Some Economics of Pure Digital Currency

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1 Introduction

As digitization has progressed, there has been an increase in what have come to be termed *pure digital currencies*. These are virtual goods that have the characteristics of money; offering a unit of account, a medium of exchange and a store of value. They are digital in the sense that they have no physical counterpart; specifically, they are not a claim on real assets. To be sure, fiat money in the form of paper notes are not themselves necessarily a claim on any real assets; as Keynes wrote "why would anyone outside of a lunatic asylum wish to use" them as a store of wealth? (Keynes, 1937) However, at the very least, they can be used to pay the taxes of the government that issued them (Quiggin, 2013). This is not true of perhaps the purest of digital currencies, Bitcoin. But Bitcoin, while attracting much recent attention, is perhaps more the exception than the rule when it comes to digital currencies.

It is important to distinguish pure from *impure digital currencies*. The latter are digitized transactions that involve the execution of a contractual promise to transfer actual currency between two accounts (i.e., from one owner to a new owner). This has been extensively studied in the literature on payment systems and specifically, the contractual terms and standards that government the settlement of inter-account transfers of currency.[1] In effect, this is a digital layer to a set of activities that were previously performed non-digitally. In this case, however, digitization plays a straightforward role of reducing transaction costs associated with payments including the carrying of physical money, the storage and protection of that money and the provision of short-term liquidity; as most naturally seen with credit and charge cards. As this has been extensively studied, we will not concern ourselves with such digitization here.

But the payments system literature has an important connection for what we will

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[1] See Rochet and Tirole (2002) and Gans and King (2003).

emphasise regarding digital currencies in this paper: payments systems spurred economics research into platforms; in particular, their pricing and competitive elements.[2] A platform is a business, mechanism or institution that brings together two or more distinct parties (or more generally, groups) for their eventual mutual gain. Platforms that facilitated digital transactions, such as credit card associations, brought together buyers and merchants without the need to physically engage with their respective banks. Instead, they were able to transact with banks acting behind the scenes to settle accounts. Thus, trade between buyers and merchants became more efficient. In this regard, a platform like this has an important association with currency. Currencies are said to solve the problem of the double coincidence of wants. That is, they enable transactions to take place between three or more interested parties even when all those parties are not present. By being a store of value, currency becomes a medium of exchange. In principle, any scarce good can perform this function (Fama, 1980). In practice, there are pressures to ensure the good that is the medium of exchange ties up as few real resources as possible.

Thus, one can argue that currencies themselves are intrinsically platforms but what is interesting is that, for the most part, pure digital currencies have been set up in association with non-currency specific platforms. For instance, Linden dollars were set up as a currency inside the game, *Second Life*. Participants could earn Linden dollars by trading with other players for virtual goods. And players could bring more Linden dollars to the game by ‘buying in’ with actual dollars. What was interesting was that Linden dollars earned in the game could be converted back into actual dollars. Thus, there was the potential for some individuals to earn more actual dollars than they put in. This gave rise to calls for some taxation of that as income but, in reality, was no different from the real world example of issuing of casino chips.

Other platform-specific currencies did not have the full convertability of Linden dollars.

[2] See Rochet and Tirole (2003), Armstrong (2006), Weyl (2010).

Game console makers (Nintendo and Microsoft) required players to pay for points that could be used to purchase games. However, once points were paid for they could not be converted back. In Microsoft's case, consumers also required points to purchase songs on their Zune portable music player. Nintendo have since phased their points system out and Microsoft has been criticised for using points that may obscure true purchase value for some consumers. By contrast, Sony asked for pre-payment of funds to download games to its console but did not have an alternate unit of account while Apple allowed consumers to purchase songs and games directly on their iOS platform. It is likely that these systems were in response to logistical and fee issues associated with credit card payments (e.g., for small transactions those fees could be a burden to merchants). Overtime this became less of an issue as the volume of transactions rose, allowing merchants to bundle smaller consumer transactions into larger ones and save on those payment costs.

While these platform-specific currencies could be seen as moves to improve transactional efficiency subject to existing constraints, others that have evolved appear to be more tightly linked with the overall functioning of the platform. For instance, in the online multiplayer game, World of Warcraft, players can perform activities and earn WOW Gold that allows them to buy improved weaponary amongst other things. While this might seem like a currency akin, literally, to Monopoly money, WOW Gold could be expanded in supply by the activities of players. For this reason, players were prohibited from trading WOW Gold outside of the game. This, however, did not prevent a black market from arising; literally outsourcing 'Gold farming' to be produced by players in countries with low market wages. In other cases, such as FarmVille, this trading was alleviated by allowing (and profiting from) players purchasing more 'FV Dollars' in the game. But unlike Linden dollars, this currency could not be converted back into real dollars.

It is these digital currencies that are platform-specific and can be exchanged 'inwards' for real dollars that is of interest to us here.[3] In Section 2, we will discuss in more detail the case of Facebook Credits that have this feature. The reason we focus on them is because commentators in 2011 saw them as a threat to traditional currencies. "Could a gigantic nonsovereign like Facebook someday launch a real currency to compete with the dollar, euro, yen and the like?" wrote Matthew Yglesias (2012). And there was this from payments economist, David Evans (2012):

> Social game companies could pay developers around the world in Facebook Credits and small businesspeople could accept Facebook Credits because they could use them to buy other things that they need or reward customers with them. In some countries (especially those with national debts that are greater than their GDPs) Facebook Credits could become a safer currency than the national currency.

In other words, there was concern that Facebook Credits could become a currency, like the 2013 attention grabber, Bitcoin that involved full convertability.

These predictions have raised issues as to whether such platform-specific currencies should be subject to additional regulation and oversight. However, in our opinion, first it would be useful to understand whether such expansion of the role of platform-specific credits would be in the interests of platform owners. Specifically, would it be worthwhile for a currency such as a Facebook Credits to move from limited convertibility to full convertibility? If the answer is no, as we will argue below, then it would appear that the concerns being raised are potentially over-blown.

