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Banning bitcoin

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ABSTRACT

We employ a monetary model with endogenous search and random consumption preferences to consider the extent to which a government can ban an alternative currency, like bitcoin. We define a ban as a policy whereby government agents refuse to accept an alternative currency and mete out punishments to private agents caught using it. After identifying monetary equilibria where an alternative currency is accepted, we then derive the conditions under which a ban might deter its use. As in earlier studies, we show that a government of sufficient size can prevent an alternative currency from circulating without relying on punishments. We also show that, given its size, a government can ban an alternative currency so long as it is willing and able to mete out sufficiently severe punishments.

1. Introduction

In August 2014, the Russian Ministry of Finance announced a proposal to ban bitcoin.[1] A draft bill, made public in October 2014, classified bitcoin and other digital currencies as "money surrogates."[2] Since Article 75 of the Constitution of the Russian Federation designates the Central Bank as the sole issuer of currency and prohibits the introduction and issuance of currencies other than the ruble, labeling bitcoin a money surrogate would place it squarely outside the law. Indeed, the draft bill outlined a series of fines for those caught using bitcoin. Individuals, officials, and legal entities creating or issuing digital currencies would be subject to fines of 30,000–50,000 rubles ($750–$1250), 60,000–100,000 rubles ($1500–$2500), and

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[1] We assume the reader is already familiar with bitcoin. Velde (2013) offers a primer. See also Hendrickson and Luther (2014), Luther and White (2014), White (2014), Yermack (2013), Böhme et al. (2015), Dwyer (2015), and Selgin (2015). Luther (2013) and Fernandez-Villaverde and Sanches (2016) consider private outside monies more generally.

[2] The classification echoed a statement made earlier in the year by the Prosecutor General's Office of the Russian Federation (Bradbury, 2014).

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500,000–1 million rubles ($12,500–$25,000), respectively (Rizzo, 2014a).[3] Those disseminating information that permits the release of money surrogates would face similar fines. Although the proposed fines were reduced in November 2014, they remained punitive.[4]

By December 2015, a revised bill had made it all the way to the Duma, Russia's legislative assembly. Fines outlined in the bill ranged from 20,000 rubles ($265) to 5 million rubles ($66,264) (Palmer, 2016). The draft bill was withdrawn in May 2016, though a revised version was expected to follow (Higgins, 2016a). More recent reports suggest Russia might not go through with the proposed ban (Rizzo, 2016). At the very least, it seems likely that Russia will permit its citizens to use bitcoin in foreign transactions (Higgins, 2016b).

Most governments have made little or no effort to ban bitcoin.[5] However, those attempting to prevent their citizens from holding or transacting with bitcoin typically employ policies along the lines of those proposed in Russia. In Bangladesh, for example, those caught using bitcoin could spend up to 12 years in prison (Higgins, 2014).[6] Much the same could be said about recent efforts and proposals to ban other alternative currencies, like the Liberty Dollar and E-Gold in the U.S. (White, 2016) or the U.S. dollar in Cambodia (O'Byrne, 2017), Nigeria (Kazeem, 2016), and Syria (Barnard, 2013). As these cases make clear, governments intent on preventing an alternative currency from circulating do not typically limit their efforts to transactions policy—that is, refusing to accept or spend it. Rather, they pass laws prohibiting the creation, issuing, or circulation of alternative currencies and punish offenders with fines or imprisonment.

The standard approach to considering whether a government can prevent an item from functioning as a commonly accepted medium of exchange does not allow government agents to punish private agents caught using that item.[7] Instead, it limits analysis to the effectiveness of government transactions policy in a random matching (Aiyagari and Wallace, 1997; Li and Wright, 1998) or partially directed search (Hendrickson et al., 2016) model.[8] In these studies, a subset of the population is instructed to employ an exogenously imposed strategy (e.g., always accept government currency, never accept bitcoin). Then, the conditions under which this transactions policy is sufficient to prevent an item that would have been commonly accepted in the absence of the policy from being commonly accepted are derived. The standard approach finds that, in general, a government can discourage private actors from accepting an alternative currency like bitcoin when the fraction of agents employing the exogenously imposed strategy is sufficiently large.

One problem with operationalizing the standard approach concerns the interpretation of agents employing the exogenously imposed strategy. Are these agents buying and selling goods on behalf of the government? If so, one might view government spending as a share of the economy as a reasonable proxy for size. Or, might some of these agents merely follow the strategy handed down by the government while buying and selling goods for themselves? If so, one would need to take into account the extent to which citizens are naturally law abiding and can be coerced into following the law.

