Challenges to currency
Will cash resist the e-money challenge?

SUMMARY

The euro's introduction highlights several shortcomings of cash and coins, and some advantages of paying with plastic, but is hard currency an endangered species, threatened by technologically more advanced means of payments, electronic transfers, e-money and the like? If the last twenty years are any guide, the answer is no. We find that modern payment technologies have little impact on currency usage. To understand this lack of effect, we distinguish between demands for large- and small-denomination banknotes. Competition from existing electronic retail payments' products focuses mostly on small to medium-sized purchases where small bills (less than the £50) are most common. By contrast, there are few signs, nor much likelihood, of past or current electronic products displacing holdings of large bills without government intervention. Large bills, which account for over half the stock of outstanding currency in many OECD nations, are mainly held for hoarding and bad behaviour motives ranging from hard crime to paying the plumber under the table; for such purposes the anonymity of cash is, and is likely to remain, superior. As concerns policy implications, we note that, although issuing large denomination bills facilitates 'bad behaviour', withdrawing big bills is unlikely for political reasons. Governments could try to induce e-money usage as a means of discouraging bad behaviour, but we argue that any attempt to force a complete shift to electronic transfer, and to try to ban, or to prevent, the domestic use of cash would be appallingly illiberal.

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The challenges facing currency usage: will the traditional transaction medium be able to resist competition from the new technologies?

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1. INTRODUCTION

'Cash is dirty . . . Cash is heavy . . . Cash is inequitable . . . Cash is quaint, technologically speaking . . . Cash is expensive . . . Cash is obsolete.' This is how James Gleick (1996) summarizes the case against cash. By contrast, electronic means of payment are clean, technologically advanced and supposedly cheap and convenient. Thus, it is not surprising that 'new economy' representatives have been optimistic that currency will be replaced by technologically more advanced electronic transfers and e-moneys of assorted varieties (Capie and Gormez, 2000; Craig, 1999). In a similar vein, monetary economists like Dowd (1998), Friedman (1999) or King (1999) have predicted the imminent disappearance of currency from common usage.

Table 1. Value of cash holdings per capita in US$

	1990	1999
Canada	608	834
USA	998	1 908
Japan	2 003	4 594
Switzerland	2 811	2 771
Austria	1 827	1 543
Belgium	1 238	1 177
Denmark	742	874
Finland	472	506
France	829	767
Germany	1 230	1 592
Greece	724	741
Ireland	616	996
Italy	1 004	1 135
Luxembourg	1 244	1 182
Netherlands	1 337	1 098
Portugal	442	529
Spain	1 146	1 306
Sweden	1 224	1 303
UK	473	695

Sources: Table 2.4, Loke (2001), BIS (2001), ECB (2001) and own calculations. Exchange rate used to convert euros into US$: 1 euro = 94 cents.

In view of these supposed shortcomings, the demand for currency remains remarkably strong (see Table 1).[1] Taking 1999 as an example, the average cash to GDP ratio in the EU is 4.1%, in the US it is 5.6% and in Japan it is as high as 12%. These numbers would appear to imply that each person on average would hold about US$1908 in the US, and in Japan US$4594 worth of Yen if all such cash was held domestically. The picture is even more surprising if one looks at data for large notes outstanding (see Appendix A in the Web Appendix on http://www.economic-policy.org). According to the currency statistics each American should have carried 14 one hundred dollar bills, and each German at least one 1000 DM bill (US$625) in 1999. These numbers are hardly congruent with normal money holdings for day-to-day purchases. Moreover, in spite of numerous innovations in the payment systems, currency balances have kept rising in most countries.

Note that these figures seem vastly greater than the amount that ordinary people, you and I, carry around in our wallets and pockets for the purpose of facilitating day-to-day consumption expenditures. But how large is the size of the transactions balances maintained for such everyday purposes? On the basis of ingenious modelling, Loke (2001) estimates such balances to average (between 1990 and 1998) about $35 per person in the USA and $40 (equivalent) in the UK. Even though the per capita average includes children and those institutionalized (hospitals, jails, old-age

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[1] Moreover these comparative data on the growth of currency holdings are in several cases biased downwards by being translated into US dollars during a period when the real effective exchange rate of the dollar was appreciating quite strongly. In terms of ecu, or in own currency terms, the growth in currency holdings appears even stronger (Snellman *et al.*, 2001: p. 133).

homes), who will generally hold zero, or very small, cash balances, this estimate does seem on the low side. Older estimates of Avery *et al.* (1986, 1987) and Boeschoten (1992) are a little higher. But even if we were to multiply by, say, an arbitrary factor of three (in part to account for currency held in retail outlet tills), it is clear that, at any rate for most countries, the amount of currency carried around by ordinary people (or held in retail outlet, point of sale (POS) tills) to facilitate consumption expenditures is only a fraction, in some countries a small fraction, of overall currency outstanding.

What is happening? What accounts for all this currency holding in excess of ordinary consumption expenditure transaction needs? The answer to this is that there are two separate markets (needs) for currency, although the precise dividing lines between them are fuzzy. The first market is to satisfy the standard transactions needs; the second is to provide a store of value, and a more occasional means of payment, either in second countries (outside the country of issue) whose own currencies are regarded as deficient, usually because of severe inflation, or in the country of issue to provide anonymity for the holder/user who is engaged in activities (black or grey economy) that he does not want to become known, especially not to the tax authorities. Such 'bad behaviour' should be interpreted broadly. It not only includes illegal activities, but also legal activities that are regarded by some as sufficiently immoral, or suspect, to want to avoid others knowing about them – for example gambling, alcohol, purchases of pornography, even perhaps cigarettes, especially if smuggling is suspected; see Goodhart and Krueger (2001), Rogoff (1998), Schneider and Enste (2000). In addition, both bad behaviour and simple mistrust of other people, creates an incentive to hoard (Boeschoten, 1992; Krueger, 2000; Van Hove, 1999b). Almost by definition, accurate data on currency held as a result of mistrust or nefarious activities domestically (tax evasion, other crime, gambling, drugs, prostitution, etc.) are unavailable.[2] By the same token, accurate data on currencies held outside their country of issue (mainly held in US$ and DM, but also to a lesser extent in Swiss Francs and Dutch guilders) are sparse.

