The Canadian Experience with Counterfeiting

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- *Because of the important role that paper money plays in Canada's payments system, counterfeiting is a significant public policy issue. Both the public and the central bank have a stake in preventing counterfeiting.*
- *Changing technology in the form of photocopiers and computer printers has led to a marked increase in the threat of counterfeiting in all economies since the early 1990s.*
- *An appropriate policy response to this crime is necessary to maintain the public's continued confidence in the national currency.*
- *Estimating the stock of counterfeits circulating is necessary to assess the threat from counterfeiting, including the possible loss of confidence in a currency. A composite method is proposed as an effective alternative to existing methods.*
- *Indications are that there was one counterfeit note in circulation for every 290 Canadians in 2001 and that the value of outstanding counterfeits was less than 19 cents per person.*
- *The incidence of counterfeiting has nearly doubled since 2001. The Bank of Canada is continuing to introduce a new series of bank notes with more advanced security features to discourage counterfeiting.*

Counterfeiting has recently been in the spotlight of public and media attention, even though it is not the most lurid of crimes. Still, there is much uncertainty about the level of counterfeiting, leading to rumour and speculation among the public. *The Economist* (2001) cites one forensic analyst who claims that as much as 2 to 3 per cent of the former eurocurrencies and 30 per cent of U.S. dollars circulating in Russia, Eastern Europe, Africa, and elsewhere may be counterfeit. These levels for U.S. dollars contrast markedly with reports by the U.S. Secret Service that only $47 million counterfeit notes were detected in the United States during 2001.[1]

The recent attention raises a number of issues. Does the heightened interest reflect changes in the significance of counterfeiting? What cost does counterfeiting impose on Canadians? How significant are counterfeits relative to overall currency? What policy challenges does counterfeiting pose? This article addresses these issues with specific reference to the counterfeiting experience in Canada for 2001.[2]

Counterfeiting is a significant public policy issue because, despite rumours of its demise, paper money still remains an important part of our payments system. Approximately $36 billion in currency was in the hands of the public during 2001. Over 50 per cent of the notes consisted of $20 bills, with the remainder spread fairly evenly among the other denominations. Canadian individuals and businesses (including financial institutions) held, on average over 2001, almost 1.1 billion notes, or approximately 35 notes per person, an amount equal to more than $1,200 per capita, with 40 per cent of the value consisting of $100 notes.

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1. See also Judson and Porter (2003), who deal directly with the circulation of counterfeits outside the United States.

2. Estimates of circulating counterfeits for the years 1993 to 2003 are provided in the Addendum to this article.

Counterfeiting is a significant public policy issue because, despite rumours of its demise, paper money still remains an important part of our payments system.

A number of parties have stakes in the prevention of counterfeiting. The public, especially those handling many currency payments, want to know the chances they face of receiving a bogus bill in any transaction. Central banks, which issue currency, want to know the degree to which their currency has been corrupted by counterfeits. Counterfeits represent a loss to these issuers, and a sufficient level of counterfeit circulation may challenge the public acceptability of a currency.

While both the public and the press are showing increased interest in counterfeiting, economists have rarely studied it. This article seeks to redress the imbalance by addressing the economic issues raised by counterfeiting. It begins with a description of the changes in technology that have heightened the potential threat from counterfeiting, followed by an examination of its economic costs to Canadians and a discussion of the usefulness of different measures of counterfeiting. It then proposes a technique for determining the extent of counterfeiting using available data and presents estimates of the extent of counterfeiting of Canadian currency.

New Challenges from Technology

The history of counterfeiting is as old as the history of money itself. The first commodity monies tempted counterfeiters to find cheaper materials to substitute for those used in the money.[3] Later, the development of paper money made counterfeiting more attractive by lowering the costs of producing money to a fraction of its value in exchange. Not all changes in the evolution of money have encouraged counterfeiting. Some, such as the move away from many private currencies to national currencies, deterred counterfeiting because the larger scale of production of legitimate currency justified greater investment in security. The move towards a national currency also meant the public would need to be familiar with the features of only one currency to protect themselves from counterfeits.[4]

For most of the twentieth century, counterfeiting was limited by the expensive investment in engraved plates and offset presses needed to produce credible forgeries. The introduction of sophisticated scanners, colour photocopiers, and ink-jet printers in the early 1990s dramatically changed counterfeiting technology by sharply lowering the costs. This change has been reflected in a marked increase in the detection of counterfeits in Canada since the early 1990s. By 2000, photocopies and ink-jet printed notes accounted for 98 per cent of all the counterfeits detected in Canada.

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The changing technology has also altered both the organization of counterfeiting and its vulnerability to detection. Offset printing required substantial equipment that was difficult to conceal. Moreover, counterfeits were produced in substantial runs and stored before being placed into circulation. Together, these features exposed counterfeiting operations to raids by law-enforcement authorities. The new techniques allow counterfeits to be produced on demand, reducing the need for inventories and dispersing them in a wider variety of locations, making them more difficult to find.

These changes have also altered the way in which counterfeits are detected. Since 1990, detection has shifted from the discovery of hoards of uncirculated counterfeits towards the exposure of counterfeits in circulation, which in 2001 accounted for 96 per cent of the number of counterfeits detected in Canada.

3. Commodities that can be used as a medium of exchange and a store of value are referred to as commodity monies. Historical examples include gold, silver, diamonds, cattle, and furs.

4. The exploits of the Johnson family in Canada and the United States in the 1880s illustrate the limited investment in security for some private bank notes. Speer (1904) recounts that the Johnson forgeries could be distinguished from authentic notes because they were "too perfect" and lacked the engraving flaws present in the authentic notes.

