Seeding the Technology S-Curve? The Role of Early Adopters in Technology Diffusion

Christian Catalini

catalini@mit.edu

Catherine Tucker cetucker@mit.edu

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Why Should You Care?



OCTOBER 31ST-NOVEMBER 6TH 2015

Our guide to America's best colleges Myanmar's free-ish election Those ever-creative accountants America takes the fight to IS Coywolves: the new superpredator

The trust machine How the technology behind bitcoin

Economist.com

could change the world



The Blockchain



1st Block Hash

Transaction 4

Transaction 5

Transaction 6? Transaction 7?

+

1st Block

2nd Block

Mining the next block

The Blockchain





Computer Science Economics and Market Design

Law



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IP & Smart Contracts



IoT, AI Robotics

Agenda

- Why should you care?
- The MIT Digital Currency Experiment
- Seeding the technology S-curve? The role of early adopters in technology diffusion





MIT is about to become the world's first Bitcoin economy



Who Will Benefit From Digital Currency? Bitcoin Experiment Gives A Glimpse

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MIT conducts world's largest Bitcoin experiment

A pot of \$500,000 will be used to hand out free Bitcoins to every undergraduate at MIT later this year, in the hope of spurring research, innovation and entrepreneurialism around digital currencies among students





EXECUTIVE PROGRAMS CORPORATE

NEWSROOM

Ambition and uncertainty as Bitcoin experiment nears

Published: July 17, 2014

A student group plans to give \$100 to every undergraduate, while faculty watch with interest



Dan Elitzer and Jeremy Rubin of the MIT Bitcoin Project

This fall, Dan Elitzer will give every MIT undergraduate \$100.

There are a few catches. Elitzer, MBA '15, will distribute the money through the MIT Bitcoin Project, which has raised \$540,000 from donors, mostly MIT alumni. And the no-strings-attached payments won't be in U.S. dollars. They will be in Bitcoins.

Key Challenges

- Uncertainty (risks for students, regulation, foreign, security)
- IRB application ... + MIT OGC, IRS, Treasury, FED
- Students' objectives versus research objectives (e.g., ability to randomize, Stanford experiment): can we learn anything even if everyone cashes out the next morning?
- Tech complexity, no compelling use case, seeding only one side of the market
- Questions over the LATE: what can we learn from MIT?



- ~4,500 undergraduate students eligible
- Educational content on digital currencies, risks and challenges, different types of wallets, privacy and security, securing digital assets
- Survey on Bitcoin, entrepreneurship, digital payments, social network
- Students had to select a wallet and generate their own wallet address
- PGP and encryption
- Overall process: **15 to 45 minutes**
- Launched on October 28th
- 5 days to get on the waiting list

Main Randomizations

- Timing of the distribution
- Public commitment
- Wallet choice
- Incentive in exchange for social network
- Privacy prompt

5 Days to Get on the Waiting List



▲ [-] **nuibox** 25 points 2 days ago

Wow, hurry and sign up you only have 5 days!?!

permalink

[-] thbt101 9 points 2 days ago

Yeah, I had the impression each student was going to be handed bitcoin (or emailed or whatever). This is a far more limited way to do it that will probably only reach a limited number of students.

permalink parent

[-] SlickCoin 3 points 1 day ago

It's MIT. I bet they get 90% participation.

permalink parent

🔺 [-] todu 40 points 2 days ago

Finally! I've been looking forward to see what comes out of this experiment and project. At least now, it's really started. I hope they report their findings during this school year, also, and don't just wait to release everything they learned at once once the school year is over.

permalink

[-] Onetalinerd 40 points 2 days ago

that it's only for a few days to claim it and that they don't even mention the free \$100 in the email they sent.

permalink parent

First 12 hours

One MIT undergraduate student tries to hack us... ...and fails!



