# Bitcoin Adoption and Beliefs in Canada

**Daniela Balutel**, **Christopher S. Henry**, **Jorge Vásquez**,
**Marcel Voia**

Université d'Orléans & A.I. Cuza University – Université Clermont Auverge / CERDI – Smith College – Université d'Orléans .

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# Road Map

- Motivation
- Theoretical Model
- Data
- Empirical Strategy
- Discussion of Results
- Conclusion

# Background and motivation

*To begin with basics, the term 'crypto-currency' is a misnomer 'crypto,' yes, but 'currency,' no. For something to be considered a currency, it must act as a reliable store of value, and you should be able to spend it easily. These instruments possess neither of these characteristics, so they do not constitute 'money.'*

*Governor Stephen S. Poloz, 14 December 2017*

- Bitcoin is still in early stages by all available evidence, however:
  - This can change quickly (S-curve)
  - Widespread adoption would have serious implications for central banks.
  - Introduction of CBDC, (Deputy Governor Timothy Lane speech).
- Understanding drivers of diffusion, surveys by:
  - Bank of Canada: Bitcoin Omnibus Survey: to monitor trends in the adoption and use of Bitcoin and other cryptoassets (2016-2019).
  - Federal Reserve Bank of Atlanta: Measuring Consumer Cryptocurrency Adoption and Use (2014-2019)
  - Oesterreichische Nationalbank: Future importance of Bitcoin for payments (2018).

# Possible mechanisms of Bitcoin diffusion

- Beliefs about the future - adopters are anticipating BTC will have value in the future even if it is not yet apparent
- Network effects - Metcalfe's Law – value of a network of size n increases order $n^2$ via: Facebook, Twitter, Amazon, etc.
- Social learning - adoption is influenced by information we get from our peers.
- Speculation / price - may drive adoption from not regular type investors
- Bitcoin as cryptoasset - Is Bitcoin now a legitimate part of a diversified portfolio? Is investment driving adoption?
- Criminal activity - both directions: from investors (transfer illicit money) and toward investors (hacking/scamming)

# Model Overview

- We introduce uncertainty and gradual learning to a standard adoption diffusion model (*a la* Bass).
- **Uncertainty:** technology can be either "good" or "bad."
- Adoption decisions depends on agents' *beliefs* about the technology.
- Also, agents' adoption choices may generate useful information to others.
- **Learning process:** a good technology always survives, but a bad one can collapse at a positive rate.
  - Breakdown rate depends on the level of adoption.
    - In such event, an adopter faces a normalized loss equal to 1.
    - Idea: a bad technology is more likely to fail when more people adopt it (e.g. congestion/delays, cyber-attacks).

  $\Rightarrow$ The *survival* of Bitcoin provides information about its quality

  - "No news is good news" (e.g., Keller and Rady, 2015, TE).

