A Bayesian DSGE Approach for Modelling Cryptocurrency

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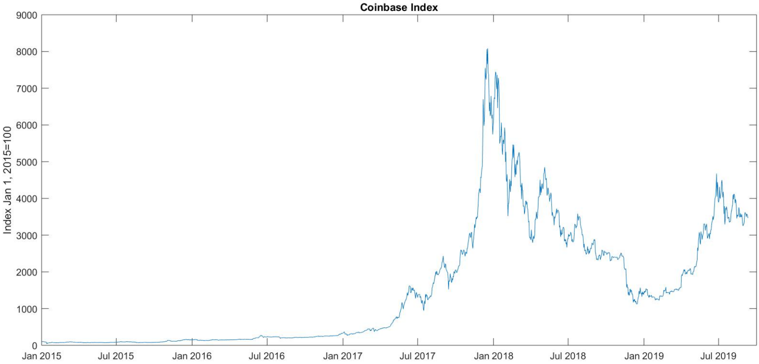
Motivation

- Cryptocurrency has recently gained considerable interest from investors, central banks and governments worldwide.
- Some central banks are exploring the possibility of using cryptocurrency. In a recent report, Christine Lagarde, President of the European Central Bank, has anticipated the necessity to issue a digital.
- A large number of companies and banks have created the Enterprise Ethereum Alliance in order to customise Ethereum for industry players.
- PayPal announced that its users can buy, sell and hold select Cryptocurrencies directly using their Cash or Cash Plus account.
- Electric car maker Tesla announced on Feb 8, 2021 that it invested 1.5 USD billion in Bitcoin, making it the biggest investment by a mainstream corporation into the most popular cryptocurrency.
- The value of cryptocurrencies has experienced exponential growth. However, their volatility is large with regular daily swings up to 30%.

Coinbase Index (CBI)



What is a cryptocurrency?

- A cryptocurrency is the private sector counterpart of government issued currency.
- Cryptocurrency is issued in divisible units that can be easily transferred in a transaction between two parties.
- Digital currencies are intrinsically useless electronic tokens that travel through a network of computers.
- For example, the key innovation of the Bitcoin system is the creation of a payments system across a network of computers that does not require a trusted third party to update balances and keep track of the ownership of the virtual units.
- The technology behind the system is called Blockchain (i.e., it is a growing list of records, called blocks, that are linked using cryptography).

Our Contributions

- We develop and estimate a DSGE model in order to evaluate the economic repercussions of cryptocurrency: our model extends standard monetary business cycle models by including demand and supply of cryptocurrency.
- We contribute to the ongoing debate concerning the nature of cryptocurrency by suggesting that cryptocurrency should be treated similarly to government currency.
- We compare the responses of real money balances for government currency and cryptocurrency to several demand and supply shocks driving the economy including monetary policy shocks.
- We evaluate the response of main macroeconomic fundamentals to productivity shocks for production of cryptocurrency.
- We are able to quantify the contributions of cryptocurrency demand and supply shocks through a variance decomposition analysis.

Results

- Strong substitution effect between the real balances of government currency and those of cryptocurrency in response to technology and monetary policy shocks.
- Cryptocurrency productivity shocks imply a fall in the nominal exchange rate. Output and inflation fall whereas the nominal interest rate increases. However, the magnitude of the effects of these shocks is much lower than "traditional" shocks.
- Specific supply shocks play an important role in the variation of cryptocurrency demand and nominal exchange rate.
- The functional form of the utility function matters in terms of the responses of several macroeconomic aggregates to crypto shocks.
- A gain in cryptocurrency productivity induces stronger decreases in output and inflation in the case of non-separable utility function between consumption and real balances of cryptocurrency.
- The larger is the response of the monetary policy rule to a change in government currency growth the stronger is decline in output.

Modelling Cryptocurrencies: Previous Literature

- Athey et al. (2017) found that the exchange rate of fiat currency to Bitcoin is determined by: (*i*) the steady state transaction volume of Bitcoin; (*ii*) the evolution of beliefs about the likelihood that the technology survives.
- Sockin and Xiong (2018) developed a model in which the cryptocurrency has two main roles: (*i*) to facilitate transactions of certain goods among agents; (*ii*) as the fee to compensate coin miners for providing clearing services for the transactions.
- Garratt and Wallace (2018) and Schilling and Uhlig (2019) focused on the exchange rate of Bitcoin and its theoretical determinants.
- Fernández-Villaverde and Sanches (2019) built a model of competition among privately-issued fiduciary currencies. They found that the economy will end up in a state of hyperinflation.

