Three Types of Money Creation

Haoqian Zhang, Supervised by Prof. Bryan Ford, EPFL

Thanks Basescu Cristina and Marchal Alexis.
<table>
<thead>
<tr>
<th>Rent Per Month</th>
<th>Geneva</th>
<th>Beijing</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartment (1 bedroom) in City Centre</td>
<td>2,032.61 Fr. (14,557.07 ¥)</td>
<td>1,018.11 Fr. (7,291.47 ¥)</td>
<td>-49.91 %</td>
</tr>
<tr>
<td>Apartment (1 bedroom) Outside of Centre</td>
<td>1,544.58 Fr. (11,061.94 ¥)</td>
<td>621.80 Fr. (4,453.16 ¥)</td>
<td>-59.74 %</td>
</tr>
<tr>
<td>Apartment (3 bedrooms) in City Centre</td>
<td>3,575.93 Fr. (25,609.94 ¥)</td>
<td>2,125.27 Fr. (15,220.69 ¥)</td>
<td>-40.57 %</td>
</tr>
<tr>
<td>Apartment (3 bedrooms) Outside of Centre</td>
<td>2,836.96 Fr. (20,317.62 ¥)</td>
<td>1,328.65 Fr. (9,515.46 ¥)</td>
<td>-53.17 %</td>
</tr>
<tr>
<td><strong>Buy Apartment Price</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price per Square Meter to Buy Apartment in City Centre</td>
<td>12,818.18 Fr. (91,800.82 ¥)</td>
<td>14,309.30 Fr. (102,479.88 ¥)</td>
<td>+11.63 %</td>
</tr>
<tr>
<td>Price per Square Meter to Buy Apartment Outside of Centre</td>
<td>9,458.33 Fr. (67,738.37 ¥)</td>
<td>7,185.59 Fr. (51,461.54 ¥)</td>
<td>-24.03 %</td>
</tr>
<tr>
<td><strong>Salaries And Financing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Monthly Net Salary (After Tax)</td>
<td>5,375.55 Fr. (38,498.42 ¥)</td>
<td>1,224.10 Fr. (8,766.69 ¥)</td>
<td>-77.23 %</td>
</tr>
<tr>
<td>Mortgage Interest Rate in Percentages (%), Yearly, for 20 Years Fixed-Rate</td>
<td>2.02</td>
<td>5.14</td>
<td>+154.06 %</td>
</tr>
</tbody>
</table>

*Data from numbeo.com*
GLOBAL REAL HOUSE PRICE INDEX

Global housing markets have been steadily climbing up.

SOURCE: Bank for International Settlements, European Central Bank, Federal Reserve Bank of Dallas, Seville, and national sources

IMF.org/housing  #HousingWatch
This Talk:

(1) Money Creation in Modern Economy
(2) Cryptocurrency is Different
(3) Currency Issuance Language (CIL)
(4) Community Cryptocurrency
(5) Monetary Policy Language (MPL)
(6) Demurrage Implementation and Application
Outline

1. Proof-of-Credit
   US Dollar, Euro
2. Proof-of-Resource
   Gold, Bitcoin
3. Proof-of-Personhood
   Universal Base Income, Mutual Credit
Outline

1. **Proof-of-Credit**
   
   US Dollar, Euro

2. **Proof-of-Resource**
   
   Gold, Bitcoin

3. **Proof-of-Personhood**
   
   Universal Base Income, Mutual Credit
Money Creation in Modern Economy

Assets: Liabilities:

<table>
<thead>
<tr>
<th>Bank A</th>
<th>Bob</th>
</tr>
</thead>
<tbody>
<tr>
<td>100K$ Cash</td>
<td>100K$ Deposit</td>
</tr>
<tr>
<td>Deposits</td>
<td></td>
</tr>
<tr>
<td>Loan of Bob</td>
<td></td>
</tr>
</tbody>
</table>

Assets: Liabilities:

