Problems in the Undertakings of the Collaborative Economy: Co-Utile Solutions

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Abstract In the current era of the digital economy, the collaborative economic system, being a successor of the capitalist system, has led to a greater wave of sharing of scarce resources and to the creation of interdependent networks of rational beings. In spite of its promising features of abundant liquidity and efficient utilization of the underutilized scarce economic resources, the system is still in its early stages of development and suffers from some serious problems that hamper its deployment. In order to unlock the potential of this economic system, there is a need for conciliating the individual freedom of economic agents and the common good of the information society encompassing it. In this chapter, we tackle this issue by relying on the recently minted concept of co-utility, which refers to a self-enforcing and mutually beneficial interaction among self-interested agents. By means of co-utility, we aim at mending some of the fractures underlying the collaborative economy due to key hindering factors for potential collaboration. Further, the potential collaborations within each of the use cases presented in this text (i.e., the crowd-based business models and the P2P online lending market) are fostered by co-utile solutions, arising either naturally or artificially through incentive schemes.

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1. Introduction

The collaborative economy (also known as mesh or sharing economy) refers to technology-oriented supply-demand facilitation, with an on-demand extension of the concept to the previously underutilized resources [12]. This has resulted in an efficient utilization of scarce resources, which is the main motivation underlying the economic theory. In its raw sense, the core principles assumed to govern the system are: collaboration, empowerment, transparency, humanity and altruistic sharing for the common well-being.

[26] argues that there is a paradox in the capitalist system and that the invisible hand that has been responsible for the capitalism's success has led to a new successor paradigm called the collaborative economy. Yet, some of the new business models we came across with this trend have elements of altruism and rent combined. For the collaborative system not to collapse and destroy itself, the values derived should rest on the principles of mutual help and ethics. These are precisely the values underlying to co-utility, a novel concept for designing interaction protocols among agents that conciliate their selfish and rational choices with societal welfare (see [8] and [7], and the first chapter of this book).

By proposing co-utile solutions for the collaborative economy, our aim here is to foster its applications and its core principles in all potential areas, with a demand-led lens like all novel innovations. Specifically, co-utile protocols, being self-enforcing and mutually beneficial, contribute to making transactions efficient by suppressing sub-optimal interactions.

In this chapter, we will be focusing mainly on the crowdsourcing and FinTech markets in general, including crowdfunding, P2P lending and cryptocurrencies.

2. The collaborative economy: an overview

The collaborative economy is an economic system characterized by the underlying key economic features of sharing, leasing, swapping, selling, buying, lending, giving and bartering. With these key transactional features, it has the potential to unlock the idle capacity in the utilization of the scarce economic resources mainly using, but not limited to, the Internet [12]. Financial technologies including the business lines of peer-to-peer (P2P) transactions, crowdfunding and crowdsourcing, innovation and educational marketplaces, are some of the common structures of this economy. The collaborative economy paradigm revolves around the core principles of collaboration, empowerment, transparency, humanity and altruistic sharing for the common well-being, which results in efficiency with no hyper-consumption. The emergence of irreversible consumer behavior is one of the catalysts for a widespread replication of this system all across the globe. By irreversible consumer behavior we mean a preference shift of

the digital society to a new form of utilization of goods and services instead of the traditional form of consumption.

According to [26], capitalism has led to its own mutation into a new collaborative economic system that he calls the ‘zero marginal cost society’. However, some scholars argue that the collaborative economy, which has initially manifested itself in the form of sharing economy, has more tendency to be pure capitalism. For example, [24] proposes networks with members’ co-ownership rather than operating in the form of monopolistic platforms like Uber. His argument sounds like a call for a co-utile interaction, which we will introduce in the following section. A prominent example of a successful co-ownership model in the real world is the John Lewis Partnership,,a UK-based retail company co-owned by the employees (Salaman and Storey 2016).