# The Dynamics of Adoption, Beliefs and Survival

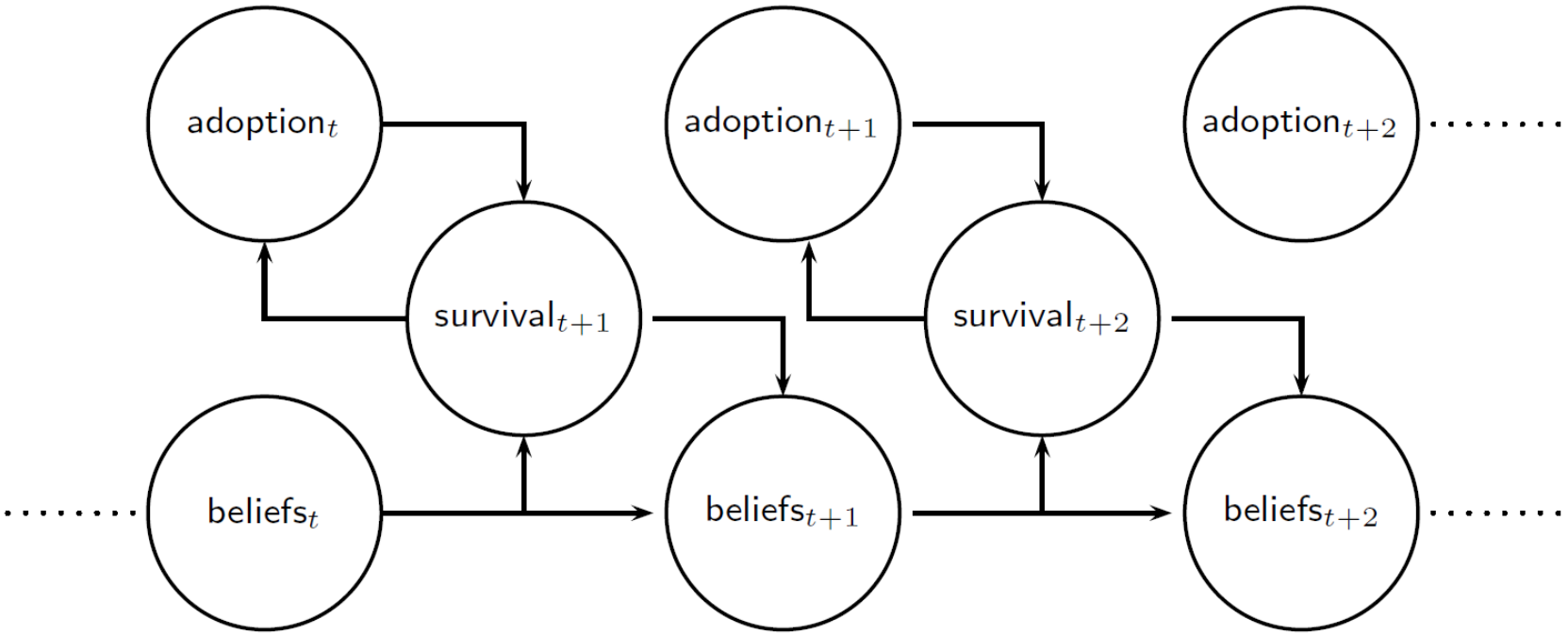
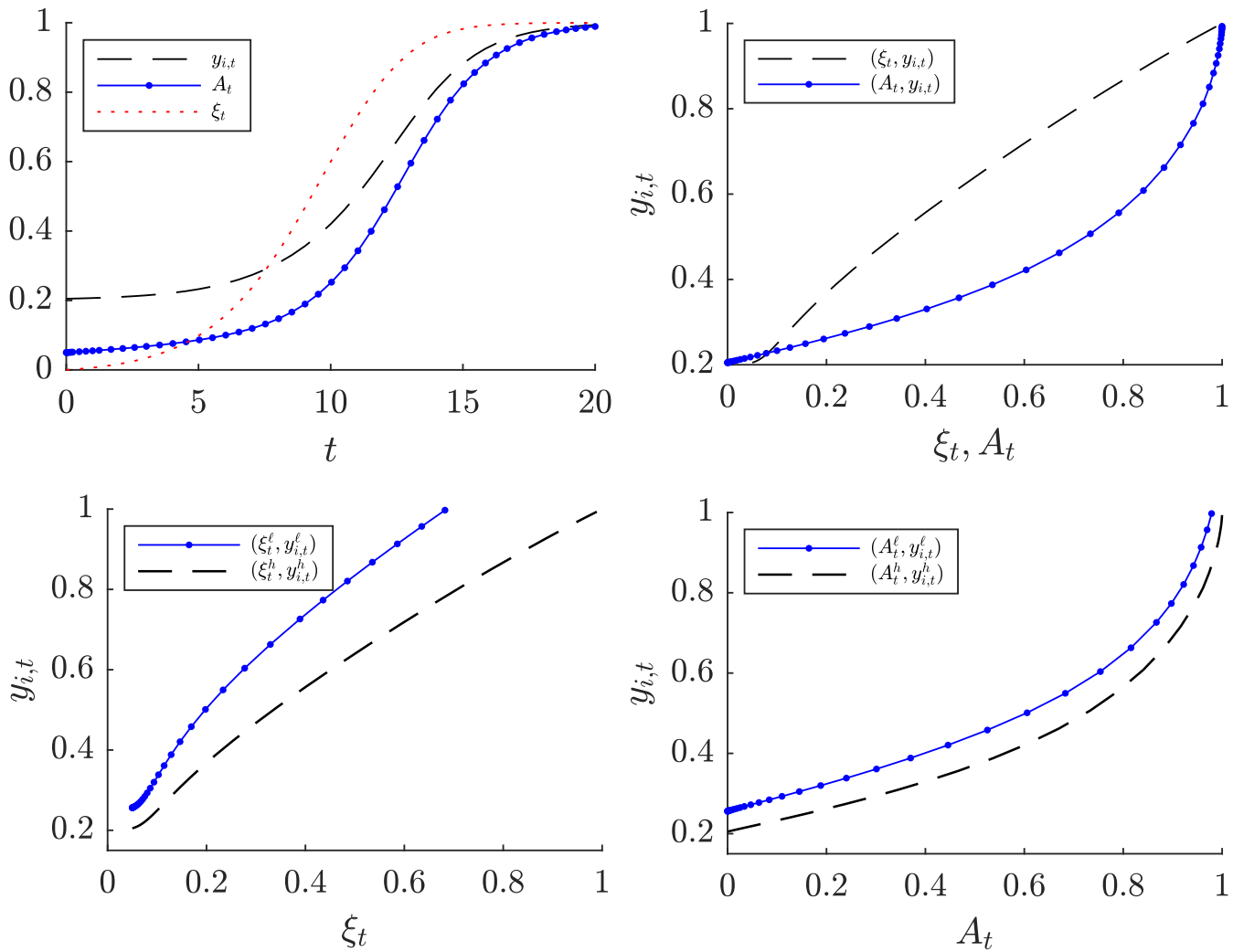



Figure: Starting from a common prior belief in period t that the technology is good, current adoption and beliefs affect the survival of Bitcoin, which in turn affect the individual decision to adopt Bitcoin. The survival rate and current beliefs then influence beliefs in the next period, and so on.

# Predictions of the model via simulation




**Top left:** Aggregate and individual adoption increases with time. **Top right:** Individual adoption increases with higher beliefs and aggregate adoption. **Bottom:** Decreased adoption cost leads to higher individual adoption as a function of beliefs (left) and aggregate adoption (right).

# Connecting the model with the data

$$a_{it} = Pr(\beta_0 + \beta_1 A_{it} + \beta_2 \xi_{it} + \beta_3 \xi_{it} A_{it} + \beta_c X_i) + \epsilon_{it}$$

**Model predictions:**

1. $(A_t, \xi_t) \uparrow$ as $t \uparrow$.

   $\implies$ $Pr(a_{it} = 1)$ is positively related to $A_t$ and $\xi_t$.

2. $\downarrow$ in adoption cost $c$ $\implies$ $\uparrow A_t$ and $\uparrow \xi_t$.

   $\implies$ $Pr(a_{it} = 1) \uparrow$ as $c \downarrow$.
   Adoption cost $c$ proxied by age group; assume that 18-35 year olds have lower costs vs those aged 35+.