But there is no doubt that such holdings are vast. Doyle (2000) finds in his recent study that roughly 30% of US currency and up to 77% of the Swiss currency is held abroad (see also the studies of Porter and Judson, 1996 for the US and Seitz, 1995 for Germany). Such huge foreign money holdings can be attributed to international criminal activity and also to 'dollarization' in countries with high inflation records and an unstable political environment ('bad behaviour' of governments).

Bad behaviour creates a demand for anonymous means of payment. Depending on the particular circumstances, there are different varieties of 'anonymity'. The payer and payee may not trust each other and therefore prefer not to reveal their identities.

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[2] A potential measure is to test what proportion of notes outstanding has been physically contaminated by contact with drugs, notably cocaine that is often 'snorted' in this way. A report by J. Burns in the *Financial Times* (4 October 1999: p. 4), stated that more than 99% of all the capital's banknotes revealed some, perhaps minute, traces of cocaine!

Similarly, the payer and payee may not wish anybody else to know about the trans-action. It is tempting to relate this demand for anonymity mainly to criminal activities. However, anonymous means of payment also help to preserve a certain amount of privacy. They allow people to do things without having to account for them later on.

Anonymity provides one of the most important distinctions between the character-istics of currency on the one hand and e-money and access products on the other. Currency is almost completely anonymous. As a bearer instrument neither of the two parties involved in a cash transaction nor anybody else has to know the identity of the payer and the payee. The transaction itself is known by necessity only to the two parties involved. Because no written or electronically stored record is required the payment transaction does not leave a trail behind that would allow a third party to infer that such a transaction took place.

By contrast, most e-transfers immediately provide a record of what a customer has bought, i.e. exactly what goods/assets, to two counter parties, to the seller and to the underlying financial institution. Even when e-purses are developed, which do not necessitate (but may allow) such information transfers, they must involve electronic equipment. How can the payer/payee be confident that the other counter party will not be recording the transaction in a manner that may leave an audit trail that can subsequently be followed? This point can be illustrated by the use of supposedly anonymous cellular phones linked to a prepaid account. An Italian serial murderer had used his account to phone other members of his family as well as the victims. By recording all the numbers on that account the Italian police were finally able to identify the owner. Anonymity was not as good as he had assumed.[3]

As discussed more extensively in Section 2, the characteristics of e-money products *currently available* in the market are not such as to encourage existing holders of large value notes to switch into them. This includes concerns about security and privacy, as well as anonymity. This raises a question whether (future) innovations might be able either to reduce the anonymity of currency usage or to enhance that of electronic transfers, so that the present relative advantages of cash might be eroded.

Here views differ. Our own view is that it would be extremely difficult to envisage an electronic transfer that does not leave a potential record either with the payer, the payee (or a third party).[4] How can the payer/payee be confident that the other counter party will not be recording the transaction in a manner that may leave an

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[3] We are grateful to Giuseppe Bertola for bringing this story to our attention.

[4] H. Leinonen of the Bank of Finland in private correspondence with one of the authors (September 2001) wrote, '*Anonymous e-money is a possibility*. You are right in that audit trails and shadow accounting is needed in e-money for security reasons, but this does not hinder the introduction of different levels of anonymity. The best example of anonymous account money is/was the anonymous numbered accounts at Swiss banks. With different levels of anonymity I refer to technical methods to hide the relationship between the numbered chip card account and the possessor. One method is to introduce a trusted party, e.g. the issuer or a governmental agency that converts the cryptographically hidden number into real account numbers. This would mean [that] neither [the] merchants nor the banks learn the identity or real number of the chip accounts. The trusted party would neither have to [have] full information on transactions. Depending on the political decisions the audit trail could be opened through the third party for example to prosecute criminals. Depending on how 'difficult' the opening of the hidden audit trail will be, the system will have different levels of anonymity. This is again a concern related to all registers kept in the society.'

audit trail that can subsequently be followed (see BIS, 1996a: especially p. 26 and BIS, 1996b:, pp. 8/9)?

From the point of view of an issuer a completely cash-like e-money would raise serious problems of fraud control. Such problems may well prevent issuers from offering such a product. Moreover, on public policy grounds, would the authorities wish to countenance another alternative (and more modern and convenient) medium of exchange, which also was anonymous? Indeed, in Section 4, we shall discuss the wider public policy issue of how far the authorities should go in trying to shift people out of (anonymous) currency usage (e.g. by ceasing to issue big bills) into electronic transfer systems that can be monitored.

We have not tried, nor would we have any particular ability, to add to the literature that attempts to estimate the stock of currencies held abroad or for 'bad behaviour' reasons domestically. Instead, following Doyle (2000) and Rogoff (1998),[5] we shall assume that a reasonable, but obviously far from perfect, proxy for the division of the markets between currency held to facilitate ordinary consumer expenditures on the one hand, and 'bad behaviour'/second country stores of value, is the size (value) of the note. Drug dealers do not muck about with small bills; retail purchases are normally made with small bills (note that, according to the *Financial Times*, August 2001, some retailers in the Euro-zone were requesting the European Central Bank (ECB) to hold back on the issue of large Euro-notes, in order to reduce initial problems of verification and making change). Where the dividing line comes is again obviously somewhat arbitrary. For the purposes of our statistical exercise in Section 3, we have put it at a value of £50 – above £50 being large; below £50 being small.