The collaborative economy is characterized by abundant liquidity. PricewaterhouseCoopers in 2015 estimated that, by the year 2025, transactions under this economy are expected to generate about $335 billion at a global level. Despite its rich liquidity for the players, the collaborative economy has posed many challenges that prevent traditional players from embracing it. The new business models of this economic system are disrupting the incumbent customer base of traditional sectors and also making their business models and services obsolete. On the other hand, with the new business models of collaborative economy, new risks arise. These new models are exposed to new challenges and uncertainties unique to their individual set-up. This is mainly due to the dynamics and hasty evolution of the business models to cope with the new regulatory and legal codes and latest technology-based competition from their players. Furthermore, this economy poses a challenge to the governments, for which enacting new rules and regulations that cope with the dynamics of the collaborative business models is hard. This will also disrupt the government's revenue with a fundamental transformation of the market players joining the new business models before new rules are enacted. Another important issue is the mistrust between the players within the system itself. This results from the uncertainties and asymmetric information that exist in most of the transactions of the collaborative economy models. Hence, in this system, reputation is a highly valued asset, and it is regarded as the currency and capital of the collaborative economy (see [2] and [11]).

3. Co-utility

Co-utility refers to a philosophy of economic and social norms based on mutually beneficial interactions. It explains mutuality in the framework of the social rational choice theory, in which an agent taking part in any form of interaction is bound to a self-rational choice which is in line with the rational choice of another agent it interacts with. Formally defined, an outcome for any game is co-utile, if

and only if (1) it is equilibrium of the game, (2) it is a Pareto-optimal outcome and (3) playing the game gives a strictly higher payoff to all the players involved than not playing the game ([8] and [7]).

Furthermore, it is worth mentioning the following key points about the co-utility theory.

(i) Players involved in any co-utile interaction can have either symmetric or asymmetric goals. For example, in the case of a P2P file sharing network, the goals of all the agents involved in this network are the same. But if we take P2P online lending, the goal of a borrower is soliciting finance, whereas that of a lender is making profit at a given interest rate.

(ii) A proportional flow of values in a co-utile interaction is a necessary condition in order to keep a positive utility to all the agents involved, yet this flow of values does not need to be equal.

(iii) Co-utility can arise either naturally or artificially through incentive mechanisms. Here, it is important to consider the timing of the payoffs to any co-utile games attained, i.e. immediate or future expected payoffs. This will help capture the dynamics of co-utile interactions between rational agents, especially when designing artificial incentives that will guarantee co-utility in co-utility amenable games. In some cases, an agent may do a favor to another because the other has favored this agent in the past or is expected to do so in the future. Hence, in addition to spontaneous interactions, the co-utility framework can be designed to consider the dynamics with time.

(iv) As stated in the formal definition of co-utility, co-utile interaction results in superior payoff to all agents involved over the next best alternative interaction. Hence, the efficiency of any co-utile game can be measured by quantifying the intrinsic efficiency advantage of co-utile interactions over the other options.

(v) The basic requirements for the fulfillment of an efficient co-utile interaction are collaborative demand (i.e., the ability and willingness of the parties involved in the co-utile game), commitment and trust between involved parties, a common platform for the interaction, and a post-transaction positive utility.

Co-utility is also important in the public relations and interactions of an organization with its customers and stakeholders. For instance, a fair market price service provision by a supplier, which neither undercuts the supplier's profitability nor passes on unnecessary cost increases to the customers, is mutually beneficial both for the sustainability of the business suppliers and for achieving a cost-effective access to the company's services by the customers. Hence, co-utility as a business strategy can deliver sustainable profitability of the business while benefiting the customers. One example of this can be a business strategy followed by Mars Inc., an American global manufacturer of confectionery, pet food, chocolate, candy and other food products. In 1998, when Russia defaulted on its foreign debt, in order to keep their customer base in this country the company designed a lifeline offer of a product without payment until it was resold, which averted bankruptcy and allowed continuing their operations even during this uncertain period.

In a more general and aggregate sense, co-utility may also apply to the two-way democratic communication between the government and the citizens, whose interaction is based on the principles of mutuality, empathy, trust and solidarity. This communication is done through a two-way symmetric communication, characterized by negotiation, conflict resolution and respect. One key type of government interaction with the citizens is carried out through national policy development. For example, in the policy of holding a low inflation, there exists a dynamic inconsistency arising from people's rational expectation on the expansionary/contractionary monetary policy measures taken by the government in response to a low/high expected inflation [27]. Two of the models proposed under this scenario are the reputation and delegation model.

In the reputation model, policy-makers with more than a two-period office stay (i.e. more than two terms) will aim at either maximizing wealth or fighting inflation, .A policy-maker can "cheat", because people's expectation (and trust) can be affected by the policymaker's decision, which is the unrevealed type of the policy maker. The reputation model implies that uncertainty about the characteristics of policy-makers reduces inflation. If a policy-maker does not cheat, expectations for inflation will be lower. If it cheats, the reputation is damaged and expectations for inflation will be higher.