**Empirical interpretation:**

1. $\hat{\beta}_1, \hat{\beta}_2$ significant and $> 0$, $\hat{\beta}_3$ significant and $< 0$.
2. Simultaneity: individuals with high beliefs are more likely to adopt and, conversely, individuals who adopt are more likely to have high beliefs.
3. As functions of $A_{it}$, $\xi_{it}$, $\Pr(a_{it} = 1)$ higher for those with lower adoption costs.

# Empirical strategy: Two-stage CF approach

1. First stage - Model of Beliefs:

$$\xi_{it} = \delta X_{it} + \gamma Z_{it} + u_{it}$$

$\xi_{it}$ is the belief of individual $i$ at time $t$, $X_{it}$ are individual level observables (age,$age^2$, gender, education, etc.); $Z_{it}$ is an exclusion restriction;

2. Second Stage - Model of Adoption:

$$a_{it} = \Pr(\beta_0 + \beta_1 A_{it} + \beta_2 \xi_{it} + \beta_3 \xi_{it} \times A_{it} + \beta_c X_{it} + \theta \widehat{u}_{it}) + \varepsilon_i$$

$a_{it}$ is the individual $i$'s Bitcoin adoption at time $t$, $A_{it}$ is the local network, $\widehat{u}_{it}$ is a control function derived from the first stage.

# Identification

Baseline model does not account for the fact that beliefs are likely to be endogenous.

- Positive beliefs about BTC may drive adoption.
- Or, adopting may cause us to have high beliefs (confirmation/hindsight bias)

Need an exclusion restriction for first stage: Use supply side to construct $Z_{jt}$: $\Delta ATM_{jt}$ is the growth in Bitcoin ATMs in region $j$ at time $t$.

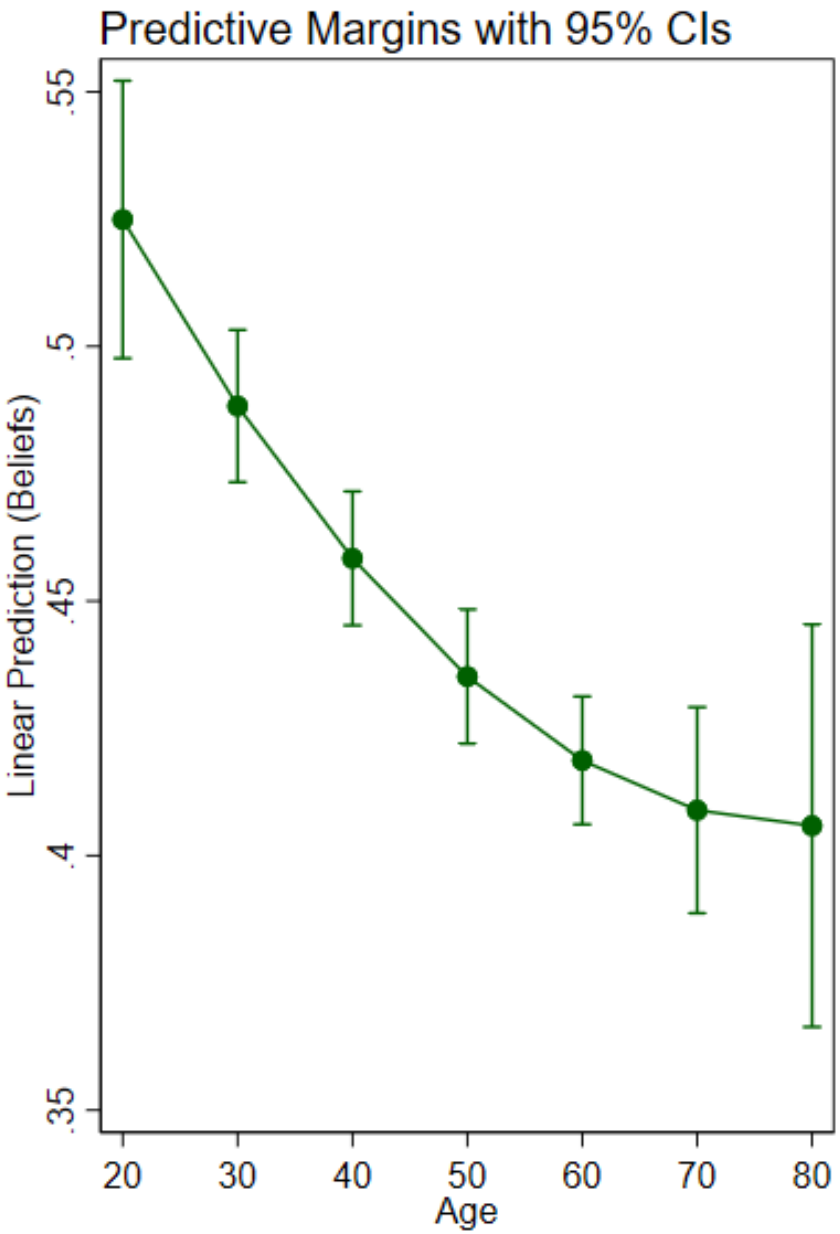
- ATMs' suppliers provide this service after observing an increase in Bitcoin demand.
- Regional change in Bitcoin ATMs does not follow contemporenous Bitcoin adoption.