The outline of this paper is as follows. In the next section, we detail our motivating case of Facebook Credits. Section 3 then considers a model of platforms and how different attributes of a platform-specific currency can influence platform business models. Our goal here is not to

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[3] There are currencies that have the alternative feature: they can be earned via activity only and then converted into real goods and services; for instance, airline and other loyalty points schemes.

model any one platform, in particular, but to give a framework for some suggested forces that will impact on any platform-specific currency choices. Future work, tailored to specific platforms, would likely yield richer results. Section 4 then considers some issues associated with regulation. As these are fast moving and involve deeper issues of monetary economics rather than digitization per se, we merely note some of these. A final section offers some thoughts as to future research directions.

2 Motivating Case: Facebook Credits

In the middle of 2009 the most popular social networking site, Facebook, introduced its virtual currency—Facebook Credits (FB Credits). In 2011, Facebook announced that game developers on its platform would be required to process payments solely through Facebook Credits.[4] Even before that announcement, as noted above, many commentators expressed concern that FB Credits will become global currency, and maybe take over state-issued currency.

As early as 2009, predictios were made that "Facebook could rival PayPal by creating a virtual currency and making it usable for financial transactions, essentially making Facebook Credits the currency of the web."[5] And with 1 billion users,[6] this currency would be more popular than most state currencies. After the 2011 announcement, those voices became more frequent.[7] It may have been one of the factors leading European Central Bank to investigate

[4] "Facebook Sets July, 1, 2011 Deadline to Make Credits Sole Canvas Game Payment Option," Inside Facebook. Retrieved December 4, 2012 (http://www.insidefacebook.com/2011/01/24/facebook-sets-july-1-2011-deadline-to-make-credits-sole-canvas-game-payment-option/).

[5] http://mashable.com/2009/12/15/facebook-credits-currency/.

[6] http://newsroom.fb.com/News/457/One-Billion-People-on-Facebook

[7] See, e.g., http://emergentbydesign.com/2011/04/04/the-bank-of-facebook-currency-identity-reputation/ and http://www.slate.com/articles/business/cashless_society/2012/02/facebook_credits_how_the_social_network_s_currency_could_compete_with_dollars_and_euros_.html

virtual currencies in 2012.[8]

Facebook equipped its Credits with limited functionality. One can buy Credits (i.e., exchange state-issued currency for FB Credits) at the rate 50 FB Credits for $5 USD, with quantity discounts.[9] FB Credits can be spent in any Facebook application that accepts them.[10] It is also important to note that buying FB Credits is not the only way of obtaining them. A user can *earn* the Credits if they test a new game, or take a survey.

However, the users cannot transfer FB Credits between each other. They also cannot exchange FB Credits back for state-issued currency. This severely limits functionality of FB Credits as a means of payment. Clearly, with such limited functionality, FB Credits cannot really become a global currency rivaling state-issued currencies. Internet pundits, however, claim that it is only a matter of time, and soon Facebook will turn Credits into a functional currency—by allowing inter-user transfers, and exchanging the FB Credits back into the state-issued currency.[11]

In this paper, we claim that it would not be beneficial for Facebook to equip FB Credits in those additional attributes. Facebook's main source of revenue is advertising, which is directly linked to activity of the users on the platform. Therefore, Facebook's objective is to increase activity of its users. Limiting functionality and allowing for both "buying" and "earning" are features that maximize activity on the platform. Users spend FB Credits to enhance their platform experience, which increases their utility from using the platform and leads to more activity. With "buying" and "earning" both time poor and time rich users obtain the Credits. If

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[8] See "Virtual Currency Schemes" European Central Bank, October 2012, available at http://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemes201210en.pdf

[9] E.g., for $10 there is 5% bonus, and one receives 105 Credits.

[10] The applications were required to use FB Credits between July 2011 and June 2012. Before and after that period use of FB Credits was voluntary.

[11] e.g., http://www.slate.com/articles/business/cashless_society/2012/02/facebook_credits_how_the_social_network_s_currency_could_compete_with_dollars_and_euros_.html

Facebook were to allow for reverse exchange (i.e., exchanging FB Credits to state currency), the time-rich users would sell the Credits their earned without increasing their activity on the platform. Allowing a transfer of FB Credits between users opens a way to the exchange of FB Credits into state-issued currency bypassing the platform: users can transfer FB Credits and pay each other outside the platform for the acquired Credits, as has happened with WOW Gold. Thus, current functionality of FB Credits is optimal for Facebook's objective.

3 The Model

Consider an environment with one platform and two users, *A* and *B*.[12]

3.1 Users

Each user *i* can spend some time x_i using the platform, which yields utility $v(x_i, x_j)$. To account for consumption complementarity between the two users, the utility of *i* depends on their own consumption (x_i) as well as the consumption of the other user (x_j) The utility of an agent is increasing as they spend more time on the platform (but the rate of increase is declining). Due to complementarity, their utility and marginal utility increases also when the other agent spends more time on the platform; i.e., $\frac{\partial v(x_i,x_j)}{\partial x_i} > 0$, $\frac{\partial^2 v(x_i,x_j)}{\partial x_i^2} < 0$, $\frac{\partial v(x_i,x_j)}{\partial x_j} > 0$ and $\frac{\partial^2 v(x_i,x_j)}{\partial x_i \partial x_j} > 0$.

Each user has total time *Z* available. The time can be spent either on using the platform, or working. When working, the user can earn wage *w* per unit of time. The total amount of money earned allows the user to consume a *numeraire* good (i.e., a composite of goods and services consumed outside of the platform), which adds to user's utility. Both users are the same,

[12] The model can be easily extended to *A* and *B* denoting types of users with arbitrary number of agents in each type. The qualitative results stay the same, but the notation is more complicated.

with the exception of the wage—user A earns higher wage than user B ($w_A > w_B$). Hence, if user i spends n_i time to earn the *numeraire* , then they can consume $n_i w_i$ of the *numeraire* .