In what follows, we consider the extent to which governments can ban an alternative currency like bitcoin. We employ a monetary model with endogenous search and random consumption preferences developed by Hogan and Luther (2014). As Hendrickson et al. (2016) explain, a model in which agents deliberately choose with whom to trade is well suited for considering bitcoin since those using it to make illicit transactions might actively avoid transacting with those holding the currency favored by government. At the same time, randomness in consumption preferences—which amounts to an agent occasionally deciding not to buy anything after arriving at a place where they would like to make a purchase—provides enough friction to generate a useful role for money.[9]

Agents in the model have access to two intrinsically worthless items: an official government currency ("currency") and an alternative medium of exchange ("bitcoin"). We first articulate the conditions under which bitcoin is accepted. Next, we impose a policy whereby a subset of agents refuses to accept bitcoin as payment and punishes those met in exchange who offer to transact with bitcoin. Since these agents have the ability to punish others, we suggest they should be viewed as government agents in the narrow sense. As such, we do not merely assume that some private actors follow the government strategy but, instead, allow their decisions to be determined endogenously as a response to the incentives created by the government.

As in earlier studies, we show that a government of sufficient size can prevent an alternative currency like bitcoin from circulating without relying on punishments by refusing to use the alternative currency in its own transactions. Nonetheless, if the government is not sufficiently large, then a transactions policy is not sufficient to prevent the alternative currency from being accepted in equilibrium. We go beyond the existing literature by showing that, given its size, a government can ban

[3] Subsequent versions of the bill clarified that those unable to pay the fine would be imprisoned.

[4] Under the revised bill, individuals creating or issuing digital currencies could be fined 20,000–40,000 rubles (about $431–$862). The maximum fines for officials and legal entities creating or issuing digital currencies were reduced to 80,000 rubles ($1753) and 500,000 rubles ($10,781), respectively (Rizzo, 2014b).

[5] Hill (2015) maintains that bitcoin is illegal in just nine countries (Bangladesh, Bolivia, Ecuador, Iceland, Indonesia, Kyrgystan, Russia, Thailand, and Vietnam) and restricted in three others (China, India, and Jordan).

[6] Although the U.S. government has not attempted to ban bitcoin, it has arrested and prosecuted bitcoin users it claims were operating a money transmitting business without registering with the Treasury Department's Financial Crimes Enforcement Network (Melendez, 2016).

[7] Salter and Luther (2014) consider the historical debate.

[8] Similarly, Lotz and Rocheteau (2002) employ government transactions policy in the context of launching a new currency. See also Selgin (1994, 2003). Waller and Curtis (2003) assess the effects of government transactions policy on the values of competing international currencies.

[9] Goldberg (2007) offers a similar model, wherein an agent knows what good they want but is randomly matched with one of the particular trading partners holding that good.

an alternative currency like bitcoin so long as it is willing and able to mete out sufficiently severe punishments. The severity of the punishments required to prevent the alternative currency from circulating is a function of the size of government, preferences, the cost of production, and exogenous variables in the model. The severity threshold is also dependent on the fraction of agents who are willing to accept the government's preferred money. These results suggest that transactions policies and punishments are complements rather than substitutes.

2. The model

The model consists of a set of agents $A = [0, 1]$, which is divided into G types. The number of goods available to trade is equal to the number of types. Let $i = 1, 2, \ldots, G$ be an index of types. Agent i produces good i and consumes a subset of the available goods. Let n denote the number of goods that each individual agent consumes, where $n < G$. The goods produced are neither storable nor are they divisible. An individual who purchases a good in their preferred subset gets utility, U_t. The production cost for each agent, regardless of the type of good produced, is C_t.

There are two storable assets, official government currency ("currency") and an alternative medium of exchange ("bitcoin"). At the beginning of time, a fraction of agents, M, are endowed with currency and a fraction, B, are endowed with bitcoin. The remaining fraction of agents, $1 - M - B < 0$, do not receive any endowment. It follows that the aggregate supply of currency is $M \in (0, 1)$ and the aggregate supply of bitcoin is $B \in (0, 1)$. Let $m \in \{0, 1\}$ be an index of whether an individual is holding currency and $b \in \{0, 1\}$ be an index of whether an individual is holding bitcoin. Each index is publicly observable. However, no individual can observe the trading histories of other individuals in the model and therefore trade is anonymous.

Some fraction, $\phi \in (0, 1)$, of the population is designated as government agents. We suppose that government agents have access to a punishment technology whereby they can reduce the utility of an agent with whom they are matched. If a government agent who is not holding currency or bitcoin meets with an agent holding bitcoin to trade, the government agent not only refuses to engage in the transaction, but also levies a punishment of size P_t. Note that government agents are identical to private agents in every way *except* for how they deal with transactions involving bitcoin.

The matching process follows Hendrickson et al. (2016).[10] In particular, the matching process consists of two stages. In the first stage, agents are partitioned into three groups. Given this partition, the matching rule is given by $g(s_t)$, where s_t is the state of the economy at the time of the partition. A trading rule $\tau(g_t, s_t)$ then summarizes trading decisions given the matching rule and the state of the economy. In the second stage, agents receive a preference shock in which they want to consume a specific good among their subset of consumption choices. Since there are n goods in each agent's subset, the probability of consuming a particular good is $\rho \equiv 1/n$.