On the other hand, a model of delegation delegates the monetary policy to an independent inflation-averse institution. The problem with this model lies in its limitation of the risk aversion principle, for example, during economic shocks. In such case, the implementation of a stabilization policy is limited because the underlying assumption of linear social welfare is too strong while, on the other hand, monetary policy fluctuations also result in fluctuations in consumption and fluctuations in working hours, which result in disutility for the workers. Hence, lags of policy effects, the existing economic state and uncertainty about the future limit the realization of a stabilization policy. Because a stable economy hosts and pulls healthy investments, collaborative and mutually inclusive acts, both by the government and by the citizens, are needed. In this regard, the notion of co-utility can play an important role in the interaction between the government and the citizens.

Our main aim w.r.t. co-utility is to foster the application of the innovative models of collaborative economy and core principles to all potential areas, with a demand-led lens like the replications of all previous novel innovations of the universe. In the next section, we present some of the business models of the collaborative economy that are co-utility-amenable by design and discuss how co-utile interactions may be designed.

4. Co-utility-amenable models of the collaborative economy

This section approaches the collaborative economy by introducing the concept of co-utility into the existing business models, with the aim of enhancing their efficiency and the social welfare in general. These business models, which highly rely on the ICTs, fall under the umbrella of the digital economy (aka Internet or web economy). We start with the crowdsourcing business model, followed by the two main FinTech funding models (crowdfunding and P2P online lending) and last, but not least, cryptocurrencies.

4.1 Crowdsourcing

Crowdsourcing is a method for outsourcing a task to an anonymous crowd. Any individual worker taking part in the crowdsourcing market makes a choice based on a cost-benefit analysis of the participation. There exists a co-utile interaction in this market as long as the goals of requester and worker are complementary and the qualification type of the worker matches the task. Let u_i be the utility function of a worker in the crowdsourcing market. Then,

$$u_i(\mathcal{T}, e) = f_i(\mathcal{T})[\alpha_i r_i(e) - c_i(\mathcal{T}, e)], \qquad (1)$$

where $f_i(\mathcal{T})$ is a binary function specifying whether or not task $\mathcal{T}$ matches worker i's interest and qualifications (ability); $f_i(\mathcal{T}) = 0$ implies worker i is not interested or not qualified to perform the task; $f_i(\mathcal{T}) = 1$ implies worker i is qualified and willing to exert effort towards this specific task; e is the effort level to perform the task; $r_i(e)$ is the expected reward to worker i for effort e; α_i is a weight variable reflecting how much the individual values the reward; and $c_i(\mathcal{T}, e)$ is the task-specific cost of effort to worker i (e.g., it can take the form of time devoted to reading, understanding and performing the task, expenses incurred to perform the task, etc.). If $c_i(\mathcal{T}, 0) = 0$, no effort is then exerted and, for the worker, there is no cost associated to this task. There is also a trade-off between labor and leisure, l, in the participation decision of a worker. This calls for a reasonably satisfactory per-task pay that outweighs the utility of leisure, $u_i(l)$. A rational worker i supplies labor in a crowdsourcing market if $u_i(\mathcal{T}, e) > 0$ and $u_i(\mathcal{T}, e) > u_i(l)$.

Similarly, a rational requester in a crowdsourcing market will choose crowdsourcing over any other way of outsourcing his task based on the expected return. The utility function of requester j, u_j, in a monetary reward-based crowdsourcing depends on the minimum threshold it expects to gain from the task accomplishment ($\mu(\mathcal{T})$), and total output of the assigned task, y. It is defined as:

$$u_j(y, w_j, Crd, \mu_j, \mathcal{T}) = \alpha_j(y - w_j Crd\text{-}\mu_j(\mathcal{T})), \quad (2)$$

where α_j is a weight variable reflecting how much the requester values the overall gain from the output; Crd is the crowd labor supply; and w_j is the per-task pay offered by requester j. A rational requester who wants a task $\mathcal{T}$ to be performed will post the task to the anonymous crowd only if $u_j(y, w_j, Crd, \mu_j, \mathcal{T}) > 0$.