<table>
<thead>
<tr>
<th>900K$ Loan of Bob</th>
<th>900K$ Deposit of Bob</th>
</tr>
</thead>
<tbody>
<tr>
<td>100K$ Cash</td>
<td>100K$ Deposit</td>
</tr>
</tbody>
</table>
The Debt-Based Economy

<table>
<thead>
<tr>
<th>Money Creation</th>
<th>Debt Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>900K$ Deposit</td>
<td>900K$+</td>
</tr>
</tbody>
</table>

1. Majority of money is created by commercial banks.
2. Money creation relies on lending and borrowing.
3. The amount of debt exceeds the total money supply.
Central Bank

The Bank of England
Promoting the good of the people of the United Kingdom by maintaining monetary and financial stability.

0.75%
Current Bank Rate
Next due: 26 March 2020

£435bn
Quantitative Easing Asset Purchase Programme

£10bn
Corporate Bond Purchase Scheme

1.3%
Current inflation rate
Target: 2.0%
Goal of Central Bank

Inflation and the 2% target

We are responsible for keeping inflation (price rises) low and stable. The Government has set us a target of keeping inflation at 2%
Goal of Central Bank

What is inflation?

Inflation is a measure of how much the prices of goods (such as food or televisions) and services (such as haircuts or train tickets) have gone up over time.

Usually people measure inflation by comparing the cost of things today with how much they cost a year ago. The average increase in prices is known as the inflation rate.

So if inflation is 3%, it means prices are 3% higher (on average) than they were a year ago. For example, if a loaf of bread cost £1 a year ago and now it’s £1.03 then its price has risen by 3%.

Use our inflation calculator to find out how prices have changed over the years.

How inflation is measured

Each month, the Office for National Statistics (ONS) collect around 180,000 prices of about 700 items. They use this ‘shopping basket’ to work out the Consumer Prices Index (CPI). CPI is the measure of inflation we target.
Asset Price Inflation

Goods & Services

Assets
Asset Price Inflation

Goods & Services

Assets
Outline

1. Proof-of-Credit
   US Dollar, Euro

2. Proof-of-Resource
   Gold, Bitcoin

3. Proof-of-Personhood
   Universal Base Income, Mutual Credit
Proof-of-Resource
Cryptocurrency

Cryptocurrency is debt-free money

Set/change the currency issuance mechanism

Challenges:

Optimal monetary policy for cryptocurrency.

Encourage real exchange and discourage speculation
Currency Issuance Language

```json
{
  "base": "block",
  "period": 1,
  "update": [
    {
      "formula": "50 / (2 ** (Height / 210000))",
      "target": "BlockMiner"
    }
  ]
}
```
Currency Issuance Language

{
    "base": "year",
    "period": 1,
    "update": [
        {
            "formula": "50 * 52500 / (2 ** (Year / 4))",
            "target": "BitcoinSupply"
        }
    ]
}
Currency Issuance Language

```json
{
  "base": "block",
  "period": 1,
  "update": [
    {
      "formula": "BaseReward",
      "target": "BlockMiner"
    },
    {
      "times": "len(UncleBlocks)",
      "formula": "BaseReward*(9-UncleBlocks[i].k)/8",
      "target": "UncleBlocks[i].Miner"
    },
    {
      "condition": "len(UncleBlocks)>0",
      "formula": "len(UncleBlocks)*BaseReward/32",
      "target": "BlockMiner"
    }
  ]
}
```
Currency Issuance Language

```json
{
  "base": "year",
  "period": 1,
  "update": [
    {
      "formula": "BaseReward \times \text{DailyBlocks} \times 365",
      "target": "\text{EtherSupply}"
    },
    {
      "formula": "BaseReward \times \text{DailyUncles} \times (9 - \text{UnclesK}) / 8 \times 365",
      "target": "\text{EtherSupply}"
    },
    {
      "formula": "BaseReward / 32 \times \text{DailyUncleBlocks} \times 365",
      "target": "\text{EtherSupply}"
    }
  ]
}
```
Ether Supply
Currency Issuance Language

Implementation:

Go Language, using Expr Library

Application:

(1) Plug into different platforms.
(2) Simulation (account level or macro level)
(3) Focusing only on currency issuance.