Familiarity with Bitcoin

- 12% none •
- **29%** moderate \bullet
- **53%** slightly familiar lacksquare

6% very or extremely familiar (13.5% has a wallet)

Please describe the extent to which you are familiar with Bitcoin

 Not at all familiar (did not know about Bitcoin at all before the Bitcoin experiment at MIT) Slightly familiar (have read or heard about Bitcoin in the news) Moderately familiarity (have researched it somewhat) Very familiar (feel like I have fairly complete knowledge of Bitcoin and how it

 Extremely familiar (feel like I am expert on Bitcoin and how it works) How often have you used Bitcoin in the past 6 months? *

How many times do you expect to use Bitcoin in the next 6 months?

What makes Bitcoin most attractive to you? Select up to 2 (you can use the CMD key on a Mac or the CTRL key on a PC) *

Key on Alvac or the CITL Key on a PC)* Easier to use that cash Easier to conduct transactions with online vendors than other payment methods Lower transactions from one Bitcoin wallet to another are not officially tracked by governments More secure than other payment methods. I think the collar price of a Bitcoin will increase, so I want to buy them as an investment Beenfits when traveling internationally or sending money overseas Independence from government currencies.

To what extent do you agree or disagree with the following statements? Answer on a scale of 1-5 where (1) = Strongly disagree and (5) = Strongly agree.* Bitcoin and related cryptocurrencies will redefine the way the world transacts 1 2 3 4 5 Don't Know

Bitcoin is riskier to use than traditional forms of payments such as cash or credit

I expect my use of Bitcoin and related cryptocurrencies to increase significantly over the

