A Novel Defense Solution towards Currency Wars

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Abstract. This paper investigates the following problem: How could a nation possibly design a measure to counter large-scale sudden flight of foreign investments in order to avoid the undesirable disastrous consequences? Continuing [2], and based on how a currency war could be potentially raged against a nation, all results herein are established by making use of the results of feedback systems. Based on theoretical reasoning and systemic analysis, this paper develops a self-defense mechanism that could conceivably protect the nation under siege. When a nation tries to accelerate its economic development, large amounts of foreign investments would generally be welcomed. And at the same time, a lot of such foreign investments would strategically rush into the nation in order to ride along with the forthcoming economic boom. However, recent financial events from around the world indicate that how to avoid the disastrous aftermath when a large-scale flight of foreign capital appears suddenly is still not well understood and well planned out. This fact vividly shows theoretical and practical value of this work.

Key words: purchasing power, feedback system, monetary policy

1. INTRODUCTION

1.1. Currency War

Since World War II, the form of war has changed. The main battlefield of modern warfare has quietly shifted from direct military operations to the economic maneuvers. Fundamentally, all modern forms of warfare are currency related. Although there is no physical battleground, both the scales and benefits the conflicts eventually generate out of the competition for the financial highlands are no less any those of any war in history.

Each financial crisis can be seen as the signal of a currency war. Our present world on the average experiences about 10 massive financial crises per years. The results are that the relevant countries lose their leadership, if there was any, and have to stay in the consequent economic shadows for years to come, or might be worse, they can no longer recover and return to their previous glory. For example, the British sterling crisis, Japan's decade of recession after the Plaza Accord, southeastern Asia's financial crisis, and so on. These related countries did not experience any military conflict, and did not have the time to use any advanced weaponry that had been prepared for use. Compared to a military warfare, currency wars had made these countries pay a much greater economic cost. The reality is that most nations today have no need, and are unable to resolve conflicts by employing conventional wars, because by using the idea of currency wars one can achieve his desired goals.

Klein [11] showed in his empirical analysis that capital account liberalization has different effects on economic growth in different countries. Henry [8], based on event study, discussed the effects of stock market liberalization on the emerging market countries' economic reform and equity market prices. Li and Zhang [12], based on a dynamic model of Aghion, analyzed the impact of capital account liberalization on economic and financial stability. They also used cross-sectional data model involving 57 countries, further studied the economic consequences of opening direct investment for different country samples. Zhang [31] analyzed the conduction of a financial crisis as the breakthrough point based on the demonstration effect of the conduction, and tried to investigate financial crises from one side. Li [13] established the currency substitution VEC model and made a dynamic analysis of extent of China's currency substitution and the relationship between its influence factors.

After reviewing previous theoretical analyses with recent cases of speculative attacks in the arena of international finance, we surely see the following predicament. When a nation tries to

accelerate the economic development, due to its capital account, liberalization and loose monetary policies, large amounts of foreign investments would be welcomed; and at the same time, a lot of such foreign investments would strategically rush into the nation in order to ride along with the forthcoming economic boom. Therefore, a serious question at this junction is: How could a nation possibly design a measure to counter such foreign investments to leave suddenly in order to avoid the undesirable disastrous consequences?

In this work, based on the studies and discussions of how China's capital account liberalization affects international capital flows and the economy and finance, we study the evolution mechanism of a currency war by using systems theory.

1.2. Literature Review

1.2.1. Importance of Capital Account Liberalization

Capital account liberalization is an important proposition of international finance, and has been a focus of attention of economists. As a result of the liberalization in industrialized countries, the issue of capital account liberalization is almost entirely concentrated on developing countries. In the economic globalization today, with the influence of liberalization of external and induced current accounts, implementation of capital account liberalization in developing countries in fact has become an inevitable choice. But since the 1990s, the world has been prone to financial crises, such as the Mexican financial crisis in 1994, the Asian financial crisis in 1997, and, a few years after that, the outbreak of the Brazil's financial crisis, Venezuela's financial crisis, and Argentina's financial crisis. The varying degrees of the crises reflect negative impacts on economies and finances as caused by international capital flows consequent to the liberalization of capital accounts [1].

1.2.2. Inevitability of Currency Wars

With the development of civilization, economies, and societies, after World War II, several of the world's major military powers have found that the use of force, including nuclear weapons, has become increasingly handicapped in resolving disputes. So, the economy has become a battleground, currency wars have already been referred to as a frequent agenda through news outlets. Removing potential threats in the global monetary system has been the goal of the globalized economy of the modern world. Previous reports on defense strategy towards currency wars can be categorized into active defense and passive defense. Gagnon [5] indicated that 22 countries had boosted their economy and created employment opportunities by intervening in foreign-exchange markets. Gagnon and Bergsten [6] estimated that 91 economies increased their external deficits as some other countries manipulated their currencies so that they had to devalue their currencies as a hedge.

The capitalist world is bound to the outbreak of economic crises, which represent the best time to repudiate debts. For example, in 1847, the then wealthy British even got out of its debts in China and the United States by using bankruptcy, creating a precedent example of how debts could be repudiated [18]. This technique can be surely employed today more readily than any time in history, creating more pains and uncertainties in the world.

Mathematically, an economic system can be written approximately in the following form of an n-dimensional constant coefficient linear system [29]:

$$\begin{cases} \dfrac{dx}{dt} = Ax + Bu \\ y = Cx \end{cases},$$

where its state space is assumed to be X, and all relevant terms in these equations were defined in [2,3].

