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China's Renminbi Currency Logistics Network: A Brief Introduction

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Abstract

Currency logistics is becoming a field of increasing interest and importance both in government and academic circles. In this paper, China's nationwide logistics network for the Renminbi is discussed. In addition to its basic structure, its key problems such as production costs, inventory levels, and transportation and storage security are described and analyzed.

Key words: currency supply chain, Renminbi, logistics management

1. Introduction

Oftentimes, discussions of cash or the basic money supply measure, M_0 (cash in circulation), is only the realm of macroeconomic theory and monetary policy. As valuable as these insights are, even in our increasingly digital economy, cash is still largely a physical medium of exchange. In almost all nations, physical cash and coins are backed, minted or printed, and supplied by a central bank in cooperation with government and commercial banks and businesses across the country. As has been discussed by Rajamani et. al. [1], Geismar, et. al. [2] and the European Central Bank [3], the nature of the logistics and physical distribution of 'cash supply chains', 'cash chains', or 'currency chains' is still

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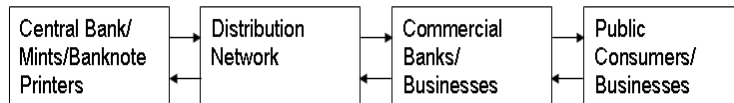


Figure 1: Basic structure of a closed-loop currency supply chain.

largely untouched in the published literature with the exception of discussions of institutional cash management.

The central monetary authority of every nation, and those of supranational monetary authorities such as the European Central Bank (ECB), face the classic supply-demand and distribution issues that face any business or military when distributing goods. Among the most important decisions are to contract with a public or private mint and printing bureau to produce currency, ascertain the demand for cash both within and outside of the country, how to handle the physical notes and coins based on this demand and the financial and business sector framework, the extent of public or private management of the distribution and cash warehousing network, security in this distribution network, recirculation of banknotes and coins back to a central authority where obsolete and debilitated currency can be removed from circulation, and how to effectively cut out counterfeit currency from the supply chain.

A useful framework of the cash supply chain as a closed-loop supply chain where both forward distribution and reverse logistics are considered was discussed in [1]. As seen in Figure 1, generally, there is a forward and backward motion of notes throughout the supply chain as notes are distributed to the public and notes are take back for sorting and many are removed from circulation. Schautzer [4], Carlin [5], and the Reserve Bank of India [6] discuss the cash supply chains of Austria in the context of the EU, Australia, and India respectively. Each of these countries has a system of logistics that is fit to its individual circumstances. In Austria’s case, like other Euro countries, both the national central banks and the ECB work together to determine banknote demand, production, and distribution across the Eurozone.

In this paper, a brief introduction to China’s Renminbi currency logistics network is provided. Section 2 describes China’s economy and government financial institutions. Section 3 gives China’s currency circulation, denominations, and structure. Section 4 shows China’s currency management and distribution. Section 5 reveals risks to the currency supply chain and the authors’ proposed solutions. Finally, we have concluding remarks and recommendations for future research.



Figure 2: 100 RMB note design.

2. China: Economy and Institutions

The People's Republic of China has undergone a rapid and massive transformation since 1978 when its economic liberalization began. China has now become the world's third largest economy, with a 2008 GDP of \$4.4 Trillion, and has undergone double digit annual growth for most of the last several years. Having the world's largest population of 1.4 billion people, it unsurprisingly has the largest volume circulation of banknotes in the world, Zhang [8]. In 2007, the People's Bank of China (PBOC) handled 165.3 trillion Renminbi (RMB), issuing 82.8 trillion RMB and receiving/sorting 82.5 trillion RMB, PBOC [10].

The Chinese currency, the RMB, is non-convertible and managed by the PBOC, the Chinese central bank. It is legal tender throughout mainland China but not Hong Kong S.A.R., Macau S.A.R. or Taiwan which will not be covered in this paper. Table 1, lists the coin and note denominations in the current fifth series of banknote styles which began rollout in 1999 and completed rollout in 2005 [10]. Figure 2 also shows a sample banknote, the 100 RMB denominated note. The official responsibility of cash currency policy given to the PBOC is laid out in the "People's Bank of China Law" guidelines [10]. In addition, the current monetary policy is outlined in the PBOC's "Monetary Policy" documents available on its website [10]. Like most modern currencies, the RMB has evolved over time in order to increase durability and has added a variety of anti-counterfeiting measures to the note.

