Judges' Commentary: Digital Currency

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Introduction

For this year's ICM™policy problem, teams investigated a question that is frequently in the news: Can the benefits of an international digital currency be sustained? Some experts believe that a universal decentralized digital currency with internal security such as blockchain can make markets more efficient by eliminating barriers and overhead costs in the flow and storage of money. With digital currencies becoming more widely available, citizens can now use them like traditional currencies to buy and sell goods. Further, digital currencies are not affected by national borders, making them useful for international business transactions. It is clear that digital money has many transactional benefits for the global marketplace.

Some governments, however, view the lack of regulation and anonymity around these currencies as too risky. Reputations of some existing cryptocurrencies have already been adversely affected by their use in illicit transactions, such as tax sheltering, money laundering, and purchasing illegal merchandise.

However, a universally-accepted currency could enable efficient global financial markets and may protect assets against regional inflation fluctuations and artificial manipulation of currencies by national governments. If a universal digital system became available, what would happen to the current banking systems and traditional national currencies?

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The 2019 social policy problem (Problem F) asked teams to identify key factors that would limit or facilitate digital currency growth, access, security, and stability at both the individual and national levels. The teams' analysis had to consider the long-term effects of such a system on the world economy and on relations between countries. Teams were required to use the results of their models to write a one-page policy recommendation for national leaders on the possible benefits and concerns of adopting an internationally recognized currency system.

Benefits of such a digital currency to individuals and nations may include:

- There can be increased privacy and security through blockchain encryption.
- There would be reduction in overhead cost associated with centralized financial management and crossing national borders.
- Transactions are instantaneous, avoiding delays from banking policies or exchange rules.
- Transactions do not require formally held bank accounts and can be made with just an email address or a thumbprint.
- Global currency could potentially lead to a more equitable monetary system, whereby access and earnings are better distributed across the world.

Concerns of universal, decentralized, digital currency could include:

- Blockchain security and the overall complexity and computational cost of the security for cryptocurrencies may be unsustainable.
- International agreement on the rules and regulation of a global monetary system would be extremely cumbersome and difficult to achieve.
- National banks could be threatened and pitted against the global banking system.

There were many issues and questions that teams considered during their modeling of the problem. These included:

- What are the main factors that determine whether individuals or a nation will adopt digital currencies?
- What are the factors that determine the adoption of a digital currency system for individuals or nations?
- Could individuals or nations across the world ever trust one universal international currency?
- Is blockchain an adequate and effective system to build trust in a global digital currency?

- What would be the financial challenges of a global decentralized digital financial market?
- What are the factors that could cause volatility in this market? How can they be reduced?
- How will a digital currency affect traditional markets and economies?
- Can fiat currencies and digital currencies coexist?
- How can current national currencies be exchanged for new digital currency?
- What are the sales and tax implications of assets sold using digital currency?
- How should debt and loans be handled and who should hold the debt?
- Should currency value ever be added to or removed from the system in order to stabilize the market?
- How should future monetary events be decided and controlled, if they are needed?
- What roles would the United Nations, International Monetary Fund, World Bank, World Trade Organization, and national governments play in regulating digital currency?
- What are the considerations of having governments involved in the regulation of the digital market?
- How would the global digital market affect developed vs. underdeveloped nations?
- How can deleterious effects be minimized?
- Are there ethical considerations for adopting a system that may benefit citizens of some countries over others?
- What would be the long-term effects if traditional banking were to become obsolete?
- Are global markets more or less stable than centralized, regional monetary systems?
- Could there be an event that damaged the entire digital market destroying the world's digital currency?

The teams built mathematical models to account for these various factors and used their models to justify policy recommendations. Policies often referred to system growth, personal access, security, privacy, and stability of the system. Some of the factors in teams' models are shown in **Figure 1** from the report by Central South University, China (Team 1910285).