Assume that X_C is the subspace of X that consists of all controllable states and X_{NO} the subspace that consists of all non-observable states. Then the state space X can be decomposed into the following four subspaces:

$$X_1 = X_{No} \cap X_C,$$

$$X_2 \text{ such that } X_C = X_1 \oplus X_2,$$

$$X_3 \text{ such that } X_{No} = X_1 \oplus X_3, \text{ and}$$

$$X_4 \text{ such that } X = X_1 \oplus X_2 \oplus X_3 \oplus X_4.$$

If we assume the dimensionality of X_i is n_i, then we have $n_1 + n_2 + n_3 + n_4 = n$. By choosing a basis $\{e'_1, \cdots, e'_{n_1}\}$ in X_1, $\{e'_{n_1+1}, \cdots, e'_{n_1+n_2}\}$ in X_2, $\{e'_{n_1++n_2+1}, \cdots, e'_{n_1+n_2+n_3}\}$ in X_3, and $\{e'_{n_1+n_2+n_3+1}, \cdots, e'_n\}$ in X_4, we can introduce the following coordinate system:

$$\sum{}_{CO} = \{e'_1, \cdots, e'_{n_1}, e'_{n_1+1}, \cdots, e'_{n_1+n_2}, e'_{n_1++n_2+1}, \cdots, e'_{n_1+n_2+n_3}, e'_{n_1+n_2+n_3+1}, \cdots, e'_n\}.$$

For any $x \in X$, let T be the transformation from the original coordinate system $\sum$ to the new system $\sum_{CO}$ so that $x = Tx'$, where the i-th column is the coordinates of e'_i in the original system $\sum$. So, T is obviously non-singular. Now, in $\sum_{CO}$ we denote $x' = [x_1^T, x_2^T, x_3^T, x_4^T]^T$, where

$$x_1 = [x'_1, \cdots, x'_{n_1}], \quad x_2 = [x'_{n_1+1}, \cdots, x'_{n_1+n_2}],$$

$$x_3 = [x'_{n_1++n_2+1}, \cdots, x'_{n_1+n_2+n_3}], \text{ and } x_4 = [e'_{n_1+n_2+n_3+1}, \cdots, e'_n].$$

With this coordinate transformation, the Kalman canonical decomposition theorem of the control theory [10] implies the following: The previous constant coefficient linear system approximation of an economic system can be written in the coordinate system $\sum_{CO}$ into the following canonical form

$$\begin{cases} \dfrac{dx'}{dt} = \begin{bmatrix} A_{11} & A_{12} & A_{13} & A_{14} \\ 0 & A_{22} & 0 & A_{24} \\ 0 & 0 & A_{33} & A_{34} \\ 0 & 0 & 0 & A_{44} \end{bmatrix} x' + \begin{bmatrix} B_1 \\ B_2 \\ 0 \\ 0 \end{bmatrix} u \\ y = \begin{bmatrix} 0 & C_2 & 0 & C_4 \end{bmatrix} x' \end{cases}$$

and the original system can be decomposed into the following four subsystems:

$$S_1 : \begin{cases} \dfrac{dx_1}{dt} = A_{11}x_1 + B_1 u + f_1 \\ y_1 = 0x_1 = 0 \end{cases}, \text{ where } f_1 = A_{12}x_2 + A_{13}x_3 + A_{14}x_4$$

$$S_2 : \begin{cases} \dfrac{dx_2}{dt} = A_{22}x_2 + B_2 u + f_2 \\ y_2 = C_2 x_2 \end{cases}, \text{ where } f_2 = A_{24}x_4$$

$$S_3 : \begin{cases} \dfrac{dx_3}{dt} = A_{33}x_3 + f_3 \\ y_3 = 0x_3 = 0 \end{cases}, \text{ where } f_3 = A_{34}x_4$$

$$S_4 : \begin{cases} \dfrac{dx_4}{dt} = A_{44}x_4 \\ y_4 = C_4 x_4 \end{cases},$$

where the subsystem S_1 does not have any observable output, the subsystem S_2 can be completely observed and controlled, the subsystem S_3 does not have any output and cannot be affected by any control variable, and the subsystem S_4 is not influenced by any control variable.

What this theoretical result implies is that in the most general circumstance, each economic system is vulnerable to external influences through first the subspace S_1, and then the subspaces S_3 and S_4. And, domestic monetary and fiscal policies can only effectively affect the subsystem

S_2 and the consequent results on S_2 can also be readily observed. The rest of the presentation of this paper turns to the topic of how to defend oneself against currency attacks without much symbolic connection with what is presented in this subsection.

1.2.3. Currency Superiority of the United States

In order to maintain the central position of power in the world economy, the U.S. is ready to fight against the threat of any currency system. As of this writing the U.S. has deployed three strategic fronts centered on the dollar.

(1) Expansion of Global Influence

In history, the first to the dollar's dominance as the center of the strategic front formed shortly after World War II. On June 5, 1947, George Marshall, the 50th Secretary of State of the U.S.A., who had a long-term strategic mind, delivered a historic speech, declaring that the U.S. was ready to help with the European recovery that was to be funded by the U.S. with the most potentially far-reaching Marshall Plan. This program aimed to make Europe American. All allies receiving the U.S. economic aids had to be centered on the dollar; and the recovery from the aftermath of World War II made Europe a mixture consisting largely of American interests, values and informal contact networks. And European countries also undertook political and economic commitments and obligations. That warranted that the United States would have a good hand in the following contest with the economy of the Soviet Union, and greatly curbed the forces of Soviet communist in Europe to advance further from the east to the west. However, the dollar, whose value tumbled in Europe, was used to purchase additional U.S. goods to enter Europe. The consequence was a substantial devaluation of the dollar, leading to a confidence crisis in the dollar. European countries then began to hedge the value of the dollars in their hands with gold. In October 1960, the first dollar crisis erupted. On August 15, 1971, Nixon announced a "new economic policy". The U.S. provisionally stopped the convertibility of the dollar into gold, and refused to sell gold to foreign central banks, which not only made the gold-linked dollar in name only but also caused a complete collapse of the Bretton Woods system. However, as the sole oil pricing currency, the dollar gained a qualitative leap and drew for the first time the boundaries, beyond which the U.S. would employ public actions and deploy military forces. This strategic front of protecting the unique relationship between oil and the dollar, as the time goes on, has become an integral part of American global power. The establishment of cultural, economic and political networks around oil countries has become a global force for American expansion of global influence [26].