The Role of Money in Optimizing Models: Previous Literature

- Nelson (2002) presented empirical evidence for the US and the UK that real money base growth matters for real economic activity.
- Christiano et al. (2005) have included money among the variables of interest finding that the interest rate and the money growth rate move in opposite directions in response to a monetary policy shock.
- Ireland (2004) has shown that, if changes in the real stock of money have a direct impact on the dynamics of output and inflation, then that impact must come simultaneously through both the IS and the Phillips curve relationships.
- Andrés et al. (2009) have analysed the role of money in a general framework focusing on the US and the EU. Their findings showed the forward-looking character of money demand.

Theoretical model: outline

The economy consists of:

- The representative household.
- A continuum of entrepreneurs indexed by n, where $n \in [0, 1]$, under perfect competition producing cryptocurrency.
- A continuum of monopolistically competitive firms, indexed by $i \in [0, 1]$, producing differentiated varieties of intermediate production goods, and a single final production good firm combining the variety of intermediate production goods under perfect competition.
- Monetary authority sets the nominal interest rate following a modified version of the Taylor rule.
- We abstract from capital accumulation.

Model: Households

The representative household of the economy maximizes the following expected stream of utility:

$$\max_{\{C_t, H_t, B_t, M_t^g, M_t^c\}} E \sum_{t=0}^{\infty} \beta^t A_t \left[u\left(C_t, \frac{\frac{M_t^g}{P_t}}{E_t^g}, \frac{\chi_t \frac{M_t^c}{P_t}}{E_t^c} \right) - \eta H_t \right] \tag{1}$$

The budget constraint each period is given by:

$$M_{t-1}^g + \chi_{t-1} M_{t-1}^c + T_t + B_{t-1} + W_t H_t + D_t = P_t C_t + \frac{B_t}{R_t} + M_t^g + \chi_t M_t^c \tag{2}$$

Consumption and real balances of government currency and cryptocurrency are non-separable. Cryptocurrency enters as an alternative currency with respect to government currency. Our assumption is in line with the definition of cryptocurrency as private digital currency.

Model: Entrepreneurs

Following Sockin and Xiong (2018), we introduce a cost of producing cryptocurrency given by: $\kappa^{-\phi_t} Q_t^c$, where Q_t^c is the amount of tokens that the entrepreneur is producing.
In addition:

$$\phi_t = \xi_t + \nu_t \tag{3}$$

is the entrepreneur's productivity.
Entrepreneurs also gain a fraction $(1-\rho) \in (0,1)$ from selling the cryptocurrency to households at price $\frac{P_t}{\chi_t}$. Thus, entrepreneurs maximise their profits with respect to Q_t^c:

$$\Pi_t = \max_{\{Q_t^c\}} \left((1-\rho) \frac{P_t}{\chi_t} - \kappa^{-\phi_t} \right) Q_t^c \tag{4}$$

Model: Production Goods Firms (1)

The representative final goods-producing firm uses:

$$Y_t = \left[Y_t\,(i)^{\frac{(\theta-1)}{\theta}}\; di \right]^{\frac{\theta}{(\theta-1)}} \tag{5}$$

where θ is the price elasticity of demand for each intermediate good. The final goods-producing firm maximizes its profits by choosing:

$$Y_t\,(i) = \left(\frac{P_t\,(i)}{P_t} \right)^{-\theta} Y_t \tag{6}$$

Competition drives the final goods-producing firm's profits to zero in equilibrium, determining P_t as:

$$P_t = \left[(P_t\,(i))^{1-\theta}\; di \right]^{\frac{1}{1-\theta}} \tag{7}$$

Model: Production Goods Firms (2)

The representative intermediate goods-producing firm uses:

$$Y_t(i) = Z_t H_t(i) \tag{8}$$

As in Rotemberg (1982), the intermediate goods-producing firm faces a quadratic cost of adjusting its nominal price, measured in terms of the final good and given by:

$$\frac{\phi}{2}\left[\frac{P_t(i)}{\pi P_{t-1}(i)} - 1\right]^2 Y_t \tag{9}$$

Model: Monetary Policy

The model is closed by adding an interest rate rule for monetary policy of the form:

$$\ln\left(\frac{R_t}{R}\right) = \rho^r \ln\left(\frac{R_{t-1}}{R}\right) + (1-\rho^r)\,\rho^y \ln\left(\frac{Y_t}{Y}\right) + (1-\rho^r)\,\rho^\pi \ln\left(\frac{\pi_t}{\pi}\right) + (1-\rho^r)\,\rho^{\mu^g} \ln\left(\frac{\mu_t^g}{\mu^g}\right) + \varepsilon_t^r \tag{10}$$

where:

$$\mu_t^g = \frac{\frac{M_t^g}{P_t}}{\frac{M_{t-1}^g}{P_{t-1}}} \tag{11}$$

The monetary authority adjusts the short-term nominal interest rate in response to deviations of output and inflation from their steady-state levels as well as government currency growth.