Coins (in “yuan”)	Notes (in “yuan”)
0.1	1
0.5	5
1	10
	20
	50
	100

Table 1: Current fifth series Renminbi coin and banknote denominations.

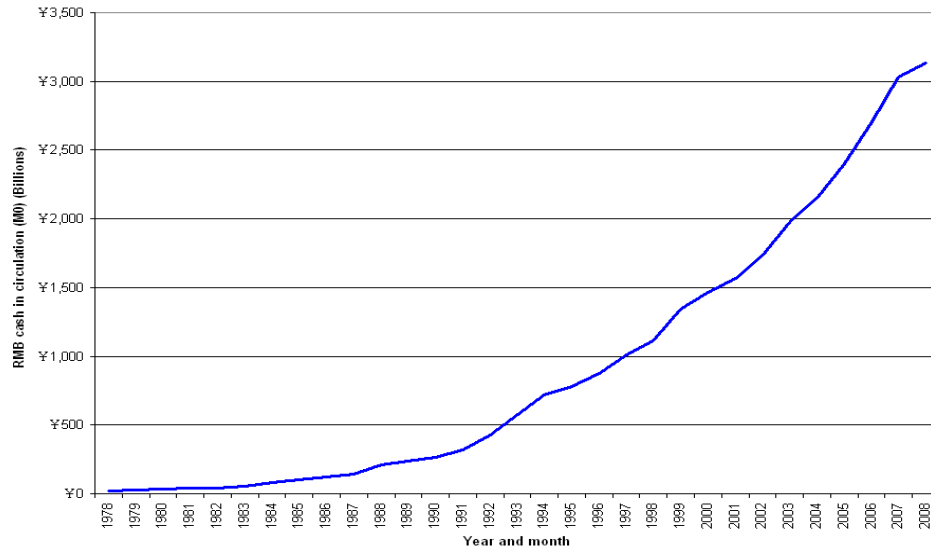


Figure 3: Annual M_0 by year from 1978 to October 2008. Data source: PBOC [10]

3. China’s Currency Circulation, Denominations, and Structure

China has had to deal with an exponentially growing money supply during its period of rapid growth over the last few decades. In Figures 3 and 4 are M_0 statistics from China over time. Figure 3 shows annual year-end M_0 since 1978 and Figure 4 shows monthly M_0 since December 1999. M_0 has grown from 21 billion RMB in 1978 to over 3 trillion RMB at present, a 147-fold increase [10]. Through investigation, we find that annual spikes of the monthly M_0 curve in Figure 4 are due to increased withdrawals and circulation due to gift giving and purchases on the Chinese New Year holiday. Though the monetary policy aspects of this are widely discussed and debated, it presents a massive logistical challenge which would require a co-committed expansion in production, infrastructure, and distribution capabilities to prevent shortages.

A brief history of China’s cash policy until 1998 is given by Guo[12] which

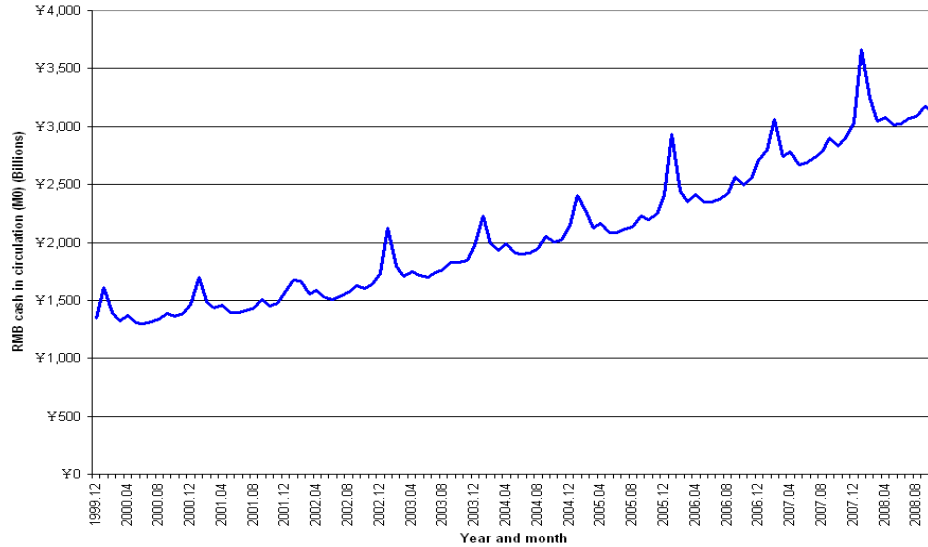


Figure 4: Monthly M_0 from December 1999 to October 2008. Data source: PBOC [10]

divides the growth of the cash culture in China into three phases: 1978-1980, 1981-1984, 1985-1988, 1989-1993, 1994-1997 based largely on the increases of the average yearly net increase in M_0 in each period. China's money supply as expected has largely increased due to the increasing needs of societal transactions, rises in consumer prices, and interest rate policies effect on the money supply.