(2) Expansion of Its Economic System and Political Will

The second strategic front of consolidating the center position for the dollar was soon employed after the formation of the first one. Because liberal economic reforms, as proposed by Chicago school of economics, took place successfully in Latin America, the U.S. was successful in promoting its capitalist form of economy in terms of geopolitics and in radiating the particular economic form to other socialist countries. The U.S. subversively tried to make Chile, Bolivia, Mexico, and some other countries to abandon the influence of the Soviet economic model. With the collapse of Soviet Union and economies in Eastern Europe, the United States achieved its important strategic goal to changing the political map of Europe that was formed since World War II, and become a dominant force in the global monetary system and acquired its political advantage over others [25]. It should be noted that since the start of the new century, with the initial regionalization of the RMB, Sino and U.S. currencies have been in competition for global influence; and because of the marginalization of the dollar by China, the U.S. has determined to exclude China from the economic power center [26]. In 2011, the most important strategic goal of the United States for the next 10 years consisted of: The United States must expand to the west, dramatically increase diplomatic, economic, strategic and other investments in Asia Pacific to play a leading role in the entire 21st century, because the Pacific region will serve as the center of nation's prosperity and global leadership [26].

(3) Globally Comprehensive Containment Capability

This third strategic front was formed much later in time. The previous two strategic fronts made the United States maintain a multifaceted, cross-cutting, integrated containment capability: Even if there were such a country that could surpass the United States in terms of military might, that country would still be hampered by its economic capacity, technological innovation, and social development so that it would no longer be a potentially threaten. More importantly, the advantage of technological innovations of the U.S. led to strategic advantages in many areas, such as the deployment of conventional forces around the world, competition in energy production, climate warming, space network, computer technology, and so on. Military force becomes less critical in terms of defending national interests, while its importance only lies in helping the United States to establish a decisive advantage in the world. Weak dollar monetary policy was used to hinder economic influence of developing countries. However, unexpectedly, such monetary policies that might shift the U.S. debt crisis also made the economic strengths of these developing countries both constrained and strengthened at the same time. In other words, America's massive QE monetary policy was introduced at the expense of its national political influence, while its long-term strategic goals are immeasurable.

The inconsistency between the monetary dominance of the dollar and the health of the world economy will continue to evolve. In order to reduce the risk of foreign exchanges, various countries will put aside the dollar, and settle their international trades with its own currency. A new currency pattern will be formed [25].

1.2.4. Increasing Influence of Chinese Currency

To reduce the pain created by large-scale quantitative easing in the U.S.A., and to maintain its currency sovereignty, China has adopted a strategy to marginalize the dollar while expanding the influence of its RMB [26].

(1) The Center Front of Marginalizing the Dollar Strategy

In the center front, to support and strengthen the RMB's global influence, China in recent years relied mainly on signing RMB's bilateral currency swap agreements, expanding the regionalization of trade settlement in RMB, and selectively deepening multilateral cooperation (e.g. free trade agreements). In order to ensure the safety of all its assets that are priced in the dollar, China exercises strategic relations with other developing countries in order to promote its RMB's global ambition while restrict the effect of the dollar. Due to the increasing global influence of RMB, China indeed poses a potential and visible threat to the U.S. through extensive global-scale deployments of its RMB while providing a new currency alternative to the world. China's activities have resulted in such a directional trend in the international arena that many governments, including some in Europe, tend to "marginalize the dollar" rather than oppose to the expanding global influence of RMB. In addition, because China's overall economic level has been below that of the United States, the trend has positively contributed to the implementation and expansion of China's strategy of marginalizing the dollar [26].

(2) The international Front of Marginalizing the Dollar Strategy

In the international front, China relies more heavily on political and diplomatic methods. Some countries have recognized the fact that heavy dependency on the United States is not appropriate in terms of international trades and currencies [25,26]. This is the political foundation for China to implement the RMB trade settlements and bilateral currency swap agreements in the world. And, it represents a time to establish a broad, united front of currency union in politics, which would include mainly developing currencies and emerging countries in the currency markets, secondly all of the capitalist countries that are seriously, and adversely affected by the dollar hegemony. The union would establish a multilateral currency swap fund for its member countries in order for them to resolve all crises as caused by the instability of the current international currencies and the world financial system due to the instability of the dollar.

(3) The Outside Front of Marginalizing the Dollar Strategy

In the outside front, the U.S. is clearly aware of the growing, worldwide movement of marginalizing the dollar. This will certainly encourage the U.S. to exploit any existing weaknesses or economic friction in order to slow down China's economic growth and its

expanding global currency influence. As a currency policy tool, the exchange rate of the dollar has shown its dual effect. On one hand, depreciation of the dollar leads to a sharp rise in the trading price of the dollar-denominated commodities, such as oil and gold, forces countries from around the world to increase their demand for the dollar, triggers global inflation, and exploit people including the American people themselves. On the other hand, in order to avoid the dollar exchange rate to rise from the increased demand for the dollar, the U.S. government increased the supply of the dollar through massive QEs, which not only reduce the fiscal deficit and valuation of foreign debts, but also enables the government to devalue the dollar to achieve the relative appreciation of other currencies so as to realize comparative advantage of the weak currency in exports. To counter such uncertainties, China has maintained the stability of its exchange rate with the dollar and appropriate trade scale [25,26].