Is the question whether currency may, or may not, become technically out-moded and replaced by e-money, one that should matter particularly to economists (as contrasted with those working in banks or currency producers)? We believe that the answer is that it should, and for a number of reasons. First, there has recently been a lively debate, nicely typified by the papers on 'The Future of Monetary Policy' in Posen (2000), whether the ability of central banks to conduct such policy depends on the existence of a sufficient volume of central bank liabilities. The hypothetical question of whether, and how, central banks might still be able to control interest rates and nominal economic magnitudes, should central bank liabilities tend to become eliminated, is theoretically interesting. But, if currency usage is actually going to remain almost as large as in the past (despite the new technological developments), then that would settle that issue empirically.

Second, as already noted, much of the demand for currency (especially for large value banknotes) comes from those who want to make anonymous transactions in the grey or black economies, those who want to hoard or those who need a safe store of value in the form of foreign bank notes (in countries with unstable and inflationary

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[5] As Rogoff (1998: pp. 165–270) notes, it is extremely difficult to estimate the division of those notes *not* held for domestic transactions purposes between those held externally and in the 'underground' economy.

tendencies). Our paper is a follow-up of Van Hove and Vuchelen (1996) and Rogoff (1998) in this Journal, and extends this work in several respects, notably in asking (Section 4) where the trade-off lies between anonymity and liberalism on the one hand and information, efficiency and the suppression of 'bad behaviour' on the other.

Third, the relationship between monetary aggregates and the wider economy, whether in the form of demand for money studies, or in assessing the effect of monetary innovations on output and inflation, provides a key building block in macro-monetary economics. This relationship has been buffeted by various product innovations, many triggered by technological developments, in recent years. Our study here, notably in Section 3, of the effects of e-money, and of other technological developments, on the demand for currency is a (minor) contribution in this field.

Fourth, there is the interaction between currency usage and fiscal policy. Since currency typically is non-interest-bearing, currency usage provides seigniorage, and hence a useful source of revenue to the state. Meanwhile there are also reverse influences. If tax rates are 'too high', for example on cigarettes in the UK, people will try to avoid and/or evade such taxes, and such activities will usually involve a large use of currency. This subject was also covered by Rogoff (1998), and again our work represents an extension of his earlier paper.

Fifth, shortly after this paper had been completed, a unique occasion in the history of currencies will have occurred, the transfer from the national currencies of the nation states of the Euro-zone to the euro itself. After a relatively short period, in most cases two months, the previous national currencies will cease to be acceptable as legal tender, at retail outlets, and after a rather longer period, usually six months, they may no longer be acceptable at banks within each country.[6]

How will this affect the present holders of such currencies, especially the holders of large value notes, such as hoarders abroad or those in the grey/black economies domestically? Sinn and Westermann (2001) have suggested that the weakness of the euro in 1999 and 2000 has been partly due to a sharp reduction in the demand for DM by criminals and people in Eastern Europe. Those in the black economy could find it hard to exchange large sums of DM into euro without running into money-laundering reporting requirements. In Eastern Europe DM have been much used as a saving instrument. People are not, however, sure about the effects of the conversion to euro. For both groups US Dollars or Swiss Francs might be preferable. Meanwhile the press have been filled with anecdotes about unusually large numbers of purchases of luxury items, cars, yachts and even houses paid for by down payment of high-value currency notes in the Euro-zone countries. Perhaps after the event we may learn a bit more about the identities and motives of holders of such notes?

In the meantime the currency changeover will involve a shock to people's monetary habits and inertia. This should of itself provide a more fertile ground for the

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[6] Central banks will accept their own national banknotes for a period between 10 and 30 years. Some central banks have set no time limit.

introduction of new payments' technologies. (On the effect of inertia in preventing a shift to new payment technologies in the USA, see Craig, 1999 of the FRB Cleveland). Perhaps more important, during the early days of the changeover when payers can tender national currencies as well as euros, the transaction time necessary to make change may rise significantly; one of us hopes to undertake an empirical test of this in January 2002. If so, the time involved in payment may (temporarily) become significantly shorter with cards than with cash, so cards may become the more pre-ferred means of payment for both payer and payee. On such grounds we expect the changeover to provide a fillip for e-money usage, though the lasting effects will prob-ably be small. Initially, it had even been expected that e-purse schemes might be able to provide a means of making euro-payments throughout the euro-area before 2002. Thus, it was hoped, the changeover to the euro would boost the case for e-purses (European Commission, 1998). However, soon it became clear that it would be impossible to achieve interoperability between national e-purse schemes before 2002. In fact, it still is not clear when e-purse schemes will be interoperable. Thus, on this count, cash has beaten e-purses. From 2002, cash will be usable throughout the euro area – e-purses not.

2. E-PURSES, ACCESS PRODUCTS AND CASH: RELATIVE USAGE, TRANSACTIONS COSTS AND SECURITY

2.1. New technologies in retail payments

New payment technologies in the retail sector can be divided into two groups: elec-tronic access products and e-money (BIS, 1996a). Electronic access products can be defined as products that allow customers to use electronic means of communication to access monetary balances held in an account. In most cases, such an account will be a bank account but it is also possible that the account is held with a non-bank (e.g. PayPal). Electronic money is defined as monetary value that is electronically stored on a technical device in the possession of the customer. It is a claim against the issuer, not against the payer.

Whereas electronic access products can be seen as the electronic equivalent of a cheque, e-money can be interpreted as the electronic equivalent of cash. However, such a clear dividing line exists only at the conceptual level. In reality, many payment products are a mix of the two categories (Krueger, 2001). In particular, most e-money systems fall short of the ideal of a perfect electronic cash equivalent.

So far, electronic access products such as debit and credit cards have been much more successful in gaining market share than e-money (see Table 2). In most coun-tries, debit card schemes were rolled out during the 1980s. In 1987 debit card usage was still modest. In some countries they were hardly used or not used at all. But by 1999 debit card usage reached a much higher level and surpassed credit card usage in almost all of the countries surveyed.