1 2 3 4 5 Don't Know

1 2 3 4 5 Don't Know

Never, don't have a wallet Never, but I do have a Bitcoin wallet

Once 2-5 times 6-10 times More than 10 times

 Not at all Once 2-5 times 6-10 times More than 10 times

next three years

Over the past 6 months, how did you conduct your Bitcoin transactions? Select all		In an paymente (rese than 40)	ist month? *	associated with it, similar to a checking account
that apply (you can use the CMD key on a Mac or the CTRL key on a PC) *	Otes	1 2 3 4 5 Don't Know	0	1 2 3 4 5 Don't Know
Through the browser on my mobile phone	Cuo		1	
Using a computer or tablet	Which course are you enrolled in or intend to enroll in?*			
Using a Bitcoin ATM		C		
During the past 6 months, what was the average value range for your Bitcoin	Do you know how to code? *	Beer to peer payments (aplitting abacks taxi caba, etc.)	3	
transactions? Select one *		Peer-to-peer payments (splitting checks, taxi cabs, etc.)) 4-6	To what extent do you trust the following entities to provide fina
	Not at all	1 2 3 4 5 Don't Know	7-10	as digital wallets, credit or debit cards, or mobile payment servi
<\$2	A little) > 10	a scale from 1-5, where (1) = Not at all and (5) = To a great exter
○ \$2-\$5	O Well	0 0 0 0 0 0	ann bin is a funical Manma naumant far usu? *	Your bank
○ \$5-\$10		n n	ow big is a typical venino payment for your	1 0 0 4 E Danit Kanu
○ \$10-\$20	Have you ever released an app in one of the major app stores? (Apple, Android) *		<\$2	1 2 3 4 5 Don t Know
S20-\$100	Yes	Checkout counter/kiosk	\$2-\$5	0 0 0 0 0 0
○ >\$100	<u>○</u> No		\$5-\$10	
		1 2 3 4 5 DOILLKINW	\$10.\$20	A wall actablished technology firm
What are your greatest concerns about using Bitcoin? Pick the top 3 (you can use	Do you own a credit card that you are able to use for discretionary expenses (e.g.,		000 000	A well-established technology littl
the CMD key on a Mac or the CTRL key on a PC) *	going out to eat, taking a taxi)? *		\$20-\$100	1 2 3 4 5 Don't Know
Fluctuations in value	Yes		>\$100	
Acceptance among vendors	 ∩No	Restaurant	/ith how many different people have you sent or received payments using PayPal.	
Difficulty of use	0	s	quare Cash or similar (non-Venmo) in the last month?*	
Fear of loss of funds from your wallet (e.g. losing passwords, computer stolen, etc.)	In the last year, did you have a paying job that helped contribute to your living	1 2 3 4 5 Don't Know		An innovative start-up
Lack of government regulation	expenses at MIT? *		0	1 2 3 4 5 Don't Know
Getting in trouble with the U.S. government	Yes) 1	
Getting in trouble with a non-U.S. government	(No		2	0 0 0 0 0
Other, please specify			3	
Unsure	How often do you use Venmo? *	Online snopping (including travel, e.g. airtare)	4-6	A well-known reteiler
		1 2 3 4 5 Don't Know	7-10	
Other Concerns	O Never		. 10	1 2 3 4 5 Don't Know