Each user aims to maximize their utility given the time constraint:

$$\max_{x_i, n_i} \quad v(x_i, x_j) + n_i w_i$$

$$\text{such that} \quad x_i + n_i \le Z \ .$$

Clearly, the constraint binds in the optimum, so $n_i = Z - x_i$; and the utility maximization problem simplifies to $\max_{x_i} v(x_i, x_j) + (Z - x_i) w_i$.

In the interior solution,[13] the optimal usage, $\hat{x}_i$ is given by:

$$\frac{\partial v(\hat{x}_i, x_j)}{\partial x_i} = w_i \ . \tag{1}$$

As $\frac{\partial^2 v(x_i, x_j)}{\partial x_i^2} < 0$, $w_A > w_B$ implies $\hat{x}_A < \hat{x}_B$. That is, the user earning higher wage is choosing to spend less time on the platform.

Example. *Suppose that* $v(x_i, x_j) = x_i^{\alpha} x_j^{1-\alpha}$, *for* $\alpha > \frac{1}{2}$. *Combining the first-order conditions, we get*

$$\frac{w_A}{w_B} = \left(\frac{\hat{x}_B}{\hat{x}_A} \right)^{2(1-\alpha)} .$$

Clearly, $w_A > w_B$ *implies* $\hat{x}_A < \hat{x}_B$. *Moreover, there are multiple equilibria possible. Any*

[13] Corner solutions may happen for very high and very low w's. When w_i is low enough that $\frac{\partial v(\hat{x}_i, x_j)}{\partial x_i}|_{x_i = Z} > w_i$, then the user spends all their time using the platform, $\hat{x}_i = Z$. Notice that in such a case, increasing x_j does not change $\hat{x}_i$, but decreasing x_j may decrease $\hat{x}_i$ below Z if the derivative decreases to $\frac{\partial v(\hat{x}_i, x_j)}{\partial x_i}|_{x_i = Z} < w_i$. Similarly, when w_i is high enough that $\frac{\partial v(\hat{x}_i, x_j)}{\partial x_i}|_{x_i = 0} < w_i$, then the agent spends no time using the platform, $\hat{x}_i = 0$. Decreasing x_j will not change i's consumption decision. But increasing x_j may induce i to set positive $\hat{x}_i > 0$, when the increase in x_j increases the derivative to $\frac{\partial v(\hat{x}_i, x_j)}{\partial x_i}|_{x_i = 0} > w_i$.

combination of x_A *and* x_B *such that* $\frac{w_A}{w_B}=\left(\frac{\hat{x}_B}{\hat{x}_A}\right)^{2(1-\alpha)}$ *and* $x_B \le Z$ *constitutes an equilibrium. Multiplicity of equilibria is not surprising, given the consumption complementarity.*

3.2 The Platform.

We assume that additional usage can earn the platform revenue, $r(x_A + x_B)$ where $r > 0$ is the revenue from an additional unit of activity; say from advertising. Absent any other revenue sources, the platform aims at maximizing the total usage: $x_A + x_B$. As we observe below, the sale of platform-specific currency can represent another revenue source that may result in the platform not acting to maximize total usage.

Example (continued). *Given multiplicity of equilibria, the platform's usage depends on the equilibrium played. In our example, the largest usage that may be obtained in an equilibrium is for* $\hat{x}_B = Z$ *and* $\hat{x}_A = Z\left(\frac{w_B}{w_A}\right)^{\frac{1}{2(1-\alpha)}}$. *The smallest one is arbitrarily close to 0, when* $\hat{x}_B = \varepsilon \neq 0$ *and* $\hat{x}_A = \varepsilon\left(\frac{w_B}{w_A}\right)^{\frac{1}{2(1-\alpha)}}$.

3.3 Enhancing the Platform: "Buying" and "Earning"

Suppose that now the platform allows the users to acquire options, e_i, that enhance the value of platform usage. For example, this may be additional options in a game. The enhancement increases the usage utility; i.e., for the same level of usage: $v(x_i, e_i', x_j) > v(x_i, e_i, x_j)$ for $e_i' > e_i$. Moreover, we assume that $\frac{\partial v(x_i, e_i', x_j)}{\partial x_i} > \frac{\partial v(x_i, e_i, x_j)}{\partial x_i}$, $\frac{\partial v(x_i', e_i, x_j)}{\partial e_i} > \frac{\partial v(x_i, e_i, x_j)}{\partial e_i}$ for $x_i' > x_i$ and $\frac{\partial v(x_i, e_i, x_j)}{\partial e_i} \to \infty$ as $e_i \to 0$.[14] The enhancement may be obtained by "buying" it, or by "earning" it (e.g., through testing functionality). Specifically, we assume that $e_i = \gamma y_i + \phi t_i$, where y_i are the units of the *numeraire* ("buying") and t_i are in

[14] This is on the top of usual second-order conditions: $\frac{\partial^2 v(x_i, e_i, x_j)}{\partial x_i^2} < 0$ and $\frac{\partial^2 v(x_i, e_i, x_j)}{\partial e_i^2} < 0$.

units of time ("earning").

User *i*'s utility in the environment with the enhancement is

$$v(x_i, e_i(t_i, y_i), x_j) + (Z - x_i - t_i)w_i - y_i \ , \tag{2}$$

which the user maximizes by choosing x_i, t_i, and y_i subject to the constraints that $y_i \le (Z - x_i - t_i)w_i$ and $Z \ge x_i + t_i$. For a solution interior in all three variables, the first-order conditions are:

$$\text{w.r.t. } x_i : \frac{\partial v(x_i, e_i, x_j)}{\partial x_i} = w_i \tag{3}$$

$$\text{w.r.t. } t_i : \frac{\partial v(x_i, e_i, x_j)}{\partial e_i} \ \phi = w_i \tag{4}$$

$$\text{w.r.t. } y_i : \frac{\partial v(x_i, e_i, x_j)}{\partial e_i} \ \gamma = 1 \ . \tag{5}$$

Notice, however, that t_i and y_i are perfect substitutes in achieving e_i. Therefore, each user chooses only one way of obtaining e_i, whichever is cheaper. "Buying" a unit of e_i costs the user $\frac{1}{\gamma}$ while "earning" it costs $\frac{w_i}{\phi}$.