Both requesters and workers involved in this market maximize their respective utilities and collaborate for their best interest. Therefore, the crowdsourcing market is a potentially co-utile market with the natural incentives underlying the market. Yet, like many other collaborative economy models, this business model suffers from some limitations. The main one is that this model is of limited applicability for any type of task outsourcing, for example, those tasks which require privacy. Another key problem is that monetary rewards to workers are mostly very low, which will have a macroeconomic effect.

4.2 FinTech in a broader view

Financial technology, abbreviated as FinTech, refers to technology-oriented business lines of the digital economy. FinTech companies range from crowdfunding and peer-to-peer lending to algorithmic asset management and facilitation of investments, financial planning, portfolio management, thematic investing, payments, data collection, credit scoring, education lending, digital currency, exchanges, working capital management, cyber security and quantum computing. Lending Club, Kickstarter, Prosper, Betterment, Xoom, 2iQ Research, ZestFinance, Coinbase, SecondMarket, Tesorio , iDGate, Motif Investing, Stripe, and Square are some examples of marketplaces in this industry. In addition, already-established IT companies like Facebook Apple Pay, Android Pay, and Google Wallet are also actively involved in the money-transfer markets and mobile payments. This wave of technological penetration in the financial industry has created a significant pressure to the traditional incumbent players in the market. Tech startups come up with an improved artificial intelligence, automation, algorithmic decision-making, cost-effective data mining and processing, and a convenient and efficient speed of operation while capturing the low-end customers' preference. According to a report by McKinsey & Co. [19], traditional banks could lose about 60% of retail profit to tech startups in the coming few years.

Unlike the traditional form of business models, each individual user is a co-originator of value in this new system. Hence, we see that there is a space for co-utility underlying these business models. In order to elaborate these in more detail,

we present some FinTech sub-industries and business lines which are co-utility-amenable by nature.

4.2.1 Investment crowdfunding

Crowdfunding is a fund-raising business model that depends on sourcing finances from a given network of crowd, mainly through the Internet. The key players in this market are the project initiator/requestor, the crowd, and an intermediary platform that facilitates a link in the network. It takes the form of either investment crowdfunding including debt-based, equity-based, profit-sharing or hybrids of these, or donation crowdfunding, also called reward-based crowdfunding. Crowdfunding is an example of a co-utility amenable game. The market can be modeled using a financial market imperfection model accounting for the information asymmetry and risk-averse behavior of the investors and project initiators (see [30] and [27]). The expected return to a crowdfunding investor i can be defined as:

$$E(R_i) = \pi x_i D + (1-\pi)[-(1+r)C_i - \alpha_i], \qquad (3)$$

where $\pi = (\gamma^* - \mathrm{D})/\gamma^*$ is the probability at which the entrepreneur rewards the investor with amount D as per the debt contract and takes the surplus; x_i is the proportion of investor i's investment in the project, C_i is invested amount and r is the random interest rate. $\sum_{i=1}^{n} x_i = 1$ and $D_i = x_i D$. By solving for D, the optimal debt contract at which the return based investment decision takes place is at $D = \frac{\gamma* - (1+r)C_i - \alpha_i}{2x_i}$. Hence, given a negative exponential utility function of investor i: $u(R_i) = -e^{-\beta_i R_i}$, where $\beta_i > 0$ is the risk-aversion factor for investor i, a rational investor i invests if and only if $u_i > 0$ and $u_i(R_i^*) \geq u_i\big((1+r)C_i\big)$. A rational entrepreneur j's investment decision also depends on the net expected return from its project given as:

$$E(R_j) = \gamma - [(1+r)C + \alpha], \qquad (4)$$

where γ is the expected output of the project. Given a face value of the project v, entrepreneur j broadcasts the project for crowdfunding if $\gamma - [(1+r)C + \alpha] > v$, given that the required rate of return is not more than the optimal rate of return $(1+r)C \leq R^*$. Hence, given the entrepreneur's utility function $u_j(C, r, \gamma, V) = -e^{-\beta(\gamma - (1+r)C - \alpha - V)}$, where $\beta > 0$ is a risk-aversion coefficient for the entrepreneur, it broadcasts its project if $u_j(C, r, \gamma, V) > 0$ and $u_j(C, r, \gamma, V) \geq u_j(V)$.