Model: Exogenous Shocks

The preference shocks follow autoregressive processes:

$$\ln\left(A_t\right) = \rho^a \ln\left(A_{t-1}\right) + \varepsilon_t^a \tag{12}$$

$$\ln\left(E_t^g\right) = \rho^{eg} \ln\left(E_{t-1}^g\right) + \varepsilon_t^{eg} \tag{13}$$

$$\ln\left(E_t^c\right) = \rho^{ec} \ln\left(E_{t-1}^c\right) + \varepsilon_t^{ec} \tag{14}$$

Common and specific supply shocks of cryptocurrency follow autoregressive processes:

$$\ln\left(\xi_t\right) = \rho^{\xi} \ln\left(\xi_{t-1}\right) + \varepsilon_t^{\xi} \tag{15}$$

$$\ln\left(\nu_t\right) = \rho^{\nu} \ln\left(\nu_{t-1}\right) + \varepsilon_t^{\nu} \tag{16}$$

Aggregate technology shock follows autoregressive process:

$$\ln\left(Z_t\right) = \rho^z \ln\left(Z_{t-1}\right) + \varepsilon_t^z \tag{17}$$

Log-linearized equations

- IS equation: utility is non-separable $\rightarrow$ real balances for government currency and cryptocurrency appear in the IS curve.
- Money demand relationship for government currency, with income elasticity, interest semi-elasticity, elasticity of real balances of government currency with respect to government currency demand shocks and cross-elasticity with cryptocurrency.
- Money demand relationship for cryptocurrency, with income elasticity, interest semi-elasticity, elasticity of real balances of cryptocurrency with respect to cryptocurrency demand shocks and cross-elasticity with government currency.
- Phillips curve includes real balances for government currency and cryptocurrency.

Log-linearized equations (cont.)

- The FOC of the profit maximization problem of entrepreneurs shows a negative relationship between the entrepreneurs' productivity and the exchange rate between government currency and cryptocurrency.
- Entrepreneurs' productivity depends on the common productivity in the cryptocurrency sector and on the specific productivity of the entrepreneur.
- Monetary policy rule (Taylor rule) implies that the interest rate adjusts to output, inflation and government currency growth.

Estimation

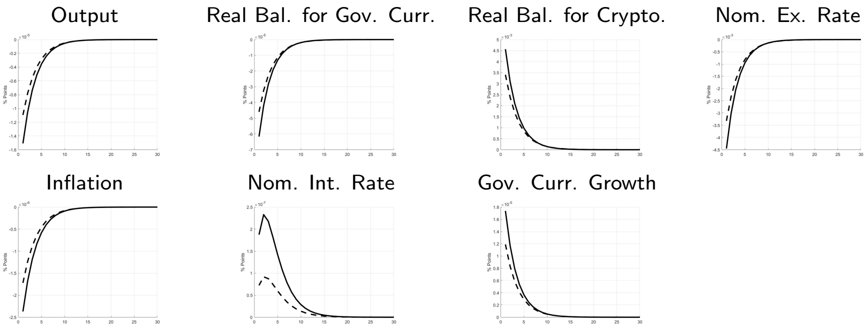
- We estimate our model using Bayesian methods for the period 2013:M6-2019:M3 $\rightarrow$ monthly data.
- Observed data: US economy.
- We construct two new series to proxy the quantity of cryptocurrency and technological development, respectively.

Shocks	**Observed Variables**
Technology Shock	Industrial Production Index
Shock to Household's Preferences	Private Consumption
Shock to Household's Demand for Government Currency	Money Stock M2
Shock to Household's Demand for Cryptocurrency	Bitcoin Price
Common Supply Shock of Cryptocurrency	Cumulative Initial Coin Offering (ICO)
Specific Supply Shock of Cryptocurrency	Nvidia Volume Weighted Average Price
Monetary Policy Shock	Effective Federal Funds Rate

