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The Design and Printing of Bank Notes: Considerations When Introducing a New Currency

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Abstract

Many newly independent or systemically transforming countries feel a pressing need to--or must--introduce their own national currency. Other countries simply wish to enhance the attractiveness, usefulness, durability, and/or security of their currencies. However, it is difficult to find consistent published information on the various aspects of this process.

This paper attempts to ameliorate this problem by discussing the main issues in designing, producing, and printing a new currency, in order to help those charged with these tasks to proceed in an orderly and informed manner. Attention is also given to examining the options that may be available when this exercise must be undertaken on an emergency basis, with little or no warning.

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Planning for the new issue or replacement of a national currency has, for many countries, been made more difficult by the lack of consistent published information on the various aspects of this process. This paper attempts to ameliorate part of this problem by reviewing the main issues in designing, producing, and printing a new currency.

The paper discusses the problems that may arise when introducing or changing a national currency. Since many people view the currency as an important national symbol, design decisions may become emotional and contentious, resulting in long production delays. Yet the object of this exercise is usually to establish or restore confidence in the currency. Thus, the design selection process should minimize delays and seek to ensure that the currency is "user friendly," durable, easily recognizable, and reasonably secure against counterfeiting. Key aspects of these design decisions are outlined, as are such issues as the initial value of the currency, the denominations to use, and the broadest considerations regarding the quantity of bank notes to print.

The paper also addresses the choice of who should print the currency. In the short run, it is often better to use a private printer, especially if the country lacks a bank note printing works. In the longer run, many countries may prefer to produce their own bank notes. However, the bank note printing industry appears competitive, partly because many countries have excess capacity at their bank note printing works.

Issues including the time involved in designing and printing bank notes, as well as the costs of producing various types of bank notes, are then outlined. The paper also argues that an educational campaign should be a prerequisite for introducing a new currency. While the primary objective should be to reduce the risk of counterfeiting, such a campaign will also help ensure that the currency gains immediate acceptance.

The paper reviews alternative steps that can be taken when there is inadequate time to produce new bank notes in an orderly manner. The favored alternatives include modifying the plates of the country that formerly printed the notes to print "new" bank notes and overprinting or affixing stamps to existing notes. However, each method may have its difficulties. The next best alternative is to print near-bank-note quality coupons. A country should avoid printing low-quality bank notes or hand stamping existing notes because of the risk of counterfeiting.

I. Introduction

Newly independent or structurally transforming countries often feel a pressing need to introduce their own national currency. In fact, at times it is a necessity, either because the currency of an earlier union is being demonetized or because the former dominant member is making it difficult for the newly formed--or freed--country to use the country's former currency. In addition, many countries that already have their own currency wish to enhance the currency's attractiveness, usefulness, durability, and/or security. However, this task is made difficult by the lack of consistent, published information of the various aspects of this process. 1/

This paper seeks to help ameliorate part of this problem by discussing the main issues in designing, producing, and printing a new currency. 2/ While the main source material is published documents, information, and discussions with experts in the field, the paper also draws upon material produced by the Monetary and Exchange Affairs Department of the IMF in connection with its technical assistance work in a number of countries that have been confronted with this problem.

The paper is intended to help those charged with designing, producing, and printing a new currency to proceed in an orderly and informed manner, including helping to ensure that key items are not overlooked and that the job is done in a cost-effective manner. However, it should not be forgotten that many of the issues in this process are deep and complex. Professional outside assistance may also be needed when attempting such an undertaking.

The body of the paper is in seven sections. Section II covers issues relating to the design of bank notes, including design selection and philosophy; colors, texts, and subjects; user needs; security features; and durability. Section III examines issues relating to the initial value of the currency, the denominations to use, and the broadest considerations regarding the quantity of bank notes to print. Section IV reviews production issues such as what entity should be responsible for printing notes, whether a private printer should be used, and the time and cost of production and delivery. Section V discusses the need for an educational

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1/ Russia's demonetization of pre-1993 ruble bank notes in July 1993 forced seven of the countries of the former Soviet Union--Azerbaijan, Armenia, Belarus, Kazakhstan, Tajikistan, Turkmenistan, and Uzbekistan--to suddenly face a situation where their domestic currency had been demonetized by its issuer. This led these countries to scramble to produce their own currencies. In its efforts to help these countries, IMF staff discovered the absence of a coherent literature on this subject.

2/ A paper by Abrams and Cortés-Douglas (1993) attempted to address other aspects of introducing a new currency by examining the policy, institutional, and technical issues associated with the process of introducing a new currency.

campaign when issuing a new bank note series. Section VI analyzes various options that can be taken as emergency measures if the country does not have sufficient time to properly prepare and issue a new bank note series from the outset. Section VII raises a few issues relating to the issuance of coins. Section VIII contains concluding remarks.

II. Design of Bank Notes

The design of a national currency is important for many reasons, ranging from the philosophic to the pragmatic. Those in charge of designing a new currency must realize that many people see their national currency as a symbol of national independence or as a reflection of their political philosophy. As a result, discussions of the design of new bank notes and coins tend to be emotionally charged and time-consuming.

On the other hand, the main objective of issuing a new currency should be to establish or restore public confidence in the domestic currency. Aesthetic and nationalistic issues should not be permitted to overshadow more down-to-earth concerns such as ensuring that the currency is "user-friendly," durable, easily recognizable, and reasonably secure against counterfeiting. 1/ These factors, together with price stability, lead to trust in the domestic currency.

Many considerations need to be taken into account when designing a note. These include: how the design will be selected, the design philosophy, the main themes and texts, the size, user considerations, security features, and durability.

1. Selecting the design

Given the emotional importance many attach to the design of the national currency, a good first step is to lay out a clear mechanism for making design decisions. Time permitting, it is best to have the decision making carried out by a broad-based, high-level committee that includes dignitaries; representatives from the banks, government, academia, and the arts; and one or more other experts on currency printing and handling. The highlight of the committee's work is often organizing a national competition for the best design, and perhaps the appropriate name for the currency.

Before the competition, the committee should decide on the number of denominations of bank notes to produce (see section III.2). In most cases, the committee will also determine the theme(s) 2/ for each denomination of

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1/ Many often favor producing a national currency that serves as an elegant national "calling card," but this is likely to be an expensive mistake, particularly if inflation is not yet fully under control.