The crowdfunding market is prone to a number of risks due to information asymmetries and uncertainties. Due to the risk underlying this market, it is still in its early stage of development. With the practical problems *underlying the market,* there exists a non-return-based investment decision, which limits the co-utile nature of the market. We can categorize the major problems arising in this market into two main categories: *fear of disclosure effect* (entrepreneurs) and *mistrust effects* (investors). Accounting for the mistrust effect, the investor's utility function can be redefined as

$$u_i(R,\ \Gamma) = \begin{cases} -e^{-\beta_i \Gamma R} & \text{for } \Gamma \neq 0 \\ 0 & \text{for } \Gamma = 0 \end{cases}, \qquad (5)$$

where Γ = trust, and $\Gamma \epsilon [0,1]$; $\Gamma = 1$ if investors completely trust the entrepreneur and $\Gamma = 0$ if investors do not trust the entrepreneur. The fear effect on the side of the entrepreneur accounts both for the fear of failure and the fear of disclosure, which implies the risk of copy by competitors, especially for interactive digital media developers and content producers. Accounting for the *fear effect,* the utility function for entrepreneur can be defined as:

$$u_j(C,\ r,\ \gamma, V, \mathcal{F}) = \begin{cases} -e^{-\beta \mathrm{F}(\gamma - (1+r)C - \alpha - V)} & \text{for } \mathcal{F} \neq 0 \\ 0, & \text{for } \mathcal{F} = 0 \end{cases}, (6)$$

where $\mathcal{F}$ implies no-fear and $\mathcal{F} \epsilon [0,1]$; $\mathcal{F} = 1$ if the entrepreneur can broadcast its project content with no fear and $\mathcal{F} = 0$ if the entrepreneur has maximum fear.

Hence, beyond the return-based investment decision, a co-utile point of collaboration in this market is the Pareto-optimal point at which the optimal level of no-fear and trust is attained. This can be attained through artificial incentive schemes, which can tackle the risks underlying the market. The first mechanism can be enforced through encryption, by securing the private key with a decentralized timestamp for neutralizing the fear effect. The second is to employ an efficient reputation mechanism to resolve the *mistrust effect*. One possible reputation mechanism is the community-based reputation system in which credible projects are signaled by heads of a given group/network, who bear the risk of failure of a project with a sufficient skin in the game ([30]; [13]). Yet, this mechanism lacks the property of being decentralized and self-enforcing, which prevents it from being co-utile in its operation. Hence, a better-suited option is to use a decentralized co-utile reputation protocol in which reputation scores of all players in the network are computed in a distributed way (see [9] and the discussion on P2P lending below).

4.2.2 Peer-to-peer lending

Another co-utility amenable FinTech business model is P2P lending. Peer-to-peer lending is a web-based direct borrowing and lending practice between individual agents. This market acts as a substitute for the brokerage in transaction banking functions of the traditional banking. Lending Club and Prosper are some examples of online platforms facilitating the transaction between the P2P lending networks. A relatively higher rate of return in this market attracts potential lenders to invest in P2P loans rather than in any other alternative investments. In the same way, borrowers choose to borrow from the P2P online lending rather than other alternative sources of financing, like banks, mainly due to the relatively lower interest rates, [20]. In addition, borrowers prefer P2P online lending rather than traditional lenders since, in some cases, loans of low credit grade might be approved in P2P lending market, which could be rejected by the traditional banks. Stated formally, the borrower's utility function U_b in this market depends on its residual income after the loan repayment discounted to its present value over the term of the loan, given the urgency on the loan origination at a given time defined as:

$$U_b = U\left(y + \delta(t)\left(l_0 - P\frac{1-(1+i)^{-n}}{i}\right)\right), \qquad (7)$$

where y stands for the borrower's income, the term $\frac{1-(1+i)^{-n}}{i}$ is the present value of a loan amount l_0 with future annuity payments P, n is number of terms of the loan and i is a random interest rate; $\delta(t)\epsilon[0,1]$ is a weight parameter representing the level of impatience of the borrower to get the loan at a given time t; $\delta(t)$ values close to 1 imply higher patience level of the borrower. A rational borrower makes a loan request that maximizes its utility.