In what follows, our analysis is confined to the steady state. There are four possible equilibria: (1) a non-monetary equilibrium, (2) an equilibrium in which only currency is accepted in trade, (3) an equilibrium in which only bitcoin is accepted in trade, and (4) an equilibrium in which both currency and bitcoin are accepted in trade. Since we wish to consider the extent to which a government can ban alternative currencies like bitcoin, our analysis is confined to the equilibria in which bitcoin is accepted.

2.1. Value functions

When two agents meet, there is no guarantee that trade will take place. If two agents meet and neither is holding an asset, then trade can only take place through barter if there is a double coincidence of wants. In addition, when an agent with currency or bitcoin (a buyer) is matched with an agent who is not holding an asset (a seller), trade will only occur if (a) the buyer wants to purchase the good produced by the seller, and (b) the seller is willing to accept the asset held by the buyer. Let the probability that an agent accepts currency be π. Note that, with both private and government agents in the model, the probability that an agent accepts bitcoin can be written as $\theta = \phi\theta_g + (1 - \phi)\theta_p$, where θ_g is the probability that government agents accept bitcoin and θ_p is the probability that private agents accept bitcoin. Consistent with the transactions policy employed by the government described above, government agents will never accept bitcoin ($\theta_g = 0$). The probability that a seller will accept currency is $\Pi(\pi)$, where this can be understood as the best response of the seller given the probability that other agents accept currency. The probability that a seller will accept bitcoin is $\Theta(\theta)$, where this can be understood as the best response of the seller given the probability that other agents accept bitcoin.

Let V_0 be the value function for a seller, V_m be the value function for a buyer who is holding currency, and V_b be the value function for a buyer who is holding bitcoin. The value function for a seller can be written as

$$rV_0 = a_0\rho^2(U - C) + \max_{\Pi \in [0,1]} a_{0,m}\Pi(\pi)\rho(V_m - V_0 - C) + \max_{\Theta \in [0,1]} a_{0,b}\Theta(\theta)\rho(V_b - V_0 - C) \tag{1}$$

where r is the discount rate, $a_{0,m} \in \min\{1, \frac{M}{1-M-B}\}$ is the probability that an agent not holding either asset is matched with an agent holding currency, $a_{0,b} \in \min\{1, \frac{B}{1-M-B}\}$ is the probability that an agent not holding either asset is matched with an agent holding bitcoin, and $a_0 \in \max\{0, (1 - a_{0,m} - a_{0,b})\}$ is the probability that two individuals without assets are matched.

[10] The present model differs from the earlier endogenous matching model of Corbae et al. 2002,2003 Corbae et al. (2002, 2003) by assuming that, once matched, agents receive a preference shock.

The value function of a buyer holding currency is given as

$$rV_m = a_m \pi \rho (U + V_0 - V_m) - \delta_m \tag{2}$$

where $a_m \in \min\{1, \frac{1-M-B}{M}\}$ is the probability that a buyer with currency will be matched with a seller and δ_m is the storage cost of currency.

The value function of a buyer holding bitcoin is given as

$$rV_b = a_b \rho (1-\phi)\theta_p (U + V_0 - V_b) - a_b \phi P - \delta_b \tag{3}$$

where $a_b \in \min\{1, \frac{1-M-B}{B}\}$ is the probability that an agent with bitcoin is matched with a seller and δ_b is the storage cost of bitcoin.

2.2. Bitcoin equilibria

A seller will be willing to accept bitcoin if they think that they will be able to exchange bitcoin for goods in the future at a sufficiently low storage cost. The same is true of currency. It follows, then, that the best strategy for sellers is to accept currency when $V_m - V_0 - C \geq 0$ and accept bitcoin when $V_b - V_0 - C \geq 0$. The best responses of sellers are given as

$$\Pi(\pi) = \begin{cases} 0 & \text{if} \quad V_m - V_0 - C < 0 \\ \in (0,1) & \text{if} \quad V_m - V_0 - C = 0 \\ 1 & \text{if} \quad V_m - V_0 - C > 0 \end{cases} \tag{4}$$

$$\Theta(\theta) = \begin{cases} 0 & \text{if} \quad V_b - V_0 - C < 0 \\ \in (0,1) & \text{if} \quad V_b - V_0 - C = 0 \\ 1 & \text{if} \quad V_b - V_0 - C > 0 \end{cases} \tag{5}$$

The purpose of our paper is to examine the role of bitcoin bans on the acceptance of bitcoin. As such, we are primarily concerned with the conditions under which bitcoin is accepted in equilibrium. There are two cases to consider. In the first case, bitcoin is accepted but currency is not. In the second case, both bitcoin and currency are accepted. We restrict our attention to symmetric equilibria in which $\Pi(\pi) = \pi$ and $\Theta(\theta) = \theta$.