2. FRAMEWORK DESCRIPTION

2.1 Preliminaries

Lemma. For any positive definite symmetric matrix W and any constant $y > 0$, the following inequality holds true

$$-y\int_{-y}^{0} \dot{x}^T(t+\xi)W\dot{x}(t+\xi)d\xi \leq (x^T(t)-x^T(t-y))W(x(t)-x(t-y)) \tag{1}$$

Proof: Because W is a positive definite symmetric matrix, there is $D > 0$ such that $W = D^T D$. Let $G = (g_1,\ldots,g_n) \in R^n, \|G\| = 1$, be a constant vector G of length one. Then in the light of Cauchy inequality, we have:

$$\int_{-y}^{0} D\dot{x}(t+\xi)^T D\dot{x}(t+\xi)d\xi \int_{-y}^{0} G^T G d\xi \geq (\int_{-y}^{0} G^T D\dot{x}(t+\xi)d\xi)(\int_{-y}^{0} D\dot{x}(t+\xi)^T G d\xi) \tag{2}$$

Therefore, we have

$$\int_{-y}^{0} \dot{x}^T(t+\xi)W\dot{x}(t+\xi)d\xi \geq \frac{1}{y}(\int_{-y}^{0} G^T D\dot{x}(t+\xi)d\xi)(\int_{-y}^{0} D\dot{x}(t+\xi)^T G d\xi)$$

$$= \frac{1}{y}\left(x^T(t)-x^T(t-y)\right)\left(D^T G \cdot G^T D\right)\left(x(t)-x(t-y)\right)$$

$$= \frac{1}{y}(x^T(t)-x^T(t-y))W(x(t)-x(t-y)) . \text{Q.E.D.}$$

2.2 The main result

Consider the following situation with a polynomial lag

$$\begin{cases} \dot{x} = Ax(t) + \sum_{i=1}^{n} A_i x(t-h_i) + Bw(t) + B_1 u(t) & 3(a) \\ \\ z = Cx(t) + \sum_{i=1}^{n} C_i x(t-h_i) + Dw(t) + D_1 u(t) & 3(b) \\ \\ x(t) = \varphi(t), t \in \left[-\overline{h}, 0\right] \end{cases} \tag{3}$$

Let

$$V = x^T Px + \sum_{i=1}^{m} \int_{t-h_i}^{t} x^T Q_i x dt + \sum_{i=1}^{m} \int_{t-h_i}^{t} (h_i - t + \xi)\dot{x}^T (hR_i)\dot{x} dt \tag{4}$$

Then we have the following theorem.

Theorem 1. If the decision matrix $M = M_1 + M_2 + M_3$ of system (3) satisfies $M_1+M_2+M_3 < 0$, then system (3) is stable.

Proof. A stability condition of system (3) is that the eigenvalues of M are negative numbers. This condition of equivalence means that the decision matrix M must be negative definite, that is, $M = M_1 + M_2 + M_3 < 0$.

In fact, we can do the following symbolic calculation:

$$\dot{V}(t) = \dot{x}^T(t)Px(t) + x^T(t)P\dot{x}(t) + \sum_{i=1}^{m} x^T(t)Q_i x(t) - \sum_{i=1}^{m} x^T(t-k_i)Q_i x(t-k_i)$$

$$+ \sum_{i=1}^{m} \dot{x}^T(t)(k_i^2 R_i)\dot{x}(t) - \sum_{i=1}^{m} \int_{t-k_i}^{t} \dot{x}^T(\xi)(k_i Q_i)\dot{x}(\xi)d\xi \qquad (5)$$

$$= 2x^T(t)A^T Px(t) + 2\sum_{i=1}^{m} x^T(t-k_i)A_i^T Px(t) + 2W^T B^T P\dot{x}(t) + \sum_{i=1}^{m} x^T(t)Q_i x(t)$$

$$- \sum_{i=1}^{m} x^T(t-k_i)Q_i(xt-k_i) + \sum_{i=1}^{m} \dot{x}^T(t)(k_i^2 R_i)\dot{x}(t) - \sum_{i=1}^{m} \int_{t-k_i}^{t} \dot{x}^T(\xi)(k_i Q_i)\dot{x}(\xi)d\xi .$$

Notice that

(a) $\displaystyle\sum_{i=1}^{m} \dot{x}^T(t)(k_i^2 R_i)\dot{x}(t)$

$$= (x^T(t) \quad x^T(t-k_1) \quad \cdots \quad x^T(t-k_m) \quad W^T) \begin{pmatrix} A \\ A_2 \\ \vdots \\ A_m \\ B \end{pmatrix} (\sum_{i=1}^{m} k_i^2 R_i)\begin{pmatrix} A^T & A_1^T & \cdots & A_m^T & W^T \end{pmatrix} \begin{pmatrix} x \\ x(t-h_1) \\ \vdots \\ x(t-h_m) \\ W \end{pmatrix}$$

$$= (x^T(t) \quad x^T(t-k_1) \quad \cdots \quad x^T(t-k_m) \quad W^T) M_1 \begin{pmatrix} x \\ x(t-h_1) \\ \vdots \\ x(t-h_m) \\ W \end{pmatrix}$$

where

$$M_1 = \begin{pmatrix} A(\sum_{i=1}^{m} k_i^2 R_i)A^T & A(\sum_{i=1}^{m} k_i^2 R_i)A_1^T & \cdots & A(\sum_{i=1}^{m} k_i^2 R_i)A_m^T & A(\sum_{i=1}^{m} k_i^2 R_i)W^T \\ A_1(\sum_{i=1}^{m} k_i^2 R_i)A^T & A_1(\sum_{i=1}^{m} k_i^2 R_i)A_1^T & \cdots & A_1(\sum_{i=1}^{m} k_i^2 R_i)A_m^T & A_1(\sum_{i=1}^{m} k_i^2 R_i)W^T \\ \vdots & & \ddots & & \vdots \\ B(\sum_{i=1}^{m} k_i^2 R_i)A^T & B(\sum_{i=1}^{m} k_i^2 R_i)A_1^T & \cdots & B(\sum_{i=1}^{m} k_i^2 R_i)A_m^T & B(\sum_{i=1}^{m} k_i^2 R_i)W^T \end{pmatrix} \qquad (6)$$