Estimated Results for Endogenous Parameters

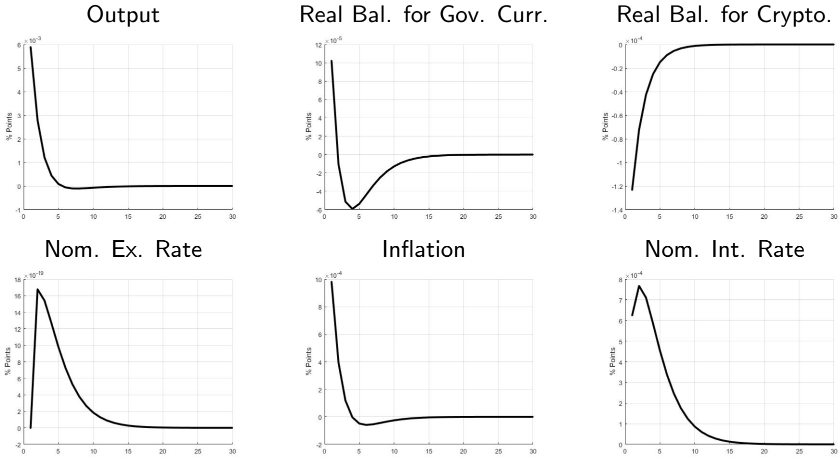
Parameter	*Symbol*	*Priors*			*Posteriors*		
		Dist.	Mean	St. Dev.	Mean	Conf. Inter.	
Output El. to Real Bal. of Gov. Currency	ω_2	G	0.200	0.050	0.195	0.102	0.284
Output El. to Real Bal. of Cryptourrency	ω_3	G	0.050	0.010	0.035	0.024	0.046
Income El. of Gov. Currency Demand	γ_1	G	0.015	0.005	0.021	0.009	0.032
Interest Semi-El. of Gov. Currency Demand	γ_2	G	0.150	0.050	0.140	0.066	0.214
El. of Real Bal. of Gov. Curr. wrt Gov. Curr. Dem. Shock	γ_3	G	0.900	0.100	0.664	0.593	0.733
Cross El. of Gov. Cur. Dem. and Crypto. Dem.	γ_4	G	0.500	0.050	0.554	0.467	0.638
Income El. Cryptocurrency Demand	γ_5	G	0.015	0.005	0.013	0.006	0.020
Interest Semi-El. of Cryptocurrency Demand	γ_6	G	0.150	0.050	0.155	0.073	0.236
El. of Real Bal. of Crypto. wrt Crypto. Dem. Shock	γ_7	G	0.800	0.100	1.034	1.014	1.053
Cross El. of Crypto. Dem. and Gov. Cur. Dem.	γ_8	G	0.600	0.100	1.011	0.985	1.037
Ex. Rate Crypto. / Gov. Cur. El. wrt Prod.	ϱ	G	0.900	0.100	0.777	0.638	0.916
Share of Crypto. Common Prod. on Crypto. Tot. Prod.	$\frac{\xi}{\phi}$	G	0.500	0.050	0.572	0.482	0.662
Interest. Rate Smoothing	ρ^r	B	0.800	0.050	0.808	0.765	0.852
Taylor Rule Coef. on Output	ρ^y	B	0.200	0.010	0.153	0.142	0.163
Taylor Rule Coef. on Inflation	ρ^π	G	1.800	0.050	1.980	1.900	2.063
Taylor Rule Coef. on Gov. Currency Growth	ρ^{μ^g}	B	0.200	0.050	0.459	0.368	0.555

Shocks to Cryptocurrency Productivity

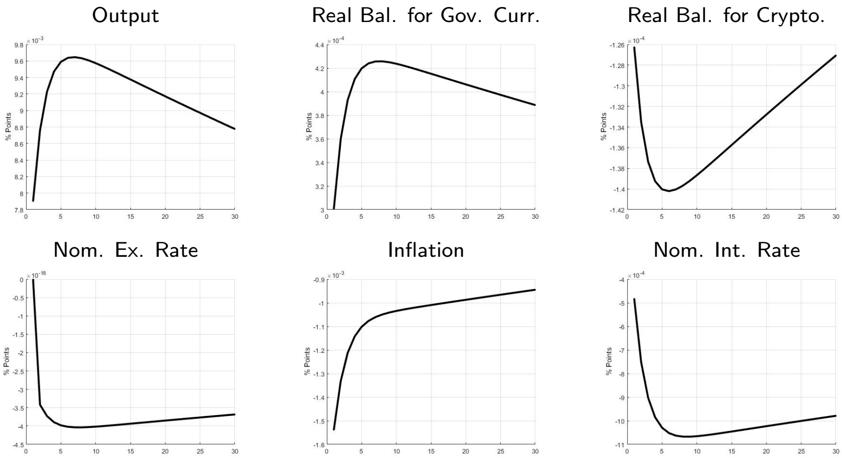


Solid lines = common productivity shock of cryptocurrency.
Dashed lines = specific productivity shock of cryptocurrency.