2/ Possible themes are a person, an object, an animal, an event, or a subject that the citizenry find to be appropriate.

bank note, although this too can be done by competition. The committee should be sensitive to the various interest groups within the country when choosing the themes. While most countries prefer to have a portrait in a commanding position on each bill and coin, experience has shown that the selection of individuals is far more contentious than that of nature scenes or buildings. 1/

Ideally, all the main--and perhaps most vocal--interested parties should be allowed to comment, or even be brought into the discussions, so that they feel they have had an input into the process. However, the committee should either make the final decision or be solely responsible for preparing the final report. 2/

The competition can be held in various ways. In some cases, each entry is the complete design of a given bank note. In others, separate competitions are held for each of the major aspects of the currency unit, for example, the general layout, the portrait(s), any watermarks, and even the design of any security threads. Once the competition is over, printing experts should nevertheless be given some freedom to modify the designs for reasons of security and/or durability.

Unfortunately, for many new countries, such a competition is an expensive, time-consuming luxury they can often ill afford. If time and money do not allow this approach, an alternative is to have the central bank or a committee make the decisions on its own, perhaps in consultation with a bank note company. However, even then, it may be wise to allow certain groups to help select or even design some aspects of individual bank notes. A broad range of lobbies can be placated if each bank note is allowed to contain several themes, and if each bank note in a series has a different theme. 3/

2. Approaches to design

Certain decisions should be made about the design philosophy before the design process begins, such as whether the bank note should be an expression of the culture of the country, whether it should be part of a serial design, and whether there should be a relationship between the two sides of the note. In some cases, prior decisions have also been made to use a certain art style, such as traditional or contemporary (national), in

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1/ Disputes over subject matter, such as the exclusion or under-representation of women and/or indigenous minorities, have at times given rise to significant delays in the release of new currency issues.

2/ Normally either the central bank, the Government, the Parliament or a certain minister is legally empowered to choose the design of the national currency.

3/ Allowing different themes on each denomination of bank note also makes it easier to agree to give a discouraged group consideration when the next bank note is introduced.

the design. A country's currency traditions should also be considered, since the public is more likely to accept notes that are broadly similar to those they are used to seeing. Design decisions might also be influenced by the desire to have notes that are similar to a selected series of bank notes, such as those of a friendly nation. 1/

Costs can be reduced and time saved when all denominations have one uniform side, although different colors can still be used.

3. Colors 2/

A few countries, notably the United States, prefer to have all their bank notes printed in a single set of colors so that they can be easily identified as the national currency; this approach may also lower production costs. However, most countries opt to use a different color for each denomination of bank note, so that each can be quickly and easily recognized by its color. This choice is especially important when a new series of bank notes is introduced, since once the colors are chosen, they will likely be used in subsequent issues. 3/

One technique is based on the six-color circle presented below:

yellow

orange green

red blue

purple

In this system, one segment of the circle is used for the higher-denomination notes, while the remainder of the circle is used for lower-denomination notes. For example, if red and purple are used for higher-denomination bank notes, the orange, yellow, green and blue could be used for lower denominations.

The secondary colors in a bank note should be the neighboring colors in the color circle. For instance, if a note's predominant color is green, then yellow and blue should be the secondary colors. On the other hand, a red note should have orange and purple as its secondary colors. For security reasons, notes should also include several areas in different

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1/ For example, the design of Lithuania's bank notes was influenced by Finnish notes.

2/ For a useful discussion of the color combinations, including complementary colors and colors wheels, see van Renesse (1993), pp. 45-49.

3/ For example, since 1904, all 10-guilder notes issued in the Netherlands have been blue.

shades of grey, since color copying machines have difficulties with the color balance if more than one grey color is used.

To avoid confusion, the dominant colors of each denomination should be different and distinct. A good test to check the choice of colors is to look at the note from a certain distance and ask: what is the one dominant color of the note? If the answer is not clear, then other colors or a different design should be chosen to improve note differentiation.

4. Main themes

Portraits are usually chosen as the main theme or part of the main theme of a bank note. The individual portraits in a series of bank notes are better recognized when each is differentiated. This can be done by (a) using both men and women; (b) orienting the portraits in different ways (looking to the left, forward, or to the right); and (c) having different special features on the different portraits, such as one with a moustache, another one with earrings, and a third with glasses or a hat. The great advantage of portraits is that the public is generally better able to identify counterfeit bills that have pictures of individuals, particularly when the image is of a famous person.

On the other hand, plants, animals, or buildings are often used because they are less contentious than portraits of individuals. In addition, they are generally cheaper to produce than portraits, particularly engravings of widely recognized individuals.

5. Texts

There is much flexibility regarding the written texts to include on a bank note. However, as a minimum, the country name and issuing agency should be written on the front, while the value should be clearly printed in large numerals on both sides, and spelled out on the front. More than one language can be used. For instance, the Swiss notes include four languages, while Belgian and Norwegian notes include two.

Numerous other texts may be found on bank notes, including:

- place of issue;
- name of the person whose portrait is on the note, and possibly the day of birth/death, profession, or the reason chosen;
- a national slogan;
- copyright text;
  date of approval of first or most recent printing or any other specific date, e.g., independence day;
- warning to potential counterfeiters;

- the titles of the persons who will sign the note (Governor, Chief Cashier); 1/ and, less commonly,
- the name of the printing works, or the designer(s).

Opinions regarding the content of any microlettering on the note also vary. Some argue that a text should be of interest to the public and should have some relation to the design (e.g., the portrait on the note). Others prefer that the microlettering state the value of the note, the issuer, or the country of issue.

6. Size

Most modern bank notes are between 65 mm and 80 mm in height. This is an appropriate height for currency-handling machines, vending machines, and modern cash registers. The storage of bank notes is also made easier and more efficient when all denominations are of the same height.

Views on the optimal length of bank notes vary. Some favor issuing different note-lengths to help the public, particularly the visually impaired, to discriminate between different denominations. On the other hand, when all denominations have the same size and the same watermark, it is possible to economize on paper ordering, since all bank notes can be printed using the same lot of paper. Thus, while there are clear benefits to issuing bank notes of a uniform height, argument for having notes of a uniform width is more open to dispute.

Most currency-handling machines are designed to handle currency between 140 mm and 160 mm in length. However, some countries have chosen to issue very small-sized notes. This is usually done for low-value or for temporary bank notes (see section VI.3). Smaller notes have the advantage of being cheaper to produce. However, they tend to wear out more quickly, particularly if they are printed on low-quality paper. In addition, they are harder to handle, and it is often difficult to process them using modern cash-handling equipment. Users also complain that small-sized notes are easily mislaid.