Definition. A bitcoin equilibrium is an equilibrium in which bitcoin is accepted in trade. A bitcoin equilibrium exists if $\theta_p = 1$ or $\theta_p = \hat{\theta}_p$ where

$$\hat{\theta}_P = \left(\frac{\phi}{1-\phi}\right)\frac{P}{\rho(U-C)} + \frac{\delta_b + rC}{a_b\rho(1-\phi)(U-C)} + \frac{a_0\rho}{a_b(1-\phi)} + \frac{a_{0,m}(V_m - V_0 - C)}{a_b(1-\phi)(U-C)}$$

if $V_m - V_0 - C > 0$, and

$$\hat{\theta}_P = \left(\frac{\phi}{1-\phi}\right)\frac{P}{\rho(U-C)} + \frac{\delta_b + rC}{a_b\rho(1-\phi)(U-C)} + \frac{a_0\rho}{a_b(1-\phi)}$$

if $V_m - V_0 - C \leq 0$.

Note that the threshold probability is higher when currency is accepted than when currency is not. Since trade is anonymous, only barter is possible when currency and bitcoin are not traded in equilibrium. If currency is already in circulation, then the marginal benefit from accepting bitcoin is not as high as it would be if currency were not accepted. As a result, when currency is accepted, the probability threshold for bitcoin acceptance is higher than it is when currency is not accepted.[11]

The threshold for the probability of acceptance is also an increasing function of the fraction of agents that are government agents and the size of the punishment. It follows that the government has two mechanisms by which it can limit the acceptance of bitcoin.

2.3. The effectiveness of bans

As alluded to above, a ban on bitcoin is a policy in which the government not only refuses to accept bitcoin in transactions, but also punishes any individual it detects using bitcoin. In other words, there are two elements to a ban: a transactions policy and a punishment policy. In what follows, we consider the complementary role of each of these policies. First, we derive a threshold for the size of government that is sufficient to prevent the acceptance of bitcoin in equilibrium, taking the severity of the punishment as given. Second, we derive a threshold for the severity of the punishment that is sufficient to prevent the acceptance of bitcoin in equilibrium, taking the size of government as given.

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[11] It is also important to note that $\lim_{\phi \to 0} \theta = \theta_p$. Under this scenario, this threshold is identical to Hendrickson et al. (2016).

2.3.1. Transactions policy

Note from the equilibrium condition derived in the previous section that, as the size of the government increases, the threshold for the probability that a private individual is willing to accept bitcoin gets larger. It is therefore possible that a government of sufficient size can prevent the acceptance of bitcoin in equilibrium. This leads to the following proposition.

Proposition 1. *Define*

$$\hat{\phi} \equiv \begin{cases} \dfrac{[[a_b\rho\theta_p - a_0\rho^2](U-C) - \delta_b - a_{0,m}\rho(V_m - V_0 - C) - rC]}{a_b[\rho\theta_p(U-C)+P]} & \text{if} \quad V_m - V_0 - C > 0 \\ \dfrac{[[a_b\rho\theta_p - a_0\rho^2](U-C) - \delta_b - rC]}{a_b[\rho\theta_p(U-C)+P]} & \text{if} \quad V_m - V_0 - C \leq 0 \end{cases} \tag{6}$$

If $\phi > \hat{\phi}$, then bitcoin will not be accepted in equilibrium.

Proof. Define $N = V_b - V_0 - C$. Note from the definitions of the value functions that $\partial N/\partial\phi < 0$. A seller will be indifferent to accepting bitcoin if $V_b - V_0 - C = 0$. This indifference condition can also be written as $rV_b - rV_0 - rC = 0$. Substituting value functions (1) and (3) into this condition and solving for ϕ yields Eq. (6). Since $\partial N/\partial\phi < 0$, then any $\phi > \hat{\phi}$ implies that $N < 0$ and, therefore, bitcoin will not be accepted in equilibrium. □

Proposition 1 establishes the threshold for the size of government necessary to prevent the acceptance of bitcoin in equilibrium. There are two characteristics of this threshold that are of particular interest. First, this threshold is lower when everyone accepts currency in equilibrium. This is due to the fact that, when there is one medium of exchange that everyone is willing to accept, the marginal value of an additional medium of exchange is lower than it otherwise would be. Second, there is a complementarity between the transactions policy and the punishment policy associated with the ban. Specifically, as the severity of the punishment increases, the threshold for the size of government required to eliminate bitcoin from circulating in equilibrium falls.

2.3.2. Punishment policy

As shown in Proposition 1, the size of the government necessary to prevent the acceptance of bitcoin in equilibrium is decreasing in the severity of the punishment. It follows that there is a symmetric result for the threshold severity of punishment.