The Costs of Counterfeiting

Counterfeiting has three types of costs: redistribution costs, prevention costs, and confidence costs. The redistribution and prevention costs are similar to those of any other type of crime. The confidence costs are the consequence of the special role that currency plays in the economy.

Redistribution costs refer to the loss of purchasing power suffered by the people who end up holding counterfeits when they are discovered. This cost consists of the goods and services that victims exchange for the counterfeit notes. A further redistribution cost arises because counterfeits displace authentic notes issued by the central bank. The central bank loses its so-called seigniorage—the flow of interest it would receive from the government securities that it acquires through issuing new currency—to the counterfeiters. Economists note that redistribution costs are not a cost to the economy overall, since the losses suffered by the public and the government are matched by the gains of the counterfeiters—hence the term redistribution costs.

Prevention costs arise from the efforts that individuals, businesses, governments, and central banks take to escape bearing the redistribution costs of counterfeiting. Individuals and businesses incur costs through their efforts to avoid accepting counterfeits. Some of these costs consist of expenditures taken to identify counterfeits, such as training staff or investing in counterfeit detectors. Others arise from not using currency or specific issues of currency out of fear of accepting a counterfeit. In some cases, a specific denomination may be avoided by suffering the inconvenience of using other denominations. In other cases, using currency may be avoided by employing other forms of payment, such as cheques, debit cards, credit cards, or foreign currency, which may be less convenient.

The prevention efforts of government and central banks differ from those of individuals and businesses in that they are directed at stopping counterfeiting itself. For governments, these costs consist of the extra policing and judicial expenses. For central banks, prevention costs arise from incorporating increasingly expensive security features into currency and withdrawing from circulation and prematurely replacing issues that have become vulnerable to counterfeiting. Unlike redistribution costs, prevention costs represent a loss to society as a whole: resources are directed from other uses to the prevention of counterfeiting. If counterfeiting is typical of other crimes, the preventive costs will be a multiple of the direct costs. Brantingham and Easton (1998) estimate that total costs to Canadians from property crimes in 1996 were $11.5 billion when prevention costs are taken into account, an amount that is 2.5 times the direct cost of property crime.

The *confidence costs* of counterfeiting arise because of the special network characteristics of currency. Like a telephone, currency is of little use to a person unless others use it as well. The decision of some people to switch away from using currency will impose costs on users because they have fewer partners to transact with. If enough people lose faith in a particular denomination or in a currency as a whole, it will be compromised as a means of making payments.[5]

Perception, as distinct from reality, can be important in determining whether a currency can retain the public's confidence. When some retailers refuse to accept a particular note, this has a demonstration effect on other retailers who, although not having any unfortunate experience themselves, may decide not to accept the note. Customers may also choose not to use that note, not because they fear counterfeits, but because they fear that the notes will not be accepted.

Experience with the $100 note suggests that people may question their confidence in a currency even with relatively low levels of counterfeiting. During 2001, 46,649 counterfeit $100 notes were detected from an outstanding stock of almost 160.2 million authentic notes, or less than three counterfeits for each 10,000 authentic $100 bills in circulation. Nevertheless, this level of counterfeiting caused as many as 11 per cent of merchants in some areas to refuse to accept $100 bills (Bank of Canada 2001). To the extent that people change their currency-holding patterns, the Bank would have to bear the cost of replacing $100 bills with multiples of lower-denomination notes.

The extreme case of loss of confidence in all issues of a country's currency will require its replacement. To date, there is limited experience with respect to the point at which confidence in a currency becomes lost. In part, this is because currencies printed on inexpensive photocopiers and ink-jet printers pose a different kind of threat than in the past. Nevertheless, the costs of counterfeiting have a parallel, albeit imperfect, in the costs of inflation. Here, historical experience suggests that currency is so useful that people continue to use it even at very high inflation rates. Unlike the costs of inflation, the costs of counterfeiting are, however, disproportionately concentrated among merchants,

5. Nosal and Wallace (2001) develop a model that suggests that counterfeiting may preclude the possibility of a monetary equilibrium. This result confirms that counterfeiting is a serious threat that warrants substantial preventive actions, even though its occurrence in practice may be low.

especially fast food outlets and convenience stores, where currency is the predominant means of payment. This difference in the incidence of costs means that shifts away from currency use could take place at lower levels of overall cost than the shifts that take place as a result of inflation.

One possibility, when confidence is lost, is that a foreign currency would replace the domestic currency in circulation. Even if this can be an orderly process at the hand-to-hand currency level, costly adjustments would be required in the restatement of the accounts of financial institutions and other financial contracts into the substitute currency. Alternatively, domestic currency could be replaced by other methods of payment, such as cheques and debit cards. In this case, the costs would be less, since the currency could still be used as the unit of account even though it did not pass in circulation.

It is difficult to estimate the costs to society as a whole from losing the use of a national currency for making payments. Such a loss would initially affect everyone in the economy because of the time and effort necessary to switch to a new payments method. Over a longer period, everyone also faces the expense of using a means of payment that is less efficient than currency. For these sources of loss, even a small cost per person has substantial consequences, given that virtually everyone uses currency. In addition to these costs, the government will lose because the benefit from its central bank's seigniorage will be transferred to the issuers of the replacement for domestic currency. Future progress in the adoption and development of alternative technologies for making payments, such as debit cards or e-money, could alleviate the consequences of reduced confidence in a currency, should it occur.