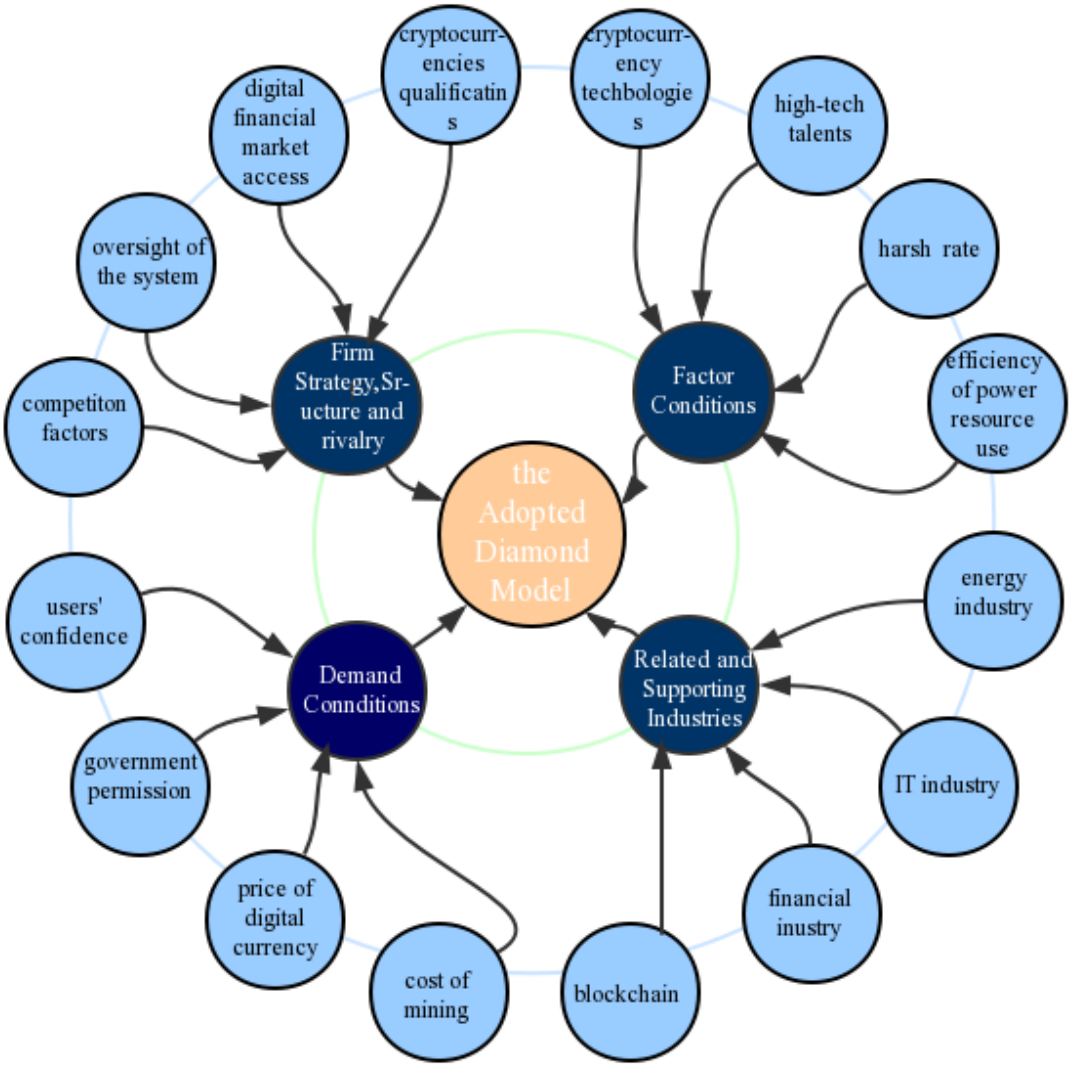


Figure 1. Factors considered in the model by Team 1910285 from Central South University, China.

The strongest papers discussed how their model supported particular policies, as well as the assumptions and limitations of their models.

Teams usually began by researching the many nuances of current and proposed digital- and crypto-currency systems. Many teams used standard economic models and principles even if they were changing some of the assumptions to model a digital currency. Teams built models that were either entirely digital or else mixed, with digital currencies alongside traditional currencies. Some teams spent most of their modeling on capturing and ameliorating the negative aspects of a broadly-adopted digital currency. Nearly every team concluded that a fully universal digital currency was not possible. Very few teams felt that a decentralized (non-regulated) digital currency could entirely replace traditional banking, given the current state of countries' monetary systems.

Many teams clustered or classified countries, suggesting different kinds

of digital systems for different kinds of countries. Often, the teams focused on a specific class of countries to develop a coherent model.