If $w_i < \frac{\phi}{\gamma}$, then user i only "earns" the enhancement, and $y_i = 0$. Then, the two relevant first-order conditions are:

$$\frac{\partial v(x_i, e_i, x_j)}{\partial x_i} = w_i \ \text{ and } \ \frac{\partial v(x_i, e_i, x_j)}{\partial e_i} \ \phi = w_i \ . \tag{6}$$

When $w_i > \frac{\phi}{\gamma}$, then user i only "buys," i.e., $t_i = 0$. Then, the two relevant first-order conditions are:

$$\frac{\partial v(x_i,e_i,x_j)}{\partial x_i} = w_i \text{ and } \frac{\partial v(x_i,e_i,x_j)}{\partial e_i}\gamma = 1 . \tag{7}$$

We assume here that *Z* is large enough that solutions on the relevant parameters (x_i and t_i, or x_i and y_i) are interior. For an interior x_i, we can prove the following result.

Lemma 1. *Holding e_i and x_j fixed, a user i with lower w_i optimally chooses higher usage, x_i.*

> PROOF: Since *Z* is large enough for x_i to be interior for both users, $\frac{\partial v(x_i,e_i,x_j)}{\partial x_i} = w_i$. With $w_A > w_B$, for the same e_i and x_j, the derivative is higher for the higher-wage user. And since $\frac{\partial^2 v(x_i,\cdot)}{\partial x_i^2} < 0$, the derivative is higher for smaller x_i. Hence $x_A < x_B$ if e_i and x_j are unchanged.

Given that users have different wages, in equilibrium it will not be the case that e_i and x_j is the same for both users. With the higher usage x_i, the marginal benefit of enhancement is higher. Thus, users with lower w_i choose larger e_i, which further increases their optimal usage.

Lemma 2. *The low-wage user acquires more enhancements and has higher usage in equilibrium.*

> PROOF: We conduct this proof in two steps. In the first one, we show that the low-wage user acquires more enhancements for a fixed x_i and x_j. In the second step, we combine the result of the first step and of Lemma 1 to complete the proof for the equilibrium outcome.
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> When both w_A and w_B are greater—or both lower—than $\frac{\phi}{\gamma}$, we find that low-wage user acquires more enhancement directly from the second-order conditions (for a fixed x_i and x_j). The interesting case is when $w_A > \frac{\phi}{\gamma} > w_B$. In this case the first-order conditions are $\frac{\partial v}{\partial e_B}\phi = w_B$ and $\frac{\partial v}{\partial e_A}\gamma = 1$. Those conditions imply $\frac{\partial v}{\partial e_B} = \frac{w_B}{\phi}$ and $\frac{\partial v}{\partial e_A} = \frac{1}{\gamma}$. And since $\frac{\phi}{\gamma} > w_B \Leftarrow \frac{1}{\gamma} > \frac{w_B}{\phi}$, then $\frac{\partial v}{\partial e_A} > \frac{\partial v}{\partial e_B}$. Therefore, if faced with the same x_i and x_j, $e_A < e_B$.
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> In the second step of the proof, notice, from Lemma 1, we know that $x_A < x_B$ for the

same e_i and x_j. Moreover, because own consumption has larger effect on utility than x_j, it is still that $x_A(x_B) < x_B(x_A)$ for the same e_i. Moreover, from the previous step of this proof, given x_i and x_j, $e_A < e_B$ reinforces the fact that in equilibrium $x_A^* < x_B^*$ (i.e., $x_B(e) - x_A(e) < x_B^*(e_B^*) - x_A^*(e_A^*)$).

Notice that the usage increases more when both ways of procuring e_i are available. Because the users choose the cheaper way, they choose more e_i than they would if only one way of procurement was allowed. Higher e_i leads to higher x_i. Moreover, due to consumption complementarities, it further increases the consumption of the other user, x_j. This shows that by allowing both "earning" and "buying" an enhancement of the platform usage (e.g., Facebook points), the platform increases the usage; as compared to allowing for only one type of enhancement procurement.

Proposition 1. *When the platform allows for both "earning" and "buying" of the enhancement, the direct usage, $x_A + x_B$, (weakly) increases by more than when the platform allows for only one type of enhancement procurement (only "buying" or only "earning").*

The increase is "weak," because if both users are choosing the same means of obtaining the enhancement, and the only option is the optimal option, adding a new option does not strictly improve the usage. The following proof focuses on the interesting case where the improvement is strict.

PROOF: Let $w_A > \frac{\phi}{\gamma} > w_B$. Suppose that only option "buy" is available. Both $i = A, B$ choose their enhancement investment and usage based on (7). Let B's optimal choices in this case $\hat{x}_B$ and $\hat{e}_B$.

When it becomes possible to "earn," user B prefers to go for the new option, and chooses enhancement $\hat{\hat{e}}_B$ according to condition (6). Since $\frac{w_B}{\phi} < \frac{1}{\gamma}$, then $\frac{\partial v(\hat{x}_B, \hat{e}_B, x_A)}{\partial e_B} > \frac{\partial v(\hat{x}_B, \hat{\hat{e}}_B, x_A)}{\partial e_B}$, which implies $\hat{\hat{e}}_B(\hat{x}_B) > \hat{e}_B(\hat{x}_B)$. But then also $\hat{\hat{x}}_B > \hat{x}_B$. So, in equilibrium $\hat{\hat{e}}_B$ and $\hat{\hat{x}}_B > \hat{x}_B$. Given the complementarity in users' activity, increasing

x_B also increases x_A. Thus, allowing for "earning" platform enhancement along with "buying" increases total platform usage, by increasing both x_B and x_A.

In a similar way we can also show that starting from "earning" only, and then allowing "buying" as well increases total platform usage by increasing both x_A and x_B.