Estimating the Stock of Counterfeits

The extent of counterfeiting in an economy can be measured by the current flow of recoveries or by the outstanding stock of counterfeit bills. These measures differ in their significance as well as their availability. The flow of recoveries can be measured directly and measures the costs incurred by individuals and businesses from accepting bogus currency.[6] The stock of outstanding counterfeits, on the other hand, shows the degree to which any currency, or denomination of currency, has been corrupted by counterfeits. By doing so, it provides a basis for determining the seigniorage losses to monetary authorities from the displacement of the currency they issue.[7] Equally important, it indicates the potential threat to the continued use of paper money.[8]

Unlike the flow of recoveries, the stock of counterfeits cannot be measured directly. While it might appear that the stock of counterfeits in circulation would be closely related to the flow of recoveries, this impression is incorrect. Table 1 shows that the same stock of counterfeits can be consistent with widely different levels of detection, depending on the length of time counterfeit notes remain in circulation. The 129,000 counterfeits recovered during 2001, for example, could be consistent with an outstanding stock as small as 350 if counterfeits circulate for one day, or as large as 645,000 if they circulate for five years.

Method of Estimation

In a rare attempt to measure the stock of circulating counterfeits, the U.S. Treasury (2000) used two approaches: the parts-found-in-processing (PFP) method and the life-of-counterfeits (LOC) method. Each approach has shortcomings. This article focuses on an alternative composite approach (COMP) that overcomes the

Table 1

Relation Between the Number of Notes in Circulation and the Length of Time They Circulate, Based on the Rate of Detection* for 2001

Average circulation of counterfeits	Counterfeit notes in circulation
1 day	350
1 week	2,500
1 month	10,750
1 year	129,000
5 years	645,000

*Annual rate of detection: 129,000 notes

6. Measuring total recoveries requires co-operation between policing authorities, who are responsible for determining the number of counterfeits recovered, and central banks, which detect counterfeits while processing bank notes. The Bank of Canada is unusual among central banks in publishing statistics with respect to recoveries. See Bank of Canada (various years).

7. Taxpayers are the ultimate losers in this case because the profits of the Bank of Canada are regularly transferred to the government.

8. Such a threat could materialize suddenly through the discovery of a simple test that distinguishes real from counterfeit currency. Tom Ferguson, Director of the U.S. Bureau of Engraving and Printing, related how a simple detector that left yellow marks on real bills because of their protein content was able to distinguish real U.S. currency from counterfeits. Not surprisingly, counterfeiters quickly countered by placing yellow marks on their bills to suggest that they had already passed the test. Still, this device altered the technology of counterfeit detection in a short period of time and revealed the extent of one type of counterfeiting.

limitations of the PFP and LOC methods by building on their strengths and using a richer set of data than either of the other two approaches.

Parts-found-in-processing approach

The basic PFP approach extrapolates the rate at which the monetary authorities detect counterfeits in their currency processing to the entire stock of currency. PFP would measure the stock of counterfeits accurately if (i) detected counterfeits were found only in the Bank of Canada's note processing and (ii) the notes processed by the Bank were representative of outstanding currency with respect to the share of counterfeits.

Unfortunately, the conditions necessary for the PFP method are not fulfilled. Individuals and businesses detected the majority of counterfeits in 2001, with the Bank of Canada accounting for only 22 per cent of total detections. The Bank's share of detections ranged from a high of 32.8 per cent for $10 notes (processed on average once a year) to a low of 10.6 per cent for $100 notes (processed on average once every 10 years).

The U.S. Treasury has adapted the PFP approach to account for counterfeit detections made within the private sector. The adapted version (PFP') assumes that the total detection rate per million notes in circulation bears the same relationship to the detection rate of the monetary authority as the total number of detections per year does to the annual number of detections by the monetary authority. This adjustment, however, has the shortcoming that it assumes that currency turns over in the public's transactions with the same frequency as it is processed at the central bank.[9,10]

Life-of-counterfeits approach

The LOC approach uses an entirely different starting point by extrapolating the flow of discovered counterfeits to the outstanding stock using an estimate of the life of a counterfeit. The shortcomings of the LOC approach are more practical than those of the PFP approach: data on the circulating life of counterfeits are meagre.[11]

The Composite Method

The proposed composite approach (COMP) overcomes some of the limitations of the other two methods. It recognizes explicitly that screening for counterfeits takes place both inside and outside of the Bank of Canada. The public and banks in their transactions, and the banks in their processing of currency, are the sources of screening outside of the monetary authority. The proportion of counterfeits removed from batches of currency before they are passed to the Bank of Canada will depend on the efficiency of screening when currency is transferred between individuals, businesses, and banks.

The COMP method combines elements of both PFP and LOC to estimate the stock of circulating counterfeits. Like the PFP approach, it uses data on the rate at which the monetary authority detects counterfeits in its processing. It also requires data on either the turnover of the currency or, like the LOC approach, the life of counterfeits. It also makes use of data on the annual flow of counterfeits detected outside the monetary authority.

The COMP approach makes use of the following relationships:

- the relation between the life in circulation of a stock of counterfeits and the flow of annual detections
- the turnover rate for currency implied from the estimated stock of counterfeits and counterfeit detections by the general public, and
- the relation between the stock of outstanding counterfeits and the rate of detections by the monetary authority, given the efficiency of detection by the general public.[12]

The data used for the COMP estimates are presented in Table 2.

The estimates make use of a unique set of information collected by Canadian law-enforcement authorities from the recovery of a series of high-quality counterfeit $100 notes circulating in the late 1990s. Certainly this series was atypical of counterfeit issues: its high quality brought it to the attention of the authorities and led to its being designated as a series. Moreover, the series was produced in sufficient numbers that it accounted for 80 per cent of $100 counterfeits detected during 1999.

The pattern of recoveries for this counterfeit series from 1998 through 2001 (Chart 1) shows that the number of

9. Turnover refers to the number of times a note is transferred in making transactions. The life of a note refers to the time between a note being placed into circulation and the time it leaves circulation. They are related in that notes with high turnover wear out more quickly and, as a result, have a shorter life. The relationship is not perfect because notes may be withdrawn before they are worn out.