There are two types of lenders in the P2P lending: pure lenders that rely on their own capital for investing in the P2P lending, and lenders with reinvestment, who are those partially or fully relying on a borrowed capital for reinvesting in the same network in order to make profit through arbitrage opportunities in the market, termed as *P2P loan carry trade*. Hence, the utility functions of the lenders in this market depend on their type. The lender's utility depends on the net lending profit. The expected utility function for the pure lender with a loan amount l_0 is given as:

$$u_l = \sum_{n=1}^{n} u[(i-r)l_0\gamma(t)p(t)]\,, \qquad (8)$$

where i and r are the nominal and real market interest rates, respectively, $\gamma(t)$ is the proportion of the loan paid at time t over the loan period n, and $p(t)$ is the probability of default at time t. The utility function of the borrower with a re-investable borrowing is defined as:

$$u_l' = u\left(\frac{rL - r'(L-K)}{K} - \frac{\delta^2(\Pi)}{2\beta}\left(\frac{L}{K}\right)^2\right), \quad (9)$$

where K is the borrower's investable capital, L is the loan amount and r and r' are the random lending and borrowing interest rates, respectively. The lender makes a profit from the spread between r and r' in the loan *P2P loan carry trade*. The utility maximization problem of the lender with a re-investment motive depends on the difference between the total return on the loans, $\frac{rL - r'(L-K)}{K}$, and the total funding cost, $\frac{\delta^2(\Pi)}{2\beta}\left(\frac{L}{K}\right)^2$ which stands for the total risk of this investment as a product of the risk on the loans, $\delta^2(\Pi)$, and lenders leverage, $\left(\frac{L}{K}\right)^2$ (see [4]).

Hence, provided the formulation and discussion above, we argue that the P2P lending market is co-utile as long as it operates well enough and that there is enough finance circulating in the network with a large number of borrowers and lenders. However, the information asymmetry and market uncertainties impose a limit on the efficient and smooth flow of resources within the P2P lending network. In order to avert the problem of mistrust arising in this market, we propose a decentralized co-utile reputation mechanism that allows computing the reputation of each agent in the lending network in a self-enforcing way. In this protocol, local and global reputations of borrowers in the network are computed based on the outcome of direct transactions between borrowers and lenders.

The local reputation of borrower j, with respect to lender i, is the aggregate payoffs that i has gained from the set of direct transactions, Y_{ij} (capturing i 's total satisfaction/dissatisfaction over the set Y_{ij}). It is given by $S_{ij} = \sum_{y \in Yij} u(x)_{iy}$, where $u(x)_{iy}$ is the utility of lender i with money return x, in the transaction $y \in Y_{ij}$, performed with a borrower j. The utility from a lending transaction can be redefined as $u(x)_{iy} = 1 - {}^{2}/_{(1+\exp(x))}$, which gives values between [-1, +1] so that satisfaction scores are computed in a uniform fashion; $u(x)_{iy}$ values close to -1 represent dissatisfaction due to default and $u(x)_{iy}$ values close to +1 reflect satisfaction. Following [15]), the local reputation values are normalized to be positive for a potentially non-defaulting borrower and zero otherwise (i.e, for defaulting borrower or a newcomer to the market). A matrix of normalized local reputation values C for the whole lending network is constructed with zero entries for those borrowers and lenders with no interaction. Furthermore, this protocol works under the assumption that there are some pre-trusted agents who work for the well-being of the system, lenders in our case. Hence, lenders are assigned a small positive reputation score of $1/n$, where n is the number of players in the network. Another important assumption under this protocol is that trust is transitive, that is, if lender i trusts borrower j, then she also trusts another borrower k, who is trusted by borrower j. This assumption is important for the

computation of the global reputation, which is the aggregated normalized local reputation over all the set of direct transactions of the borrower.

The global reputation score g_{ik} of k is estimated as $\hat{g}_{ik} = \sum_j c_{ij} c_{jk}$, where c_{ij} is the normalized local reputation values of k from other agents j who have a direct lending transaction with k, and c_{jk} is the local reputation value of j from the past record of transactions with lender i. The co-utile nature of the protocol lies in the fact that the global reputation of each agent k is computed by one or several other agents (called score managers of k) on behalf of k, which themselves are lending and borrowing peers participating in the same network. Through successive computations, the global reputation scores converge and sum up to one. Thus, the global reputation score for the whole network is the left eigenvector of the normalized local reputation and it is initialized with a pre-defined small positive global reputation score. The protocol is self-enforcing and hence co-utile with interesting features, such as being anonymous, cost-effective and attack-tolerant (see [29] and [9] for the details on the construction and computation).