Table 2. The spread of new payment instruments

	Debit card transactions per capita 1987	Debit card transactions per capita 1999	Credit card transactions per capita 1987	Credit card transactions per capita 1999	EFTPOS terminals per 1 mio 1999	e-Money transactions per capita 1999
Belgium	4.11	34.7	0.75	4.8	9 746	4.45
Denmark	2.84	69.7	0.5	2.1	13 155	1.48
Germany	0.01	5.2	0.62	4	3 663	0.25
France	9.69	48.6	0.05	n.a.	13 181	n.a.
Italy	0	4.3	0.22	3.8	7 551	0.01
Netherlands	0	44.3	0	3.4	9 209	n.a.
Finland	11.36	51.1	9.27	11.6	11 617	0.1
Sweden	3.21	22.2	1.79	6.4	9 160	0.02
United Kingdom	0	35.3	9.19	25.1	11 778	n.a.
Japan	0.01	n.a.	2.88	6.51	130**	n.a.
Canada	0.01	54.3	27.16	37.5	13 280	n.a.
USA*	0.42	27.5	29.55	68.94	8 600	n.a.

Notes: * indicates offline debits included; ** indicates 1998. EFTPOS = electronic funds transfer at the point of sale.

Sources: ECB (2001), BIS (2001) Humphrey *et al.* (1996) and own calculations.

E-money has been far less successful. Many pilots failed and many large rollouts of e-purse schemes have been met with lukewarm reactions from consumers and merchants. Purely software-based products such as DigiCash's 'eCash' have vanished from the market. The non-significance of e-money in the market contrasts with the large attention e-money received from regulators, academics and the media. Between 1996 and 2000 the BIS published no less than four reports dealing with e-money. The ECB (EMI) published two reports in 1994 and 1998 and the European Commission passed a Directive on Electronic Money Institutes in 2000. The attention e-money received can be explained by its technological sophistication and the fact that many of the e-money pioneers were non-banks.

E-money was made possible by developments in cryptography (such as public key cryptography and blind signatures) and smart card technology (Böhle, 2001). In the 1980s smart cards were introduced as prepaid phone cards and to secure debit/credit transactions. From offering prepaid cards for phone services (or transport) it was a small step to offer prepaid cards that were also accepted by third parties. NTT took this step in the late 1980s and Danmønt in 1992 (Böhle, 2001; Godschalk and Krueger, 2000). The most ambitious e-purse project is the Mondex project launched in 1991. Mondex is the only e-purse scheme that allows purse-to-purse payments. Since its first pilot in Swindon in 1995, Mondex has been tested in a number of other pilots but has not seen a large roll-out yet. Those e-purse schemes that are used in the market, such as Proton or GeldKarte, do not allow received funds to be immediately re-spent. The payee can only return them to the issuer who will validate them and credit them to the payee's account.

Table 3. Various instruments in retail payments in Germany and the UK

	Germany (% of value of transactions)*				UK (% of volume of transactions)**			
	Cash	Cheque	Credit card	Debit card	Cash	Cheque	Debit card	Credit card
1990					80	10	0.5	2
1994	78.7	8.3	3.3	2.5				
1997	76.5	3.5	3.5	9				
1999	73		3.8	14.1				
2000					72.4	6.5	6	3.8

Notes: * indicates retail transactions (supermarkets, department stores., drug stores, etc.); ** indicates households' payments for goods, services and financial transactions.

Sources: Germany: e-card business (1998: p. 20), EHI press release, own calculations, UK: APACS press release, own calculations.

The most widely noticed development in the area of e-money was perhaps DigiCash's trial with 'Cyberbucks' initiated in 1994. Cyberbucks were a software-based product issued by a non-bank, apparently effortlessly crossing borders. That seemed to be the hallmark of a new area in payments. The reality looked different. DigiCash licensed its system to a number of banks (including Mark Twain Bank and Deutsche Bank). However, the system was never widely used and trials were discontinued. In 1998 DigiCash filed for bankruptcy (see Web Appendix B).

2.2. Current usage of alternative payment media at the point of sale

Table 2 shows that credit card payments and in particular debit card payments have been strongly increasing since the late 1980s. By 1999 Danes made, on average, almost six debit card transactions per month and US citizens about the same number of credit card transactions. But in terms of volume of transactions, cash is still king. The competitiveness of cash is reflected in its continuing high market share in retail payments. In spite of the impressive growth rate of card usage, cash usage has declined only marginally. In Germany, for instance, between 1994 and 1999, the share of cash payments at the real POS has fallen only a little from 78.7% to 73% (see Table 3). According to recent estimates, in Holland the share of cash in retail transactions is even higher. Jaarsma and Rijt-Veltman (quoted in Van Hove, 2000b) derive a share of cash transactions of 83%. Even in the UK, traditionally a more cheque-oriented economy, cash is by far the most important means of payment (see Table 3) in spite of a significant decline in cash usage throughout the 1990s. All of these figures are in line with estimates of the Federal Reserve System (1998) for the US, Japan and Europe.

These numbers show that cash is a competitive payment product and that most countries are still far away from a cash-less society. So far, the one instrument that has strongly lost ground vis-à-vis new payments methods is the cheque (ECB, 1999a: pp. 46–47).

Unlike access products, e-money has not yet made its mark on the market. Network money is not used at all and most e-purse schemes are struggling. According to the ECB (2000: p. 53), in June 2000, the value loaded onto e-purses within the euro area was a mere €140 million. In all countries, usage per card is small and the cash-substitution effect is negligible. Moreover, in some countries e-purse use seems to be stagnating or even declining. Danmønt, one of the oldest e-purse schemes, has basically had constant usage figures over the last three years (Danmønt, 2001). In Germany, the number of activated e-purses (of the 'GeldKarte'scheme) and the number of transactions rose in 1999. But the number of terminals and the value of transactions declined (Riehm, 2000; PaySys, 2001).