It is useful to reflect how this proposition is relevant for discussions on digital currency. For instance, Facebook Credits represent a unit of account. It could have been that, like Microsoft and Nintendo, these credits were solely bought. In this way, they would merely be a way of converting real currency into on-platform payments. However, to the extent that some users of the platform are income or wealth constrained, this would reduce their use of enhancements. Complementarity amongst users would then imply a reduction in overall activity on the platform. Instead, by offering a means of earning enhancements, the platform provides an alternative pathway for income-constrained users. Of course, this may be strengthened if such earning was itself platform activity – as sometimes occurs – but we have supressed that effect here.

The proposition also demonstrates how allowing 'inwards convertability' from real currency onto the platform, more usage is encouraged from income-rich users. Once again, complementarity amongst users leads to more overall usage from this. Thus, while World of Warcraft may officially prohibit 'gold farming' there is a sense in which it increases platform usage. Of course, it could be imagined that digital currencies associated with platforms could go further and allow 'outwards convertability.' It is this feature that would put those currencies on a path to competing with state-issued currencies. We turn to examine this option next.

3.4 Reverse exchange

Here we show that if the platform were to allow for reverse exchange of "earned" credits into state-issued currency, it would decrease the platform usage.

Proposition 2. *If the platform allows for reverse exchange of* e_i *into* y_i *at any positive rate, it lowers the platform usage.*

> PROOF: Suppose that user *i* can spend t_i to get $e_i = \phi t_i$, but then can convert it back into cash at a rate of μ: $y_i = \frac{e_i}{\mu} = \frac{\phi t_i}{\mu}$. Then, the effective wage of user *i* is $\frac{y_i}{t_i} = \frac{\phi}{\mu}$. If the platform puts no restrictions on this exchange, it allows all agents with outside wage $w_i < \frac{\phi}{\mu}$ to achieve the effective wage of $\hat{w} = \frac{\phi}{\mu}$. But from the previous results we know that increasing the wage lowers the equilibrium usage x_i, as well as e_i actually used on enhancement of platform usage (instead of redeeming[15] for y_i).

The proof here did not take into account the fact that reverse exchange would be costly for the platform. In other words, it is unambiguously detrimental to the platform. Thus, so long as the goal of the platform is to maximize the direct activity ($x_A + x_B$), platforms have no incentive to allow for 'outwards convertability' or reverse exchange. In other words, despite the concern of commentators, platforms that utilize digital currencies for 'within platform' transactions have no incentive to move towards full convertability.

3.5 Optimal choice of γ and ϕ

Each user's choice of whether to earn or purchase an enhancement depends on the prices, $1/\gamma$ and $1/\phi$ and their relationship to the user's wage. The prices chosen by a platform depend on their precise objective. Thusfar, we have focussed on the impact of various platform choices on $x_A + x_B$; direct platform usage. This would be relevant if the platform's only source of revenue was, say, advertising. In this case, the platform would aim to set both γ and ϕ as high as possible so that, regardless of how a user chooses to obtain the enhancement, each does so. In effect, the enhancement would be built into the platform and there would be little interesting question regarding currencies.

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[15] Since part or all of the enhancement is redeemed, it does not enter as e_i into $v(x_i, e_i, x_j)$.

In some important situations, the platform may also earn the same advertising revenue from usage involved in earning an enhancement. In this case, the platform would aim to maximize $r(x_A + x_B + t_A + t_B)$. The platform may then benefit from users engaging in a variety of activities (depending on the nature of $v(.)$) but regardless would want ϕ to be as high as possible so that all users earn the enhancement. For γ, the platform faces a trade-off. Decreasing γ can induce high wage types to switch their activity towards earning the enhancement which directly increases t_A. However, it involves some substitution from x_A which, depending upon $v(.)$, may lead to a reduction in activity by B. Thus, it is not possible to characterize this price in the general case.

Of course, the purchases of enhancements can also represent an alternative revenue stream for the platform. In this case, it would be reasonable to consider the platform as maximizing $r(x_A + x_B) + (y_A + y_B)$ or $r(x_A + x_B + t_A + t_B) + (y_A + y_B)$. Depending on the level of r, the platform may prefer to withdraw the possibility of earning an enhancement and force all agents to buy it. Regardless, prices will be set so that each user's time constraint is binding and focussed on the platform; either through activity or income. That is, for users buying an enhancement, $t_i = 0$ and $y_i = (Z - x_i)w_i$ while for a user earning the enhancement, $y_i = 0$ and $t_i = Z - x_i$.

This allows us to identify the first order conditions for users. For users earning the enhancement, it is:

$$\left.\frac{\partial v(x_i, e_i, x_j)}{\partial x_i}\right|_{e_i=\phi(Z-x_i)} = \phi \left.\frac{\partial v(x_i, e_i, x_j)}{\partial e_i}\right|_{e_i=\phi(Z-x_i)} \tag{8}$$

Notice that this condition is independent of w_i. Thus, the optimal usage schedule is the same for both types of agents. Similarly, for a user buying the enhancement, we have:

$$\left.\frac{\partial v(x_i,e_i,x_j)}{\partial x_i}\right|_{e_i=\gamma(Z-x_i)w_i}=w_i\gamma\left.\frac{\partial v(x_i,e_i,x_j)}{\partial e_i}\right|_{e_i=\gamma(Z-x_i)w_i} \tag{9}$$

Thus, users will differ in their usage levels depending on the wage. This suggests that allowing users to buy enhancements can be useful when it is optimal to exploit their differential usage rather than ignore it. Of course, a precise characterization is not possible in the general case. For our running example, however, we can provide a more precise conclusion.