(b) $\displaystyle\int_{t-k_i}^{t} \dot{x}^T(\xi)(k_i R_i)\dot{x}(\xi)d\xi \le (x(t)-x(t-k_i))^T (k_i R_i)(x(t)-x(t-k_i))$

$$-\sum_{i=1}^{m} \int_{t-k_i}^{t} \dot{x}^T(\xi)(k_i R_i)\dot{x}(\xi)d\xi \le (x^T(t) \quad x^T(t-k_1) \quad \cdots \quad x^T(t-k_m) \quad W^T) M_2 \begin{pmatrix} x(t) \\ x(t-h_1) \\ \vdots \\ x(t-h_m) \\ W \end{pmatrix}$$

where

$$
M_2 = \begin{pmatrix} -R_1 & R_1 & \cdots & R_m & 0 \\ R_1 & -R_1 & \cdots & R_m & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ R_m & R_m & R_m & -R_m & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}
\tag{7}
$$

Plugging eqs. (6) and (7) into eq. (5) gives

$$
\dot{V}(t) = \begin{pmatrix} x^T(t) & x^T(t-k_1) & \cdots & x^T(t-k_m) & W^T \end{pmatrix} M \begin{pmatrix} x(t) \\ x(t-h_1) \\ \vdots \\ x(t-h_m) \\ W \end{pmatrix}
$$

Because $M = M_1 + M_2 + M_3$,

$$
M_3 = \begin{pmatrix} A^T P + PA + \sum_{i=1}^{m} Q_i & PA_1 & PA_2 & \cdots & PA_m & PB \\ A_1^T P & -Q_1 & 0 & \cdots & 0 & 0 \\ A_2^T P & & -Q_2 & \cdots & \vdots & \vdots \\ \vdots & 0 & & \ddots & \vdots & \vdots \\ A_m^T P & 0 & 0 & \cdots & -Q_m & 0 \\ B^T P & 0 & 0 & \cdots & 0 & 0 \end{pmatrix}
\tag{8}
$$

Now, the stability condition of the general system with polynomial lag is:
$$
M_1 + M_2 + M_3 < 0.
\tag{9}
$$
Q.E.D.

4. CASE STUDY

As in [2,3], we continue to use w to represent the vector $\begin{bmatrix} w_1 & w_2 & w_3 \end{bmatrix}^T$ of categorized monetary policies $w_1, w_2 \ldots, w_n$, which are accordingly grouped into three categories as follows:

$W_1 =$ the set of all those monetary policies that deal with the population meeting the minimum need to maintain the basic living standard;

$W_2 =$ the set of all those monetary policies that deal with the population's need for acquiring desired living conditions; and

$W_3 =$ the set of all those monetary policies that deal with the population's need for enjoying luxurious living conditions.

Similar to the concept of overall balance of international payments, we introduce an economic index vector $z = \begin{bmatrix} z_1 & z_2 & z_3 \end{bmatrix}^T$ such that z_i measures the state of the economic sector i, $i = 1, 2, 3$. When the purchasing power increases, people will purchase more assets and products from foreign countries, the overall balance of international payments will decrease (foreign exchange expenditure increase); When the purchasing power decreases, people will sell more assets and products from the domestic country, and the overall balance of international payments will increase (foreign exchange revenue increase).

We established the systemic model (eq. (3)) with polynomial lag. In this model, we use symbol Z to represent the state of the national economy, w_1, w_2, and w_3 the positive and negative effects of the monetary policies on the performance of the economy directly, or on the currency demand and supply to have an impact on the economy indirectly. Here $u(t)$ is a random vector with a nonzero mean. Due to the fact that economic development can be seen as a continuous process, the current change in the money stock is determined by the current monetary policies,

money stock, and the previous money stock. And the current performance of the economy is also determined by the current monetary policies, money stock, and the previous money stock.

Here x is the 3×1 matrix $[D_1 - S_1 \ D_2 - S_2 \ D_3 - S_3]^T$ of the categorized difference of demand and supply of money, referred to as the three parts of the state of the economic system. Specifically, our systemic model divides the economy into three sectors E_1, E_2, and E_3. Compared to sector E_2, which consists of such goods, services that are used by citizens to acquire desired living conditions, sector E_1 consists of living necessities. Sector E_3 consists of such goods, services that are used by the citizens for their enjoyment of luxurious living. Our systemic model of the national economy indicates that our separation of the economy into these three sectors can help properly manage the market reaction to the monetary policies. When the monetary policies have positive effect on the performance of the economy, people in every economic sector will purchase more assets and products with the increase of the purchasing power of their income, (foreign exchange expenditure increases); when monetary policies have negative effect on the performance of the economy, people in every economic sector will sell more assets and products with the decrease of the purchasing power of their income (foreign exchange revenue increases).