2.3. The business implications of security, anonymity and hoarding

In spite of all the attention e-money has received it is possible that the main threat for cash might come from debit cards. In recent years debit cards have quickly gained considerable market share in the segment of POS payments. Indeed, in Iceland debit and credit cards have been so successful that some economists think that the end of cash may be close there (De Grauwe *et al.*, 1999). However, if anonymity is as important as we think (see below), debit cards will never completely replace cash. Apart from anonymity, costs and convenience may also favour the use of cash. For some recent statistics on relative costs see Web Appendix C. Even as online connections are getting faster and cheaper, the need to have such a connection and the time to type in the PIN (validate it, type it in again if an error occurred, etc.) make online transactions inconvenient – even for people who are not concerned about anonymity. So, the final blow for cash would have to come from other, more cash-like, means of payment. The prime candidate is the e-purse (embedded in a card or a mobile phone).

Often it is argued that e-purses are only having a slow start because of network effects and excess inertia (Craig, 1999; van Hove, 1999a). Once critical mass is achieved, it is argued, e-purses will be widely used and may eventually drive out cash. However, this argument overlooks the point that e-purse schemes may be more costly than is commonly understood and that the characteristics of e-money will never match those of cash. In particular, e-money will hardly ever be suitable for hoarding.

When comparing cash and e-money the risk of fraud is an important factor. As far as cash is concerned, counterfeiting is not a large threat. In relation to the entire stock of bank notes counterfeiting is only of marginal significance. According to the Fed, in 1995, detected counterfeits amounted to 0.0075% of the currency in circulation (Allison and Pianalto, 1997: p. 562). Although this is high compared to countries like Germany (see Table 4), it is hardly an alarming figure. Of course it may be possible that detected counterfeits give a misleading picture. However, as Allison (1996: p. 321) points out, the Fed receives a large portion of the total currency balances each year.

Table 4. Detected counterfeits in three countries

	Detected counterfeits	Bank notes in circulation	Counterfeits as % of circulation
United States (1995)	30 million US$	390 billion US$	0.0075
Canada (1999)	4.2 million Can$	36.5 billion Can$	0.011
Germany (1999)	2.316 million DM	274 billion DM	0.00079

Sources: Allison (1996: p. 321), Allison and Pianalto (1997: p. 562), Bank of Canada (2000a: p. 30 and 2000b), Deutsche Bundesbank (2000: pp. 126–28).

Each month about 20% of the domestic circulation is received. Since all bank notes that are returned to the Fed are examined, the Fed gets a fairly accurate picture of the amount of counterfeiting.

The reported figures can hardly be used as an argument against cash. Plastic card fraud, for instance, causes much higher losses. In the UK alone, plastic card fraud (debit-, credit-, and check-card) produced losses of more than UK£100 million in almost every year since 1990 (APACS, 2000).

While counterfeiting is hardly a fundamental threat for currency it may well be one for e-purses. In particular for those types of e-purse that promise anonymity, counterfeiting may become a large problem (Ely, 1997: pp. 102–3). In order to defend themselves against the attempts of hackers, e-purse issuers will have to upgrade their systems continuously. But even if they do so, a risk remains that hackers could successfully break the encryption (Bonorris, 1997: p. 33; Pollack, 1996; Wayner, 1998). Last but not least, attacks from the 'outside' are not the only problem. Even when safety against attacks from outside may be satisfactory, this still leaves fraud committed by insiders. The BIS (1996a: p. 52) emphasizes that an attack on 'administrative security' during the manufacturing, issuing and distribution process may be a more severe problem then attempts to break the code embedded in stored value cards.

Risk has some unpleasant implications for e-purse issuers. The typical e-purse user is no expert in encryption and therefore unlikely to be willing to shoulder the risk of counterfeiting.[7] Therefore, issuers will have to carry the risk themselves if they want to persuade households and firms to switch to e-purses. This implies that issuing e-purses can be a very risky business. As McAndrews (1997: p. 24) points out, digital counterfeiting can easily wipe out the entire reserves of an e-purse system. Even a 100% backing of the e-money stored on e-purses could be insufficient to prevent bankruptcy (McAndrews, 1997: p. 14).

When assessing existing security measures, the BIS (1996a: p. 21) concludes that adequate security for electronic money systems can be achieved. However, as the

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[7] Cash users are forced to shoulder the risk of fraud. However, simple visual inspection can help a cash-user to some extent to determine whether a bank note is fake or not. In the case of e-money such inspection is impossible for the normal user.

BIS points out, there is a trade-off in the areas of cost, functionality, speed and reliability. Thus, higher security involves either less seigniorage (maximum balances per card), less convenience and flexibility for the user (restricted offline use, time limits) or higher costs (better storage devices, better cryptography, online authorization etc.). Thus, security issues may have important implications for costs and revenues.

So, a key problem for e-purse issuers is counterfeiting. Given the potentially large scale of fraud, issuers will have to find an effective way to deal with this risk (and the other risks involved in running an e-money scheme). In order to protect themselves, e-money issuers will have to use the following means against counterfeiting:

- frequent technical updates;
- limitations on the maximum amount that can be stored on cards;
- limitations on the duration of e-money balances;
- no peer-to-peer payments.

Limitations on maximum values do not just decrease the maximum damage that can occur within a certain period. Low maximum values also create smaller incentives for hackers. Thus, the lower is the maximum balance per card, the lower the probability of counterfeiting. Therefore, risk considerations favour fairly low limits for the maximum balances that can be loaded onto a card. Limitations on the duration of e-money balances allow issuers to frequently update e-money balances. The use of technically advanced systems is an important protection against fraud. Finally, the exclusion of peer-to-peer transactions – in particular, anonymous peer-to-peer transactions – allows issuers a more effective control of the system, most importantly, faster recognition of an attack.

Such measures to reduce the dangers of counterfeiting and fraud do not just reduce risks, they also have potentially huge effects on the costs and revenues of e-money issuers. Frequent updates of the system in order to stay on top of technological developments substantially increase the costs of e-money schemes. The other measures limit the ways in which e-money can be used. In particular, they restrict the use of e-money for hoarding purposes. This has adverse implications for e-money issuers. Only a fraction of the total stock of bank notes, maybe not even 5%, is used for legal payments (Avery *et al.*, 1986, 1987; Boeschoten, 1992). Even in Norway, which is generally perceived as a law-abiding country, Humphrey *et al.* (2000) estimate that 67% of the value of all cash outstanding was used in illegal activities in 1999, possibly rising to about 80% in 2005.

