and technology can better support human economic endeavors is rich and relevant opportunity for CSCW.

A more diverse ecosystem of currency and exchange, including alternate and complementary currencies, could contribute to greater economic equity and stability [24]. A planning document created as part of the, United Nations Millennium Declaration process [45], called for national governments: "To make serious commitments to restructure the global financial architecture based on principles of equity, transparency, accountability and democracy, and to balance, with the participation of civil society organizations, the monetary means to favour human endeavour and ecology, such as an alternative time-based currency." This statement was not included in the final UN Declaration, and eight years later Western economies collapsed. The statement was recently deleted from the UN website.

Technologists understand well that change occurs at the edges of incumbent paradigms, eventually undermining less effective paradigms [1]. Similarly perhaps, the global financial architecture is unlikely to be reformed significantly through top-down initiatives of the UN. Incumbents do not give up power, rather they lose it to innovation and disruption. The opportunity for CSCW is to help reform global financial systems through design.

ACKNOWLEDGMENTS

We thank our collaborators in our timebanking and peer-to-peer exchange projects. This work was supported by the U.S. National Science Foundation (IIS 1218544, 1406858).

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