10. This assumption would imply the following rates of turnover for Canada: $5 = once a year, $10 = once every 10 months, $20 = once every eight months, $50 = once every five years, and $100 = once every 10 years.

11. As discussed below, unique data are available with respect to one series of $100 counterfeit notes that circulated in Canada during the late 1990s.

12. The method of estimation is expressed in equation form in the Addendum to this article. The method is described more fully in Chant (2004).

Table 2

Data for Estimating Outstanding Counterfeits, 2001

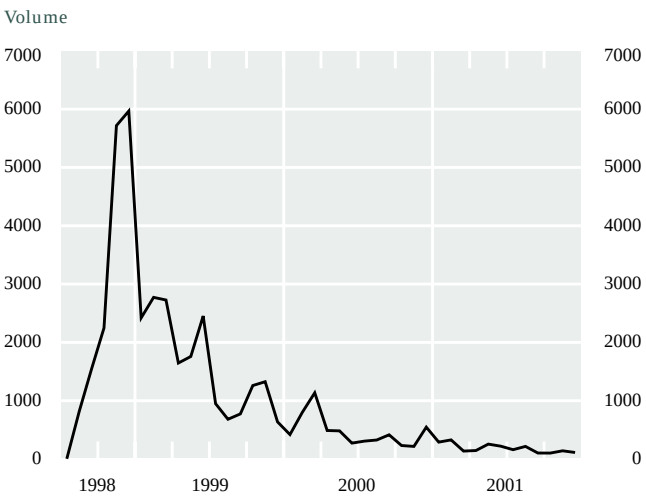
	$5	$10	$20	$50	$100	Total
Detection rate per million by Bank	13.06	147.60	26.02	39.11	264.14	49.06
Public's share of detections	0.67	0.69	0.72	0.85	0.90	0.78
Annual detections	5,306	40,791	30,839	5,275	46,649	128,860
Public detections	3,577	27,942	22,285	4,483	41,783	100,070
Life of counterfeit* (years)	-	-	-	-	1.04	-
Life of authentic notes (months)	23	22	42	73	108	-
Outstanding stocks of bank notes (millions)	145.4	94.8	504.7	97.4	160.2	1,002.5

*Derived from a designated series of $100 counterfeit notes

counterfeit notes passed reached a peak in November 1998, near the time of the arrest of the forgers, and then declined steadily thereafter. The decline, at a rate of approximately 8 per cent per month, corresponds to an expected life in circulation of 12.5 months for these notes.[13] This expected life of a counterfeit $100 note provides the anchor for the rest of the analysis.

Chart 1

Pattern of Recoveries for $100 Counterfeit Series, 1998–2001



13. The analysis makes use of the concept from physics of mean lifetime of a particle, which is expressed as the reciprocal of the rate of decay per period.

Sources of bias

The COMP estimates should be treated as conditional because their derivation is based on a number of assumptions.

- The reported recovery rate for the identified series corresponds to the actual recovery rate.
- The assumed life of counterfeits based on the identified series reflects the experience of $100 counterfeits overall.
- The relation between the life and turnover rate of notes of different denominations represents actual experience.
- All counterfeits detected in circulation are reported in the Bank of Canada data.
- Notes processed by the Bank of Canada are representative of notes in circulation.
- The Bank of Canada detects all counterfeits present in the notes that it processes.

The estimates of circulating counterfeits made on the basis of the composite method are thus conditional on these various sources of bias.[14] Only one of these biases, the one arising from the assumption that the Bank detects all the counterfeits present in the notes it processes, unequivocally leads to an underestimate of the number of counterfeits in circulation.[15] While it is possible that the Bank fails to detect all counterfeits in the notes it processes, it is unlikely that they miss a significant proportion. The Bank scrutinizes bank note deposits using public security features and features for the exclusive use of the central bank. For counterfeits to pass central bank examination, they would need to incorporate both types of security features. Another of the biases is ambiguous: failure of the assumed relation between currency life and turnover to correspond with the actual relation could lead to either an overestimate or an underestimate of circulating counterfeits. Sensitivity tests, however, suggest that even substantial differences in turnover values close to those estimated would not materially affect the estimates of circulating counterfeits.[16] It can be shown that all the remaining identified biases result in conservative

14. These sources of bias and their consequences are discussed more fully in Chant (2004).

15. The U.S. Treasury also makes this assumption in developing its estimates. Allison and Pianalto (1997) concede, however, that the Federal Reserve only detects "virtually all counterfeit notes," not all counterfeits in the notes that it processes.

16. For example, raising the assumed turnover of $20 bills by 10 per cent would raise the estimate of counterfeits outstanding by just 0.8 per cent.

estimates, in that they overstate the degree of counterfeit notes in circulation. Though the remaining bias is ambiguous, the effects are likely to be small.

The Estimates

The COMP estimates of outstanding counterfeits presented in Table 3 show a number of features of the counterfeits circulating during 2001. Counterfeiting in that year was predominantly a problem for $100 notes, which accounted for 58 per cent of the numbers and 88 per cent of the value of counterfeits estimated to be in circulation. The estimates also provide an overall indication on the significance of counterfeiting. Counterfeits appear to have accounted for no more than 0.03 per cent of outstanding notes for any denomination and only 0.008 per cent of the total number of outstanding bank notes. Counterfeits in total are estimated to have been 0.015 per cent of the value of outstanding currency.