If the demand for e-money mainly comes from people who want to use it as a means of payments in legal transactions, average balances per smart card are likely to be small. A back-of-the-envelope calculation shows the seigniorage potential. In 1999 there were roughly 100 million e-purses in the euro area. If each card carried an average balance of €50 (a 'generous' assumption given that the 1999 average balance was about €1.4) total e-money balances would be €5 billion. At an interest rate of 4% this would yield €200 million in seigniorage. That is equal to €2 per card.

Given that a card costs already €2.5, this is hardly enough to break even because technical change and normal 'wear and tear' limit the life span of a card.[8]

If seigniorage is not high enough to cover the costs of e-purse schemes, issuers will have to rely on fees. Relatively high fees will not, however, make it easier to market e-money. So far, merchants have resisted the introduction of costly new payment methods. Customers are often quite content with existing means of payment (Good, 1998: p. 15; Van Hove, 2000c) and are not willing to pay for yet another card.

In our view of the likely attitudes of customers and merchants, there are clearly narrow limits for the potential scale of fees. This implies, first, that it is unlikely that interest will be paid on e-money balances and, secondly, that it is still not clear whether e-money schemes could ever become profitable (Godschalk and Krueger, 2000; Goldfinger, 1999).

Even though it may well be possible technically to create electronic payments systems that provide anonymity, three main factors – costs, systemic risks and regulation – are likely to militate against that. For all these reasons e-money systems are likely to be limited to small maximum values, facilitating small payments. Moreover, electronic access products are having a stronger impact on the demand for paper-based (cheque) payment systems, than on cash.

The clear implication is that e-money is not a major threat to the continuation of the usage of cash, and/or to its role, for example in the provision of seigniorage revenues, as a central bank liability. Indeed, any central bank wishing to encourage a shift from cash usage to e-money, as is being envisaged in Singapore (see Section 4), would find their balance sheet, and seigniorage, shrinking, as the inhabitants looked to other currency assets, e.g. US dollars, as a vehicle both for hoarding and for transactions requiring anonymity.

3. THE DEMAND FOR CURRENCY

We have argued that there are essentially two, largely separate, markets for currency; these are, first, a market for large value notes to facilitate 'bad behaviour', and, secondly, a market for small bills for ordinary, every-day consumption payments' purposes. Next, we provided evidence to suggest that non-cash electronic payments mechanisms, or at least those so far available, should mainly compete in this second market. If so, the coefficients on some determining variables should differ when we regress them on large and small (value of bill) currency holdings. Moreover, the standard income and interest elasticities may also differ between large and small bill holdings. We have no particular priors on the relative size of the respective income elasticities, but the interest loss on a €500 bill is of some significance, whereas that on a €5 note is not. This section aims, *inter alia*, to examine such

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[8] Davis (2000) quotes estimates that a European-wide smart card system based on CEPS (Common Electronic Purse Specifications) would cost between US$4.8 and 6.6 billion.

questions empirically using cross-country time series analysis. One reason for using such panel data is the limited length of years for which several of the key series were available. Another is that developments, for example in the use of currency and of electronic means of payment, have differed quite markedly between countries, so that looking at single countries could lead to results that do not hold more widely.

But we run ahead of ourselves. The standard form of demand for money functions, ever since Goldfeld (1973) or even before, Laidler (1969), Goodhart and Crockett (1970), relates real money balances (on the assumption, whether tested or not, of a unitary price elasticity), to a scale variable, usually real GDP, and a variable (or variables) to measure the opportunity cost. Since currency has a zero nominal rate, the short-term nominal interest rate is the obvious measure of that opportunity cost. Some of the explanatory data series used – e.g. for crime, for electronic competitors to cash such as ATMs and EFTPOS (electronic funds transfer at the point of sale) – needed to be normalized onto a per capita basis, so all variables (except interest and tax rates) have also been divided by population; so the dependent variable is real currency balances per head.[9] Estimating the demand for all currency and for large and small bills separately on annual data from 16 OECD nations yields results that were, we thought, rather good (see Table 5).

3.1. Basic currency demand results

One, initially somewhat surprising (to us), result was that the response to interest rates was not significantly different between large and small currency holdings. As Loke (2001) has shown, however, the advent of credit cards, which allow users to avoid interest loss, relative to cash usage, may well have raised the interest elasticity on small bills.

3.2. Additional 'bad behaviour' determinants of currency holdings

Having set out our basic equation above, we then introduced a set of variables that might influence 'bad behaviour' motives for currency holding. The standard variable used in such exercises is the ratio of tax payments to GDP, on the view that the higher the tax ratio (TR) the greater the incentive for tax evasion through the black/grey economies. The literature on the effects of this variable, however, indicates very mixed results.

Cagan (1958) was the first to argue that the high amount of cash outstanding could be due to the demand for cash in the underground economy. The ratio of taxes to GDP should increase money holdings as citizens try to evade taxes by shifting part of their economic activity to the black or grey economy, in which paying with cash

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[9] See Web Appendix Part D for data sources. It is also shown in the Appendix that the normalization by population has no significant influence on our results (compare Table D4 and Table 5 in the main text).