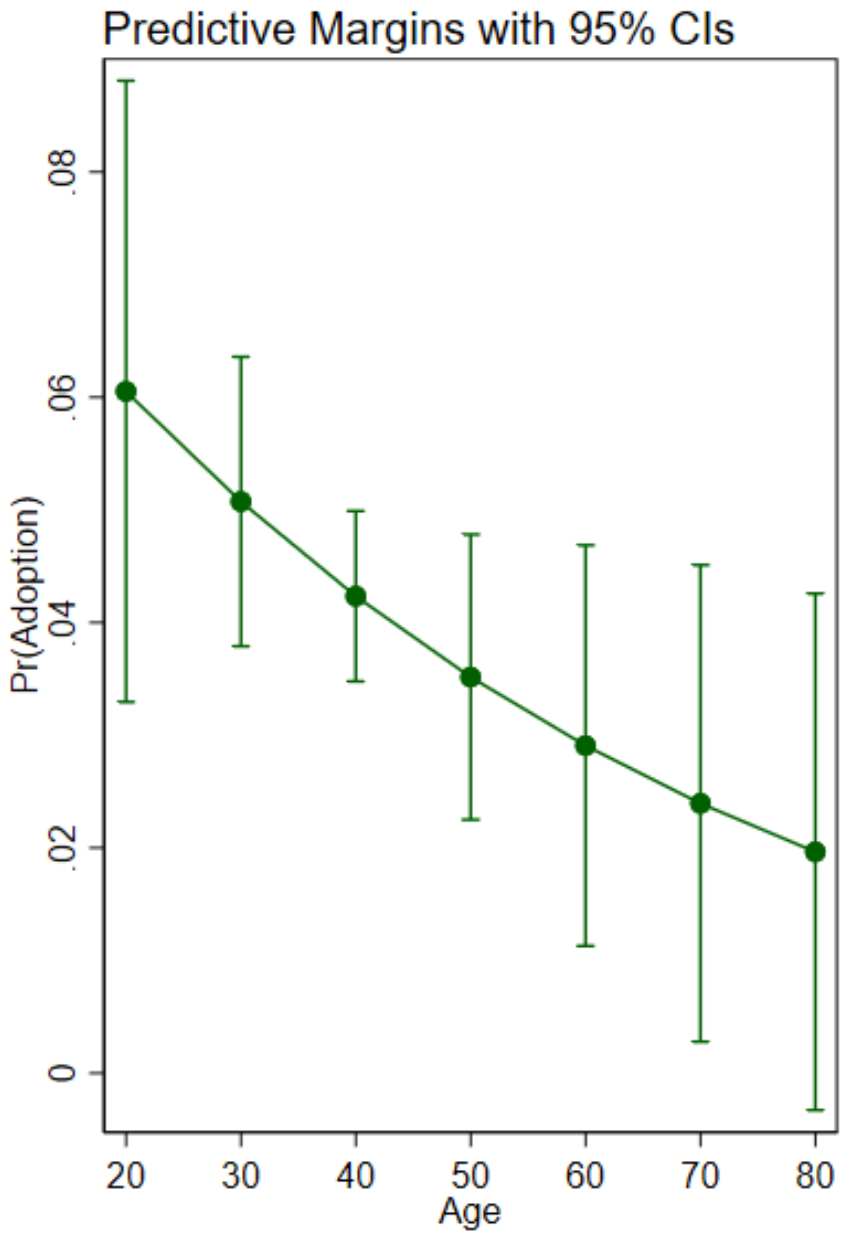
Table: **Correlation of Bitcoin ATMs Growth with Bitcoin Adoption**

| $\rho$ | Btc ATM Growth (2016-2017) | Btc ATM Growth (2017-2018) |
|---|---|---|
| Bitcoin Ownership | -0.0016 | 0.005 |

- The nonlinearity of age is used as an identification mechanism as there is a difference in functional form between the two-stage