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Table 3

Estimates of Counterfeits in Circulation by Denomination, 2001

	$5	$10	$20	$50	$100	Total
Private rate of detection (%)	5.6	5.7	8.9	10.6	12.8	-
Per million notes outstanding	13.8	156.5	28.6	43.7	302.9	83.8
Annual turnover of currency	31.6	33.0	17.3	10.0	6.7	-
Life of counterfeit in years	0.38	0.36	0.47	0.81	1.04	-
Lifetime turnover of counterfeits	11.98	12.02	8.09	8.04	7.00	-
No. of counterfeits	2,012	14,840	14,421	4,259	48,515	84,047
Share of total by number (%)	2.4	17.7	17.2	5.1	57.7	100
Value of counterfeits ($)	10,060	148,400	288,400	212,950	4,851,500	5,511,310
Share of total by value (%)	0.2	2.7	5.2	3.9	88.0	100

Source: Derived by methods described in Chant (2004)

How do these stock estimates differ from other information about counterfeits? Table 4 compares the estimates for 2001 with another measure of counterfeits, the recoveries from circulation during the same year. The comparison shows that the new estimates strengthen and reinforce the indications that counterfeiting in 2001was primarily a problem of high-denomination bills. Table 4 suggests that $5 and $10 counterfeits were much less important in 2001 in terms of circulating counterfeits than they were for recoveries. Their share fell from over 35 per cent of recoveries to just 20 per cent of the circulating stock and from 7 per cent to just 3 per cent in value. In contrast, the share of $100 counterfeits in number was almost 60 per cent higher among circulating counterfeits than it was among recoveries. The $100 notes accounted for 88 per cent of the value of all circulating counterfeits.

Table 4

Comparison of Measures of Counterfeits, 2001

	$5	$10	$20	$50	$100	Total
Recoveries						
Number	5,306	40,791	30,839	5,275	46,649	128,860
(% of total)	(4.1)	(31.7)	(23.9)	(4.1)	(36.2)	(100)
Value ($)	26,530	407,910	616,780	263,750	4,664,900	5,979,870
(% of value)	(0.4)	(6.8)	(10.3)	(4.4)	(78.0)	(100)
Estimated circulation						
Number	2,012	14,840	14,421	4,259	48,515	84,047
(% of total)	(2.4)	(17.7)	(17.2)	(5.1)	(57.7)	(100)
Value ($)	10,060	148,400	288,400	212,950	4,851,500	5,511,310
(% of value)	(0.2)	(2.7)	(5.2)	(3.9)	(88.0)	(100)

Conclusions

This article has analyzed different aspects of the recent Canadian experience with counterfeiting. Conditional estimates indicate that the incidence of circulating counterfeits in Canada is a small fraction of the forensic analyst's speculations for European and U.S. currencies noted in the introduction. The analysis suggests that the probability of any bill being counterfeit is estimated to be less than one in 10,000 for Canadian currency overall. Indications are that there was one counterfeit note in circulation for every 290 Canadians in 2001 and that the value of outstanding counterfeits was less than 19 cents per person.[17] The estimates also strengthen the perception that counterfeiting in Canada during 2001 was a greater threat for high-denomination bills than it was for low-denomination bills.

17. See the Addendum for an update to 2003.

These estimates may appear to be at odds with current perceptions of the severity of counterfeiting. This difference may be understandable because the costs of accepting bogus currency tend to be concentrated among "small ticket" retailers such as fast food outlets and convenience stores. Dealing with these merchants gives passers of counterfeit bills the opportunity to receive authentic currency as change when paying for small purchases with high-denomination bills. Small retailers are especially vulnerable because they tend to rely more than others on part-time, less-skilled employees. In some areas of the country, merchants have focused attention on counterfeiting by refusing to accept some denominations, like the $100 bill.

Another perspective on the costs of counterfeiting comes from comparing losses from counterfeiting with those from other payment mediums. The Canadian public lost less than $6 million from accepting fake currency during 2001 while, in comparison, total losses from bank credit card fraud exceeded $142 million, more than 20 times as much.[18] These differences appear much larger than can be accounted for by payments transacted by each method of payment. Currency would need to turn over just slightly more than three times per year to support the volume of transactions made by credit cards. Our estimates of turnover range from just under 7 for the $100 note to more than 30 for the lowest denomination notes.

The Canadian public lost less than $6 million from accepting fake currency during 2001 while, in comparison, total losses from bank credit card fraud exceeded $142 million, more than 20 times as much.

The method proposed in this article could be extended to cross-country and historical comparisons if information about the critical variables with respect to the circulating life of counterfeits were available. Such an extension could exploit the variety of different security devices in national currencies at different times and across various denominations in order to assess their effectiveness.[19] The results of such an analysis could provide the basis for the development of further measures to prevent counterfeiting.

The probability that counterfeit notes accounted for approximately 0.008 per cent of the currency in circulation in 2001 should not be grounds for complacency: the technology available to counterfeiters continues to advance. Public policy towards counterfeiting will be influenced by an inherent paradox of crime prevention: the threat of a crime, in some sense, is not measured by actual crime rates, but by the rates that would be observed in the absence of prevention. The observed counterfeiting levels reflect the substantial expense of features such as elaborate designs, security devices, and distinctive paper incurred by the Bank of Canada to prevent the illicit duplication of its currency; the private costs borne mainly by retailers in their efforts to avoid accepting counterfeits; and the public costs of education, policing, and the administration of justice. Assuring appropriate policy responses to the threat of counterfeiting, including those of law-enforcement agencies and courts, is vital because failure to deal with counterfeiting could possibly threaten the public's confidence in all or a part of a country's currency.

Public policy towards counterfeiting will be influenced by an inherent paradox of crime prevention: the threat of a crime, in some sense, is not measured by actual crime rates, but by the rates that would be observed in the absence of prevention.