4.2.3 Cryptocurrency and the blockchain technology

i. Cryptocurrency

Cryptocurrencies are another example of digital finance models that are co-utility-amenable. They are considered as the virtual game-changers that meet the FinTech business model needs for digital value transfer and exchange. This technology has made possible geographically unbounded, frictionless, secure and cost-effective flows of values across the globe. Cryptocurrencies like Bitcoin (BTC) are peer-to-peer payment systems in which direct transactions between peers are conducted without a central party. Transactions between peers are confirmed by network nodes and recorded in the blockchain (i.e., a public mutually distributed ledger). The blockchain uses cryptology to guarantee trust between transacting peers in a decentralized way. Some traditional banks and financial institutions facing competition from the new FinTech wave are working to use this technology for a cross-border money transfer and trading (e.g. CBA, Australia, which uses the Ripple payments).

Despite their promising features, these decentralized virtual currency systems also have some limitations. Some of these include (1) difficulty in the exchange with other currencies, (2) being a tool for black market operation and tax evasion purposes in some cases, (3) being prone to potential theft attack of private keys, (4) expensive electricity cost for computations and (5) a possible attack by selfish miners/mining pools who could subvert the system for their own benefit ([10]; [16]; [14]).

In order to characterize the behaviors of miners in the Bitcoin network, we present the model in the following simplistic way. In its current setting, miners are rewarded based on successfully mining a new block (fixed amount of 25BTC ≈12500€ at the current rate of exchange, while the correspondence between the BTC and euros is not fixed) and additional 1.33% of the transactions in the added block [16]. Every miner in Bitcoin aims at maximizing the revenue from mining. Hence, the profit function of any miner, m is defined as follows:

$$\pi_m(r, f(\lambda_m), c_m(\lambda_m, t)) = f(\lambda_m).r - c_m(\lambda_m, t), \qquad (10)$$

where r is the reward, λ_m is the miner's relative computational power as compared to other miners in the network, $f(\lambda_m)$ is a binary function of successfully solving the puzzle on time ($f(\lambda_m) = 1$ if the miner successfully mined a new block in time before other miners given its computational power λ_m,and $f(\lambda_m) = 0$ if the miner fails to successfully mine the new block on time), $c_m(\lambda_m, t)$ is the unit cost of mining a new block, which depends on the investment in the computing resources and also the time devoted to solving the puzzle, t is the opportunity cost of mining any other new block. The miner's total profit that he wants to maximize is the sum of profits from all the new blocks he mined. Thus, the miner's profit maximization problem can be stated as:

$$Max \sum_{i=1}^{n} [f(\lambda_m).r - c_m(\lambda_m, t)], \qquad (11)$$

where n is the total number of new blocks mined by miner m.

Given the profit maximization problem stated above, miners in the Bitcoin network use various strategies by investing in expensive computational resources or employing a number of strategic attacks against other competent players in the network. In practice, the bitcoin mining game is an asymmetric information game. Rational miners in the Bitcoin network decide on the identification of the block to be mined and when to release or withhold the block ([16]; [22]). Due to the information asymmetry underlying the game, there can be a number of selfish mining attacks. A game-theoretic analysis by [16] shows that, under both asymmetric and complete information of a mining game, miners with relatively smaller computational power will not deviate from the bitcoin system design, while those with larger computational power will have an incentive to deviate. [10] also assert this magnitude effect by the colluding selfish miners who can generate unfair revenues. Likewise, [6] and [22] showed that a selfish mining pool can make a profit by withholding the block to infiltrate other mining pools in the mining network and consequently make unfair returns. On the other hand, [14] showed that mining pools with a relatively larger computational power are also exposed to a DDoS attacks by the smaller ones aimed at slowing down and weakening the target pools.