The contest judges felt that some teams gave too much emphasis to Bitcoin or another specific digital currency or in creating and building their own form of currency. Another issue that concerned the judges was that some teams assumed that like traditional currencies, the supply of digital currency was controllable and, if necessary, infinite. The result was that teams incorporated multilevel regulatory and control systems that ultimately turned the universal currency back to one that is managed at the national level. Teams often returned to the idea that some kind of centralized system is needed to regulate the economy, with digital currencies being feasible only in specific instances in international business and trade transactions. **Figure 2** shows the functions of a central bank in the model produced by Central South University, China (Team 1910285).

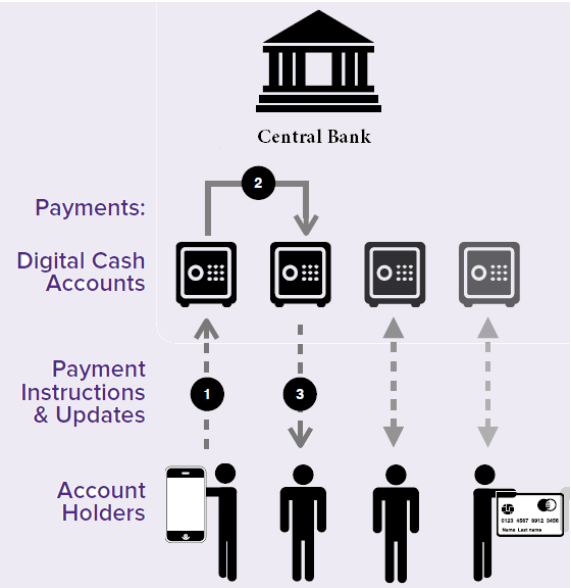


Figure 2. Functions of the central bank accounts in the model by Team 1910285 from Central South University, China.

Discussion of Outstanding Papers

The four strongest papers, rated as Outstanding, used an array of modeling techniques and analytic methods to deal with both issues of scalability (relevant for both small and large countries and full or partial conversions to digital currency) and dynamics (short-term and start-up effects along with the long-term issue of stability). The teams were able to explain why they selected those particular models and often incorporated concepts and theories from economics to explain their results. Importantly, these papers effectively used their models to provide meaningful policy recom-

mendations. Summaries of the four Outstanding team reports follow.

Sun Yat-sen University, Guangzhou, Guangdong China (Team 1904381): "Digital Currency System is Coming"

This team assumed that national banks would gradually adopt digital currency as the country's primary system by selling digital currency to its citizens. The team built a virtual country, central bank, and digital currency to test their system. They then modeled the impact of the new digital currency and its interaction with other existing currencies. The team used their model to explore how the adoption of digital currency would affect gross domestic product, the foreign exchange market, and money market functions (both at the individual and national levels). They tested two different exchange rate systems (floating and fixed) and found that the systems would achieve equilibrium when proper policies were followed. They used their model to track the effects on international capital flow and found that decentralized digital currency would be more efficient when barriers to currency flow are removed. They concluded that implementing such a currency globally would also enhance the world's prosperity.

They proposed a United Nations-affiliated organization that they named the World Digital Money Bank to regulate the global digital currency. Their work indicated significant potential for more adoption of a universal digital currency, but their model did not lead to significant decentralization, since several layers of regulatory controls would be needed for the new currency system to be effective. Their currency system showed strengths in handling a variety of economic shocks and maintaining various currency exchange systems. For instance, the team's model took into account that digital currency systems enable users to send currency instantly via email addresses or fingerprints. These peer-to-peer payment systems provided by the companies would enable money transfers in seconds without the need for bank or currency verification.

As the team indicated, digital transactions will always exceed cash and check transactions because they are not affected by bank policies, national boundaries, citizenship, debt, or other socioeconomic factors. Therefore, due to the influence of exogenous factors such as political confrontations and policies, countries with a digital system could face significant international capital flows. An example of this is when a country is in a war, it would be advantageous for individuals who hold traditional currency within that country to exchange it for global digital money to ensure its safety. The team saw their model's weakness was that their system needed a variety of policy tools to resolve imbalances and achieve stability. Their model was also limited in scope because they considered only the interactions between two countries.

Southwestern University of Finance and Economics (School of Economics), Chengdu, Sichuan, China (Team 1905127): "General Digital Currency Circulation Model"

This team considered digital currency systems from three aspects: individual transactions, national regulations, and world trade. In considering the low likelihood that individuals would adopt digital currencies on their own, they suggested that the government could encourage its acceptance through positive intervention strategies.