Proposition 2. *Define* $\hat{P} = \max\{0, \tilde{P}\}$, *where*

$$\tilde{P} = \begin{cases} \dfrac{1}{\phi}\left[\left(\rho(1-\phi)\theta_p - \dfrac{a_0}{a_b}\rho^2\right)(U-C) - \dfrac{\delta_b}{a_b} - \dfrac{a_{0,m}}{a_b}\rho(V_m - V_0 - C) - \dfrac{rC}{a_b}\right] & \text{if} \quad V_m - V_0 - C > 0 \\ \dfrac{1}{\phi}\left[\left(\rho(1-\phi)\theta_p - \dfrac{a_0}{a_b}\rho^2\right)(U-C) - \dfrac{\delta_b}{a_b} - \dfrac{rC}{a_b}\right] & \text{if} \quad V_m - V_0 - C \leq 0 \end{cases} \tag{7}$$

If $P > \hat{P}$, the bitcoin will not be accepted in equilibrium.

Proof. As in the proof to Proposition 1, define $N = V_b - V_0 - C$. Note that sellers are indifferent to accepting bitcoin when $N = 0$. Note further that $\partial N/\partial P < 0$. The indifference condition for sellers can be written as $rV_b - rV_0 - rC = 0$. Plugging in value functions (1) and (3) and solving for P yields Eq. (7). Thus, if $P > \hat{P}$, then $N < 0$ and, therefore, sellers will be unwilling to accept bitcoin in equilibrium. □

This result shows that, if the government establishes a sufficiently severe punishment, it can prevent bitcoin from circulating in equilibrium. The threshold severity of punishment is lower when everyone accepts currency in equilibrium ($\pi = 1$). Since trade is anonymous, a medium of exchange expands the feasible set of exchange opportunities. If everyone is willing to accept currency, then the marginal benefit of bitcoin in equilibrium is lower than if individuals were indifferent to accepting currency or refused to accept currency. Hence, the government does not have to impose as severe of a punishment to prevent the acceptance of bitcoin when everyone accepts currency.

The severity of the punishment is increasing in the probability that private citizens accept bitcoin. However, even if all private agents are willing to accept bitcoin ($\theta_p = 1$), there can still be a punishment of sufficient severity to prevent the acceptance of bitcoin in equilibrium.

Note the symmetric result from the previous section. The threshold for the severity of punishment is a function of the size of the government. In particular, note that $\lim_{\phi \to 0} \hat{P} = \infty$. Thus, as the size of the government gets infinitesimally small, the requisite magnitude of the punishment must become infinite. Further, note that $\lim_{\phi \to 1} \hat{P} = 0$. Thus, as the government becomes sufficiently large, a transactions policy is sufficient and the government does not need to levy any punishment at all. In fact, we have the following corollary to Proposition 2.

Corollary 1. *Suppose that*

$$\phi \geq 1 - \frac{a_0}{a_b \theta_p \rho}$$

then the necessary magnitude of punishment to prevent the acceptance of bitcoin in equilibrium is 0.

Proof. Note that a sufficient condition for $\hat{P} = 0$ is if

$$\rho(1 - \phi)\theta_p = \frac{a_0}{a_b}\rho^2$$

Solving for ϕ yields

$$\phi = 1 - \frac{a_0}{a_b \theta_p}\rho$$

Thus, if $\phi \geq 1 - \frac{a_0}{a_b \theta_p}\rho$, then there is no need to have a punishment in order to prevent the acceptance of bitcoin in equilibrium. □

Note that if $a_b < 1$, then $a_{0,b} = 1$ and $a_0 = 0$. As a result, the expected gains from barter are equal to zero. In the absence of both a punishment and an opportunity for barter, the threshold for accepting bitcoin in equilibrium declines. Evidently, this implies that a transactions policy could only work in the trivial case in which all agents are government agents. On the other hand, if $a_b = 1$, then $a_{0,b} > 0$ and it is therefore possible that $a_0 > 0$. In this case, some $\phi < 1$ might be sufficient to prevent the circulation of bitcoin even without a punishment. However, this depends on how universally the endowments of currency and bitcoin are distributed. Whenever either $a_b < 1$ or $a_m < 1$, then sellers will always be matched with a buyer who is holding either currency or bitcoin. As a result, the probability of barter is zero. Since the expected benefit from barter will be equal to zero, gains from trade can only be had through trade involving currency and/or bitcoin. As a result, the thresholds for the acceptance of bitcoin and currency will be lower than they would be otherwise and, without a punishment, a transactions policy will not be sufficient to prevent the acceptance of bitcoin.

2.3.3. Discussion

Our model provides the first attempt to examine the role of both transactions policies and punishments associated with a ban on an alternative medium of exchange. Consistent with the prior literature, we find that a sufficiently large government can prevent an alternative currency like bitcoin from being accepted in equilibrium in the absence of punishments. Unique to our model, however, is the role of punishments.

There are two key results in the model. The first is that a government can prevent the acceptance of an alternative currency in equilibrium if it is willing to use sufficiently severe punishments. This conclusion is intuitive. As the severity of punishments gets larger, the expected cost associated with engaging in the punishable behavior gets larger as well. If the expected cost gets sufficiently large, then individuals will choose to abstain from that activity. The second result is that transactions policies and punishments should be viewed as complements rather than substitutes. For example, the threshold for the size of government necessary to prevent the acceptance of an alternative currency gets smaller as the severity of the punishment gets larger. Symmetrically, countries with a larger government should be able to limit the acceptance of an alternative currency with a smaller punishment than countries with a small government.