Limitation:

(1) Not all can be modeled well in this framework
(2) Mechanics and assumptions of blockchains cannot be clearly separated
Outline

1. Proof-of-Credit
   US Dollar, Euro

2. Proof-of-Resource
   Gold, Bitcoin

3. Proof-of-Personhood
   Universal Base Income, Mutual Credit
Universal Base Income

1000$/Month  1000$/Month  1000$/Month  1000$/Month  1000$/Month
Mutual Credit
Mutual Credit

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-100$</td>
<td>100$</td>
<td>0</td>
</tr>
</tbody>
</table>

$100$
Community Currency
Community Cryptocurrency

<table>
<thead>
<tr>
<th>Identity Control</th>
<th>Blockchain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventing Sybil Attacks</td>
<td>Transparent Deterministic Monetary Policy</td>
</tr>
<tr>
<td></td>
<td>No Single Point of Failure</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>
Monetary Policy Language

(1) Currency Issuance
   Initial Distribution, Periodic Creation(block, month...)

(2) Transaction
   Transaction Fee, Condition

(3) Demurrage
   Negative Interest
Demurrage
Universal Base Income

```
{
    "base": "month",
    "period": 1,
    "update": [
        {
            "times": "len(Members)",
            "formula": "-balance(Members[i])*0.01+1000",
            "target": "Members[i]"
        }
    ]
}
```

1000 coins per month
Funded by demurrage gradually

1% per month
Rich pay more
Mutual Credit

{  
  "condition": "Value>0 && balance(Sender)-Value>=negative_limit(Sender) && balance(Receiver)+Value<=positive_limit(Receiver)",
  "update": [{
    "formula": "-Value",
    "target": "Sender"
  },
  {
    "formula": "Value",
    "target": "Receiver"
  }
]
}
Prevent Spamming

"events": [{
  "base": "day",
  "period": 1,
  "update": [{
    "times": "len(Members)",
    "formula": "-balance(Members[i])+10",
    "target": "Members[i]"
  }]
}]

10 coins per day

100% per day
Prevent Spamming

"transfer": {
    "condition": "Value>=1 && balance(Sender)>=Value",
    "update": [{
        "formula": "-Value",
        "target": "Sender"
    }]
}
Demurrage in UTXO

Transaction 1

100 Coins

Transaction 2

100 Coins

One Month Later

99 Coins

*Demurrage rate is 1% per month
Demurrage in Global Balance Model

<table>
<thead>
<tr>
<th>Current Date</th>
<th>Address</th>
<th>Value in DB</th>
<th>Timestamp in DB</th>
<th>Real Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Jan 2020</td>
<td>1BvBMSEYst</td>
<td>100</td>
<td>1 Jan 2020</td>
<td>100 coins</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*One Month Later:*

| 1 Feb 2020    | 1BvBMSEYst | 100         | 1 Jan 2020      | 99 coins     |
|               |            |             |                 |              |

*Immediately Before Receiving or Spending Coins:*

| 15 Feb 2020   | 1BvBMSEYst | 99          | 15 Feb 2020     | 99 coins     |
|               |            |             |                 |              |

*Spending 10 coins:*

| 15 Feb 2020   | 1BvBMSEYst | 89          | 15 Feb 2020     | 89 coins     |
|               |            |             |                 |              |

*Demurrage rate is 1% per month*
Demurrage in Bitcoin

(1) Encourage spending (disencourage hoarding)

(2) Replace zombie coins gradually

(3) Funding block rewards (e.g. 1% per year for block rewards)
Conclusion & Future Work

Our current monetary system is not perfect.

Cryptocurrency could be an alternative solution.