Example (continued). *Suppose that in our example, the platform introduces enhancement, and now* $v(x_i,e_i,x_j)=x_i^{\alpha}x_j^{1-\alpha}e_i^{\beta}$ *. Moreover,* $e_i=\gamma y_i+\phi t_i$ *. Then, user i's utility is* $x_i^{\alpha}x_j^{1-\alpha}(\gamma y_i+\phi t_i)^{\beta}+(Z-x_i-t_i)w_i-y_i$*. For* $w_i<\frac{\phi}{\gamma}$*, i.e.,* $y_i=0$*:*

$$\begin{cases}\alpha x_i^{\alpha-1}x_j^{1-\alpha}(\phi t_i)^{\beta} & =w_i\\ \phi\beta x_i^{\alpha}x_j^{1-\alpha}(\phi t_i)^{\beta-1} & =w_i\end{cases}\Rightarrow t_i=\frac{\beta}{\alpha}x_i$$

Using $t_i=\frac{\beta}{\alpha}x_i$*, the first order condition yields* $x_i^{\alpha+\beta-1}=\frac{w_i}{\phi^{\beta}\alpha^{1-\beta}\beta^{\beta}x_j^{1-\alpha}}$ *if the solution is interior, i.e., when* $t_i<Z-x_i$*. When* ϕ *is large enough (i.e.,* $\phi>\frac{\alpha}{\beta}\left(\frac{w_i(\alpha+\beta)^{\alpha+\beta-1}}{x_j^{1-\alpha}(\alpha Z)^{\alpha+\beta-1}\alpha}\right)^{\frac{1}{\beta}}$*), so that* $t_i=Z-x_i$*, the user's problem becomes* $\max_{x_i}x_i^{\alpha}x_j^{1-\alpha}(\phi(Z-x_i))^{\beta}$*. The optimal usage is then* $x_i=\frac{\alpha Z}{\alpha+\beta}$ *and* $t_i=\frac{\beta Z}{\alpha+\beta}$*. Notice that it does not depend on* ϕ *once the time constraint is binding.*

For $w_i>\frac{\phi}{\gamma}$*, i.e.,* $t_i=0$

$$\begin{cases}\alpha x_i^{\alpha-1}x_j^{1-\alpha}(\gamma y_i)^{\beta} & =w_i\\ \gamma\beta x_i^{\alpha}x_j^{1-\alpha}(\gamma y_i)^{\beta-1} & =1\end{cases}\Rightarrow y_i=\frac{\beta}{\alpha}x_iw_i$$

And further it yields $x_i^{\alpha+\beta-1}=\frac{w_i^{1-\beta}}{\gamma^{\beta}\alpha^{1-\beta}\beta^{\beta}x_j^{1-\alpha}}$ *for the interior solution. The corner solution, which arises when* γ *is sufficiently large is:* $x_i=\frac{\alpha Z}{\alpha+\beta}$ *and* $y_i=\frac{\beta Z}{\alpha+\beta}w_i$*.*

Depending on the wages and "prices" (γ *and* ϕ*), there are three situations possible: both agents earn the enhancement, both buy it, or one buys and the other earns. We analyze each case in turn (for the interior solution).*

1. When both agents are earning the enhancement, then any consumption patterns in equilibrium *must satisfy* $\left(\frac{x_B}{x_A}\right)^{2(1-\alpha)-\beta} = \frac{w_A}{w_B}$. *Together with the formula for* x_i *derived above, it yields*

$$x_i^\beta = \left(\frac{w_j}{w_i}\right)^{\frac{1-\alpha}{2(1-\alpha)-\beta}} \frac{w_i}{\alpha^{1-\beta}\beta^\beta\phi^\beta}$$

This is a complicated formula, but it uniquely gives x_i *with respect to the exogenous parameters.*

2. When both agents are buying the enhancement, then in any equilibrium it must be that $\left(\frac{x_B}{x_A}\right)^{2(1-\alpha)-\beta} = \left(\frac{w_A}{w_B}\right)^{1-\beta}$. *Then,*

$$x_i^\beta = \left(\frac{w_j}{w_i}\right)^{\frac{(1-\beta)(1-\alpha)}{2(1-\alpha)-\beta}} \frac{w_i^{1-\beta}}{\alpha^{1-\beta}\beta^\beta\phi^\beta}$$

3. When agent A is buying the enhancement, while agent B is earning, then in a equilibrium it must be that $\left(\frac{x_A}{x_B}\right)^{2(1-\alpha)-\beta} = \frac{w_B}{w_A^{1-\beta}} \left(\frac{\gamma}{\phi}\right)^\beta$. *And then,*

$$x_A^\beta = \left(\frac{w_B}{w_A^{1-\beta}}\right)^{\frac{1-\alpha}{2(1-\alpha)-\beta}} \left(\frac{\gamma}{\phi}\right)^{\frac{\beta(1-\alpha)}{2(1-\alpha)-\beta}} \frac{w_A^{1-\beta}}{\gamma^\beta\alpha^{1-\beta}\beta^\beta}$$

$$x_B^\beta = \left(\frac{w_A^{1-\beta}}{w_B}\right)^{\frac{1-\alpha}{2(1-\alpha)-\beta}} \left(\frac{\phi}{\gamma}\right)^{\frac{\beta(1-\alpha)}{2(1-\alpha)-\beta}} \frac{w_B}{\phi^\beta\alpha^{1-\beta}\beta^\beta}$$

Notice that, in all three cases, introducing the enhancement eliminates multiplicity of equilibria, as now x_i *are uniquely characterized by the exogenous parameters.*

Now consider the platform setting prices ϕ *and* γ *to maximize its objective. We consider four possible objective functions for the platform:*

. *(1) max* $r(x_A + x_B)$*: Platform is indifferent on whether to buy or earn. Whether* γ *is so high that both buy,* ϕ *so high that both earn, or one buys and one earns—the platform can always achieve the global maximum of* $x_A = x_B = \frac{\alpha Z}{\alpha+\beta}$*;*

. *(2) max* $r(x_A + x_B) + (y_A + y_B)$*: Platform raises* γ *so that not only both users buy the enhancement, but both reach the corner consumption schedule. The platform reaches global maximum of* $x_A = x_B = \frac{\alpha Z}{\alpha+\beta}$ *and* $y_i = \frac{\beta Z}{\alpha+\beta} w_i, i = A, B$.