For information on how to authenticate a bank note, visit the Bank of Canada's Web site at <http://www.bankofcanada.ca/en/banknotes/counterfeit/index.html>.

You can also find information by contacting the Bank directly: E-mail: education@bank-banque-canada.ca

Telephone: 1-888-513-8212

18. The costs from credit card fraud are rarely borne directly by the cardholder, given that card agreements generally limit the cardholder's losses. Nevertheless, these losses are a cost of business for card issuers and will be reflected in merchant banking fees and consumer credit charges, rather than being charged against victimized retailers or cardholders. See the Canadian Bankers Association Web site at http://www.cba.ca and click on Resource Centre/Statistics for statistics on credit card losses.

19. In addition, any such study would need to take account of other factors that may influence the incidence of counterfeiting, such as a country's level of income, the effectiveness of its law enforcement, and cultural factors.

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Addendum: Estimating the Stock of Counterfeit Notes in Circulation, 1993–2003

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The number of counterfeit detections in Canada has grown significantly since 2001. These detections rose from 128,920 in 2001 (with a face value of $6.0 million) to 208,470 ($4.9 million) in 2002 and 443,300 ($12.7 million) in 2003.

In this addendum, the methodology developed by Chant (2004)[1] is used to estimate the stock of counterfeits in circulation from 1993 to 2003. Related estimates of the public's ability to detect counterfeits, annual turnover of counterfeits, and the average life of a counterfeit are also examined.

Chant's "composite approach" to estimating the stock of counterfeits recognizes that the stock of outstanding counterfeits depends on the life of counterfeits (L), which in turn depends on central bank processing (p), and the detection ability of the public (e).

The approach exploits the information contained in public detections (PD) and Bank detections (BD) to derive key parameters of the model as:

$$\frac{e*T}{(1-e)} = p*(PD/BD) \qquad (1)$$

$$(1-e)*L = \frac{BD/p}{BD+PD} \qquad (2)$$

where T represents the number of times a counterfeit circulates per year, otherwise known as its turnover rate (see Box).

Chant's model is based on three key relationships:

Public detections (PD) depend on the ability of the public to recognize a counterfeit note ($0 < e < 1$), the number of counterfeits in circulation (C), and the turnover rate (T)

$$PD = e*T*C. \qquad (i)$$

Since the Bank of Canada will detect all remaining counterfeits that it receives in processing, **Bank detections** in any period (BD) will depend on the proportion (p) of total notes in circulation that the Bank **processes** during that period:

$$BD = p*(1-e)*C. \qquad (ii)$$

The **average life** (L) of a counterfeit is defined as the ratio of the stock of counterfeit notes in circulation to the annual flow of total detections:

$$L = \frac{C}{BD+PD}. \qquad (iii)$$

Chant uses unique information on the *life* of a particular $100 counterfeit to derive turnover and efficiency from equations (1) and (2). Given turnover of the $100, the turnover of other denominations is set by assuming a relation of proportionality between turnover and the average life of bank notes, and other parameters are derived accordingly.

One way to use the model in a time-series perspective is to hold one of the three parameters (e, T, L) constant at its estimated 2001 value and derive the other two from the above equations.

1. "Counterfeiting: A Canadian Perspective," Bank of Canada Working Paper (forthcoming), Ottawa: Bank of Canada.

The Estimates

In this exercise, two cases are examined: one in which the efficiency of public screening (e) is held at its estimated 2001 value, and one in the which annual turnover rate (T) is held fixed at its estimated 2001 value. The assumption of a constant average life of counterfeits is not contemplated because it is violated by the data. In some periods, for example, 2002 in the case of the $100 note, the right-hand side of equation (2)—which is a fraction of the counterfeit life—is already larger than the 2001 estimated average life.

Constant Efficiency of Public Screening

Chart A1 plots the estimated life of counterfeits for all denominations on the assumption of a constant efficiency of public screening. The overall rise in counterfeit lives would be consistent with the significant decline in the Bank processing rate following the introduction of the Bank Note Distribution System in 1997 (Chart A2).[2] However, the sharp rise in the average life of the $100 counterfeit bills in 2002 suggests a drop in turnover, perhaps the result of retailers refusing to accept that note.