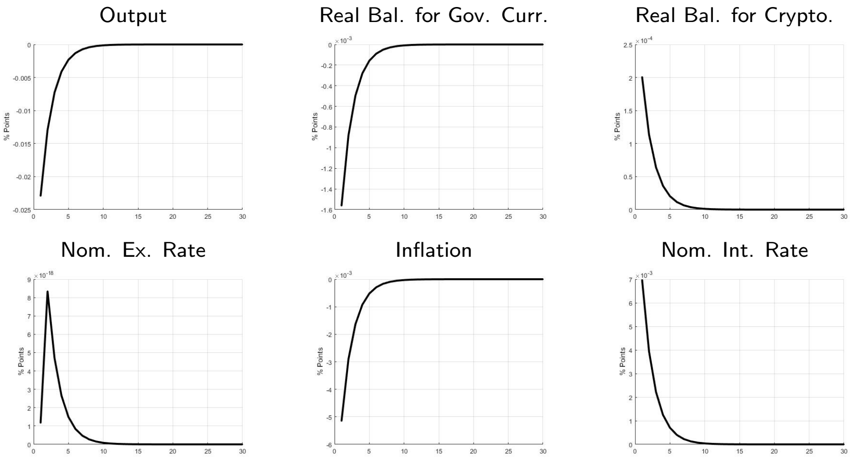
Responses to Preference Shock



Responses to Technology Shock



Responses to Monetary Policy Shock



Variance Decomposition (%)

	$\hat{y}_t$	$\hat{\pi}_t$	$\hat{r}_t$	$\hat{m}_t^g$	$\hat{m}_t^c$	$\hat{\chi}_t$
σ^a	3.52	4.04	8.07	0.01	0.00	0.00
σ^{eg}	3.08	2.78	1.41	83.08	7.09	0.00
σ^{ec}	0.24	0.30	2.15	15.85	79.29	0.00
σ^z	89.02	84.20	60.74	0.66	0.00	0.00
σ^ξ	0.00	0.00	0.00	0.00	0.00	0.02
σ^ν	0.00	0.00	0.00	0.32	13.61	99.98
σ^r	4.14	8.68	27.63	0.08	0.00	0.00

Notes: $\hat{y}_t$: output, $\hat{\pi}_t$: inflation, $\hat{r}_t$: nominal interest rate, $\hat{m}_t^g$: real balances for government currency, $\hat{m}_t^c$: real balances for cryptocurrency, $\hat{\chi}_t$: real exchange rate, σ^a: preference shock, σ^{eg}: demand shock to government currency, σ^{ec}: demand shock to cryptocurrency, σ^z: technology shock, σ^ξ: common productivity shock to cryptocurrency, σ^ν: specific productivity shock to cryptocurrency, σ^r: monetary policy shock.

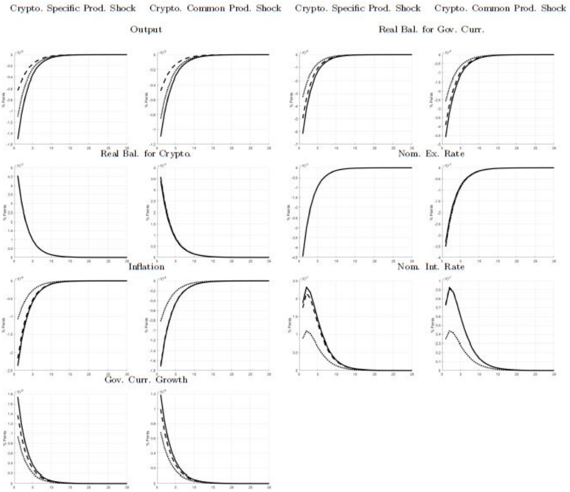
How Can Cryptocurrency Be Introduced into the Utility Function?

- Our estimated results indicated that the utility function is non-separable between consumption and the real balances of cryptocurrency.
- Here, we provide a counterfactual analysis about this non-separability assumption $\rightarrow$ ongoing debate on the nature of cryptocurrency.
  - Cryptocurrency as a private digital currency that is the alternative to government currency $\rightarrow$ non-separability between real balances of cryptocurrency, real balances of government currency and consumption in the utility function.
  - Cryptocurrency as an asset $\rightarrow$ separability between the real balances of cryptocurrency and consumption.

How Can Cryptocurrency Be Introduced into the Utility Function?