We obtained the stability criterion $M_1 + M_2 + M_3 < 0$ (eq. (9)) for the general time-delay system based on the systemic model structure with the first-order lag. Let

$$A_i = \begin{bmatrix} A_1 & 0 & 0 \\ 0 & A_2 & 0 \\ 0 & 0 & A_3 \end{bmatrix}, B_i = \begin{bmatrix} B_1 & 0 & 0 \\ 0 & B_2 & 0 \\ 0 & 0 & B_3 \end{bmatrix}, C_i = \begin{bmatrix} C_1 & 0 & 0 \\ 0 & C_2 & 0 \\ 0 & 0 & C_3 \end{bmatrix}, D_i = \begin{bmatrix} D_1 & 0 & 0 \\ 0 & D_2 & 0 \\ 0 & 0 & D_3 \end{bmatrix}$$

Because $A_iR_i = k_i$, $B_iR_i = Q_i$, and W are positive definite matrix, from eqs. (6), (7), and (8) we have

$$M_1 = \begin{pmatrix} A(\sum_{i=1}^{3} k_i^2 R_i)A^T & A(\sum_{i=1}^{3} k_i^2 R_i)A_1^T & A(\sum_{i=1}^{3} k_i^2 R_i)A_2^T & A(\sum_{i=1}^{3} k_i^2 R_i)A_3^T & A(\sum_{i=1}^{3} k_i^2 R_i)W^T \\ A_1(\sum_{i=1}^{3} k_i^2 R_i)A^T & A_1(\sum_{i=1}^{3} k_i^2 R_i)A_1^T & A_1(\sum_{i=1}^{3} k_i^2 R_i)A_2^T & A_1(\sum_{i=1}^{3} k_i^2 R_i)A_3^T & A_1(\sum_{i=1}^{3} k_i^2 R_i)W^T \\ A_2(\sum_{i=1}^{3} k_i^2 R_i)A^T & A_2(\sum_{i=1}^{3} k_i^2 R_i)A_1^T & A_2(\sum_{i=1}^{3} k_i^2 R_i)A_2^T & A_2(\sum_{i=1}^{3} k_i^2 R_i)A_3^T & A_2(\sum_{i=1}^{3} k_i^2 R_i)W^T \\ A_3(\sum_{i=1}^{3} k_i^2 R_i)A^T & A_3(\sum_{i=1}^{3} k_i^2 R_i)A_1^T & A_3(\sum_{i=1}^{3} k_i^2 R_i)A_2^T & A_3(\sum_{i=1}^{3} k_i^2 R_i)A_3^T & A_3(\sum_{i=1}^{3} k_i^2 R_i)W^T \\ B(\sum_{i=1}^{3} k_i^2 R_i)A^T & B(\sum_{i=1}^{3} k_i^2 R_i)A_1^T & B(\sum_{i=1}^{3} k_i^2 R_i)A_2^T & B(\sum_{i=1}^{3} k_i^2 R_i)A_3^T & B(\sum_{i=1}^{3} k_i^2 R_i)W^T \end{pmatrix}$$

$$M_2 = \begin{pmatrix} -R_1 & R_1 & R_2 & R_3 & 0 \\ R_1 & -R_1 & R_2 & R_3 & 0 \\ R_2 & R_1 & -R_2 & R_3 & 0 \\ R_3 & R_3 & R_3 & -R_3 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$M_3 = \begin{pmatrix} A^T P + PA + \sum_{i=1}^{3} Q_i & PA_1 & PA_2 & PA_3 & PB \\ A_1^T P & -Q_1 & 0 & 0 & 0 \\ A_2^T P & 0 & -Q_2 & 0 & 0 \\ A_3^T P & 0 & 0 & -Q_3 & 0 \\ B^T P & 0 & 0 & 0 & 0 \end{pmatrix}$$

So we can obtain an expression for $M_1 + M_2 + M_3$ explicitly. If the sum is negative, then the systemic model above is stable.

To facilitate the detailed calculation, we only select a one-dimensional case for explanation so that the three sectors in [2] become one sector. By substituting the demand and supply of money, x is defined as an exchange rate. We will still use the same symbol w to represent the vector $[w_1 \ w_2 \ w_3]^T$ of categorized monetary policies. Eq. (3a) indicates that the current exchange rate is not only determined by the current monetary policies, but also by the previous monetary policies. In this paper, our model established by empirical studies shows that when the financial crisis occurred (from 2008 to 2010), the government made the exchange rate of the RMB against the U.S. dollar remaining at around 6.8 through the implementation of a series of effective policies and instruments. Based on the systemic model structure for the second-order lag, the fitting degree of the model that contains parameters for policy implications increases 16.8% from that of the model without any parameters for policy implications, for details see Figure 1. This result means the effectiveness of the policy parameters.
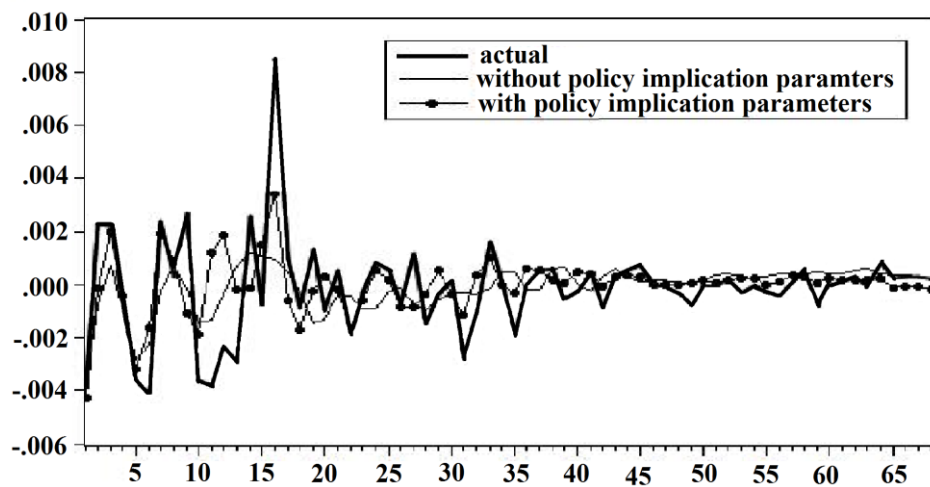

Fig. 1: Delayed effects of monetary policies (fitting after the second order difference in 68 weeks from 2008 to 2010)

When we define Z as the overall balance of international payments, eq. (3b) indicates that the overall balance of international payments is determined by the current exchange rate and the previous exchange rates. The result also shows the fitting degree of model that contains parameters for policy implications is better than that of the model without any parameter for policy implications. The policy parameters are useful and necessary in the fitting process. We also know that Z is determined by the current exchange rate and the previous exchange rates directly, and determined by the current monetary policies and the previous monetary policies indirectly. So the nature of the changing Z is determined by quantitative continuous-deferred monetary policies.