They used data from 130 countries to model the likelihood that a country would adopt digital currencies. The results showed that if the country has a stable domestic economy and a dominant position in international trade, it is more likely to adopt a hybrid monetary policy with both traditional and digital currencies. Their models indicated that even without policy intervention, developed economies would likely accept the coexistence of two currencies (digital and traditional), and eventually those countries are likely to abandon their traditional currency.

Alternatively, for countries with chaotic domestic economies and unstable currencies, it makes sense to abandon the original currency and completely adopt digital forms of currency. However, countries with firm attitudes towards domestic monetary control and more conservative concepts about marketization tended to keep their traditional currency only.

This team developed a "Long-term Government Behavior Model" that proposed domestic taxation at different levels in the traditional currency and in digital currencies. The team concluded that the proposed taxation policies would motivate governments to incentivize the use of digital currency for their citizens. Yet, the governments will still need to regulate digital currency to some extent, to eliminate the risk of illegal transactions. The team considered the effects of the currency model on individual, state, and global systems (see **Figure 3**).

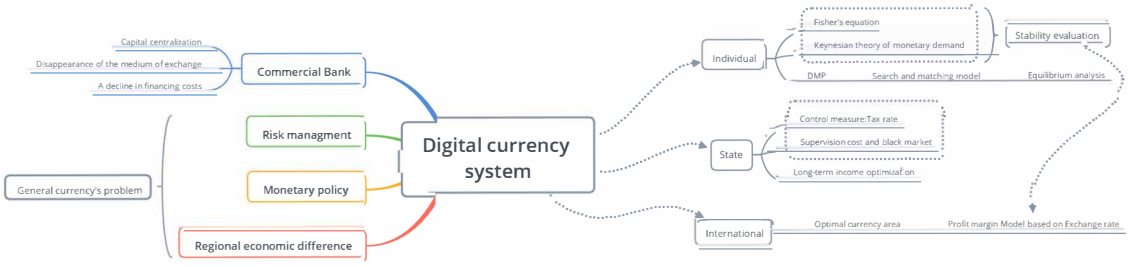


Figure 3. Relationships of money systems to users of a digital currency system, from Team 1905127 from Southwestern University of Finance and Economics (School of Economics), China.

Their model indicated that by reducing barriers to transactions across nations, digital currency will become the main medium for international trade. However, due to differences in developmental rates and regulations, traditional currencies will still have to be retained and monetary policies

will still need to be formulated by each country. There was still a need for central banks to have some control the balance of trade and capital flow for their country. This helped countries formulate sound and positive economic development programs, promote the flow of capital, and tap the most potential growth point for their economic investment.

To address the need for regulation, the team proposed a "Supranational Monetary System Model" in which digital currency is controlled by an international group. If the entire world adopts digital currency with the supranational regulators in place, their model predicted that global digital currency will stabilize and become relatively robust.

With the proposed digital currency system, the biggest challenge for governments would be the regulation and control of illegal fund-raising and black-market transactions. For example, central banks could use quantitative easing to stimulate exports, or the supranational monetary system could force the country to limit its own liabilities and balance imports and exports. The team's model verified a theory of optimal currency where digital monetary capital would flow rapidly into projects with higher real profit rates, promoting growth in the entire world economy.

Southwestern University of Finance and Economics (Institute of Economic Mathematics), Chengdu, Sichuan, China (Team 1916375): "The Future is Coming: The Revolution of Currency"

This team used cost and income functions to build a digital currency model. They used an Analytic Hierarchy Process to consider individual, national, and global factors in whether a country would adopt a new global digital currency. They estimated likely choices for different countries, while classifying them as having either small or large economies. Their model implemented a fixed exchange rate for introducing digital currency into a country. Their digital currency financial system was designed to connect individuals and institutions around the world so that currency exchange and trade between countries would be easier and more efficient. In analysis of the system over time, they used a logistic model to simulate potential changes, showing that the banking industry may lose much of its service business as the hybrid digital-traditional currency system matured.