Since the fraction of government agents is important to each of these results, it might be useful to discuss the underlying mechanism. In the model, individuals can identify the asset holdings of other individuals. However, beyond asset holdings, trade is anonymous. Given that there is partially directed search, sellers who want to hold bitcoin can search out buyers who are holding bitcoin. It is possible for bitcoin to be accepted in equilibrium, even if the government is large. This is consistent with the idea that some agents might use bitcoin for the purposes of hiding transactions from the government. The anonymity, however, also implies that government agents cannot be identified ex ante. If government agents were identifiable, then everyone holding or attempting to acquire bitcoin would avoid them. When sellers determine whether or not to accept bitcoin, their decision is dependent on their expectation of what proportion of future sellers will be willing to accept bitcoin. As the proportion of government agents gets larger, the likelihood of finding a seller to accept bitcoin declines. Note that this implies that it is the expectation of an interaction with a government agent that reduces the acceptance of bitcoin since governments are not only unwilling to accept bitcoin but will also mete out a punishment. This characteristic is important since, in reality, government agents might seek out bitcoin users for punishment.

These results raise and, to some extent, address important issues concerning the political economy of currency bans. Consider our results concerning the requisite threshold severity of punishment. In theory, a more severe punishment will deter behavior. But a sufficiently severe punishment might be impractical or impracticable. For example, a powerful government might be interested in banning an alternative currency but also concerned with maintaining its winning coalition. If meting out the requisite severity of punishment undermines its coalition, it might choose not to employ the full extent of its power. In this case, it is technically feasible to levy a sufficiently severe punishment, but doing so would be ill-advised. In other cases, the requisite punishment might exceed the government's means to levy punishments. A fuller treatment of the effectiveness of bans would consider the political costs and technical limits of punishments.

Given the potential limits of punishments, its complementarity with transactions policy seems especially important. Recall that our results suggest a more modest punishment will be sufficient to prevent the acceptance of an alternative currency if it is coupled with a similarly motivated transactions policy. If there are political costs to punishment, governments might economize by refusing to accept the alternative currency. If there are technical limits to punishment, governments might still be able to ban an alternative currency by relying more heavily on transactions policy.

While the model presented herein takes us a long way towards understanding the effectiveness of bans, it leaves several questions unanswered. For example, we take it for granted that a government might want to ban an alternative currency. Indeed, in the context of a model where they are identical to private agents, government agents reject an alternative currency at their peril. At best, the exogenously imposed strategy to refuse the alternative currency and punish others caught using it has no effect (i.e., when the alternative currency would not circulate in equilibrium anyway). At worst, it means they will be left employing an inferior medium of exchange with no offsetting benefit. And if there are political costs to levying punishments, as we have suggested, government agents would be even worse off than our model implies.

Why might governments want to ban bitcoin? In considering whether bitcoin is legal in the US, Grinberg (2011) implicitly argues that the standard justifications for existing financial markets regulations might also apply to bitcoin. More specifically, Luther (2016c) maintains that efforts to regulate bitcoin are usually justified on the grounds that they would protect consumers, prevent illegal transactions and transfers, or promote broader policy goals (e.g., ensure macroeconomic stability, raise revenue via seigniorage). If the benefits others have cited to justify regulations were high enough or the available means of regulating bitcoin were not up to the task, governments might find it more expedient to ban bitcoin outright. In any event, the benefits to banning bitcoin for government agents or the economy as a whole are exogenous in the model presented herein.

We have also taken it for granted that bitcoin might be preferred to official government currency for making transactions. Luther (2016b) offers several plausible explanations.[12] Merchants, for example, might prefer bitcoin to electronic currency since the former is not subject to chargebacks. Likewise, consumers might prefer the inability to execute a chargeback to the inability to make a transaction altogether[13]; or, if they are compensated for giving up the right to execute a chargeback with a lower price for a good purchased with bitcoin.[14] Others like that it enables pseudonymous exchange, which might be useful for those wanting to make illegal transactions or anonymous donations—or, more generally, that it can be held and transferred remotely without having to trust an intermediary. Still others like the predictable supply of bitcoin[15]; the ability to make very small transactions[16]; or simply that it is a privately-provided alternative to government monies. Hence, plausible explanations for preferring bitcoin to currency exist, but they are treated as exogenous in our model.

3. Conclusion

Whereas earlier studies consider the size of government necessary to prevent an item from functioning as money, we extend the analysis by acknowledging that governments can—and often do—punish their subjects. Our results call into question the view that only a large government can stymie an alternative to its preferred money. A government can prevent an alternative from circulating if it is willing and able to mete out sufficiently severe punishments. More generally, our approach suggests that sovereignty—that is, the ability of some agents to govern the behavior of others—is a function of both size and power.