Chinese currency denominations have changed from the first series to the current fifth series of banknotes. The general structure of the banknote composition of the money supply has changed with the needs of economic development, efforts to improve the RMB currency system, and to improve the defense of the RMB against counterfeit currency. In Tables 3 and 3, are the % of M_0 in RMB and volume for the years 1978, 1987, 1988, and 1998. Consistent with most economies, the largest volume of bills are of small denominations which is necessary in order to produce change and allow small transactions. There have been some large changes in the structure of RMB denominations as the 50 and 100 RMB notes have taken huge share from the 5 and 10 RMB notes since their introduction in the 1987 and 1988 respectively. This is likely, in part to the increasing use and acceptance of ATMs as well as rising demand for high value cash transactions. Guo [12] further predicts that the 100 RMB note will continue to hold a large share, 80%+ of M_0 by value out until 2010.

	1978	1987	1988	1998
1 & 2 RMB	16%	5%	5%	2%
5 RMB	30%	16%	16%	1%
10 RMB	49%	72%	48%	7%
20 RMB	4%	7%	8%	2%
50 RMB	N.A.	N.A.	13%	13%
100 RMB	N.A.	N.A.	11%	75%
All coins	1%	1%	N.A.	N.A.

Table 2: Percent of M_0 each banknote represents by year; 20 RMB was calculated using a plug for 100% since numbers were not given. 10 RMB in 1988 estimated based on percent in 1987 minus share capture from 50 and 100 RMB. Based on Chen [14], Guo [12]

	1978	1987	1988	1998
1 & 2 RMB	48%	22%	26%	38%
5 RMB	28%	24%	27%	8%
10 RMB	23%	52%	41%	20%
20 RMB	1%	2%	3%	3%
50 RMB	N.A.	N.A.	2%	8%
100 RMB	N.A.	N.A.	1%	23%

Table 3: Percent of total banknote volume each denomination represents by year; calculated using 1.5 used for value of 1 and 2 RMB set. Based on Chen [14], Guo [12]

4. China’s Currency Management and Distribution

According to the “People’s Bank of China Law”, the PBOC is responsible for determining how RMB are produced. The actual infrastructure for the minting/printing of Chinese currency is carried about by a state owned corporation, China Banknote Printing and Minting (CBPMC) headquartered in Beijing. CBPMC uses a network of printing and engraving and minting facilities around the country (see Figure 5) to produce banknotes and coins for subsequent distribution. Banknote printing facilities are based in Beijing, Shanghai, Chengdu, Xi’an, Shijiazhuang, and Nanchang. Mints are located in Nanjing, Shanghai, and Shenyang. Also, high grade paper for the banknotes is produced at two facilities in Baoding and Kunshan. The Baoding facility is the largest facility in the world dedicated to developing banknote material, CBPMC [11]. In addition, the PBOC has its own printing technology research division which researches new techniques for creating banknotes and making counterfeiting more difficult.

Chen [7], Zhu & Wang [9] detail the distribution and logistics network of the RMB throughout China. Here, we provide the basic structure of the RMB supply chain (Figure 6), comparing it with the general currency supply chain (Figure 1). The solid lines in the figure designate the flow of fit cash destined for and within market circulation. The dotted lines represent unfit cash which is damaged and is eventually removed from circulation.



Figure 5: Location of banknote printing facilities and mints in China. Blue circles are mints, green circles are banknote printers, and red circles are note paper producers. Data source: PBOC [10]. China map image courtesy Wikimedia author Rich4.