7. User needs and security 2/

Bank notes should be easy to use, yet secure against counterfeiting. The security features on a bank note should be chosen to meet the needs of its users, most notably the general public, cashiers, the central bank and vending machines. 3/ The public's main interest is that the denomination of a bank note be easy to check. This can be assured by printing the note's

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1/ The signatures are generally printed in letterpress under them.

2/ Van Renesse (1993) covers many aspects of bank note security in much greater detail than in paper, notably pp. 111-126.

3/ Although vending machines probably do not warrant consideration in the short term in many countries.

value on both sides, spelling it out on at least one side, and possibly by differentiating the denominations by color and/or size.

Cashiers and other individuals handling a large volume of currency generally wish for bank notes to have additional features, such as different designs on the two sides to speed the sorting and stacking, or having the main color run onto the edge of the bank note to determine denomination of a bundle from its side.

All currency users need to be able to check for counterfeit bank notes, although, in general, those handling higher volumes are more sensitive to these problems (perhaps because they are more likely to receive counterfeit currency and it is more difficult--or illegal--for them to dispose of counterfeit notes). 1/ In the past, a limited number of security features were needed; however, advances in reproduction techniques, notably the development of color copies and electronic scanners, have brought about the use of a wider range of methods to discourage or detect counterfeiting. A list of the more commonly used security features includes:

(1) Intaglio printing, which results in raised print; 2/
(2) Some combination of portraits, pictures and images, generally with one or more key subjects being engraved and printed in intaglio;
(3) Watermarks in the paper; 3/
(4) See-through registration marks, which, when held up to the light, result in an exact match of patterns or pictures on the two sides of the note; 4/
(5) Microlettering, too small to be accurately duplicated by copying machines;

1/ Public concern about counterfeit notes varies markedly between countries, and, therefore, so does the appropriate breakdown between security features desired by the general public and those desired by currency handlers.

2/ In the intaglio printing process, thick paste inks on deeply engraved printing plates are put under high pressure to transfer the ink from the plate onto the paper. This results in raised print, and a potentially great range of tonal variations. Intaglio printing can also be used to produce latent/transitory images, usually numbers or letters, that appear/disappear when the note is viewed at an angle. These features cannot be reproduced using planar printing processes such as lithography and letterpress. For details, see van Renesse, pp. 112-113 and 116-117.

3/ Watermarks may be continuous or registered (local). Both can use light and dark parts (mold-made) or only light parts (Fourdrinier). They are among the best security features because they are easily recognized by the general public. For more details, see van Renesse, pp. 96-98.

4/ Photocopying machines are not designed to perfectly align both sides of a document, so these patterns are extremely difficult to counterfeit on such machines.

(6) Security threads, such as plastic, metal, foil, and semi-exposed; 1/
(7) Tonal characteristics that are difficult to copy, such as fine-lined, multi-color patterns, gradually changing color patterns, and multiple shades of gray;
(8) A serial number, generally produced using letterpress, which is often printed twice, and can be matched by a bar code; 2/
(9) Other identifying features, such as a date, or one or more signatures;
(10) Quality rag paper, treated to have a "unique crispness" of feel, perhaps with colored or fluorescent fibers that can be physically removed from the paper; and
(11) special inks and dyes, including metallic, fluorescent, phosphorescent, and infrared transparent and/or opaque inks, as well as inks with special colors not generally available. In some cases, e.g., the United States, a key test is the pattern of distribution of the magnetic inks over the bank note.

In addition to these more common features, advances in technology have recently led to the increased use of polymers (plastics) in bank notes. A few countries have started to introduce new security features based on these features including:

(1) producing notes with a polymer substrate that is opaque except for a small window;
(2) optical security devices, such as security patches, holograms, and optically variable devices (OVDs) that are placed in windows, as in (i), and which can contain a portrait or other image and can also change colors when viewed from different angles and under different intensities of light; 3/ and, more recently,
(3) producing notes made completely out of polymer.

While polymer notes have a number of desirable characteristics, notably their longer life, they cost somewhat more to produce than traditional paper notes and should be considered only for countries where inflation is well under control.

Initially, the central bank will be satisfied with the features demanded by other large-volume domestic users, perhaps with an additional secret feature as the "ultimate" test of authenticity. Later on, however,

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1/ Plastic strips are usually marked with a repeating pattern and are visible only when held to light. Metal or foil strips, perhaps plated with cellophane, may be used to make electrical conductivity an additional test of authenticity. Iridescent strips that produce a single noniridescent color when copied with a photocopier have recently gained in popularity.

2/ Serial numbers are particularly useful because groups of counterfeit bank notes often share the same serial number.

3/ For a detailed discussion of OVDs, see van Renesse, pp. 207-225.

sorting machines can be installed that allow the use of more subtle, but more foolproof security features.

8. Durability

A major drawback of bank notes is that they wear out. However, the useful life of notes varies markedly from country to country. A study of 20 OECD countries found that the average life of bank notes varied from less than one year in Finland, Ireland, and the United Kingdom to over three years in Austria, Greece, and Switzerland. 1/

A number of factors influence the life expectancy of bank notes, ranging from the production process to local conditions. 2/ The primary production-related factor is the quality of the paper. However, factors such as the dyes used and the printing process also influence life expectancy. 3/ Certain lacquers also slow the soiling process. Polymer notes are particularly long-lived and stay cleaner than paper notes.

Weather conditions and local attitudes toward the treatment of bank notes are at least as important as the production processes. For example, other things being equal, the hotter and more humid the climate, the faster notes deteriorate. In addition, notes kept in billfolds last longer than those stuffed into pockets. Furthermore, there is no generally accepted definition of the useful life of a bank note, so some countries extend the life of their currency by relaxing the definition of a fit bank note, while others maintain a rigorously tight definition.

Another major factor influencing the useful life of a bank note is its value. The higher the value, the longer it is expected to circulate. This occurs for four reasons. First, people tend to treat higher-denomination notes better than smaller notes. Second, most transactions take place using smaller-denomination notes, so smaller notes circulate more rapidly. Third, for security reasons, higher-denomination notes are often produced using higher-quality, longer-lived methods--for example, better paper, intaglio print, and possibly a lacquer coating--than the lower-denomination notes. Fourth, higher-denomination notes are more likely to be held as a store of value, so a larger percentage of these notes are effectively taken out of circulation at any point in time. This is particularly true for the higher-value notes of currencies with stable macroeconomic conditions.

1/ Bilkes and Bennett (1993), appendix III.

2/ Studies of the life expectancy of bank notes include, inter alia, Gillieson (1977) for Canada and den Butter and Coehen (1982) for the Netherlands.