Parameter	Symbol	Benchmark			Counterfactual A with $\omega_2 = 0$ and $\omega_3 = 0$			Counterfactual B with $\omega_3 = 0$		
		Mean	Conf. Int.		Mean	Conf. Int.		Mean	Conf. Int.	
Output El. to Real Bal. of Gov. Currency	ω_2	0.195	0.102	0.284	-	-	-	0.241	0.154	0.326
Output El. to Real Bal. of Cryptourrency	ω_3	0.035	0.024	0.046	-	-	-	-	-	-
Income El. of Gov. Currency Demand	γ_1	0.021	0.009	0.032	0.015	0.007	0.022	0.017	0.008	0.025
Interest Semi-El. of Gov. Currency Demand	γ_2	0.140	0.066	0.214	0.151	0.070	0.228	0.137	0.064	0.209
El. of Real Bal. of Gov. Curr. wrt Gov. Curr. Dem. Shock	γ_3	0.664	0.593	0.733	0.948	0.786	1.114	0.716	0.621	0.804
Cross El. of Gov. Cur. Dem. and Crypto. Dem.	γ_4	0.554	0.467	0.638	0.483	0.404	0.561	0.515	0.432	0.597
Income El. Crypto. Demand	γ_5	0.013	0.006	0.020	0.015	0.007	0.023	0.014	0.007	0.022
Interest Semi-El. of Crypto. Demand	γ_6	0.155	0.073	0.236	0.149	0.068	0.226	0.158	0.074	0.241
El. of Real Bal. of Crypto. wrt Crypto. Dem. Shock	γ_7	1.034	1.014	1.053	0.998	0.981	1.015	1.006	0.992	1.019
Cross El. of Crypto. Dem. and Gov. Cur. Dem.	γ_8	1.011	0.985	1.037	1.012	0.969	1.055	1.007	0.975	1.039
Ex. Rate Crypto. / Gov. Cur. El. wrt Prod.	ϱ	0.777	0.638	0.916	0.795	0.651	0.935	0.796	0.654	0.935
Share of Crypto. Common Prod. on Crypto. Tot. Prod.	$\frac{\xi}{\phi}$	0.572	0.482	0.662	0.558	0.471	0.646	0.559	0.471	0.647
Interest. Rate Smoothing	ρ^r	0.808	0.765	0.852	0.801	0.757	0.847	0.804	0.761	0.849
Taylor Rule Coef. on Output	ρ^y	0.153	0.142	0.163	0.153	0.142	0.163	0.153	0.142	0.163
Taylor Rule Coef. on Inflation	ρ^π	1.980	1.898	2.063	1.987	1.904	2.071	1.985	1.902	2.068
Taylor Rule Coef. on Gov. Currency Growth	ρ^{μ^g}	0.459	0.368	0.555	0.448	0.352	0.545	0.456	0.363	0.553

How Can Cryptocurrency Be Introduced into the Utility Function?



Solid=benchmark; dashed=no crypto&gvt money; dotted=no crypto.

Robustness: Different Assumptions about the Taylor Rule

- We investigate the role of monetary policy in the presence of the shocks to cryptocurrency productivity.

- Different counterfactual scenarios in the parameter measuring the response of the policy rate to government currency growth (ρ^{μ^g}) in the Taylor rule:

  1. $\rho^{\mu^g} = 0$.
  2. ρ^{μ^g} is fixed double of its estimate.

- **Result**: The larger is the response of the monetary policy rule to a change in government currency growth the stronger is decline in output.

Conclusions

- In this paper, we develop a Dynamic Stochastic General Equilibrium (DSGE) model to evaluate the economic repercussions of cryptocurrencies.
- We assume that the representative household maximizes its utility given by consumption, leisure and both government currency and cryptocurrency holdings. Our model includes entrepreneurs that determine the supply of cryptocurrency in the economy.
- We estimate our model with Bayesian techniques using US monthly data for the sample period 2013:M6-2019:M3.

Conclusions

- **Impulse response analysis**
  - Strong substitution effect between the real balances of government currency and those of cryptocurrency in response to technology and monetary policy shocks.
  - Cryptocurrency productivity shocks imply a fall in the nominal exchange rate. Output and inflation fall whereas the nominal interest rate increases. However, the magnitude of the effects of these shocks is much lower than "traditional" shocks.
- **Variance decomposition analysis**
  - Technology, preference and monetary policy have the highest contribution in terms of variations in the key endogenous variables of our model.
  - Specific supply shocks play an important role in the variation of cryptocurrency demand and nominal exchange rate.

Conclusions

- **How Can Cryptocurrency Be Introduced into the Utility Function?**
  - The functional form of the utility function matters in terms of the responses of several macroeconomic aggregates to cryptocurrency productivity shocks.
  - A gain in cryptocurrency productivity induces stronger decreases in output and inflation in the case of non-separable utility function between consumption and real balances of cryptocurrency.
- **Robustness analysis**
  - The larger is the response of the monetary policy rule to a change in government currency growth the stronger is decline in output.