Table 5. Determinants of currency holdings

	Aggregate currency per capita	Large bills per capita	Small bills per capita
Real GDP per capita	0.58***	0.45***	0.46***
Nominal interest rate	−0.003***	−0.003***	−0.004***
ECM	−0.37***	−0.29***	−0.42***
Country trends:			
Belgium	−0.06***	−0.11**	−0.10
Canada	−0.01	−0.21	−0.02**
Denmark	−0.01	−0.06***	0.00
Finland	0.01	−0.05	−0.02
France	−0.03***	−0.07***	−0.03***
Germany	0.04***	−0.09***	0.03***
Italy	0.002	−0.05***	−0.003
Japan	0.005	−0.04**	−0.01
Netherlands	−0.02	−0.03	−0.03***
Austria	−0.02**	−0.06***	−0.01
Portugal	−0.05***	−0.08**	−0.01
Spain	0.03**	−0.01	−0.02***
Sweden	−0.03**	−0.08***	0.00
Switzerland	−0.05***	−0.88***	−0.04***
UK	−0.03	−0.06***	−0.01
US	0.01	−0.01	0.00
R^2	0.50	0.38	0.34
R^2-adj	0.46	0.32	0.26

Notes: Dependent variables are logs of real Cash/Large/Small/GDP per capita. ***, ** and * indicate significance at the 1%, 5% and 10% confidence level, respectively. We tested for cointegration of real GDP and real currency balances allowing for country-specific time trend; the common cointegration vector was $\beta = (1, -0.675)$. With GDP found to be weakly exogenous, we set up an error correction model, in which the first difference of log real per capita cash holdings is regressed on the first difference of log real GDP per capita, on the interest rate and on the error correction mechanism (ECM); also, due to strong and differing country trends (see Figure A2 in the Web Appendix), a country-specific constant a_i is included, thus $dm_t = a_i + b_1 dy_t + b_2 i_t + b_3 ECM$ is our estimating equation. We ran this on 16 OECD countries using annual data from 1980 to 1998. We did so both for the individual countries separately, and jointly in the panel. In the basic equation a Cook–Weisberg test rejects homoscedasticity at the 1% significance level for aggregate cash as well as for large and small bill holdings. We corrected for this by using GLS. Godfrey Breusch tests for autocorrelation in the error terms of the individual countries rejected autocorrelation in most cases. Using GLS to correct for cross-country heteroscedasticity and autocorrelation did not improve this much and was thus not further considered. See Web Appendix for further technical discussion.

is the common practice. Other studies confirmed this result; see Tanzi (1983), Pommerehne and Kirchgässner (1994), Porter and Judson (1996), Rogoff (1998) or Sprenkle (1993). Using cointegration methods, Doyle (1999) challenged these findings, however, as his results for 15 industrialized countries indicated that the amount of taxes either have no significant, or a negative effect, on currency holdings. Some older studies such as Porter and Bayer (1984) and Boeschoten (1992: p. 148) could also find no evidence that taxes had a positive impact on the demand for cash.

We can confirm that the results of entering this variable are quite mixed and vary markedly from country to country. In practice we found that the 'best' results arose when this tax-GDP variable (TR) was entered in both current and once lagged form.

The overall panel results were quite encouraging (see Table 6). As can be seen in the table, the sum of current and lagged coefficients for the tax ratio is strongly

Table 6. Panel estimation of the basic equation and the tax ratio

	Aggregate currency per capita	Large bills per capita	Small bills per capita
Real GDP per capita	0.63***	0.65***	0.38***
Nominal interest rate	−0.003***	−0.003***	−0.004***
Tax-GDP ratio (current)	−0.06	0.26*	0.15
Tax-GDP ratio (lagged)	0.15	0.41***	−0.24**
ECM	−0.35***	−0.29***	−0.42***
Country trends:			
Belgium	−0.07***	−0.20***	0.0008
Canada	0.007	0.06**	−0.017
Denmark	−0.008	−0.11***	−0.005
Finland	0.02	0.06*	−0.21
France	−0.04***	−0.14***	−0.02*
Germany	0.01	−0.12**	0.06**
Italy	0.009	−0.05***	−0.002
Japan	0.02	0.06**	−0.02
Netherlands	−0.02	−0.06**	−0.02**
Austria	−0.02*	−0.10***	0.05
Portugal	−0.03***	−0.08**	−0.02
Spain	0.05***	0.05***	−0.03***
Sweden	−0.03**	−0.11***	0.01
Switzerland	−0.03	0.06	−0.06***
UK	−0.03	−0.12***	−0.02
US	0.18	0.07***	−0.01
R^2	0.54	0.41	0.42
R^2-adj	0.50	0.33	0.34

Notes: Regressions are done by using the logarithm of real Cash/Large/Small/GDP per capita. ***, ** and * indicate significance at the 1%, 5% and 10% confidence level, respectively. The estimating equation is $dm_t = a + b_1 dy_t + b_2 i_t + b_3 TR_t + b_4 TR_{t-1} + b_5 ECM$.

Sources: see Web Appendix D.

positive for large and aggregate currency holdings, but approximately zero for small currency holdings; and the fits alter accordingly. But when we looked at the individual countries, the results were extremely mixed (see the Web Appendix).

For a selection of countries where foreign holdings are believed to be particularly important, (see Doyle, 2000), US, Germany, Switzerland and to a lesser extent Japan and the Netherlands, one might suspect that national 'bad behaviour', for which the tax ratio is a proxy, is not of great importance. As can be seen in the Web Appendix, the tax ratio loses its significance if one looks only at the US, Germany and Switzerland (the main currencies for foreign hoarding), or that same subset plus Japan. In contrast, in the subset of non-hoarding countries the tax ratio has a much larger and significant effect, especially for large currency holdings.

To see if global variables show any significant effect on hoarding countries, we tried a measure of world GDP (the sum of our country GDPs) as an alternative for national GDP; but only in the case of the Netherlands did it much improve the fit (see the Web Appendix). We also tried certain other cross-country tax variables, as detailed in the Web Appendix, for indirect and income taxes, but none 'improved' on the above results.

The second main variable, for 'bad behaviour', used by Rogoff was the intensity of violent crime; see Rogoff (1998: p. 278). As Rogoff noted, 'the theoretical effect of a rise in crime on currency demand is ambiguous, since criminals use cash heavily'. We tried to replicate Rogoff's variable as closely as possible. The crime index that we used contains the number of all murders, assaults, robberies, rapes, thefts, drugs-related crimes, bribery, fraud and other crimes. Some data on these individual series separately are also provided by the UN, but these are so sparse and partial as to be unusable econometrically.