Like many teams, their model included mechanisms for oversight and regulation of the digital currency system and a gradual introduction of the system to citizens. In their model design, most countries maintained a traditional sovereign currency while adding a digital currency for optional use, citing the reluctance that many countries would have in losing control over their monetary policies. In their policy recommendation, they suggested that countries should use a fixed exchange rate to ensure that the inflation risk is manageable for both the traditional and new digital cur-

rencies. They also recommended a global regulatory system that detects crimes, monitor taxes and is responsible for enforcing banking laws that would stabilize the monetary systems.

Central University of Finance and Economics, Beijing, China (Team 1916704): "A New Era of World Finance: The Strategy for a Global Decentralized Digital Financial Market"

This team developed a global decentralized digital currency system that addressed the lack of regulation and openness in digital currencies. They used a macroeconomic model to account for factors that would affect digital currency adoption for individuals, businesses, commercial banks, and national central banks. They selected 14 measures from four categories: access factors, growth factors, stability factors, and security factors.

The team developed a model broad enough to accommodate various economic scenarios. They considered three cases:

- a country adopts a digital currency and completely abandons its original currency;
- a country adopts a digital currency but only partially abandons the traditional currency; and
- the country does not issue any digital currencies, but allows digital currencies from non-government sources.

They used data from 163 countries to test each situation, where they estimated the economic steady state and measured the financial and economic characteristics of the resulting system. Their model indicated that adopting digital currency in all three scenarios would gradually improve the performance of the global economy and the economic relationship between countries. Their model also suggested that the first scenario was ideal for many nations—the country's central bank completely replaces the original currency with a digital currency. Their model showed that this switch also avoided violent fluctuations of the economy and eventually reached a fair and efficient monetary system.

Conclusion

The 2019 social policy problem challenged teams to understand the economic concepts related to national currencies and the unique considerations that emerge from a new decentralized, international digital currency. Teams had to build a viable model from their understanding of these economics that was flexible enough to consider various policy scenarios.

In addition, developing recommendations for policies based on the results of their models was extremely difficult. Many teams had innovative and useful ideas for parts of the problem, especially the issues of digital currency regulation and security, but were often unable to connect their model to policy recommendations within the time constraints. (See the "Expert Commentary" [Mattson 2019] in this issue for an explanation of why this was such a significant challenge.) The four Outstanding teams seemed to fulfill those tasks the best while explaining the steps and assumptions they needed to build and use their model.

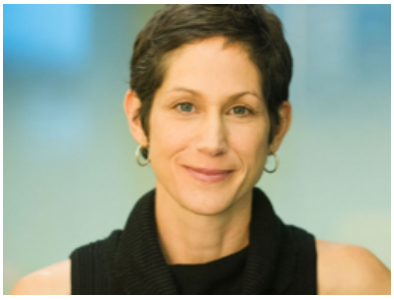
This kind of complex policy problem solving is a demanding task that is performed by public and private analysts and modelers throughout the world. The judges believe that there is a great benefit for young modelers to develop the skills that are needed to complete this year's policy challenge. They congratulate all the teams that selected this problem and wish ICM modelers well in analyzing complex issues and making valuable contributions to help decision-makers develop good social policies.

References

Mattson, Carolina. 2019. Expert's commentary: The Digital Currency Problem. *The UMAP Journal of Undergraduate Mathematics and Its Applications* 40: 243–245.

About the Authors

Chris Arney graduated from the U.S. Military Academy and served in the U.S. Army for 30 years. His Ph.D. in mathematics is from Rensselaer Polytechnic Institute. For 29 years, he taught mathematics and network science at the U.S. Military Academy. He is the founding director of the ICM and served as its director for 21 years. Before that, he was the associate director of the Mathematical Competition in Modeling for 9 years.



Dr. Kate Coronges is the Executive Director of the Network Science Institute at Northeastern University. She provides research and administrative leadership to the Institute. Her research focuses on social structures, dynamics of teams and communities, and the impact of these dynamics on communication patterns, behaviors, and performance. Previously, Dr. Coronges ran the U.S. Army's research portfolios in Social and Cognitive Networks and in Social Informatics, and served as an Assistant Professor in the Dept. of Behavioral Sciences and Leadership at the U.S. Military Academy. Dr. Coronges received a Ph.D. in Health Behavior Research and a Master's in Public Health from the University of Southern California, and graduated from UC Santa Cruz with a Bachelor's in Molecular, Cellular and Development Biology. She has been the head judge for the ICM Policy Problem for 4 years.