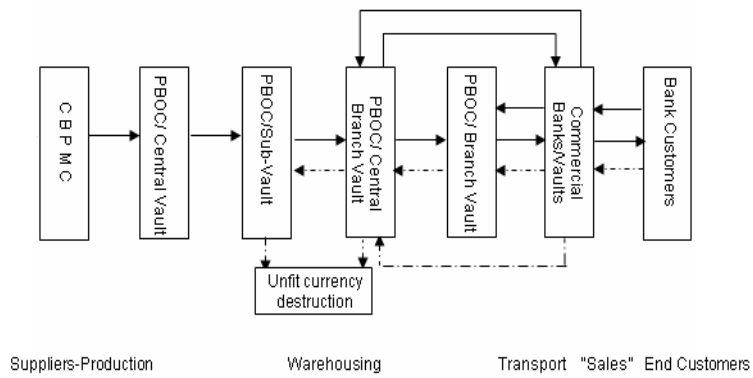


Figure 6: Basic structure of the RMB supply chain. Solid lines indicate the flow of fit cash. Dotted lines indicate the flow of unfit cash.

The RMB supply chain designates the CBPMC, PBOC, secure transportation organizations, commercial banks, and bank customers who are each a node in the network structure. The secure transportation organizations are independent armored car companies or secure transportation departments of the banks. Banknotes and coins are first forwarded to a central vault (CV) of the issue treasury (at the national level) from which they are distributed to sub-vaults (SV) of the issue treasury (at the province level). These subsequently feed into central branch vaults (CBV) of the issue treasury (at the city level) which feed branch vaults (BV) of the issue treasury (at the county level) and then vaults of commercial banks.

Finally, these banks distribute the banknotes and coins to businesses and the public through withdrawals and financial transactions. About 80% of the cash currency is in the hands of citizens divided roughly between cities and rural areas as 25% to 75%, Chen[14]. The reverse logistics portion of the chain is similar where the public deposits notes in banks which forward the bills to branch or central branch vaults of the issue treasury. At these two kinds of vaults, the bills and coins are sorted, unfit or counterfeit bills and coins are removed from circulation, and subsequently sent to be destroyed. There is no reverse flow of currency back to the central vault of the issue treasury.

As of 2005, throughout the entire distribution network, there is one central vault of the issue treasury which consists of 15 key vaults, and 32 provincial sub-vaults. There are 335 central branch vaults and 1,393 branch vaults nationwide for a total of 1,775 currency issue related vaults, which are also internal distribution centers of the PBOC and are integrated on the same currency circulation management information system, Zhang [8]. Though the exact volumes are not known, it is likely the largest volumes of banknotes are transported to the five prominent state-holding banking institutions, the Bank of China, China Construction Bank, China Industrial Commercial Bank, Bank of Communications, and China Agricultural Bank. All of these except for China Agricultural Bank are now publicly traded companies. Safety reserve (stock) levels within the distribution system are typically very high compared to other countries. According to our investigation, safety reserve requirements dictate that enough currency to satisfy at least two years of currency issuing demand must be on stock at all times, though which levels of distribution this is mostly held at is unclear. At this level, there would only be 1/2 of a turn of currency stock per year on average. Given the issue of currency 2007 was 82.8 trillion RMB (about \$12 trillion USD face value) this would imply that safety stocks would be massive to keep up with such high demand.

Currency maintained within the central and regional distribution centers is both cycle and safety stock which is not considered in circulation. These distribution centers funnel money out to the commercial banks and businesses theoretically using a FIFO system (though this is not always consistent) [8]. Under a FIFO queuing system, the average bill or coin would spend almost two years in reserve stock before entering circulation. They report this safety reserve level as being twelve times higher than the typical standard in Western developed nations. Despite these regulations, inventory management in currency

warehouses and distribution centers is still not standardized and is in need of continued modernization and the use of more advanced information technology than before.

In regulations established in 1988, “Provisional Regulations on Cash Management” and “Detailed Implementation Regulations for Cash Management”, the PBOC has declared that it is the responsibility of each bank or division to be responsible for the transport and security of the physical currency it receives and transports. Therefore, distribution centers of the PBOC and commercial banks either use their own armored cars and hire their own security and handling personnel or outsource this to a third-party. This trend, beginning in 1996 with the establishment of an armored car company in Shanghai, has continued to accelerate so that in 2004, there were at least 130 professional armored car services across the country. At present, in a few developed cities such as Beijing, Shanghai, and Shenzhen, these third party logistics providers have their own vaults. However, in other large and medium sized cities these providers often do not have their own vaults. These providers also do not work in small cities and rural areas and the commercial banks are often in charge of the risk of storing, protecting and transporting cash. From the observation of the authors, about 30% of bank personnel of some commercial banks are still involved in transporting or storing cash. Similar observations put personnel relating to the functions of security and cash management at up to 1/3 of all employees, Yang [13].