	A few times a year	0 0 0 0 0 0	5 10	0 0 0 0 0
	Once a month	н	ow big is a typical payment with this alternative for you? *	
In the past year, have you used international money transfer services such as wire				
transfers or remittances (Western Union, MoneyGram, Xoom, TransferWise,		Payment of credit card bills (if it were possible)	<32	Government
other)? *	Every day		\$2-\$5	1 2 3 4 5 Don't Know
O Max for configuration of the	How often do you use an alternative to Venmo that facilitates person to person	1 2 3 4 5 Don't Know	\$5-\$10	
Yes, for sending and receiving	payments such as PayPal or Square Cash? *		\$10-\$20	0 0 0 0 0
Yes, for receiving only		0 0 0 0 0 0 c	\$20-\$100	
Yes, for sending only	O Never	C	>\$100	A mobile carrier (such as AT&T. T-Mobile, or Sprint)
○ No	A few times a year	Online gaming or gambling sites		
Do you think in the part month Bitcoin will *	Once a month	H H	low frequently in the past six months have you used point-of-sale payments	1 2 3 4 5 Don't Know
bo you unink in the next month bitcom with		1 2 3 4 5 Don't Know ^a	pplications on your phone such as Square, PayPal, Google Wallet, or Apple Pay? "	0 0 0 0 0
Go up in value		C	Never	
O Go down in value	C Every day		A few times a year	
○ Stay the same			Once a month	How likely would you be to use Ritcoin in the following situation
	O Positively		One of month	of 1-5 where (1) = Not at all likely and (5) = Highly likely *
Consider the 5 people you socialize with most frequently at MIT.	Negatively	Products and/or services that I buy for which I would prefer to remain ar	Unice a week	or to a more (i) = not at an intery and (o) = mg/lly likely.
How many have told you that they have Bitcoin wellete prior to the start of the MIT	 Neutral 	1 2 2 4 E Dan't Know	Every day	international purchases of goods or services (e.g. buying a present f
Bitcoin experiment? *		1 2 3 4 5 DONTINNOW		country)
		0 0 0 0 0		1 2 3 4 5 Don't Know
	Do you believe Bitcoin is mostly for currency speculation? *			
	Yes			
low much cash do you usually keep on your person? (in \$) *	C No.	Saving for the future		
		· · · · · · · · · · · · · · · · · · ·		International movement of funds (sending money to and from family
	Do you believe Bitcoin is mostly for illicit activity? *	1 2 3 4 5 Don't Know		countries)
/hat do you usually use cash for? (e.g., restaurants, groceries, gas, beverages) *	⊖Yes			1 2 3 4 5 Don't Know
	○No			. 2 3 4 3 DOITCNIDW
				0 0 0 0 0
n what circumstances do you usually split bills with your friends? Rank the top 3 *	Are you planning to work (or are currently working) on a startup that will use			
1)	Bitcoin-like technology (e.g., blockchain, proof of work, etc.)? *			
	⊖Yes			
2)	(No			
	Do you have any concerns you would like to share with us?			
9				
5) 				

What Draws You to Bitcoin?