3/ High-pressure printing processes, such as intaglio, compress the paper fibers, strengthening them and slowing the unraveling of the fibers.

III. Initial Value, Denomination, and Quantity

1. Value

Countries often take great care when attempting to set the initial value of their new currency unit (and subunit). However, unless inflation is under control, the choice is arbitrary. Nevertheless, several factors should be considered when introducing a new currency unit. Perhaps the most important is that the conversion from the old currency unit should be as simple as possible. This is done by having an easily calculable relationship between the new currency unit and the old, preferably a power of 10. It is also desirable for the new currency unit or its subunit (presumably one-hundredth of the currency unit) to be, initially, roughly equal to the value of the least expensive item normally purchased individually, e.g., a piece of gum, even though inflation may gradually cause the smallest currency unit to fall out of use. 1/,2/

2. Denomination

The three main issues that are normally examined when deciding on the denominations of coins and bank notes to issue are: (i) whether to produce coins from the outset; (ii) the breaking point between the highest-value coin and the lowest-value bank note; and (iii) the initial set of denominations for coins and bank notes. 3/

The decision to issue coins should be based on expected inflation. The main problem is that while coins last longer than bank notes, they are at least as expensive as bank notes to produce (see section VII). In addition, they have a higher intrinsic value, and are of lower denominations than bank notes. 4/ As a result, the profitability of producing coins is lower than

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1/ Payne and Morgan (1981), pp. 45, 47, estimate the ideal value of the smallest currency unit is between one two-thousandth and one five-thousandth of the average day's pay.

2/ Currencies are often redenominated when the smallest unit of currency in use becomes "excessively small." This is normally done by renaming the currency unit (and subunit) and defining it as some multiple of the old currency, 10, 100, etc.

3/ Later on, decisions will be needed on when to change the denominations of coins and bank notes, including the denomination of the smallest bank note and the largest coin. For a discussion of such dynamic currency issues, see Payne and Morgan (1981).

4/ In part, because coins are generally easier to counterfeit than quality bank notes.

that of bank notes, particularly when the circulating life of the coins may be short because of high rates of domestic inflation. 1/

Two pragmatic considerations are helpful in deciding on the denominations for the coins and bank notes. 2/ First, cash boxes and sorting machines tend not to have more than seven slots. Second, experience in a number of countries indicates that people tend not to use more than six or seven different units of coins or notes in circulation. If more are produced, certain of those units will normally become unpopular and fall out of general use. 3/ This can prove an expensive mistake.

Bank note producers have found the average day's wage to be a useful deflator when determining the appropriate denominations for bank notes and coins (assuming that inflation is not too high). 4/ The decision on the highest denomination should also be influenced by the availability of alternative payments instruments, such as checks, credit transfers, and credit cards. 5/

A common and effective way of planning the ranges for the values of coin and bank notes is called the D-metric system. 6/ The system uses ratios based on an average day's pay (D). The ratios go from the smallest reasonable value for a coin to the largest reasonable ratio for a bank note. The range of ratios is then divided into two blocks, one for coins and one for bank notes (see Diagram 1). Each block is, in turn, broken down into six subranges of ratios, called slots, which do not overlap and which cover the full range of ratios in the block. The slots are related to one another by ratios set by what are referred to as the "binary-decimal triplets"--

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1/ The profit or seigniorage from issuing currency may, for the purposes of this note, be defined as the current value of the currency at issuance (what it can purchase, plus the discounted cost of the foregone interest from not having to borrow to make the purchase) less the discounted cost of keeping the currency in circulation. For coins, which are long-lived, seigniorage is mainly value less production cost. For bank notes, seigniorage includes the cost of keeping them in circulation, which includes the costs of destroying old notes and printing new ones.

2/ See Payne (1982) and Payne and Morgan (1981) for useful discussions of this topic.

3/ For example, this may be why the two-dollar bill was unpopular in the United States.

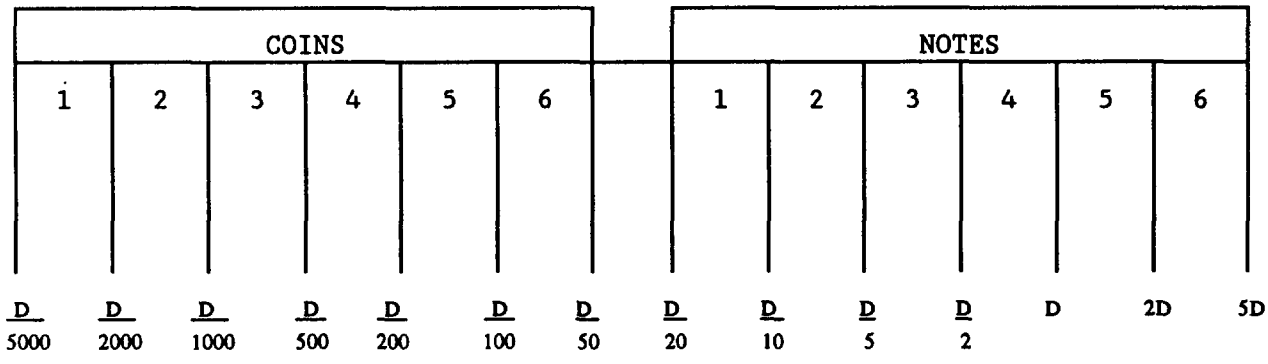
4/ For example, see Payne (1980). Others have suggested using a ratio to per capita GDP to take account of nonwage income.

5/ Since it is often more convenient, and safe, to use noncash payments instruments for larger payments, such as mortgage or rent payments or purchases of durables.

6/ The system was introduced in Payne and Morgan (1981). Payne (1982) gives a very useful description of the use of the D-metric system.

1-2-5, 10-20-50, etc. 1/ In the system, each denomination of coin or bank note should fit into a slot based on these ranges--or inversions of these ranges--with the smallest coin valued at between one five-thousandth and one two-thousandth of a day's pay and the breaking point between notes and coins set between one-fiftieth and one-twentieth of a day's pay. 2/

Diagram 1. The D-Metric System



D = average day's pay

Source: Payne (1980).

The pattern proposed fits a more general observation that coin and bank note issues generally follow one of two patterns:

(1) 1, 2, 5, 10, 20, 50, 100, 200, 500; or

(2) 1, (2.5), 5, 10, 25, 50, 100, 250, 500,

with coins and bank notes sometimes issued using different patterns. Their proposal to have the largest commonly circulated bank note in the range of two to five days' pay is followed by many industrial and developing countries. Larger-value notes tend not to circulate and may be primarily used in association with illegal activities.