# Predictive Margins of Beliefs and Adoption function of Age

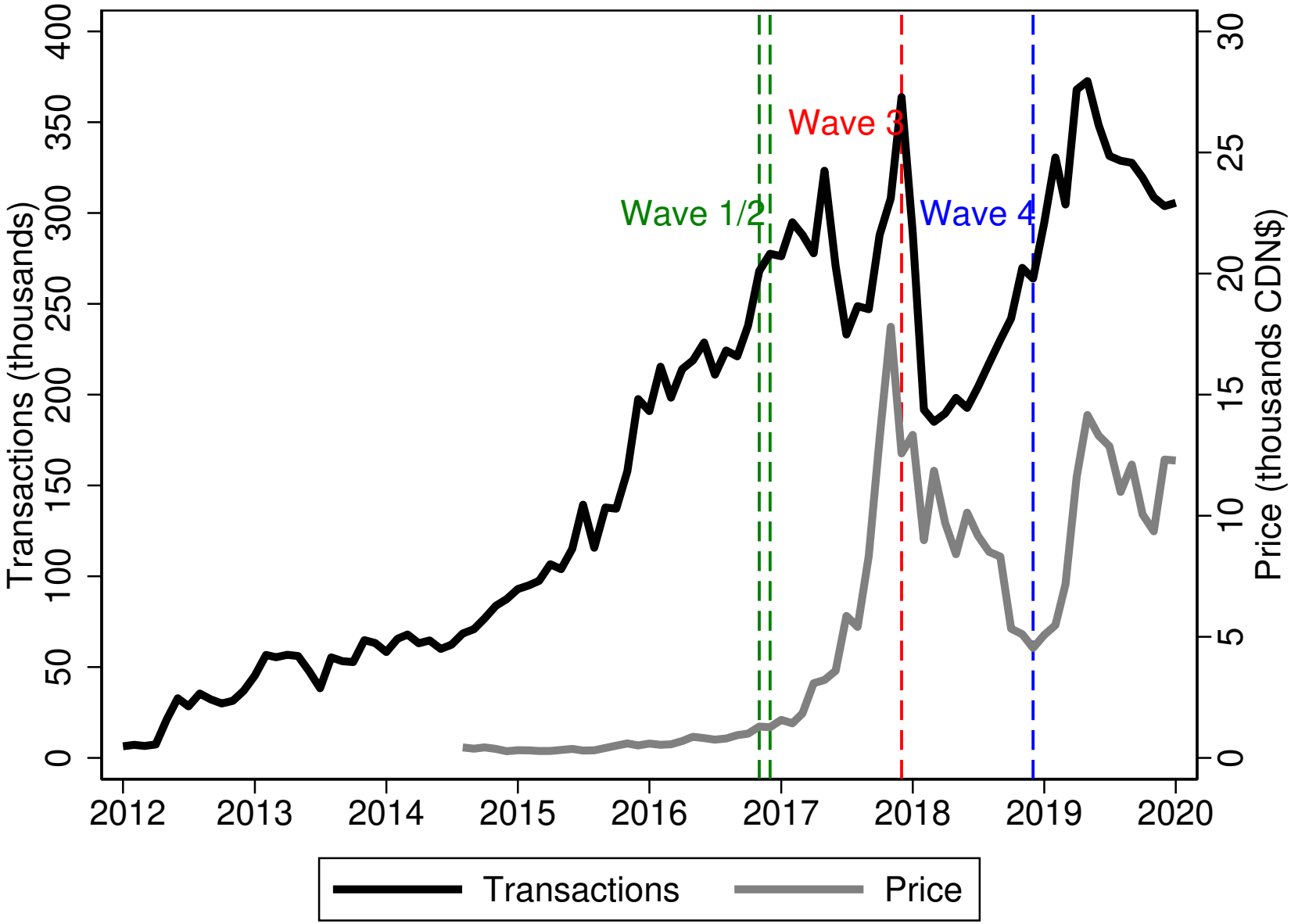


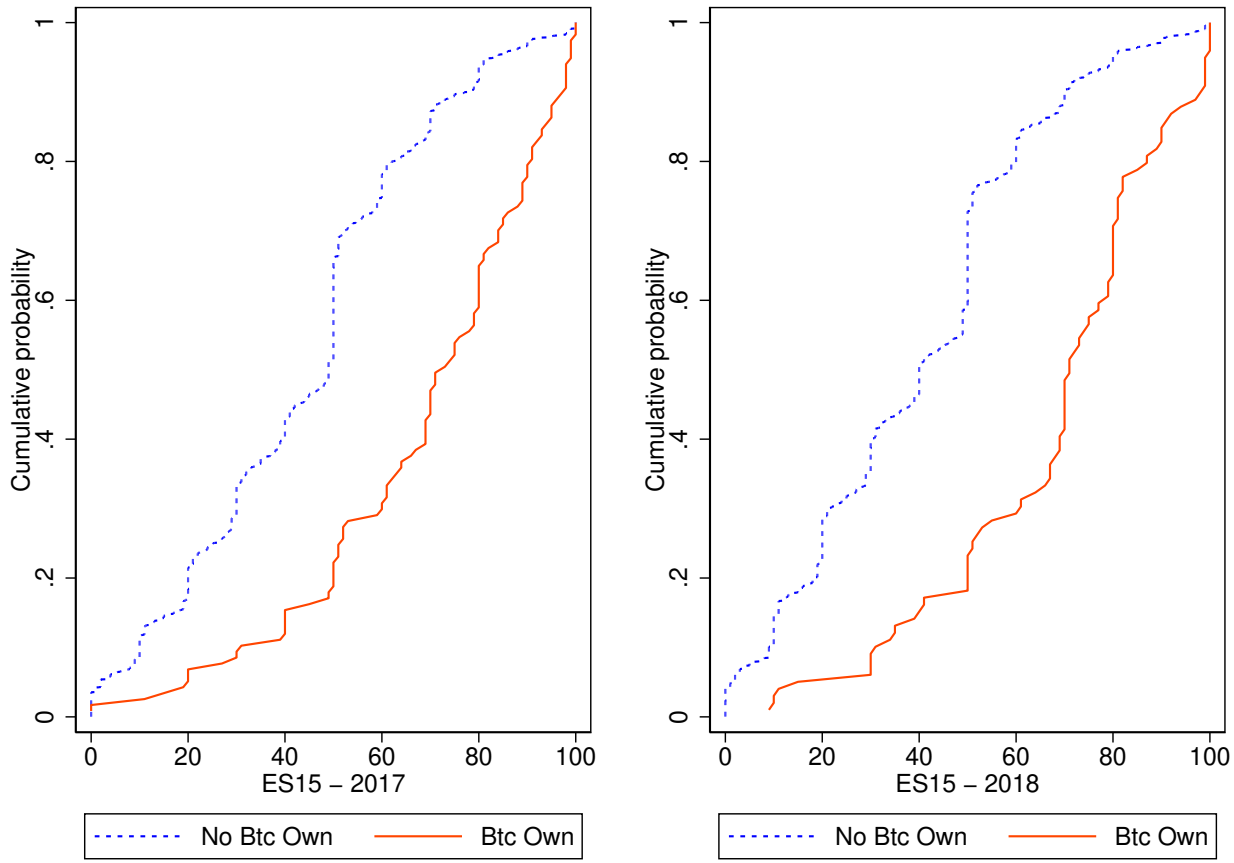
# Data: Bitcoin Omnibus Survey (BTCOS)

- First conducted in Nov. / Dec. of 2016 (no info on beliefs).
  - Conducted annually since.
  - Originally a monitoring tool, scope has evolved over time.
- Our analysis uses data from 2017 and 2018 iterations.
- Questionnaire includes: awareness and ownership; level of BTC holdings; reasons for ownership/non-ownership; knowledge of BTC features; cash holdings.
  - **Beliefs about the future of Bitcoin.**
- Key variables:
  1. Individual adoption decision of BTC in 2017, 2018 - $a_{i,t}$.
  2. Beliefs about BTC survival in 15 years - $\xi_{it}$
  3. Local network variable, (lagged probability of having friends that own Bitcoin) - $A_{it}$

# Waves of BTCOS Survey



# "How likely do you think it is that the Bitcoin system will fail or survive in the next 15 years?" ($ES15_i$)




The graph shows the expected likelihood of survival of Bitcoin in 15 years: The red line represents the cumulative distribution function conditional on positive adoption of Bitcoin, the green line is the same conditional on no adoption.