Regardless of all these drawbacks, cryptocurrency as a medium of exchange is one example of co-utility amenable game in which encrypted currencies are

minted by self-interested miners through a mathematical race that protects the blockchain within the network. With a decentralized setting of the network of miners who keep public records, potentially selfish miners can make the system inefficient. Hence, to make the ecosystem more robust and co-utile, further research work is needed to develop incentive schemes that can hinder malicious miners from subverting the system.

ii. Application of blockchain technology in organizational business processes

Beyond the cryptocurrencies, key features of the blockchain technology that are attractive to the financial institutions and to other transactional networks are: i) it is decentralized; ii) it is secured with cryptographic validation of transactions; iii) it is reasonably efficient; and iv) transaction records are transparent; see for e.g., [18] and [23] on the applications of the blockchain technology to transactional record systems and financial services other than the cryptocurrencies, some of which include securities settlement, currency exchange, supply chain management, trade, P2P transfers, asset registration, correspondent banking, regulatory reporting and AML rules. The technology guarantees efficiency in time because it lets all the stakeholders work in a common dataset and the transaction data are efficiently organized. It also allows easy information exchange with a one-time data entry in a distributed way, without a double and separate record of events, which results in a significant reduction in costs of data reconciliation, checks and transfers. Furthermore, the potential of the blockchain technology to support smart contracts makes it attractive to the financial service sector, because it can be extended with additional features that can fit the purpose of the financial service industry; for example, a permissioned blockchain network with centrally assigned transaction validators (see [28]). The technology facilitates a co-utile business process and organization by allowing rational (selfish) players to interact in a self-enforcing and distributed way.

A specific suggestion in this regard can be the potential of the blockchain technology's application to the financial management and administration industry. A trust company acts as a trustee (someone who acts as a custodian for trusts, estate-oriented services such as guardianship, estate settlement, custodial arrangements, asset management, stock transfer, beneficial ownership registration, etc. and provides audit, tax, consulting, bill pay, check writing, enterprise risk and financial advisory services and other related arrangements) to the other customer enterprises in a business-with-business (BwB) like deals (e.g. Deloitte, Northern Trust, Bessemer Trust etc.). One of the key problems underlying this business sector is the lack of trust on the trust companies, which poses a limit on the efficiency of the service delivered by the financial administration and management companies. As a result, there is a need for development of a collaborative system

in which all the stakeholders in this market can act towards the value-creation process and hence minimize the mistrust effect underlying the industry.

Therefore, the blockchain technology with its aforementioned features can help create an efficient financial service industry integrating the BwB interactions of this type in a transparent and well-organized way. In line with this, there is a need to transform the rigid accounting business models to a further digitalization and automation, and to define new potential market niches. This is because, with the newly emerging business models, the trust companies should cope with the existing technological and socio-economic trends. In this regard, we recommend the use of artificial intelligence in the sector ([1] and [17]) and the employment of co-creative and co-utile value creation mechanisms building a secure network of transactions. The trust in the network of financial services can be built by organizing a common platform that provides security and privacy by default. The business activity logs and financial data of any registered client company in the platform are saved in a common database and a potential registered and authorized trust company can access the client's data, which are secured through data protection techniques. Possible data protection methods are data anonymization/splitting (see [5], [25] and [3] on the outsourcing of computation without outsourcing control for data in the cloud), homomorphic encryption [21] or privacy preserving data mining. Here, we point out the direction of work in this regard, while specific technical design and implementations are beyond the coverage of this chapter.

5. Concluding remarks

This chapter introduced the co-utility notion as a mean to mend some of the fractures in the collaborative economy. The main purpose of co-utility is to make the collaborative and sharing principles underlying the collaborative economy self-enforcing. Co-utility in this setting can be enforced naturally or artificially through incentives. Examples of the potential co-utility-amenable games of the collaborative economy include crowdsourcing, crowdfunding, cryptocurrencies and P2P online lending.

In order to solve the key problems of mistrust and fear that appear in the crowdfunding business model, incentive schemes are proposed. These schemes are a community-based reputation scheme and data encryption. Specifically, to tackle the mistrust effect in the peer-to-peer online lending market, a distributed and co-utile reputation protocol is leveraged, so that rational peers rationally cooperate to compute each other's reputation scores. Reputation scores of borrowers are computed based on the outcome of direct transactions. Then the reputation mechanism helps filter credible borrowers based on their respective reputation scores. This reputation mechanism can be used to rate buyers and sellers in the electronic commerce market as well.

Last but not least, we have discussed cryptocurrencies and the blockchain technology underpinning the new trends of the digital economy. The discussion highlights the potential applications of blockchains and distributed ledger technology in the business-to-business transactional networks and proposes a business process design method based on the co-utility notion accounting for the collaborative nature of the system. We further discussed the behaviors of miners in the Bitcoin mining network and the negative utilities arising from the potential attacks. Based on this, we draw a general roadmap in order to achieve co-utility in the system.

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