. *(3) max* $r(x_A + x_B + t_A + t_B)$*: Platform raises* ϕ *so that not only do both users earn the enhancement, but both reach the corner consumption schedule. The platform reaches the global maximum of* $x_A = x_B = \frac{\alpha Z}{\alpha+\beta}$ *and* $t_A = t_B = \frac{\beta Z}{\alpha+\beta}$ *earning 2Z. If the platform were to* *set ϕ lower so that $w_B < \frac{\phi}{\gamma} < w_A$, then $t_A = 0$ and $x_A = \frac{\alpha Z}{\alpha+\beta}$. Thus, the platform would ears $Z(1+\frac{\alpha}{\alpha+\beta}) < 2Z$.*

. *(4) max $r(x_A + x_B + t_A + t_B) + (y_A + y_B)$: Optimal prices (and optimal users' consumption schedule) depend on w_i' s and r. The interesting case is when $w_B < r < w_A$. Then the platform is strictly better off by setting the prices such user A buys and user B earns the enhancement with consumption achieving a global maximum, $x_A = x_B = \frac{\alpha Z}{\alpha+\beta}$, $t_B = \frac{\beta Z}{\alpha+\beta}$ and $y_A = \frac{\beta Z}{\alpha+\beta} w_A$.*

3.6 Summary

For a platform whose main source of revenue is advertising (e.g., Facebook), their objective is to increase activity of its users (e.g., the use of social games). When activity on the platform is more valuable for a user when other users increase their activity (e.g., from the social component), there is complementarity in activity on the platform. A platform can provide an enhancement for user experience to encourage more activity (e.g., buying special versions of crops for your farm in FarmVille, which have higher yield than regular corps). Higher activity of one user increases utility—and activity—of other users, due to the complementarity. Because of this, if two users purchase the enhancement, the increase in activity is larger than double of activity increase resulting from a single user's enhancement. Therefore, it is optimal for the platform to encourage all users to purchase the enhancement. But some users may find the monetary cost too high, e.g., if they have a low wage. Then, the platform gains if it allows for both "buying" and "earning" of the enhancement. High-wage users will prefer to spend money than time, while low-wage users can spend time instead of money. Both types will acquire the enhancement and increase activity on the platform.

This describes the policies of many social networks and also some gaming platforms. Of particular significance is Proposition 2 that prevents platform-specific currencies from being traded back for state-issued currency. This provides a strong result that such platforms are not interested in introducing currencies that would directly compete with existing real currencies. That said, for a platform like Facebook, there is a flow of money back through developer payments: that is, a developer writes a game which induces people to purchase enhancements. The developer then receives part of the revenue that Facebook receives when Credits are purchased. Nonetheless, this is really just an extension of the platform notion where it is the game that itself is the platform of interest. Indeed, in mid-2012 Facebook announced that it would phase out Credits by the end of that year, and rely only on state-issued currencies. The users often needed to further convert Facebook Credits into currencies within apps and games, e.g., zCoins in Zynga's games. Users and developers were against this additional layer of complication and wanted a direct link to state-issued currencies. This is consistent with the model in that for Facebook's core activity, literally the activity or news feed, all features were available to all users. It could still earn essentially 'referral' fees for revenue generated by others on its platform but for its core activity, a currency would perform no additional role.

By contrast, it is easy to imagine that app developers like Zynga introduced their own currencies for exactly the same reason as in our main model: to increase activity on their "app platform." Just as Facebook Credits once bought or earned cannot be exchanged back into cash, so zCoins—once bought or earned—cannot be exchanged back into state-issued currency (or indeed Facebook Credits when they were available). It is driven by Zynga's objective to maximize activity on its *own* platform. This may, however, conflict with Facebook's objective to increase activity on Facebook platform—possibly across different apps. A richer model would be required to explore issues arising from inter-locking platforms.

A distinct argument lies behind Amazon Coins introduced in the beginning of 2013.

Amazon announced that it will give away "millions of US dollars worth" of Amazon Coins to customers, starting in May 2013. Like all other introductions of digital currencies, this attracted the usual concern about the threat to state-issued currencies. "But in the long term what [central banks] should perhaps be most worried about is losing their monopoly on issuing money," wrote the Wall Street Journal. "A new breed of virtual currencies are starting to emerge---and some of the giants of the web industry such as Amazon.com Inc. are edging into the market."[16]

However, Amazon Coins is simply a subsidy to the buyers to participate in the platform, with the purpose of starting and accelerating any indirect network effects on the Amazon's app platform. When a Kindle Fire users purchases Coins, they receive an effective discount on apps (from 5 to 10% depending upon how many Coins are purchased). Due to uncertainty about the quality of apps, a subsidy to the users is more effective than subsidy to the developers, as users will "vote" with their Coins for the best apps. At the same time, introducing Amazon Coins is potentially more convenient than subsidizing via cash, as it ensures that the subsidy is spent on Amazon app platform, and not on other services on Amazon or outside.

4 Regulatory Issues

Our analysis of platform-specific currencies, shows there is no need for specific regulation of them as their purpose is a natural complement to the business models associated with those platforms. To maximally benefit the platform, the use of currencies needs to be restricted. Thus, it is not in the interest of the platforms to provide fully functional currencies that could compete with state currencies.

In our analysis, however, we have excluded Bitcoin which is a fully covertable, pure

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[16] Wall Street Journal, Market Watch http://articles.marketwatch.com/2013-02-13/commentary/37064080_1_currency-war-bitcoin-central-banks

digital currency not associated with a given platform. Consequently, it is explicitly designed to compete with state currencies. In March 2013, US government for the first time imposed regulations on online currencies.[17] Virtual currencies are to be regulated by the US Treasury after the Financial Crimes Enforcement Network (FinCEN) decided they fall under the anti-money-laundering laws.[18] According to those new rules, transactions worth more than $10,000 need to be reported by companies involved in issuing or exchanging online currencies. The rules do not single Bitcoin out, but apply to all "online currencies." This clarification of FinCEN laws was issued after evidence emerged that Bitcoins are used for illegal activity (e.g. Silk Road). Illegal activity is a concern as the anonymity of Bitcon allows for untraceable trades.