5. Risks and Problem Solving

5.1. Reverse Logistics and Currency Destruction

Reverse logistics, being one of the most important facets of the currency process, is an area of intense research in the Chinese currency chain. First, the ratio of returned currency to issued currency is high, averaging 68% per year from 1993-2003, Chen[14]. There are two main reasons. One reason is for banks to return currency for sorting is not just to remove unfit currency but to take the storage and possibly non-interest earning currency off of their books and send it to the central bank which would pay them interest on deposited currency. Another reason is that following PBOC guidelines, the PBOC sets and ratifies quotas on the amounts of cash on hand in the vaults at commercial banks. If a bank exceeds its cash quota, it must return the excess to the PBOC. Since not all of this currency is unfit and destroyed, it indicates that it is likely the PBOC or CBPMC subsidize the storage and operations of bill and coin sorting and re-issuing. Many nations, including the United States and Australia, have begun to outsource this non-core process further down the currency chain to commercial banks or charge a fee so that such large volumes of currency will not be returned for sorting, Geismar et. al.[2] and Carlin [5]. Some nations such as South Africa have already privatized the entire process, Rajamani et. al. [1].

The ratio of unfit bills, however, is so large it necessitates the return of such large volumes of currency for sorting. The amount of unfit currency which is

destroyed each year is usually about 30% of that years issue (Chen [14], Zhu and Wang [9]) giving currency an average life of only 3 years. Reverse logistics of currency, both cleaning and destruction, are among the greatest challenges facing China's currency chain. In a 2005 report on the PBOC website [15], Chen gave statistics on the growing issues in the reverse logistics of the RMB. In 2004, China sorted 7.92 billion banknotes, a 46% jump from the previous year. Also, 15,000 metric tons of RMB were destroyed as being unfit currency. This was in fact only 58% of all currency destroyed nationwide (natural processes, manual destruction) so the actual amount of destroyed currency amounted to 26,000 metric tons. By the end of 2004, there was a nationwide network of 20 cash handling centers who purchased an additional 45 currency sorting machines and 5 currency destruction machines bringing the nationwide total to 310 currency sorting machines and 67 currency destruction machines. According to Zhang[8] each currency sorting machine costs about 1 million RMB to purchase and about 300,000 RMB per year to maintain. Each currency destruction machine costs about 18 million RMB. This puts the total purchases for reverse logistics by the PBOC at about 135 million RMB (about \$20 million USD).

Many of the unfit bills, though it is not clear how many, are due to counterfeits, especially in the high denominations. In addition, Chinese banknotes apparently have a propensity to carry germs and grow fungus over time. In 2003, an experiment was conducted at the City University of Hong Kong Microbiology Research Center which showed that a single RMB note carried more than 170,000 germ particles, Yang [16]. Unless the number of unfit and counterfeit bills can be reduced, the challenges of reverse currency logistics will only continue to increase.

5.2. High Production and Transport Costs

The recent, and mercifully brief, commodity price boom brought attention to the possibility of many coins around the world of having negative seigniorage due to costs of production and transport per weight being more than the face value of the coin. According to Zhang [8] this has been an issue for China since at least 2005. He states that for the jiao (10 fen/cent) coins and the 1 jiao note the production costs had already exceeded the face values. The 1 RMB coin and the 2 jiao banknote (fourth series) production costs were roughly equal to the face value. Given the 6.05g weight of the 1 RMB coin given by the CBPMC, we can estimate that minting production costs for coins are roughly 0.165 RMB/g. Given the 1 jiao and 5 jiao coins weigh 2.2g and 3.8g respectively their estimated production costs could be 0.36 RMB(3.6 jiao) and 0.63 RMB (6.3 jiao) showing the magnitude of the problem with these small coins. Similarly with the jiao notes, if a 2 jiao note was roughly breakeven and has a dimension of $120 \times 55\text{mm}$ then the cost per mm^2 is about 3×10^{-3} jiao per mm^2 and with a 1 jiao note of dimensions $115 \times 52\text{mm}$ shows a production cost of 0.18 RMB (1.8 jiao). It is plausible that during the recent commodity boom, even the 1 RMB coin and possibly some of the RMB banknotes had negative seigniorage.