1/ While binary denominations (powers of 2) minimize the number of notes/coins exchanged in transactions, decimal denominations are a close approximation and are generally better understood and easier to work with.

2/ The public generally prefer bank notes to coins, so they will wish the smallest note to be of a relatively low value. However, lower-value bank notes tend to wear out quickly--low-denomination notes often wear out in as few as six to eight months--so the long-term cost of issuing them can be high relative to the value. Thus, the central bank and the Government usually prefer the largest-value coin to be relatively high in value.

In countries experiencing high inflation, it may be prudent to initially avoid issuing coins, and to offer a wider range of bank notes. Under such conditions, it may be best to issue more than six denominations of notes, and to be prepared to gradually retire older, low-valued notes as they lose their purchasing power, and to introduce new higher-valued notes, to expedite larger cash payments. Under these circumstances, the D-metric system can provide a general guide for when to retire old note denominations and to issue new ones.

3. Quantity

The literature on methods of formulating decisions on the size of initial and subsequent printing runs for each denomination of bank note is complex and technical. This section does not attempt to evaluate this literature or to propose methods of making such decisions, instead, it only outlines the issues and identifies some sources of information on the subject. In this area, expert guidance can be of great value.

The initial inventory of new bank notes should be large enough to: (i) retire all of the old currency bank notes outstanding at the official conversion rate, if such a conversion takes place; plus (ii) convert any likely--possibly illegal--inflows of old currency notes less any old currency notes held by residents but not converted; (iii) fulfill any rise in the demand for bank notes following the conversion; and (iv) maintain sufficient inventories to handle the demand for new bank notes plus replacement notes pending the next printing.

Production plans should also take account of the expected demand for each denomination of bank note, since cash transactions function more smoothly when the volume of notes and the denominations supplied are demand-determined. Furthermore, the public do not like having to accept bank notes of denominations that they do not wish to hold, and any attempt to force them to do so may discredit the domestic currency and increase the demand for alternative stores of values, e.g., U.S. dollars.

If a currency is being replaced and the amount of the old bank notes outstanding is seen as adequate, it is reasonable to base the initial estimate of currency demand on the outstanding stock of old bank notes. This is usually estimated from the central bank's records on currency transactions. If the country is part of a larger area that is being split up, it is necessary to estimate the stock of old currency bank notes within the region from the records of the local central bank branch(es).

If there is evidence of a currency shortage, or the existing supply cannot be accurately estimated, e.g, because of the noncooperation of the former parent central bank, then an alternative approach is required. This can be done by estimating the value of currency demanded, and then using this as a basis for determining the volume of notes to supply. Such estimates are best made by adding together separate estimates of the demand

for currency by financial institutions and the demand outside these institutions, mainly the general public. 1/

However the estimate of the demand for bank notes is derived, it is wise to hold a large inventory in new bank notes. It is difficult to project the impact of other factors such as currency inflows and autonomous changes in the domestic demand for bank notes, e.g., from a change in expected inflation, that may follow the introduction of the new currency. In addition, prudence calls for a greater cushion, the greater the likelihood of error at any stage of the calculations. A shortage of bank notes at this critical stage can undermine the credibility of the authorities, create a premium on cash versus noncash payments, and stimulate the demand for alternative currencies. (On the other hand, holding a large inventory of bank notes may be risky if the authorities are facing hyperinflation.)

The value of currency in circulation as a percentage of GDP varies widely between countries, as a result of local factors and preferences (see Table 1). In 1992, that ratio varied from 2.9 percent in the United Kingdom to 9.1 percent in Japan.

Similar differences are observed in the volume of bank notes in circulation. While most of this variation is related to the value of currency in circulation, the number of notes in circulation is also influenced by other factors such as the mix of denominations of notes and coins issued; the pattern of the value of transactions settled in currency; and impediments to the use of higher-denomination notes or their lack of availability.

A study of twenty OECD countries found that the number of notes in circulation per capita in 1989 varied sharply. 2/ The highest issue was 101.9 in Greece, while the United States was second at 51.6. At the other extreme, the lowest issue per capita was in Turkey, at 10.9, while France was the second lowest at 23.8. The same study also found that the average value of bank notes in circulation ranged from lows equivalent to US$6 and US$13 in Turkey and Greece, respectively, to highs of US$79 in Switzerland and US$53 in the Netherlands.

When a new bank note issue is prepared, the printer must prepare not only the initial stock for distribution, but also sufficient inventories to meet the demand for each denomination of bank note until a new batch of

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1/ For a discussion of how these estimates might be made, see Bilkes and Bennett (1993), appendix IV.

2/ Bilkes and Bennett (1993), appendix III.

Table 1. Group of 10 Plus Switzerland:
Notes and Coin in Circulation
(1992)

	US$ per inhabitant 1/	As percentage of GDP
Belgium	1,239	5.9
Canada	652	3.3
France	828	3.7
Germany	1,534	7.2 2/
Italy	1,023	5.7
Japan	2,739	9.1
Netherlands	1,354	6.6
Sweden	1,467	5.1
Switzerland	2,748	8.0
United Kingdom	446	2.9
United States	1,167	4.9

Source: Bank for International Settlements, Payments Systems in the Group of 10 Countries, December 1993, p. 509.

1/ Year-end figures converted at end-of-year exchange rates.

2/ GDP for old Lander only.

notes is printed. There are several inventory models for bank notes. 1/ They are complex, but the primary determinants are the expected life of the currency, inflation and income growth, the mix of denominations issued and the time until the next printing run (which may be fixed or flexible subject

1/ For studies on the demand for currency in a particular country, see Fase (1981) and Cramer (1983) for the Netherlands, Kimball (1981) for the United States, Manski and Goldin (1982) for Israel, and Payne and Morgan (1981) for the United Kingdom. A planning model for central banks is presented in Fase, van der Hoeven, and van Nieuwkerk (1979).

to some minimum). These models are generally stable for a given country, but the coefficients vary markedly among countries.

IV. Production Issues

1. Responsibility for printing

Domestic bank notes are generally produced by either the central bank, the Treasury or Ministry of Finance, a state enterprise, or an outside printer. Perhaps two thirds of all countries use an outside printer, which is generally a private firm or the bank note printing works in another country. Most others use printing works that are controlled by their central bank. A few, notably the United States and Japan, have their notes printed by the Ministry of Finance/Treasury, while others, e.g., Indonesia and Korea, use a state enterprise. A few others have special arrangements; for example, Germany has its notes printed by a firm that is jointly owned by the Government.