Log-Linearized Expressions

$$\hat{y}_t = \hat{y}_{t+1} - \omega_1 \left(\hat{r}_t - \hat{\pi}_{t+1}\right) + \omega_2 \left[\left(\hat{m}_t^g - \hat{e}_t^g\right) - \left(\hat{m}_{t+1}^g - \hat{e}_{t+1}^g\right)\right] + \omega_3 \left[\left(\hat{\chi}_t + \hat{m}_t^c - \hat{e}_t^c\right) - \left(\hat{\chi}_{t+1} + \hat{m}_{t+1}^c - \hat{e}_{t+1}^c\right)\right] + \omega_1 \left(\hat{a}_t - \hat{a}_{t+1}\right) \tag{A1}$$

$$\hat{m}_t^g = \gamma_1 \hat{y}_t - \gamma_2 \hat{r}_t + \gamma_3 \hat{e}_t^g - \gamma_4 \hat{\chi}_t - \gamma_4 \hat{m}_t^c + \gamma_4 \hat{e}_t^c \tag{A2}$$

$$\hat{m}_t^c = \gamma_5 \hat{y}_t - \gamma_6 \hat{r}_t + \gamma_7 \hat{e}_t^c - \gamma_8 \hat{\chi}_t - \gamma_8 \hat{m}_t^g + \gamma_8 \hat{e}_t^g \tag{A3}$$

$$\hat{\pi}_t = \left(\frac{\pi}{R}\right) \hat{\pi}_{t+1} + \psi \begin{bmatrix} \left(\frac{1}{\omega_1}\right) \hat{y}_t - \left(\frac{\omega_2}{\omega_1}\right) \left(\hat{m}_t^g - \hat{e}_t^g\right) \\ - \left(\frac{\omega_3}{\omega_1}\right) \left(\hat{\chi}_t + \hat{m}_t^c - \hat{e}_t^c\right) - \hat{z}_t \end{bmatrix} \tag{A4}$$

$$\hat{\chi}_t = -\varrho \hat{\phi}_t \tag{A5}$$

$$\hat{\phi}_t = \left(\frac{\xi}{\phi}\right) \hat{\xi}_t + \left(1 - \frac{\xi}{\phi}\right) \hat{\nu}_t \tag{A6}$$

$$\hat{r}_t = \rho^r \hat{r}_{t-1} + \left(1 - \rho^r\right) \rho^y \hat{y}_t + \left(1 - \rho^r\right) \rho^\pi \hat{\pi}_t + \left(1 - \rho^r\right) \rho^{\mu^g} \hat{\mu}_t^g + \varepsilon_t^r \tag{A7}$$

Fixed Parameters

- In line with Ireland (2004), we assume ω_1 equal to one implying the same level of risk aversion as a utility function that is logarithmic in consumption.
- The parameter ψ is fixed equal to 0.1 following King and Watson (1996), Ireland (2000) and Ireland (2004). Such value implies that the fraction of the discounted present value and future discrepancies between the target price and the actual price of production goods is equal to 10%.
- The steady state values for the nominal interest rate and inflation are computed from monthly data of the effective federal funds rate and natural log changes in CPI. For our sample period they are equal to 0.70 % and 0.13%, respectively.

Estimated Results for Exogenous Parameters

Parameter	*Symbol*	*Priors*			*Posteriors*		
		Distr.	Mean	St. Dev.	Mean	Conf.	Inter.
Household's Preference Shock Pers.	ρ^a	B	0.700	0.050	0.668	0.586	0.751
Gov. Cur. Demand Shock Pers.	ρ^{eg}	B	0.650	0.050	0.623	0.548	0.700
Crypto. Demand Shock Pers.	ρ^{ec}	.B	0.550	0.050	0.622	0.554	0.690
Technology Shock Pers.	ρ^z	B	0.900	0.050	0.996	0.992	0.999
Crypto. Common Prod. Shock Pers.	ρ^ξ	B	0.600	0.050	0.679	0.616	0.742
Crypto. Specific Prod. Shock Pers.	ρ^ν	B	0.600	0.050	0.703	0.642	0.765
Household's Preference Shock St. Err.	σ^a	I-G	0.010	Inf	0.278	0.238	0.315
Gov. Cur. Demand Shock St. Err.	σ^{eg}	I-G	0.010	Inf	1.578	0.824	2.320
Crypto. Demand Shock St. Err.	σ^{ec}	I-G	0.010	Inf	3.799	3.065	4.538
Technology Shock St. Err.	σ^z	I-G	0.010	Inf	0.734	0.611	0.853
Crypto. Common Prod. Shock St. Err..	σ^ξ	I-G	0.010	Inf	0.047	0.041	0.054
Crypto. Specific Prod. Shock St. Err..	σ^ν	I-G	0.010	Inf	4.763	4.071	5.436
Monetary Policy Shock St. Err.	σ^r	I-G	0.010	Inf	0.076	0.059	0.091