5.3. Transport and Storage Security Risks

Security of currency transport as discussed earlier, is the responsibility of lower level recipients and distributors and not the PBOC. This throws into relief the fact that risks for transportation security can often be on weaker members of the currency chain. Given the lack of standardization or highly qualified outsourced vendors for this process, security and safety of currency transport is a continuing issue. Zhu & Wang [9] mention a sharp rise in currency theft and heists in recent years. In 2006, there were 26 cases of armed holdups and 31 thefts of bank or safe currency. For example in November 2006 in Hubei province's Yicheng branch of the Bank of China, 2.6 million RMB (about \$325,000 USD) was stolen. In April 2007, in Hebei province's Handan vault of the Agricultural Bank of China, a theft of almost 51 million RMB (about \$7.3 million USD) occurred. The security of transporting and storing currency is an increasingly urgent problem, especially with the explosive growth of the money supply, and will be a key issue for the future.

5.4. Problem Solving

For solving the problems discussed above, in terms of supply chain management, following the work done by Zhu & Wang [9], we point out that the bank industry of China should follow the direction of the market, as well as the realities of development in China, to carry out the integrated currency logistics management under the framework of a RMB supply chain which is re-engineered by introducing a third party between the PBOC and the banks, a cash logistics services company. The cash logistics service company would operate with contracts with commercial banks to provide cash supply chain services such as replenishing cash reserves based on historical and forecasted cash demands, cash logistics (transportation, distribution, and security), banknote quality management (such as banknote cleaning and disinfecting), external ATM management and cash replenishment, and other cash logistics and security services. The PBOC will keep the business of destroying unfit cash, but give the business of managing returned currency to the cash logistics service company. At the same time, the commercial banks will also outsource the business of cash sorting, transporting, inventory, and storage to the cash logistics service company. The goal of our recommendation is to ensure that each organization can focus on its core competence and services which will improve the RMB supply chain by allowing one 3PL type organization to focus on improving the entire supply chain and logistics.

An integrative supply chain framework consists of four critical flows: product/service value flows, market distribution flows, information flows, and cash flows, Bowersox, Closs & Stank [17]. We explain an integrated framework for the RMB supply chain based on these flows. In the RMB supply chain, the product value flow is the first steps of the RMB production and distribution including the money supply issuing planning, banknote printing, coin minting, storage and security, circulation, and receipt/reissue of currency by the PBOC. This flow operates to satisfy the cash demands of the end customers and at

the same time increase the value of the RMB. The market distribution flow consists of the management of the return of cash and other service models for the commercial banking sector. Information flow transmits and carries information on the value of RMB in circulation, the multitude of electronic RMB transactions, and the demand and amount of each denomination of RMB in the supply chain. The RMB information flow has many aspects including tracking transaction data, reserve status, and communicating strategic planning between different players in the supply chain. For example, RMB demand forecasting, distribution and inventory information to fulfill the needs of the external cash ATM network. This information is mainly transmitted via EDI and Web-based connectivity. Finally the cash flow, which relates to the receipt of RMB by institutional parties, and describes the payments to the supplying party for the cash reserves, security, transport, and other handling costs.

6. Concluding Remarks

In this paper, the China's nationwide logistics network for the Renminbi is discussed. In addition to its basic structure, its key problems such as production costs, inventory levels, and transportation and storage security are described and analyzed.

This paper provides a foundation for future research. We will further discuss the third party cash logistics (currency 3PL) management, cash logistics strategic alliance management, and cash logistics risk management. We will also explore the cash supply chain information management systems and several decision models based on management and operations research.

As one of the currencies with growing importance in the world financial system, the efficiency and effectiveness of the RMB logistics system will impact not only China but the rest of the world. This impact will likely become more marked at the point in the future that China decides to allow full convertibility for the RMB and more open capital flows. RMB are already present in significant quantities in neighboring states due to burgeoning trade, Liu et. al. [18]. It is too early to say whether physical RMB will become a major regional or even global currency on full convertibility but it is sure this event will emphasize the even greater need for modern logistics management.

More efficient transportation and inventory policies will allow lower safety stock levels as well as possibly lower rates of unfit bills. In addition, possibly moves like other countries to outsource or privatize a segment of the operations could take a great weight off the hand of the PBOC and CBPMC to allow more focus on the production aspects and lower the amount of sorting required. It seems, however, that Chinese government officials and academics have taken this problem to heart and are working for successful solutions. Earlier fractional currency shortages such as those in Guangdong and Zhejiang in 1994 [9] are increasingly less common though they are still occurring. Indeed, we found more academic articles and full books on currency logistics in the Chinese literature than the English language academic literature. Therefore we believe and wish that such a mainstream and studied subject will most likely soon both improve

China's own currency logistics and provide successful examples to the rest of the world.

Acknowledgements

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