- 35% I want to buy them as an investment
- 21% easier to use than cash
- 20% easier to conduct online transactions
- 17% independence from government currencies
- 16% lower transaction fees than traditional banking
- 12% benefits when traveling internationally and sending money overseas
- 9% more secure than other payment methods
- 8% transactions are not tracked by governments
- 7% faster funds transfers







Agenda

- Why should you care?
- The MIT Digital Currency Experiment
- Seeding the technology S-curve? The role of early adopters in technology diffusion



Research Question

What happens when the <u>natural order</u> of adoption is perturbed?



Zvi Griliches (1957) "Hybrid Corn: An Exploration in the Economics of Technological Change", Vol. 25, No. 4, pp. 501-522

In Strategy... A Process to be Managed





Focus is on Technology Abandonment

- Who gave up on the technology?
- Measured by cashing out, i.e. converting bitcoin back to USD
- Unusual feature: abandonment here had an upside, not a sunk cost
- Fine-grained activity data (blockchain, wallet providers)

Tracking Transactions versus Trusting the Survey



No systematic bias on early adopters

How Do We Identify Early Adopters?

- First to join our waiting list! (robust to survey measures)
- Analogy in process to the people who signed up first for things like Google Glass etc.

Top 25% of the Waiting List versus Others



(g) High Trust in Tech Firm or Startup for Financial Services

(h) No Trust at All in Government, (i) Financial Independent versus Not Well-Known Retailer or Carrier

How Do We Identify Perturbations to the Natural Adoption Order?

- 50% of the subjects was randomly delayed by 2 weeks (initial aim was to identify network effects)
- No one was told when they would receive bitcoin, nor explanation was given for why some people received it and others did not
- Some of our natural early adopters (top of the waiting list) were not allowed to be first to adopt

Main Results (I) Delaying Early Adopters Increases Their Cash Out Rate



Main Results (II) Delaying Early Adopters Impacts the Abandonment Curve



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 - Understanding the mechanism
 - Spillovers



It is <u>Not</u> About Being Financially Constrained



Įβ

Rest of Waiting List

Financially Independent

Top 25% Waiting List

Others
1. Not Delayed 2. Delayed

Top 25% Waiting List

Rest of Waiting List

It is <u>Not</u> About Better Information & Expectations



It is <u>Not</u> About Investment Preferences and Risk Aversion



Effect is Coming from Dorms



Large versus Small Dorms



VARIABLES	(1) ICO	(2) ICO	(3) ICO	(4) ICO	(5) ICO	(6) ICO Dorms	(7) ICO Dorms
		100		Off Campus	Dorms	Above Median Size	Below Median Size
Top 25% Waiting List	1.5851***	1.6864***	1.0427	1.2379	1.0601	1.1329	1.0561
	(0.1958)	(0.2209)	(0.2045)	(0.4517)	(0.2504)	(0.3089)	(0.5253)
Delayed			0.9236	1.3518	0.9774	1.0993	0.7211
Top 25% Waiting List * Delayed			(0.1758)	(0.4972)	(0.2096)	(0.2693)	(0.3268)
Top 25% waiting List * Delayed			(0.4086)	(0.5430)	(2.0920^{10})	(0.5731)	(2.6105)
			(0.4900)	(0.0403)	(0.0342)	(0.0701)	(2.0105)
All Delayed			0.9772	0.7125	0.9442	0.9138	1.0209
			(0.1712)	(0.2595)	(0.1849)	(0.2065)	(0.4167)
Privacy Text		0.7554^{**}	0.7286***	0.7328	0.7186**	0.6961**	0.7543
-		(0.0899)	(0.0886)	(0.1757)	(0.1020)	(0.1161)	(0.2145)
Wallet Matrix		0.8676	1.1041	0.8710	1.1889	1.2001	1.2540
		(0.1028)	(0.1361)	(0.2105)	(0.1723)	(0.1985)	(0.3840)
Public Directory		0.6889**	0.7117**	0.4161***	0.8108	0.6685*	1.2883
		(0.1028)	(0.1070)	(0.1412)	(0.1376)	(0.1382)	(0.4059)
LibertyX		9.9149***	4.8736***	9.6768***	4.0400***	4.4420***	3.1093**
Emerated Drive Deserv		(2.4674)	(1.2462)	(5.5882)	(1.1440)	(1.6089)	(1.5163)
Expected Price Decay		(0.2506)	(0.2646)	1.43(1	2.1311	2.3848	1.3229
New To Pitcoin		(0.2506)	(0.2040)	(0.4579)	(0.3402)	(0.4404)	(0.4175)
New To Bitcolli		(0.1287)	(0.1368)	(0.4122)	(0.1364)	(0.1765)	(0.1075)
East Dorms		1 7970***	(0.1308)	(0.4123)	(0.1304)	(0.1705)	(0.1975)
Last Dorms		(0.2554)					
West Dorms		(012001)	0.6235***				
			(0.1012)				
Off Campus			0.6634**				
-			(0.1229)				
CS Student			0.7760*	0.9122	0.7159^*	0.6580**	0.9175
			(0.1014)	(0.2630)	(0.1267)	(0.1387)	(0.3007)
Circle			0.1321***	0.2378***	0.1102***	0.1130***	0.1046***
C + 1			(0.0311)	(0.1193)	(0.0299)	(0.0354)	(0.0567)
Coinbase			0.5107***	1.6929*	0.3439***	0.3537***	0.3236***
The Calar			(0.0715)	(0.4895)	(0.0567)	(0.0675)	(0.1077)
top Coder				0.9000	(0.1004)	1.188(0.8083
Constant	0.0677***	0.0769***	0 4909***	(0.2009)	(0.1994)	(0.2407)	(0.5098)
Constant	(0.0117)	(0.0210)	(0.1185)	(0.0565)	(0.1022)	(0.1062)	(0.3153)
	(0.0117)	(0.0210)	(0.1105)	(0.0000)	(0.1032)	(0.1002)	(0.0100)
Observations	3.108	3.108	3.108	810	2.298	1.766	532
	3,200	5,200	- 0- 1 - 12	1 D (1	-,	-1.00	