Our work contributes to the existing literature in two ways. First, it more fully endogenizes the decisions of private agents. Whereas, in earlier works, the subset of agents employing the exogenous transactions policy could be interpreted to include *private* agents acting in accordance with the policy, we restrict this group to *government* agents and provide a mechanism—explicit punishments—whereby government agents might coerce private agents into following the policy. Second, the policies employed by the government agents in our model more closely resemble those considered by actual governments. In Russia and elsewhere, proposals to prevent bitcoin and other alternative currencies from circulating have not been limited to transactions policies. They also include specific punishments for those caught creating, issuing, or circulating rivals to the government's preferred money.

The approach taken here suggests several avenues for future research. We have taken it for granted that a government wants to ban bitcoin; that some private agents would like to use the official government currency; and that some private agents would like to use bitcoin. Although others have considered the motivations for banning or transacting with bitcoin, no one to our knowledge has attempted to include the relevant frictions necessary to derive these positions in a money matching model. We also take it for granted that governments have access to a punishment technology and, indeed, implicitly assume there is no limit to the severity of punishments a government might levy. Surely there are political economy considerations

12 See also Barber et al., 2012 Barber et al. (2012), Hendrickson and Luther (2017), Luther (2016a, 2017a,b), and Yelowitz and Wilson (2015).

13 Along these lines, Brito (2014, p. 2) suggests bitcoin is especially useful for some international transactions, since high rates of fraud have led traditional payment processors to forego business in over 50 countries.

14 Wile (2013) offers some evidence that merchants are willing to compensate their customers for reducing the risk of chargeback fraud.

15 Although the dollar exchange value of bitcoin has fluctuated greatly to date, bitcoin proponents maintain that the volatility will decline as the network of users grows. Indeed, Dourado (2015) provides some early evidence that volatility is declining.

16 The smallest transferable unit is known as a satoshi, where 1 bitcoin is equal to 10^7 satoshis.

that constrain the most severe punishments. Although these issues are beyond the scope of this article, we hope our work will encourage others to start thinking about such questions.

Appendix A

In Section 2.2 we present a definition of a bitcoin equilibrium. We defined the best response of sellers in Eq. (4) and (5). Intuitively, these conditions imply that when the value of exchanging goods for bitcoin is negative, sellers should never accept currency bitcoin. When the value of exchanging goods for bitcoin is positive, all sellers will accept bitcoin. And when the net value of going from a seller to a buyer holding bitcoin is zero, then sellers should be indifferent between accepting bitcoin and not accepting bitcoin. As a result, some fraction of sellers will choose to accept bitcoin and some will choose not to accept bitcoin. We confine our analysis to a symmetric equilibrium in which the all sellers choose the same response to an offer of bitcoin. (The same logic applies to currency.)

It follows that if $V_b - V_0 - C > 0$, then all private individuals will accept bitcoin in equilibrium and $\theta_p = 1$. However, it is also possible for a bitcoin equilibrium to exist if a sufficiently large fraction of agents are willing to accept bitcoin. Define this fraction as $\hat{\theta}_p$. This is the value of θ_p such that $V_b - V_0 - C = 0$.

To solve for $\hat{\theta}_p$, note that if $V_b - V_0 - C = 0$, then

$$rV_b - rV_0 - rC = 0$$

Plugging in Eqs. (1) and (3) into this expression and solving gives the conditions for equilibrium in Section 2.2.