If a country chooses to print its own currency, it may be preferable for the printing works to be controlled by the central bank. This could be the best way to ensure that the printer is responsive to the needs of the central bank, the commercial banks, and the general public.

2. Deciding whether to use a printer

A country planning to introduce its own currency must decide whether it wishes to produce the bank notes itself. Many countries initially favor this approach, since it allows them to more fully control the production of their currency. 1/ Furthermore, while setting up such an operation is relatively expensive, it is not difficult, particularly since certain bank note companies offer turnkey operations, in which they will design the bank notes, make the plates, set up the printing works, oversee the initial production, and train the workers, all for a set fee. Vendors also, rightly, point out that a large number of countries have set up their own print works over the last ten to fifteen years.

a. Initial considerations

While owning and operating one's own print works may seem appealing, it is not appropriate for most countries preparing to produce their domestic currency for the first time. The main drawback is that setting up such an operation takes time, and properly training the domestic staff may take even longer. Thus, such an approach risks long delays in the initial printing of the new currency. Under any circumstances, producing quality bank notes takes time. It normally takes a bank note company 18 months to three years

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1/ Another benefit of producing bank notes locally is the employment it provides.

to design, proof, print, and deliver a new bank note series, although it can be done as a rush job in as little as six to ten months. However, either option requires an efficient operation to support the production process. If a country also has to set up a bank note printing operation and train its staff in all stages of producing the new currency, the production time could easily run into years.

It may also be wise to turn over as much of the work on the design of the notes to a private printer at as early a stage as possible. As discussed in section I.1, the capacity of domestic interest groups to meddle in the note design process is almost unlimited, and the sooner it can be turned over to a commercial outsider the better. A major advantage of using a commercial printer is that it helps make the cost of production more transparent, i.e., all costs are clearly quantified. This allows one to explicitly observe--and point out--costs of any change, in terms of time and money.

b. Longer-term issues

While it may not be wise to start by setting up one's own print works, it may be appropriate to do so over the medium term. The answer depends on the value the country ascribes to controlling the production apparatus and the demand for new bank notes. 1/ The former question is political, the latter is more open to examination.

It appears that a country needs a rather large demand for bank notes if it is to produce them at or near the minimum long-run average cost of a modern printing operation. 2/ In addition, the market for printing bank notes appears to be competitive, partly because many countries with their own print works would like to lease out their excess capacity to bring down their average production cost. Thus, it is not altogether clear whether even a relatively large country is best served by building its own print works.

Contracting with an external printer gives a country time to consider the appropriate next steps before the initial contract expires, normally in three to five years. 3/ Should the country wish to set up its own print works or change printers after the contract has expired, it is useful to arrange to take possession of the printing plates, and to have access to the

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1/ The demand for new bank notes includes bank notes issued both to accommodate changes in the public's demand and to replace bank notes.

2/ Estimates of the minimum efficient scale for producing bank notes ranged from a population of around 20 million to a demand of 250 million bank notes annually. Estimates of the cost of setting up such an operation were US$35-45 million.

3/ Printing contracts tend to be large and long because this causes average costs to fall sharply owing to high fixed costs, such as note design and setting up the printing machines.

paper and dyes used in the printing operation. 1/ Companies often resist this proposal, since it puts the customer in a stronger negotiating position for the next contract; but this, like everything else, is subject to negotiation, and the bidding can be reopened if the favored bidder resists (or it can be made a precondition for bidding).

3. Time required and cost of production and delivery

Printing quality bank notes is time-consuming and expensive. The main factors that influence cost are the size of the production run, the amount of detailed engraving involved, the number and types of anti-forgery features, and the types of paper and inks. While prices are subject to negotiation, they seem to range from US$25 to US$60 per thousand bills. 2/ Superior quality notes can be considerably more expensive, while simple lithographed "coupons" printed on low-quality paper, with either a continuous watermark or no watermark, may be produced for as little as US$7-US$12 per thousand units (see section VI.3). 3/ Needless to say, bids should be requested from several companies. Some countries have also voiced satisfaction with using two or more companies to handle the printing.

Table 2 outlines the main characteristics of various options in producing a new currency. As noted, the design stage can be the most time-consuming part of the production process. However, if the project is done as a rush job (which will raise the cost of production) and amendments not permitted, the bank notes can be produced relatively quickly. "Average" quality bank notes, without a detailed engraved portrait, can be produced in as little as four to five months, with the full shipment delivered in six to eight months. However, adding detailed engravings may increase the preparation time by two to three months. On the other hand, coupons can be prepared and delivered in about half the time needed to produce simple bank notes. The time to initial delivery would be at least twice as long under a normal production schedule (partly because more time and care would go into the design stage).

V. The Need for an Educational Campaign

It is highly desirable to educate the public about any new bank note series prior to its issuance, since it is easier for counterfeiters to pass bad bills before the public becomes familiar with the look and feel of an issue. The educational campaigns should be intense and informative, and

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1/ The contract terms must be clear and detailed in these areas. Since the contract is generally with a foreign company, it may be difficult and time-consuming to retrieve the printing plates and obtain the required materials if the contract is ambiguous on these points.

2/ Assuming the number of bank notes printed is large enough to bring the cost of production close to the minimum average cost.

3/ However, such notes wear out quickly and are easily forged.

Table 2. Options to Create New Currency--Characteristics of Options

Procedure	Minimum Time 1/	Security 2/	Cost	Durability 3/	Special Points
1. Coupon--Lithograph	2 mos./ 3-4 mos. 4/	Fair	Medium	Low	Security/durability both problems
2. Bank note quality					
--intaglio, other security	4-5 mos./6-8 mos. (with priority)	Very good/ excellent	Medium/high	Good/excellent	Time spent choosing design is key
--with detailed portrait	7 mos./10 mos.	Very good+/ excellent	Medium/high	Good/excellent	Detail increases production time

1/ To initial delivery/final delivery/.

2/ From counterfeiting.

3/ Expected life of bank notes.

4/ Assumes design decisions made quickly.

begin prior to issuance of the new bank notes; for security reasons, however, color pictures of new bank notes should not be released until soon before issuance.

The campaign should seek to inform the public about the design, security features, and handling characteristics of the notes, withholding only special information about secret safety features that the central bank can use as the ultimate test of the validity of a note. Such campaigns usually include distributing brochures, press conferences, press releases, posters, and radio and television announcements (both with purchased time, and through the distribution of tapes and videos for public service announcements). Short films may also be distributed to museums, schools, etc. Foreign central and commercial banks should also be notified, and central banks and selected police organizations, e.g., Interpol, provided with samples of the new issue.