Formally describing monetary policies is the first step.
Conclusion & Future Work

More Community Cryptocurrency Applications

Extending the Monetary Policy Language

Implementing Community Cryptocurrency in Blockchain
Further Reading

(1) Money creation in the modern economy

   By Michael McLeay, Amar Radia and Ryland Thomas, 2014

(2) Can banks individually create money out of nothing? — The theories and the empirical evidence

   By Richard A.Werner, 2014
Banking System

Central Bank

Commercial Banks
Fractional-Reserve Banking

Money Supply:

100$
Bank Lending

Bank A → Alice: Loan 90$ → Goods → Bob: Goods → Deposit 90$ → Bank B

*Assuming Reserve Ratio is 10%
Balance Sheet of Bank A

Assets:
- 100$ Cash

Liabilities:
- 100$ Deposit

Assets:
- 10$ Cash

Liabilities:
- 100$ Deposit

[Diagram showing the flow of cash and loan between Bank A and Alice]
Balance Sheet of Bank B

Assets: Liabilities:

- 90$ Cash
- 90$ Deposit of Bob

Assets: Liabilities:

- Cash
- Deposit

Bob

Bank B

90$ Cash

90$ Deposit of Bob
Money Multiplier

Money Supply:

100$

90$

81$

(Up to) 1000$

*Assuming Reserve Ratio is 10%
Role of Central Bank

Money Supply:

- 100$
- 190$
- 271$
- (Up to) 1000$

*Assuming Reserve Ratio is 10%*
End of the Year

Lend 90$

90$+Interest

Alice
End of the Year

Central Bank

100$ + Interest

100$

90$

81$

(Up to) 1000$

Money Supply:

100$

190$

271$

*Assuming Reserve Ratio is 10%
The Debt-Based Economy

<table>
<thead>
<tr>
<th>Money Supply:</th>
<th>Debt:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000$ (100$ Cash + 900$ Deposit)</td>
<td>1000$+</td>
</tr>
</tbody>
</table>

1. Majority of money is created by commercial banks.
2. Money creation relies on lending and borrowing.
3. The amount of debt in the world exceeds the total money supply.
Conventional Theory

Assumed that all money is used for GDP transactions:

\[ MV = PQ \]

with constant or stable \( V \)

M is money supply. Its unit is dollar.
V is velocity of money. Its unit is per year.
Q is real GDP. Its unit is dollar/year
P is price level. PQ will be the nominal GDP.
The Quantity Theory of Credit (Werner, 1992, 1997)

Money is used for all transactions:

$$MV = PQ$$

$M$ is money supply. Its unit is dollar.
$V$ is velocity of money. Its unit is per year.
$QP$ is the values of all transactions.

$$M = M_r + M_f$$

Money used for GDP transactions, used for the ‘real economy’ (‘real circulation’) ($M_r$)
Money used for non-GDP transactions (‘financial circulation’) ($M_f$)
The Quantity Theory of Credit (Werner, 1992, 1997)

Considering growth of money supply:

\[ M_r V_r = P_r Q_r \]

\[ M_f V_f = P_f Q_f \]

Assume \( V_r \) and \( V_f \) is constant or stable:

\[ \Delta M_r \rightarrow \Delta \text{nom. GDP} \quad \text{(real economy)} \]
\[ \Delta M_f \rightarrow \Delta (P_f + Q_f) \quad \text{(asset market)} \]

Banks’ decisions reshape the economic landscape
The Quantity Theory of Credit (Werner, 1992, 1997)

The allocation of bank credit creation determines what will happen to the economy:

- **non-GDP credit**
  - Case 1: Financial credit (= credit for transactions that do not contribute to and are not part of GDP) => Result: Asset inflation, bubbles and banking crises

- **GDP credit**
  - Case 2: Consumption credit => Result: Inflation without growth
  - Case 3: Investment credit (= credit for the creation of new goods and services or productivity gains that generate income) => Result: Growth without inflation, even at full employment