# Bitcoin Adoption in Canada ($a_i$)

| $a_i$ | 2016 | 2017 | 2018 |
|---|---|---|---|
| Overall | **3.2** | **4.3** | **5.2** |
| Gender | | | |
| Male | 4.4 | 6.6 | 6.7 |
| Female | 2.2 | 2.1 | 3.7 |
| Age | | | |
| 18-34 | 9.1 | 11.1 | 10.5 |
| 35-54 | 1.6 | 3.2 | 4.9 |
| 55+ | 0.5 | 0.5 | 1.7 |
| Education | | | |
| High School | 3.8 | 3.7 | 2.3 |
| College | 1.5 | 3.1 | 5.7 |
| University | 4.3 | 6.7 | 9.1 |
| Income | | | |
| <30K | 3.1 | 4.3 | 2.8 |
| 30k-69K | 3.9 | 5.6 | 4.8 |
| 70K+ | 3.7 | 4.3 | 7 |
| Region | | | |
| British Columbia | 2.8 | 5.2 | 6.3 |
| Prairies | 2.1 | 4.1 | 6 |
| Ontario | 2.5 | 3.9 | 5.2 |
| Quebec | 5.5 | 5.1 | 4.6 |
| Atlantic | 3.2 | 3.1 | 2.8 |

# First stage results: BTC Survival beliefs

| VARIABLES | 2017 | 2018 | 2018 (Price) |
|---|---|---|---|
| Age | -0.584*** | -0.645*** | -0.646*** |
| | (0.181) | (0.218) | (0.227) |
| Age squared | 0.0037** | 0.0036 | 0.0037 |
| | (0.00188) | (0.00228) | (0.00237) |
| Expected Return | | | 1.901*** |
| | | | (0.728) |
| | (0.181) | (0.218) | (0.227) |
| ATM growth: AT | -1.256 | 0.0552 | 0.712 |
| | (1.785) | (2.362) | (2.533) |
| ATM growth: PR | -3.615* | -5.675** | -6.056** |
| | (1.854) | (2.570) | (2.712) |
| ATM growth: QC | -4.703** | -4.990** | -5.056* |
| | (1.960) | (2.512) | (2.671) |
| ATM growth: ON | -0.656 | -3.773* | -4.408* |
| | (1.715) | (2.253) | (2.388) |
| Other demographics | yes | yes | yes |
| Observations | 2,623 | 1,987 | 1,787 |
| R-squared | 0.045 | 0.054 | 0.065 |

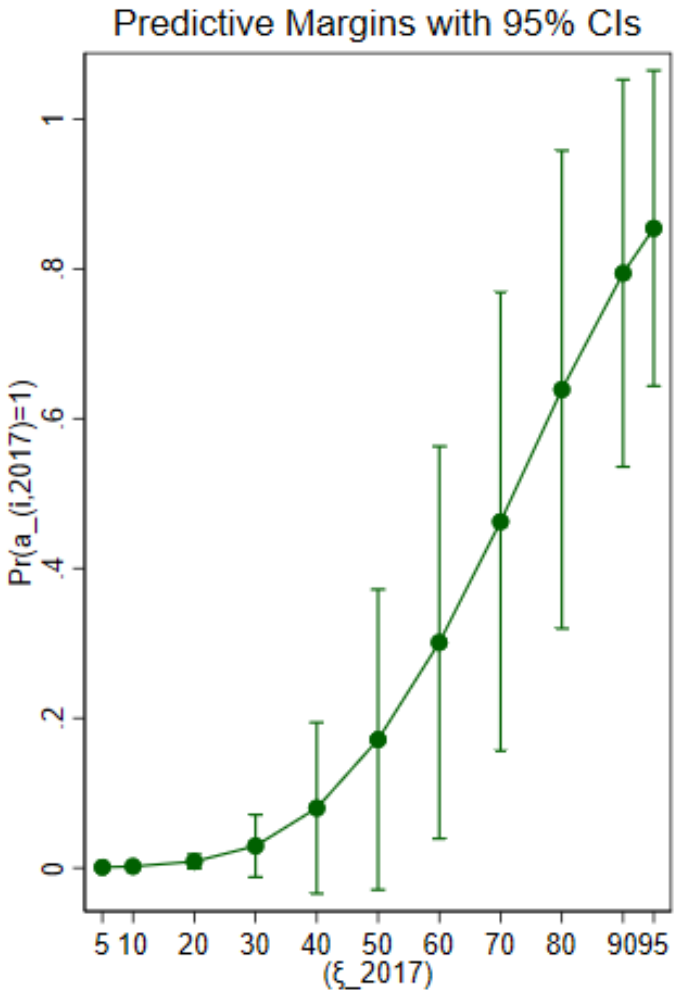
Note: Results obtained using Robust standard errors;***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