A well-designed brochure is particularly effective. It should provide a full description of the note(s), including its measurements, security features, special handling characteristics, and the colors used. It should also explain simple ways for the public and note handlers to spot counterfeits. Pictures--initially in black and white and later in color--should also be included. If funding permits, they should be distributed to all households; in addition, they should be available at banks and post offices, and they might also be distributed on the street. 1/

VI. Emergency Measures

Sometimes a country does not have enough time to complete preparations for the issuance of its currency in an orderly manner. This generally occurs when countries separate quickly and one or more of them do not wish to share, even temporarily, a common currency. 2/ When this happens, two problems may arise. First, there may be a need to differentiate the existing supply of bank notes, pending the issuance of new currencies by one or both countries. Second, if one country cannot produce its own bank notes, it may have to take steps to ensure an adequate supply of domestic bank notes pending the issuance of its own currency. Under these circumstances, there are three broad types of solutions: overprinting existing notes, reprinting modified old notes, and printing coupon-quality notes.

1/ For example, in 1986, Finland's effective publicity campaign for its new note issue included distributing brochures to every home in Finland, with small brochures made available in banks and post offices. Heinonen (1986), p.2.

2/ Sometimes one country demands that the other cease using its currency. While such a demand is difficult to enforce, the country issuing the currency can refuse to supply the other country with bank notes.

1. Overprinting existing bank notes

Existing bank notes can be overprinted to identify the issuer or to change the value of the notes. This can be done by hand stamping, by affixing a stamp, or by printing press. However, such an approach requires that the population either turn in their notes for stamping or that a large inventory of notes be available.

a. Hand stamping

The simplest way to overprint a currency is to use rubber stamps. Stamping devices can be made easily and quickly, but marking notes takes time (Table 3). If we assume that one worker can manually stamp about 5,000 bank notes in a five-hour day, it would take about 1,500 workers one month to stamp 200 million bank notes. 1/ Furthermore, the stamping process will work effectively only if new or nearly new bank notes are used, which is often not the case in countries operating under these conditions. In addition, the unstamped notes can be replaced quickly only if there is an inventory of notes in storage roughly equal to the outstanding stock of unstamped notes. 2/

Unfortunately, the security of hand stamping is not acceptable. Such stamp marks are easily and quickly duplicated, and special inks provide little additional security. This system should never be used to alter 3/the value of bank notes, and using it to identify the issuer--as when country is dividing itself up--may result in arbitrage flows even with only minor differences in the values of bank notes (since counterfeiting the stamp is cheap and easy).

In addition to speed, the other major advantage of this approach is its cost. The major cost is labor. If two thirds of the labor is for stamping and one third is for security, and one worker is paid about US$2 per day and hand stamps about 5,000 bank notes per day, then the cost of hand stamping is about US$0.60 per thousand. 4/ Stamping also has little or no impact on the durability of the original bank notes.

1/ The estimated number of bank notes needed to meet demand in an "average" country of about eight million people.

2/ Otherwise, the stamped notes must be gradually exchanged for unstamped notes. During the interim, parallel circulation of stamped and unstamped bank notes must be allowed to avoid the risk of a bank note shortage.

3/ Once again, the process will be slowed if the inventory of bank notes is not at least equal to the stock of notes that is to be replaced.

4/ The cost figures in this section are estimated in the broadest of magnitudes.

Table 3. Alternative Options to Create Interim Currency--Characteristics of Options

Procedure	Time 1/	Security 2/	Cost	Durability 3/	Special Points
Overstamping					
Hand stamp	Nil/several months	Poor	Very low	--	Security unacceptable
Paper stamp 4/	2 mos./several mos.	Good	Low	Less than underlying notes	Large labor input necessary
Printing 4/	Nil/variable	Good 5/	Very low	Same or better than if bank notes in sheets	Short production time
Old bank notes	1-2 mos./ 1-2 mos. 6/	Very good	Low 7/	Good	Few suppliers

1/ To initial delivery/final delivery.
2/ From counterfeiting.
3/ Expected life of bank notes.
4/ Requires new or nearly new bank notes.
5/ Unless changing value of bank note.
6/ Assumes printing capacity available or done by outside printer.
7/ Cost to printer.

b. Affixing stamps

Stamps can be attached to bank notes, either to differentiate them by country or to alter their value. Excluding time spent negotiating the design, a simple stamp can be designed, printed, and delivered in one or two months as a rush job, in three months otherwise. However, stamps must be affixed to clean bank notes if they are to adhere for an extended period. Thus, an inventory of new or effectively new notes is also required. It may be particularly difficult to attach stamps to soiled bank notes that have been pulled out of circulation.

Affixing stamps manually requires much time and effort. In 1993 in Slovakia, it was found that one person could affix stamps to about 3,000 bank notes per day, implying that it would take 2,500 people about one month to stamp about 200 million notes. As with hand stamps, the rapid marking of an adequate supply of bank notes can be accomplished only if a large number of workers, e.g., the army, can be quickly mobilized to undertake the task.

A stamping machine may be used if new bank notes are available. Such machines can affix about 2,500 to 5,000 stamps per hour. With 500 machines working five hours a day, 200 million new bank notes can be stamped in one month with the slower machines, while it would take half as long with the same number of faster machines. On the other hand, buying--rather than renting--such machines for a short project may be very expensive, since a quality machine costs on the order of US$30,000. 1/

Stamps provide reasonable security from counterfeiting, since they can be produced with many of the same security features as quality bank notes. Perhaps the most effective feature is intaglio print. However, the benefits of these features are limited by the smaller size of stamps, which implies that using stamps to alter the value of notes may be risky. Security can be increased by using a stronger glue that cannot be steamed off, but this slows the process of affixing the stamps.

Stamped notes are less durable than the original bank notes, since as notes age, stamps become easier to remove and in some cases fall off on their own. Thus, their use should be limited to short-term operations. For example, stamped notes circulated for about four months in Slovakia.

On the positive side, stamped notes are generally inexpensive. Medium-sized, good-quality stamps cost on the order of about US$0.70 per thousand to affix (by hand) and US$5-US$10 per thousand to produce.

1/ If 500 high-speed machines are bought to produce 200 million stamps and then they are scrapped, the cost of using the machines to affix the stamps would be on the order of US$75/thousand, plus labor.

c. Machine overprinting

Bank notes can be easily modified by machine overprinting. This can be done quickly and easily, if supplies of new bank notes are available. If the design is simple, the overprinting plate can be prepared within days. However, production will be slowed markedly if the sheets of bank notes have already been cut up into individual notes, and it may be nearly impossible if new notes are not available.