Robust Std. Errors in Parentheses

*** p<0.01, ** p<0.05, * p<0.1

Density of Computer Science Students



Above and Below the Median Density of Tech Talent, Early Bitcoin Users, and Early Adopters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	ICO in Dorms	ICO in Dorms	ICO in Dorms	ICO in Dorms	ICO in Dorms	ICO in Dorms	ICO in Dorms	ICO in Dorms
	Top Coders	Other Students	BM BTC Adopters	AM BTC Adopters	BM CS Students	AM CS Students	BM Early Adopters	AM Early Adopters
Top 25% Waiting List	0.8238	1.1974	0.8191	1.2981	1.3696	0.9343	0.3317	1.2519
	(0.3141)	(0.3587)	(0.3241)	(0.4043)	(0.4434)	(0.3280)	(0.2479)	(0.3581)
Delayed	0.4522^{**}	1.4340	0.6962	1.3197	0.8465	1.1274	0.9237	1.0058
	(0.1828)	(0.3677)	(0.2542)	(0.3639)	(0.2755)	(0.3321)	(0.3153)	(0.2966)
Top 25% Waiting List	3.7971**	1.6398	4.4449***	1.1698	3.2689***	1.1729	8.8761***	1.6336
* Delayed	(1.9889)	(0.6247)	(2.1749)	(0.4656)	(1.3970)	(0.5267)	(7.4363)	(0.6048)
All Delayed	1.1361	0.8202	0.9436	0.9726	0.8032	1.0222	0.9393	0.9957
-	(0.4049)	(0.1936)	(0.3132)	(0.2539)	(0.2312)	(0.2830)	(0.3291)	(0.2419)
Privacy Text	0.9538	0.6157***	0.9024	0.5955***	0.8109	0.6606**	0.5897**	0.7977
	(0.2336)	(0.1090)	(0.1920)	(0.1161)	(0.1668)	(0.1348)	(0.1365)	(0.1483)
Wallet Matrix	1.1866	1.1744	1.0770	1.3126	1.3852	1.0043	1.0087	1.2620
	(0.3010)	(0.2084)	(0.2410)	(0.2542)	(0.2800)	(0.2116)	(0.2381)	(0.2319)
Public Directory	0.8615	0.8034	0.8323	0.8088	0.7048	0.9205	0.8461	0.7636
-	(0.2528)	(0.1696)	(0.2093)	(0.1898)	(0.1850)	(0.2092)	(0.2269)	(0.1736)
LibertyX	3.4013**	4.1262***	4.7283***	3.8124***	8.8509***	2.2030*	5.9230***	3.2899***
	(1.8527)	(1.3877)	(1.8516)	(1.6077)	(3.7365)	(0.9635)	(2.3961)	(1.3166)
Expected Price Decay	2.8393***	1.8891***	1.6998**	2.5455***	1.3024	3.0147***	1.9787***	2.2813***
	(0.7684)	(0.3792)	(0.4593)	(0.5286)	(0.3217)	(0.6424)	(0.5116)	(0.4779)
New To Bitcoin	0.5162**	0.7582	0.6172	0.6053**	0.6443	0.5954*	0.8982	0.5214**
	(0.1689)	(0.2290)	(0.4112)	(0.1469)	(0.2144)	(0.1724)	(0.3686)	(0.1379)
CS Student	0.7562	0.6677*	0.6369	0.7885	0.8709	0.7887	0.6340	0.7549
	(0.2096)	(0.1603)	(0.1757)	(0.1839)	(0.2461)	(0.1841)	(0.1888)	(0.1690)
Circle	0.1909***	0.0800***	0.1304***	0.0993***	0.1109***	0.1160***	0.1410***	0.1025***
	(0.0811)	(0.0286)	(0.0514)	(0.0378)	(0.0463)	(0.0418)	(0.0601)	(0.0366)
Coinbase	0.3004***	0.3584***	0.4000***	0.2997***	0.4886***	0.2650***	0.6443*	0.2355***
	(0.0921)	(0.0702)	(0.1003)	(0.0663)	(0.1124)	(0.0631)	(0.1704)	(0.0520)
Top Coder	(0.0022)	(0.0102)	0.8214	1.4421	1.3637	1.0597	0.9532	1.2264
10p court			(0.2288)	(0.3401)	(0.3598)	(0.2488)	(0.2945)	(0.2753)
Constant	0.4994	0.3001***	0.4438	0.2969***	0.2923***	0.3785**	0.2557***	0.4294**
constant	(0.2362)	(0.1143)	(0.3279)	(0.1085)	(0.1250)	(0.1518)	(0.1190)	(0.1685)
	(0.2002)	(01210)	(0.0210)	(0.2000)	(0.2200)	(0.1010)	(0.2200)	(012000)
Observations	697	1.601	1.018	1,280	993	1.305	1.021	1.277
Robust Std. Errors in Parentheses								

*** p<0.01, ** p<0.05, * p<0.1

All Delayed versus None Delayed



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Abandonment Curve (Full Sample)





Delayed versus Not and Early Adopters



Spillovers within Dorms (NEA)

Above versus Below Median Share of Delayed Early Adopters



% Adoption

Spillovers and Microgeography

Floors: Above versus Below Median Share of Delayed Early Adopters (NEA Only)



Spillovers and Microgeography

Small Dorms: Above versus Below Median Share of Delayed Early Adopters (NEA Only)



Spillovers and the S-Curve

Dorms: Above versus Below Median Share of Delayed Early Adopters (NEA Only)



Key Limitations

- We are studying the very beginning of an S-curve. Not clear how this translates to the "majority"
- The delay was only 2 weeks, and no variation in length of delay
- It is MIT so LATE is strange (but perhaps most of the bias may go in the opposite direction)
- Abandonment is slightly unusual as you get a reward in cash



Summary

- Delaying early adopters increases technology abandonment
- There appear to be spillovers from this effect on peers
- Role of reputation and "identity" as technology gatekeepers?
- Overall, it is difficult to speed up technology adoption
- Partly because there is a natural order to it, and it backfires to disturb it



Thank You! catalini@mit.edu