5. IMPLICATIONS OF THE ESTABLISHED THEORY

In the internationalization process of a currency, government policy is an extremely important factor. To this end, let us consider the policy implications process of some major currencies from around the world.

GBP: Britain was the first country in the history to build modern financial institutions that grew the fastest and developed with the most perfection. British National Order passed a bill to establish a Bank of England in 1694 so that Britain became the first country in the world to have a central bank. From 1816 to 1819, British government issued a series of regulations and policies about Mint and exchange, and implemented a true gold standard, which also made Britain the world's first to implement such a standard. From the middle Ages to the 19th century when Britain became the "Sun" Empire, the British had dominated the world's finance. After World

War I, in the "Dollar Bloc" and "Franc Bloc" supplant, pound was no longer used as an international currency. After World War II, with the establishment of the Bretton Woods system, pound was degraded to a national currency [30].

USD: After a century of dormancy, with the establishment of the Bretton Woods system, the dollar became the world currency. However, as of 1971, a deficit, not seen since 1893, in the overall balance of payments of the United States emerged, and the gold reserve of the United States amounted to less than 1/5 of the foreign short-term liabilities. To prevent countries to exchange their holdings of the dollar into gold, President Nixon announced the New Economic Policy on August 15th, 1971, and his administration issued policies and laws to save the crumbling Bretton Woods system; and the Group of Ten reached the Smithsonian Agreement in December, 1971. However, these efforts failed to curb the selling wave of the dollar and the buying of gold and other currencies of the world. The Bretton Woods system collapsed in 1973. Since then, German mark, French franc, Britain pound, and other currencies began to enter the international currency system. Even since, the dollar began to embark on its long downward spiral [30].

JPY: After the Meiji Restoration, Japan established the Bank of Japan, the central bank of the country, in October 1882. Diverted to the gold standard in 1897, Japan became the Asian financial pacesetter. After World War I Japan began its dominance of the Far East and the Pacific region. After World War II Japan was taken over by America's "Allied Command". Since then, Japan implemented a series of democratization reform measures. As a result of the war on the Korean Peninsula as well as the Dodge plan in June 1950, Japanese economy quickly recovered to the pre-war levels. In 1952, Japan recovered its sovereignty and joined the International Monetary Fund and the World Bank. However, the nationalization and free convertibility of the yen is not synchronized. Since the early 1970s, the yen has become an international currency, but Japan did not issue a decree to allow foreigners to issue bond in Japan until the mid-1970s. In the meanwhile, Japanese investment in foreign securities began to liberalize. During 2013-2014, the proportion of Japanese yen traded in New York foreign exchange market was hovering around 23% [14].

Mark: After World War I, Germany became the country in the world that suffered the most from inflation. Since the end of World War II, Germany has always stressed the independence of its central bank; and the German territories occupied by the West followed the United States and established a two-stage system to avoid the government from manipulating the center bank. On July 26, 1957, the Federal German Parliament enacted the Bundesbank Act, making Bundesbank a unified central bank. After the 1973 collapse of the Bretton Woods system, the German decree introduced a floating exchange rate system. Since then, German mark became the second-largest international currency in the world only after the dollar of the United States [30].

EUR: The euro was controversial. Based on the euro zone's GDP, import and export volume when comparable to that of the U.S., many European scholars held their widespread optimism that the euro will challenge the dollar with weight tilting to the euro. But scholars of the U.S. held bearish view on the euro (Samuelson, 2000; Frankel, 2015; Soros, 2010). On January 4, 1999, the euro came into the world. Since then, the history seems to suggest that although the European Union has introduced a series of policies and regulations, the effectiveness of the policies has impacted the international community slightly [14].

China is now the second largest economy and the largest exporter in the world. With its growing economy and deepening financial reform, its RMB has the ambition to become an international currency. However, the internationalization will be a long process due to the following reasons.

The Chinese Government deems Free Trade Agreements (FTAs) as a new platform to further open up the country to the outside world and speed up domestic reforms, an effective approach to integrate the country into the global economy and to strengthen economic cooperation with other economies, as well as particularly an important supplement to the multilateral trading system. Currently, China has 20 FTAs under construction or implementation. The RMB aimed at

eventually becoming a regional financial settlement instrument and commodity with the ongoing development of the multilateral economic cooperation. It is seen as a natural and regional monetary integration which will eliminate the cost of currency trading and the risk of exchange rate fluctuations, and gradually expand the trading network, promote the economic cycle. Secondly, the internationalization of RMB will provide favorable conditions for the development and implementation of China's economic policies. This factor has a strong appeal to the Chinese government. The internationalization of RMB will enhance the autonomy of monetary policy in China and help China to get rid of problems that exist in developed countries, such as the "Mead dilemma" that to maintain external balance developing countries will have to sacrifice internal balance. This end will help China reduce the risk of economic instability and safeguard the national economic security, which is particularly important in the course of economic globalization. Finally, the internationalization of RMB will help China to guard against financial crises [28].

Within the imperfect dollar-dominated international monetary system, the internationalization of RMB will improve China's capacity of finance. When financial assets are priced (at least partially) in RMB in the world markets, China would be able to decide prices and control risk to some extent. And in the process of internationalization of RMB, China must face two types of risks:

(1) The liquidity risk. Because of the integration of the global finance, when the assets China holds are priced in a foreign currency, the government will have no means of control to provide liquidity as lender of the last resort. This risk is difficult to manage once the market becomes volatile. The assets and liabilities held by either the government or the citizens in the current account will lead a basic process of money creation. We believe that a contraction of the money supply indicates a greater liquidity problem. Even for those countries that have enough foreign exchange reserves, like China, trying to provide adequate liquidity within a brief moment of time will cause a huge impact on assets markets and create a vicious cycle.