References

Aiyagari, S.R., Wallace, N., 1997. Government transactions policy the medium of exchange and welfare. J. Econ. Theory 74 (1), 1–18.
Barber, S., Boyen, X., Shi, E., Uzun, E., 2012. Bitter to better – how to make bitcoin a better currency. Financ. Cryptogr. Data Secur., 399–414.
Barnard, A., 2013. Syria Bans Use of Foreign Currencies for Business Deals. The New York Times, August 4.
Böhme, R., Christin, N., Edelman, B., Moore, T., 2015. Bitcoin: economics, technology, and governance. J. Econ. Perspect. 29 (2), 213–238.
Bradbury, D., 2014. BTC-e Pulls Support for Ruble as Russia Bans Bitcoin. CoinDesk, February 7.
Brito, J., 2014. Benefits and Risk of Bitcoin for Small Businesses, Testimony. House Committee on Small Business, Mercatus Center, April 2.
Corbae, D., Temzelides, T., Wright, R., 2002. Matching and money. Am. Econ. Rev. 92 (2), 67–71.
Corbae, D., Temzelides, T., Wright, R., 2003. Directed matching and monetary exchange. Econometrica 71 (3), 731–756.
Dourado, E., 2015. The Bitcoin Volatility Index, Data, Available online: https://btcvol.info/ (accessed 26.03.15).
Dwyer, G.P., 2015. The economics of bitcoin and similar private digital currencies. J. Financ. Stab. 17, 81–91.
Fernandez-Villaverde, J., Sanches, D., 2016. Can Currency Competition Work?, NBER Working Paper, 22157.
Goldberg, D., 2007. Money with partially directed search. J. Monet. Econ. 54 (4), 979–993.
Grinberg, R., 2011. Bitcoin: an innovative alternative digital currency. Hastings Sci. Technol. Law J. 4 (1), 159–208.
Hendrickson, J.R., Luther, W.J., 2014. The Value of Bitcoin in the Year 2141 (And Beyond!), Working Paper.
Hendrickson, J.R., Luther, W.J., 2017. Cash, Crime, and Cryptocurrency, Working Paper.
Hendrickson, J.R., Hogan, T.L., Luther, W.J., 2016. The political economy of bitcoin. Econ. Inq. 54 (2), 925–939.
Higgins, S., 2014. Bangladesh Central Bank: Cryptocurrency Use is a 'Punishable Offense'. CoinDesk, September 16.
Higgins, S., 2016a. Russia's 'Bitcoin Ban' Faces Uncertain Future After Draft Bill Withdrawn. CoinDesk, May 19.
Higgins, S., 2016b. Bitcoin Sales Are Currency Transactions, Russia's Tax Office Says. CoinDesk, August 10.
Hill, A.W., 2015. Bitcoin Legality. Carto, March 4.
Hogan, T.L., Luther, W.J., 2014. Endogenous Matching and Money with Random Consumption Preferences, Working Paper.
Kazeem, Y., 2016. To Save its Currency, Nigeria's Central Bank Wants People Jailed for Holding on to US Dollars. Quartz, November 16.
Li, Y., Wright, R., 1998. Government transactions policy media of exchange and prices. J. Econ. Theory 81 (2), 290–313.
Lotz, S., Rocheteau, G., 2002. On the launching of a new currency. J. Money Credit Bank. 34 (3), 563–588.
Luther, W.J., 2013. Friedman versus Hayek on private outside monies: new evidence for the debate. Econ. Aff. 33 (1), 127–135.
Luther, W.J., 2016a. Bitcoin and the future of digital payments. Indep. Rev. 20 (3), 397–404.
Luther, W.J., 2016b. Cryptocurrencies network effects and switching costs. Contemp. Econ. Policy 34 (3), 553–571.
Luther, W.J., 2016c. Regulating Bitcoin: On What Grounds? Reframing Financial Markets Regulation. Mercatus, Arlington, VA, pp. 391–415.
Luther, W.J., 2017a. Getting Off the Ground: The Case of Bitcoin, Working Paper.
Luther, W.J., 2017b. Is Bitcoin Intrinsically Worthless?, Working Paper.
Luther, W.J., White, L.H., 2014. Can bitcoin become a major currency? Cayman Financ. Rev. 36, 78–79.
Melendez, S., 2016. Amid Arrests And Prosecutions, Rules Around Selling Bitcoin Remain Fuzzy. Fast Company, May 20.
O'Byrne, B., 2017. Economists Assail Opposition Proposal to Ditch US Dollars. The Cambodia Daily, June 14.
Palmer, D., 2016. Bill Seeking Bitcoin Ban Reaches Russian Legislature. CoinDesk, January 11.
Rizzo, P., 2014a. Russia Proposes Monetary Penalties for Bitcoin Use and Promotion. CoinDesk, October 3.
Rizzo, P., 2014b. Russia Lowers Proposed Penalties for Bitcoin Activities. CoinDesk, November 10.
Rizzo, P., 2016. Report: Russian Government to Abandon Penalties for Bitcoin Use. CoinDesk, August 12.
Salter, A.W., Luther, W.J., 2014. Synthesizing state and spontaneous order theories of money. Adv. Austrian Econ. 18, 161–178.
Selgin, G.A., 1994. On ensuring the acceptability of a new fiat money. J. Money Credit Bank. 26 (4), 808–826.
Selgin, G.A., 2003. Adaptive learning and the transition to fiat money. Econ. J. 113 (484), 147–165.
Selgin, G.A., 2015. Synthetic commodity money. J. Financ. Stab. 17, 92–99.
Velde, F., 2013. Bitcoin: a primer. Chicago Fed Lett. 317 (December), 1–4.
Waller, C.J., Curtis, E.S., 2003. Currency restrictions government transaction policies and currency exchange. Econ. Theory 21 (1), 19–42.
White, L.H., 2014. The market for cryptocurrencies. Cato J. 35 (2), 383–402.
White, L.H., 2016. The troubling suppression of competition from alternative monies: the cases of the liberty dollar and E-gold. Cato J. 34 (2), 281–301.
Wile, R., 2013. A Brooklyn Bodega Owner Told Us Why All Merchants Should Start Accepting Bitcoin. Business Insider, November 11.
Yelowitz, A., Wilson, M., 2015. Characteristics of bitcoin users: an analysis of Google search data. Appl. Econ. Lett. 22 (13), 1030–1036.
Yermack, D., 2013. Is Bitcoin a Real Currency? An Economic Appraisal, NBER Working Paper, 19747.