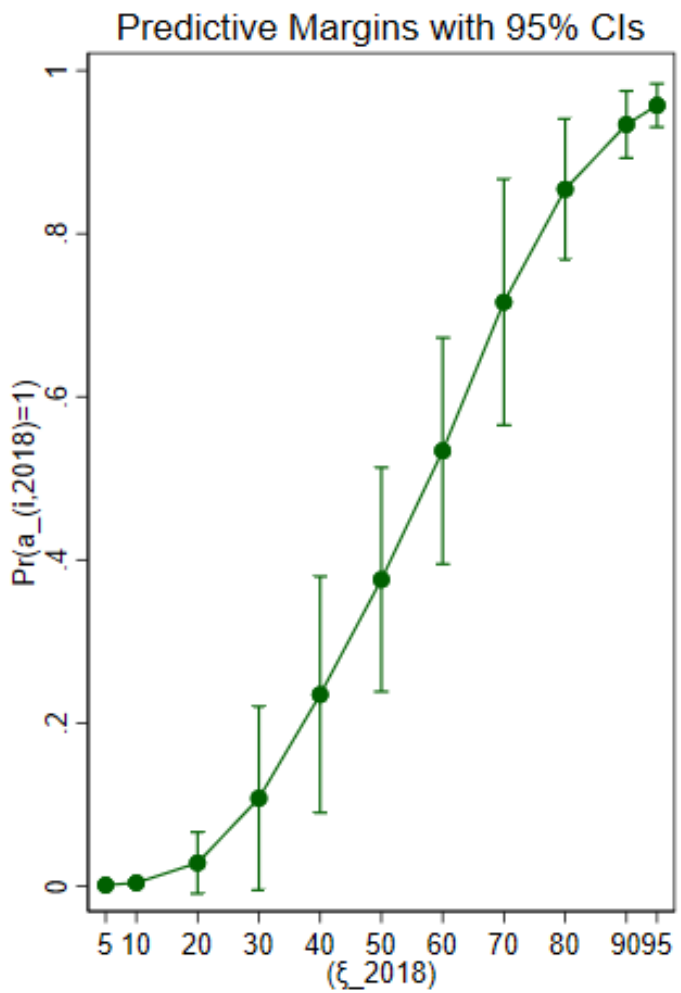
# Second Stage Results: Marginal Effects Adoption

| VARIABLES | 2017 | 2018 | 2017 | 2018 | 2018 (CF with price) |
|---|---|---|---|---|---|
| Beliefs ($\xi_{it}$) | 0.169*** | 0.204*** | 0.432*** | 0.722*** | 0.551*** |
| | (0.017) | (0.013) | (0.086) | (0.093) | (0.08) |
| Network ($A_{it}$) | 0.588*** | 0.393*** | 0.452* | 0.319*** | 0.411*** |
| | (0.210) | (0.029) | (0.273) | (0.039) | (0.054) |
| Social Interaction ($\xi_{it} \times A_{it}$) | -0.518*** | -0.493*** | -0.481** | -0.563*** | -0.619*** |
| | (0.167) | (0.157) | (0.194) | (0.145) | (0.151) |
| CF ($\widehat{u_{it}}$) | | | -0.003** | -0.005*** | -0.003*** |
| | | | (0.001) | (0.0009) | (0.0008) |
| Age: 35-55 | -0.0376*** | -0.0416*** | -0.026*** | -0.013 | -0.023* |
| | (0.005) | (0.014) | (0.001) | (0.009) | (0.014) |
| Age: $>$ 55 | -0.058*** | -0.064*** | -0.042*** | -0.008 | -0.035*** |
| | (0.004) | (0.012) | (0.003) | (0.011) | (0.012) |
| Gender: Female | -0.029** | -0.028** | -0.035** | -0.021* | -0.027* |
| | (0.013) | (0.012) | (0.017) | (0.011) | (0.014) |
| Income: 50k-99k | -0.005 | 0.041*** | -0.006 | 0.039*** | 0.044*** |
| | (0.006) | (0.012) | (0.005) | (0.017) | (0.010) |
| Income: 100k+ | -0.011** | 0.039*** | -0.009 | 0.028** | 0.033** |
| | (0.005) | (0.015) | (0.006) | (0.014) | (0.015) |
| Other demographics | yes | yes | yes | yes | yes |
| Observations | 2,623 | 2,623 | 1,987 | 1,987 | 1,787 |

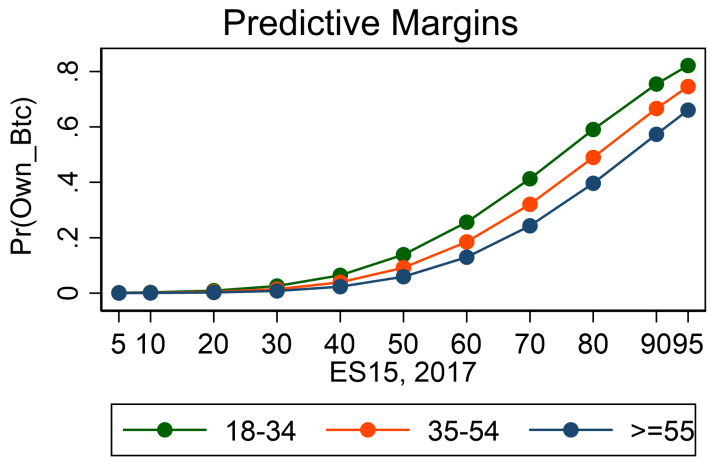
Note: Results obtained using Bootstrapped standard errors; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

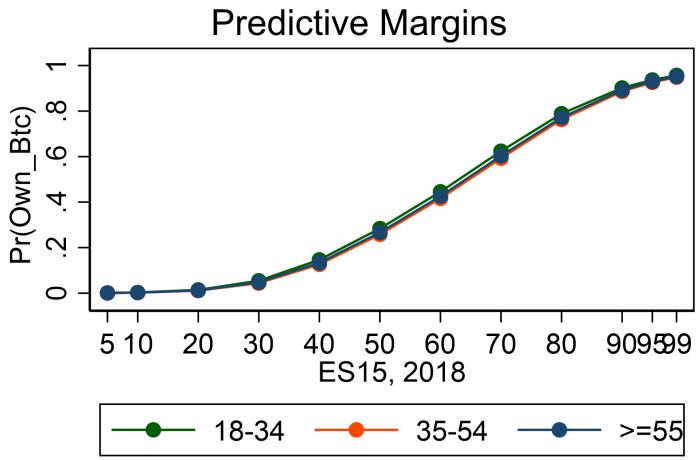
# Adoption is a Positive Function of Beliefs