(2) The risk of price fluctuations under currency mismatch. Under the floating exchange rate regime, one has to face the risk of price fluctuations. However, if assets are denominated in the local currency, the risk of price fluctuations will to certain extent be reduced. The fact that the assets held by China are denominated in foreign currencies means that China has surrendered part of its power to regulate its financial market to some foreign governments. So, whether it is for the purpose for China to maintain the stability of its economy and the security of its financial assets or for the purpose for it to balance the stability of its international trades, it is important for China to accelerate the internationalization of its currency, the RMB.

The recent rise of emerging-market economies provides a special opportunity for the internationalization of RMB, because diversified international currency represents the interests of the majority of countries. Because of these particular circumstances, China enjoys many favorable conditions to promote the internationalization of its RMB.

First, China's comprehensive national strength has increased significantly. Its fast growing economy in the past decades has laid a firm foundation for people from around the world to use RMB. Due to the introduction of prudent monetary policies, China has enjoyed favorable social reputation. For example, China has maintained the value of its RMB by curbing its domestic inflation. RMB has played a notable role in combating the recent global financial crisis. The relatively stable exchange rate has also laid a solid, reliable foundation for promoting the internationalization of RMB.

Secondly, it is the relatively liberal regime environment in China and improvement of the convertibility of RMB. In China's neighboring countries and regions, RMB has been employed in similar fashions as the dollar and other hard currencies that are relatively easy to acquire. In order to promote RMB in cross-border trade settlements, some border provinces have developed innovative institutions. ASEAN Free Trade Area for Overseas Circulation of RMB has provided a broad space for promoting RMB. Under the premise of stable exchange rate with RMB, some countries and regions, which trade and invest frequently or with large amounts with China, have

been willing to accept RMB as the denominated settlement currency. For example, in trades with Vietnam, Thailand, Myanmar, and other countries, RMB has in fact become one of the monetary instruments for settlements [26].

Thirdly, Hong Kong, a recognized center of international finance, represents a unique advantage for China. In the process of internationalizing RMB, Hong Kong can play and has played an important role. The city has a complete and mature legal system, perfect market infrastructure, and the HKMA (Hong Kong Monetary Authority) operates independently from the government. So, Hong Kong can help with the implementation of RMB's regionalization, provide useful experience for the Chinese central government. Before the Chinese financial market could become mature enough to handle the excessive volatility of the international financial market, the offshore RMB market in Hong Kong will play the role of "firewall" for the mainland. And, the financial supervisory system in Hong Kong can help the mainland government and currency authority to grasp market trends and to detect potential threats.

Although many favorable conditions exist, the regionalization of RMB is still plagued with various internal and external difficulties.

First, the degree of regional economic integration affects the scale of RMB's regionalization. In areas where trades and personnel exchanges happen frequently, especially in border areas, RMB has seen greater liquidity, and even enjoyed more popularity than the relevant national currencies. However, if a neighboring country did not reach any institutional arrangement with China, then the existing economic integration measures along the border between the two countries would not in general be extended to the whole region, where the regionalization of RMB could only be confined to the border areas. In such areas, financial services are generally in short supply and there would be no unified basis for the exchange rate of the RMB.

In some areas of Southeastern Asia that have liberalized trades and traded heavily with China, including CAFTA (China and ASEAN Free Trade Area), many countries suffer from their underdeveloped banking systems so that these countries have few financial institutions that handle the business of RMB exchange. In addition, many of these countries do not have their official exchange rates for direct conversion of their local currencies into RMB other than the black market. Also, the current security issues and conflicts in Northeastern and Southeastern Asia might very well place a damp on the internationalization of RMB and affect the confidence for RMB to be widely used in trade settlements and investments in the region.

Because of the constraints of these listed factors, the internationalization of RMB will be a gradual and long drawn-out process. That surely posts challenges for China's authorities to formulate and to implement wise currency policies. With the increase in capital liquidity and overseas business of Chinese commercial banks, the authorities better have an ability to predict, to manage, and to control risks.

6. CONCLUSION

Each currency war represents a battle without involving gunpowder. During the fight, countries try to compete for acquiring biggest economic benefits mainly by adjusting the supply and value of their domestic money. Today, more than 100 countries have been actively or passively involved in currency wars. Although some countries can benefit from currency competitions in the short term, it is doubtful whether this benefit is sustainable. And one thing is for sure: most countries, especially those involuntarily involved in the wars, will suffer great economic and social unrest.

By taking the impact of capital account liberalization of China on international capital flow and economic and financial system as an entry point, this paper establishes a dynamic systemic model with lag variables, and the stability condition of the dynamical system. Then, a one-dimensional case is developed to explain the significance of this work. Through the model we can know the following. First, stability condition of the dynamical system shows monetary policy and its subsequent effects can play an important role in the economic stability of the country under the free flow of capital, and this condition has certain warning effect. Second, how

monetary policy regulates the economy in the system. Third, the impact of monetary policy and its subsequent effects will play a decisive role in regulating economic equilibrium.

Based on what has been accomplished in this paper, we have following important suggestions on defense solutions towards currency wars.

First, it is comparatively limited in theory to study simply the dynamic systems model between two countries. Such study should be expanded to a much bigger dynamic system involving many mutually reciprocal feedback countries so that more convincing results with real policy effects can be established.

Second, the following is truly a quite complex problem: How can one improve the accuracy of assessing and quantifying the impact of different monetary policies on the economy? This problem and related issues need to be further investigated.

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