Chart A1

Average Counterfeit Life with Efficiency Constant at 2001 Levels

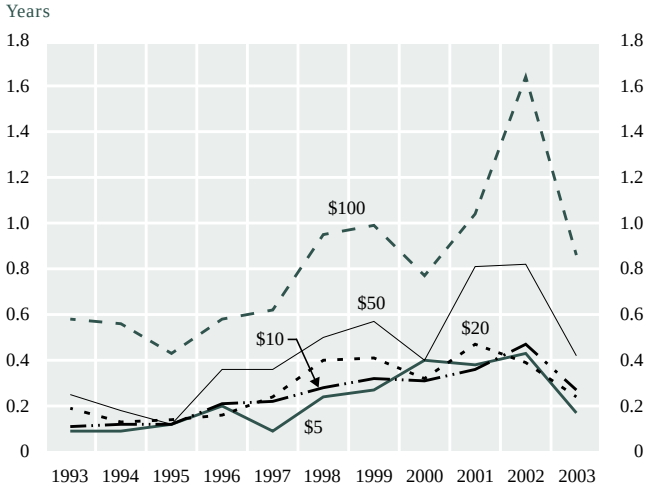


Chart A2

Bank of Canada Processing Rates by Denomination

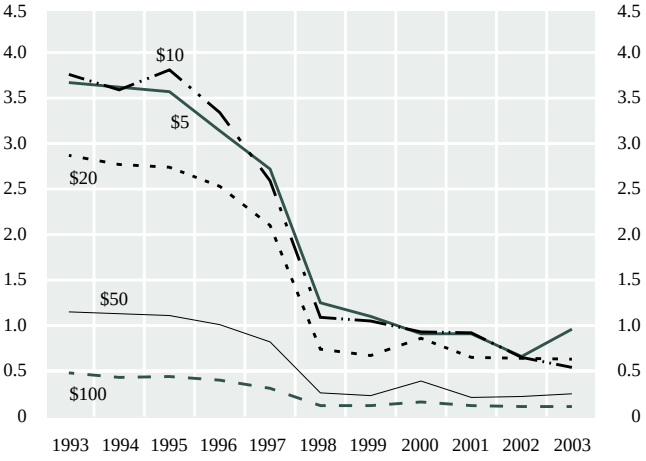
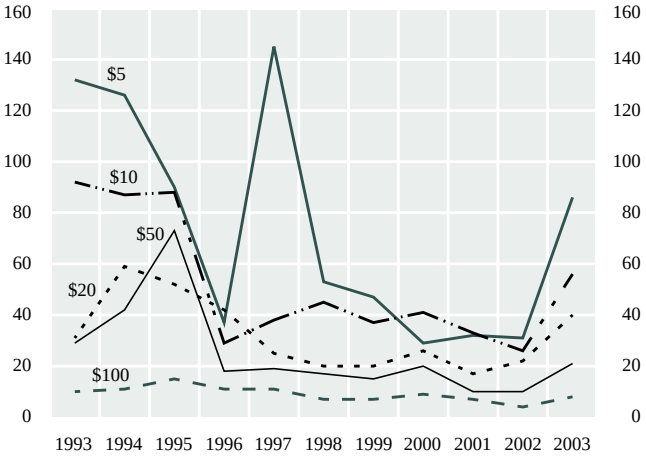


Chart A3

Annual Turnover with Efficiency Constant at 2001 Levels



The broad-based decline in counterfeit lives in 2003 that resulted from the relatively high level of public detections that year suggests an increase in the rate of public efficiency (consistent with increased public awareness) or a rise (unexplained) in turnover.

Chart A3 shows the annual turnover rates estimated for each denomination on the assumption of a constant rate of public efficiency. It shows a trend decline broken by a sharp increase in 2003 across all denomi-

2. Rates of processing bank notes at the Bank of Canada fell sharply following the implementation of the Bank Note Distribution System. For example, in 1996, 1.8 billion notes were processed, compared to 608 million in 2003. With less processing, the rate of Bank detections relative to public detections has declined. For further reading on the implementation of the new system, see Bilkes (1997).

Chart A4

Outstanding Counterfeits in Circulation with Efficiency Constant at 2001 Levels

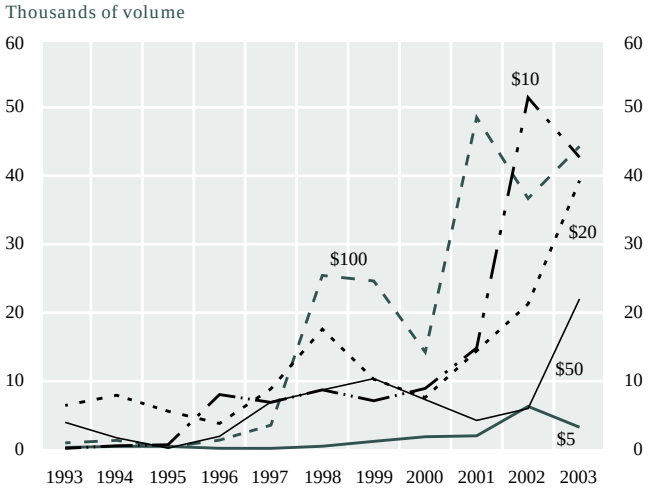
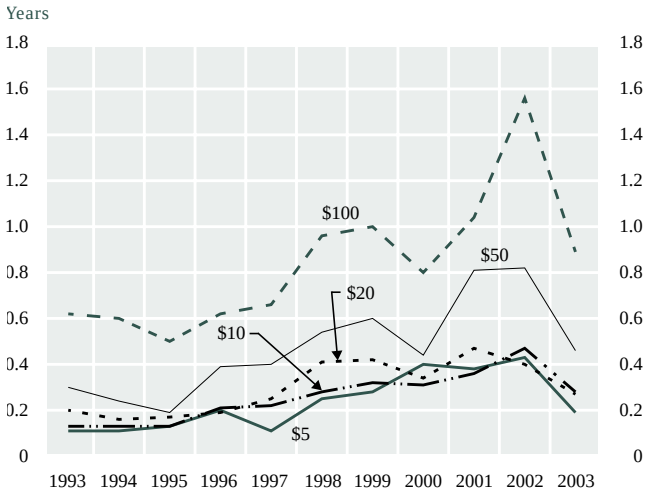


Chart A5

Average Counterfeit Life with Annual Turnover Constant at 2001 Levels



nations. The turnover of the $5 note stands out as particularly erratic; the spike in 1997, which is attributable to a large increase in public detections relative to Bank detections, is magnified by the small number of counterfeits. The same is true of the 1995 spike in the turnover of the $50 note.

Chart A4 illustrates the growth in the stock of counterfeits over the past decade on the assumption of constant efficiency of public screening.[3] Historical peaks are found in 2001 for the $100 note, in 2002 for the $5 and $10 notes, and in 2003 for the $20 and $50 notes. The highest stock of *total* counterfeits in circulation occurs in 2003, and is estimated at 151,550 notes, for a total value of $6.8 million. This represents a 25 per cent increase in volume and a 37 per cent increase in value from 2002, or an 80 per cent increase in volume and a 23 per cent increase in value from 2001. Significantly, the increase in the estimated *stock* of counterfeits is considerably less than the increase in the annual *flow* of counterfeits detected.