The security will depend on the security features included in the overstamped field. Since the overstamping will cover only part of the note, however, users may examine the alterations less closely. If overstamping changes the value of the note, the benefit to counterfeiters of altering such notes may also be large, implying that the overstamped fields should have some highly visible security features. 1/

Machine overstamping has several advantages. It will generally not reduce the life expectancy of the note. In fact, if high-pressure presses are used, as with intaglio print, the life expectancy of the note may be extended. In addition, the cost of overstamping is generally low.

2. Reprinting old bank notes

In some cases, an appealing solution is to arrange for the country that formerly produced the local bank notes to print specially marked versions of old bank notes. 2/ The notes would be overprinted--either directly on the note or by affixing a stamp--with the name of the issuing country, which may not even require an additional step in the printing process. Overprinting to alter their value might also be considered.

Using old plates would provide the country with notes that are fully recognizable by the public. The bank notes would also probably have adequate security features and be reasonably durable. The cost of such notes would also probably be low, somewhere between the high end of lithographed notes and the low end of quality bank notes, but with the added benefit that the plates may be available almost immediately.

3. Printing coupons

If time does not permit waiting for good-quality notes, a country may print a temporary bank note or coupon, ahead of the issuance of the "true" national currency. Coupons are cheaply made bank notes, usually printed using lithography, with only minimal security features. The main security features are generally in the quality of the lithography, the use of

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1/ Overprinting to change the value of a note will be riskier if there is a stock of circulating notes that have not been overprinted.

2/ Preferably from an older series that has been demonetized or retired, so that old notes are in short supply.

combination of patterns produced using daylight visible and/or daylight invisible ultraviolet ink, and the application of serial numbers by letterpress.

Coupons are usually printed on inexpensive, unmarked paper, but some additional security may be gained by using higher-quality paper. This generally involves the use a continuous, but relatively weak, Fourdrinier watermark. However, modern printing equipment can copy or imitate weak watermarks with relative ease (generally by adding gray "phantom" watermarks to the forgery).

Coupons can be produced quickly once agreement is reached on the design. If discussions on design are kept to a minimum, first supplies may be delivered to a country within two months, and the full order can generally be completed in an additional month.

Unfortunately, most coupons can be counterfeited easily, quickly, and in large volumes. For example, in Lithuania, large supplies of counterfeits were distributed within days of the first issues of coupons. The risk of counterfeiting can be reduced by affixing stamps with security features to the coupons, although this would slow the production process by adding another step to the design and printing stages.

In general, coupons are not highly durable, although the use of higher-quality paper will extend their life.

VII. Coins

While this paper focused on bank notes, a few points about coins may be useful. The main benefit of coins is that they are extremely durable, generally having a useful life of twenty years or longer. Thus, once minted, coins need not be regularly examined and replaced, as is necessary with bank notes. On the other hand, coins are more expensive and difficult to handle than bank notes, while being easier to counterfeit. They are also inconvenient--and unpopular--for use as a large-value instrument. Furthermore, the unit cost of producing coins is broadly comparable to that of bank notes, with minimal-quality, aluminum coins costing about the same as coupons or low-quality bank notes, while higher-quality bronze and copper nickel coins may cost as much or more than high-quality bank notes. As a result, the cost of producing coins is high relative to their value, i.e., seigniorage is small.

In addition, unless inflation is under control, the cost of producing the coins may soon exceed their value, making them unprofitable to produce. Furthermore, coins have some intrinsic value (i.e., alternative market value), because of their metallic content. If inflation is severe, the coins may soon be worth less than their metallic content, making it profitable for individuals to melt them down.

VIII. Conclusions

This paper was drafted to help those charged with designing, producing, and printing a new currency to proceed in an organized and informed manner. Perhaps the stickiest problem is that many people view the domestic currency as an important national symbol, so design decisions can become emotionally and politically charged, causing long delays in the production process.

The main goal when introducing a new currency is usually to establish or restore confidence in the domestic currency as rapidly as possible. Thus, the design approval process should be set up to minimize delays whenever possible. Attention should also be given to down-to-earth issues such as ensuring that it is "user-friendly," durable, easily recognizable, and reasonably secure against counterfeiting, for it is these factors, along with price stability, that result in confidence in the domestic currency.

Decisions must also be made regarding the pattern of denominations for coins and notes, the denomination of the largest coin versus the smallest bank note, the initial value of the currency, and the initial production runs for each denomination of bank note. While the paper sought to provide some guidance on the first three issues, it only provided the broadest discussion of the last issue because of the complexity of the topic.

The other main decision is who should be responsible for producing the currency. The best short-run solution may be to start by using a private printer, since it may be better able to quickly produce a new bank note series, particularly if the country lacks a complete bank note printing works, with a fully trained staff. A private printer is also better able to reduce the delays associated with design decisions, and is well informed about such issues as security features and the costs and benefits of making the currency more durable. Most firms also have well-developed algorithms for determining issues relating to the denominations of coins and bank notes, as well as the best size for the initial production run. However, printers are in business for profit, so multiple bids should be sought, and use of multiple printers is often wise. To maintain flexibility regarding future contracts, the printing contract should also specify the return of the plates after the contract lapses and guarantee access to the needed dyes and paper at reasonable prices.

In the longer run, many countries, particularly more populous ones, may prefer to produce their own bank notes. However, the bank note printing industry appears competitive, and even a large country cannot assume that printing its own currency is appropriate, partly because many countries are willing to produce notes for other countries to take advantage of excess capacity at their own bank note printing works. However, given time, a bank note printing operation is not particularly difficult to set up, and a number of firms set up turnkey operations at a fixed price.

Whatever the approach, an educational campaign should be a prerequisite for the introduction of a new currency. While the primary objective is to

reduce the risk of counterfeiting, it will also help ensure that the currency gains immediate acceptance.

Finally, emergency measures are necessary when there is inadequate time to properly produce notes. In this case, the best option is usually reprinting notes by modifying existing plates from the former parent country; however, the former parent country is not always willing and able to provide this service. The next best alternative is either to overprint or affix stamps to existing notes. However, the first option requires a large stock of new, preferably uncut, bank notes, while the latter requires a similarly sized stock of new or nearly new notes. If neither of these options is feasible, the next best alternative is to print near-bank note quality coupons, since extremely low-quality coupons and hand-stamped existing notes are highly susceptible to counterfeiting.

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