Forecast Error Variance Decomposition (%)

Period 1

	$\hat{y}_t$	$\hat{\pi}_t$	$\hat{r}_t$	$\hat{m}^g_t$	$\hat{m}^c_t$	$\hat{\chi}_t$
σ^a	6.41	4.82	6.68	0.00	0.00	0.00
σ^{eg}	5.49	2.41	1.29	83.45	7.17	0.00
σ^{ec}	0.41	0.25	1.97	15.86	80.23	0.00
σ^z	80.49	82.69	28.03	0.30	0.00	0.00
σ^ξ	0.00	0.00	0.00	0.00	0.00	0.02
σ^ν	0.01	0.00	0.00	0.29	12.60	99.98
σ^r	7.19	9.82	62.04	0.09	0.00	0.00

Period 5

	$\hat{y}_t$	$\hat{\pi}_t$	$\hat{r}_t$	$\hat{m}^g_t$	$\hat{m}^c_t$	$\hat{\chi}_t$
σ^a	1.48	1.84	6.04	0.01	0.00	0.00
σ^{eg}	1.38	1.72	1.02	82.39	7.02	0.00
σ^{ec}	0.08	0.12	1.56	15.76	78.35	0.00
σ^z	95.14	91.69	75.72	1.43	0.00	0.00
σ^ξ	0.00	0.00	0.00	0.00	0.00	0.02
σ^ν	0.00	0.00	0.00	0.34	14.62	99.98
σ^r	1.91	4.63	15.65	0.08	0.00	0.00

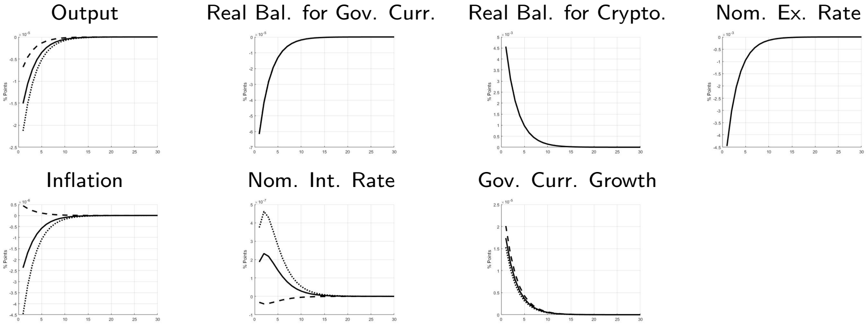
Period 12

	$\hat{y}_t$	$\hat{\pi}_t$	$\hat{r}_t$	$\hat{m}^g_t$	$\hat{m}^c_t$	$\hat{\chi}_t$
σ^a	0.59	0.99	2.54	0.01	0.00	0.00
σ^{eg}	0.55	0.95	0.42	80.39	7.00	0.00
σ^{ec}	0.04	0.07	0.64	15.38	78.11	0.00
σ^z	98.06	95.49	90.49	3.81	0.00	0.00
σ^ξ	0.00	0.00	0.00	0.00	0.00	0.02
σ^ν	0.00	0.00	0.00	0.34	14.89	99.98
σ^r	0.76	2.49	5.92	0.07	0.00	0.00

Period 30

	$\hat{y}_t$	$\hat{\pi}_t$	$\hat{r}_t$	$\hat{m}^g_t$	$\hat{m}^c_t$	$\hat{\chi}_t$
σ^a	0.25	0.49	1.03	0.01	0.00	0.00
σ^{eg}	0.23	0.46	0.17	76.08	7.00	0.00
σ^{ec}	0.01	0.03	0.26	14.56	78.10	0.00
σ^z	99.19	97.80	96.13	8.97	0.01	0.00
σ^ξ	0.00	0.00	0.00	0.00	0.00	0.02
σ^ν	0.00	0.00	0.00	0.32	14.89	99.98
σ^r	0.32	1.22	2.41	0.07	0.00	0.00

Responses to Cryptocurrency Common Productivity Shock



Solid lines denote the IRFs of the benchmark model, whereas the dashed and dotted lines represent the responses of the model in counterfactual scenarios 1 and 2, respectively.

Robustness: Responses to Cryptocurrency Specific Productivity Shock