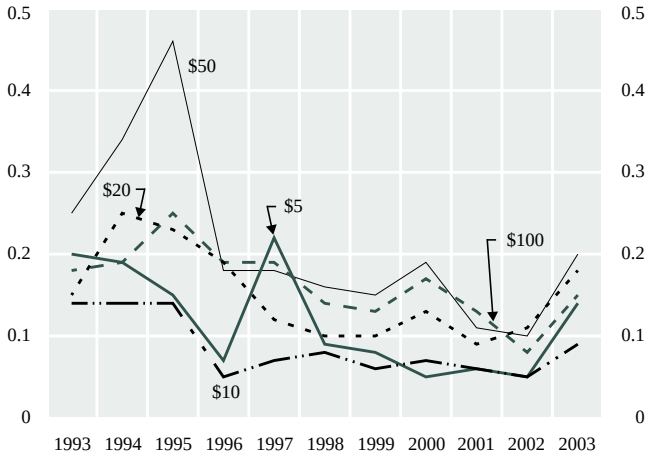
Constant Turnover

Alternatively, we can hold annual turnover constant at 2001 levels and allow counterfeit life and public efficiency to vary. As seen in Chart A5, average counterfeit life again follows a steady upward trend, followed by a drop in 2003.

3. The stock of counterfeits is estimated from equation (ii) in the Box on page 51.

Chart A6

Efficiency of Public Detection with Annual Turnover Constant at 2001 Levels



Public efficiency rates derived on the assumption of constant turnovers (Chart A6) remain fairly stable from 1997 onwards, with a slight downward trend until a pickup is observed in 2003. Increased public efficiency in 2003 coincides with the high volume of counterfeits detected by the public that year and may have been a result of media coverage and joint education efforts by the Bank of Canada and police services.

Chart A7

Outstanding Counterfeits in Circulation with Annual Turnover Constant at 2001 Levels

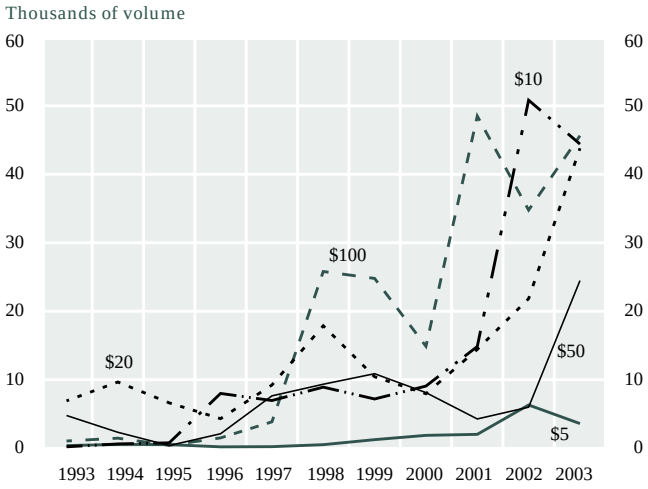


Chart A7 shows that when turnover is held constant, the total stock of counterfeits is estimated as 161,900 in 2003, for a value of $7.1 million. As in the first case, this represents a historically high volume and value of counterfeits in circulation, but a smaller increase over 2001 in the stock of counterfeits than in the annual flow of detections.

Conclusion

Estimating the equations over a span of ten years yields interesting insights into the public's ability to detect counterfeits, the average life of counterfeits, turnover rates, and changes in the stock of counterfeits.

Holding either turnover or the rate of public efficiency constant produces a gradual rise in the estimated average life of counterfeits. This seems plausible, given the changes in bank note processing since 1997. When *public efficiency* is held constant, the rise in counterfeit life would also be associated with a fall in turnover (which is not implausible, given the increased use of debit cards as a substitute for cash). When *turnover* is held constant, the rise in counterfeit life would be associated with a decrease in the public's ability to detect counterfeit notes (which is also plausible, given that improvements in reprographic technology augmented the quality of counterfeits). The truth may lie in between these two cases. Since both yield similar estimates for the stock of counterfeits in circulation, the range of probable outcomes is found to be fairly narrow (151,500 to 162,000 in 2003).

The results show a marked change in the state of counterfeiting since 2001.The incidence of counterfeiting has nearly doubled since then and is no longer primarily limited to the $100 note. In 2003, the probability of a note being a counterfeit is estimated to be highest for the $10 note, at 0.05 per cent (or 5 in 10,000), followed by the $50 and $100 notes, at 0.02 per cent, the $20 note at 0.007 per cent, and the $5 note, at 0.002 per cent (2 in 100,000 notes).[4]

Interestingly, the data on the ratio of public to Bank detections suggest that the turnover of the $100 note declined temporarily in 2002 (consistent with anecdotal evidence of reduced acceptance of that denomination among retailers). The data further suggest that the public efficiency rate rose in 2003 (consistent with increased public awareness of counterfeiting).The increase in efficiency would explain the sharp drop in the average life of a counterfeit observed in 2003.

The Bank is continuing to introduce a new series of bank notes with more advanced security features to discourage present and future counterfeiting activity. In addition, the Bank uses educational initiatives to increase public awareness. The quantum increase in bank note security is evident in the new $100 note in the *Canadian Journey* series, issued in March 2004. It will be followed by the release of the new $20 note in September 2004 and the new $50 note shortly after.

4. The new $100 note introduced in March 2004 incorporates advanced security features that have successfully deterred counterfeiters. The probability of a new $100 bill being a counterfeit is thus close to nil at present.