4.1 Central Bank concern

There may be other reasons to regulate online currencies that apply to both anonymous and account-based currencies. The European Central Bank released a report at the end of 2012 analyzing whether virtual currency schemes can affect price stability, financial stability or payment stability.[19] The report distinguishes between closed virtual currency schemes—i.e., only used within games or apps, akin to virtual Monopoly money—and virtual currency schemes that interact with state currencies, i.e., can be used to purchase real goods and services or even directly converted to state currencies. Closed virtual currency schemes are not a concern in the view of the report, as only virtual currency that interacts with real economy can affect price stability, financial stability and payment stability. However, the report concluded that currently also the latter type of virtual currency poses no risks, as such money creation is at low level. Moreover, the interaction of Linden dollars, Bitcoin and similar schemes with the real economy

[17] http://finance.fortune.cnn.com/tag/facebook-credits/
[18] http://www.newscientist.com/article/mg21729103.300-us-to-regulate-bitcoin-currency-at-its-alltime-high.html
[19] http://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemes201210en.pdf The report focused specifically on case studies of Bitcoin and Linden Dollars, but the conclusions were more general.

is low because those currencies are used infrequently, by a small group of users, and—most importantly—their use is dispersed geographically. That means their impact on the real economy is dispersed across many state currencies, hence the impact on any one state currency is negligible.

In the case of Q-coin, used only in China, the impact could be significant enough for the central bank to step in and regulate the use of virtual currencies. A social networking site, Tencent QQ introduced Q-coin to allow for virtual payments. Q-coins are purchased with Chinese state currency. Q-coin was intended for purchase of virtual goods and services provided by Tencent. However, users quickly started transferring Q-coin as peer-to-peer payments, and merchants started accepting Q-coin as well.[20] As the amount of Q-coins traded in one year reached several billion yuan, the Chinese authorities stepped in with regulation. In June 2009 the government banned exchanging virtual currencies for real goods and services, in order to "limit the possible impact on the real financial system."[21]

4.2 Currency as technology

The ECB report also acknowledges that virtual currency schemes "can have positive aspects in terms of financial innovations and the provision of additional payment alternatives for consumers." (p. 46) However, the position of a central bank is to protect state currencies from the risks the virtual currencies may pose.

Any currency can be viewed as a platform, where people need to "join" by believing in its value, i.e., they join by accepting it. Transactions occur only between people who accept the currency, i.e., have joined the platform. Currency also exhibits network effects: the more people accept it, the more value there is to accepting it.

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[20] http://voices.yahoo.com/a-virtual-currency-qq-coin-has-taken-real-value-278944.html
[21] http://english.mofcom.gov.cn/aarticle/newsrelease/commonnews/200906/20090606364208.html

If we were to consider any other technology platform instead of currency, the view expressed in ECB report would be akin to protecting the market power of an incumbent against innovative entrants. We know from technology literature that such protection usually leads to loss of efficiency, because new entrants can come up with ways to better and more cheaply serve the market, and maybe also to expand the market.

Is there a good reason for such protection? The 19th and early 20th century in North America have seen a period of so called "free banking," where private banks were allowed, under some initial conditions, to issue their own currency. That is, the state did not have a monopoly on issuing currency. However, throughout this period, regulatory interventions increased, and in early 20th century it became common practice to de-legalize issuing currency by anyone except the state.

Issuing currency is profitable, as the issuer gains seigniorage. Thus, one reason for the state to institute monopoly would be the incentive to capture the whole seigniorage profit—to the detriment of innovation. However, economic historians[22] point to other factors leading to the increasingly stricter regulation and eventually to monopolization of currency. One such factor is frequent bank failures. In a competitive environment, firms often fail, and new ones enter. In this case, however, bank failures left the customers with unredeemable (i.e., worthless) banknotes.

This undermined financial stability, and also population's trust in paper currency overall. Lack of trust sometimes resulted in bank runs, which lead to more bank failures. The trust issues were also reflected in exchange rates between currencies from different issuers. Some private banknotes circulated at a discount (i.e., $1 banknote was considered worth less than the nominal $1) when there were doubts about solvency of the bank. Another reason for lower trust was counterfeiting. Counterfeiting, of course, is a concern also with state-issued currency. But with

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[22] E.g., Rockoff (1974) or Smith (1990)

multiple issuers the number and variety of notes in circulation is larger, and it is harder for the population to keep track of genuine features.

Since the notes were only redeemable at the issuing bank and banks were typically local, the acceptance of some notes would be geographically restricted. Further from the issuing bank's location, the notes would be accepted at a discount, if they were accepted at all.

Both those factors—lack of trust and varying exchanged rates—created difficulties for trade. At times, it even created worries that the trade may collapse altogether.

But how those factors compare to the analyses in technology literature? We know that the presence of network effects often creates multiple equilibria—either lots of people join the platform because they expect lots of other people to join, or no one joins because they do not expect others to join. Similar two equilibria can be seen in currency usage. Trust in the currency helps to coordinate on the better equilibrium where people generally adopt paper currency. Another parallel in technology literature is compatibility. Having multiple networks, with limited or no compatibility lowers efficiency as compared to one single network, as under limited compatibility the network effects cannot be realized to their full value.

This brings out a well-known tension: On the one hand, the presence of multiple competing platforms creates inefficiency by limiting the extend of network effects (when compatibility is limited), and also presents the risk of coordination failure, when users will not join at all. On the other hand, a single well-established dominant platform overcomes the issue of coordination and renders compatibility irrelevant, while stifling innovation and possibly extracting monopoly profit from the users.

In issuing currency, since the 20th Century, states traditionally considered one single network as the better side of this trade-off. Whether it is still a valid conclusion with respect to online currencies is a question for future research.

5 Future Directions

To be done.

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