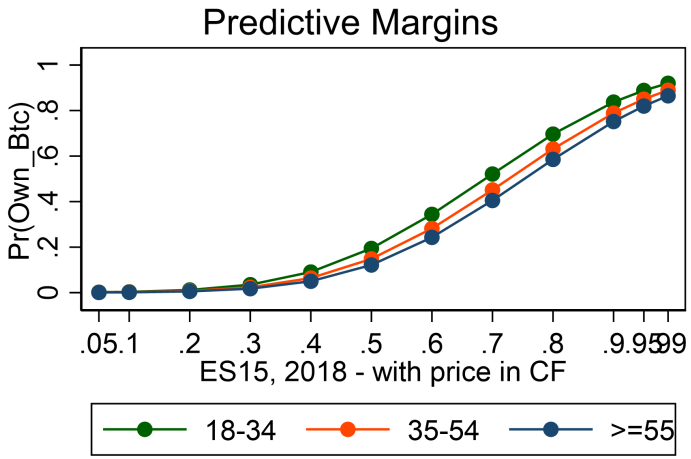


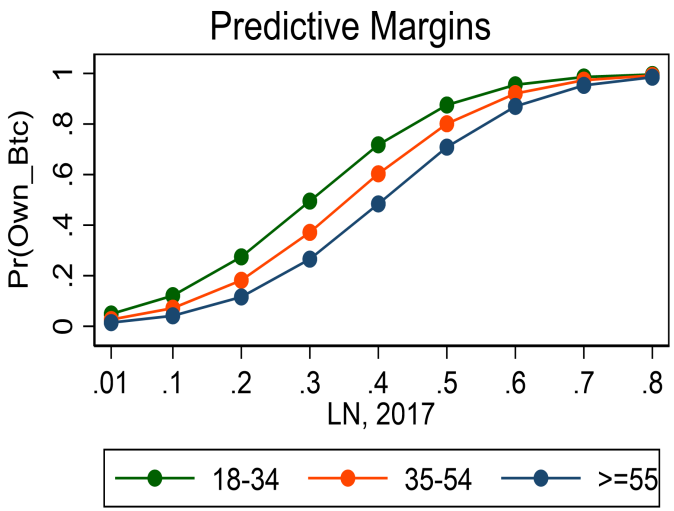
# Predictive Margines by Age Effects of Beliefs

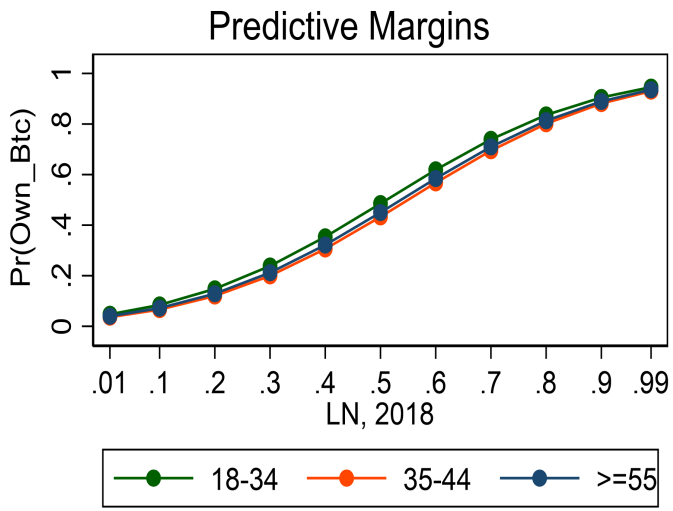


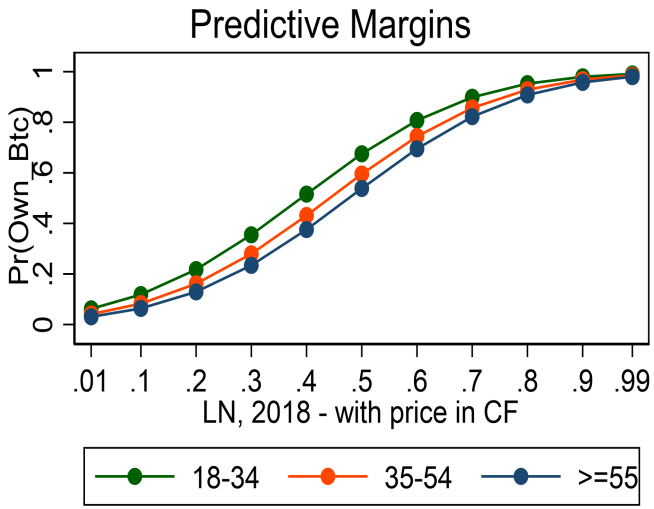



# Predictive Margines by Age Effects of Local Network - Counterfactual



# Conclusions

- Theoretical model predicts how individual learning effects, payoff-based network externalities, and information externalities shape adoption decisions.
- Using the BTCOS 2017 and 2018 surveys we test and quantify the behavioral determinants of individual Bitcoin adoption.
- The data validates all testable predictions: We find that Bitcoin survival beliefs (+), network effects (+), social interaction (-) and adoption costs (negative age effects and positive income effects)
- The signs of the predicted variables of interest suggest a predicted S-shape for Bitcoin adoption.
- The results suggest the Bitcoin adoption is in their early stages in Canada .