All crime data are suspect; did the number rise because more were reported, or because there were more crimes? Again one can question whether this index measures what we should want to measure; thus drugs, bribery and fraud should raise currency usage, robbery reduce it, and rape and murder have not much effect. As a generality we would expect the effect of crime on money holdings to be better identified by micro-level survey exercises than by macro time series studies. Anyhow the effect of adding this variable was again mixed, but it did come out as negative and significant in some of the panel exercises (which is in line with Rogoff's finding that his crime index raised the ratio of GDP/M in 14 of his 16 countries, significantly so in 12 cases). This negative finding might be explained by the fact that the index is heavily weighted towards robberies and thefts. For the countries where data were available, on average roughly 60% of crimes reported in 1997 were robberies or thefts.

3.3. Do electronic competitors to cash affect currency holdings?

Whereas there were relatively few 'bad behaviour' series that we were able to use on a cross-country basis, there were rather more possible variables to use to examine alternative non-cash means of payment but most of them turned out to be entirely insignificant. These include the volume and value of card (and cheque) payments (all appropriately normalized). The two IT, technological, variables that have had a reasonably close relationship with currency usage are the number of ATMs (automated teller machines) and EFTPOS terminals (electronic funds transfer at the point of sale) per million of population. The basic bivariate relationship between ATMs (positive) and EFTPOS (negative) and currency/GDP is shown in Figures 1 and 2. This same negative effect for EFTPOS and positive effect for ATMs continues, albeit at relatively low levels of significance, when these variables are introduced into the panel data. Unfortunately, however, comparable data are only available from 1991 until 1998. With only eight years of data, it was not possible to run individual country regressions.

Since a rise in EFTPOS makes the use of card payments easier, a negative relationship with currency usage is to be expected. This has also been found in the literature. Boeschoten (1992: pp. 141–54) finds that the rise in the number of POS terminals and the increased use of credit cards reduce the demand for cash. Porter and Judson (1996: p. 902) present results that suggest a positive impact of the number of non-cash transactions on velocity (i.e. a negative impact on the cash-to-GDP ratio).
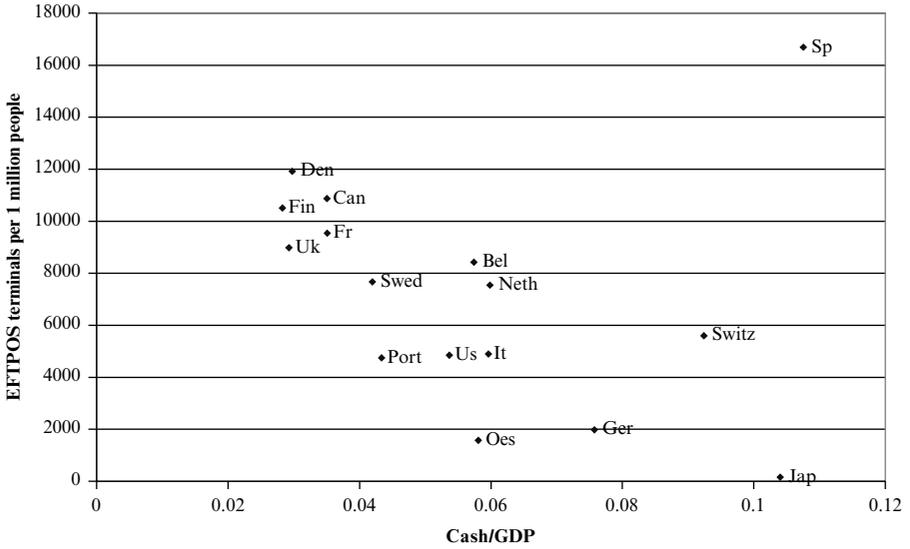
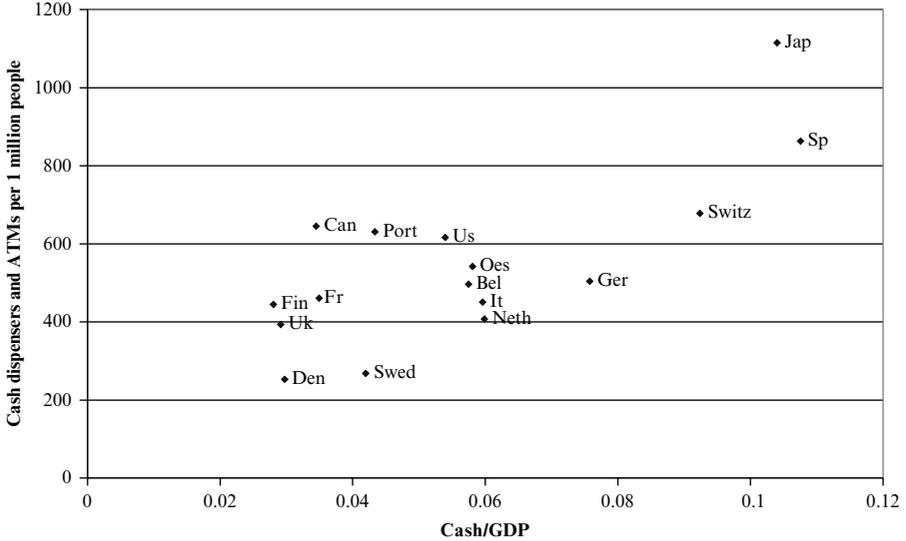**Figure 1. EFTPOS terminals and the Cash/GDP ratio**

Figure 2. Cash dispensers and the Cash/GDP ratio

In an analysis of per capita cash holdings in Finland, Snellman *et al.* (2001) find that the number of EFTPOS payments has a negative impact on the demand for cash. Again in their studies of a set of European countries, Snellman *et al.* (2001), report the same negative relationship (Table 3, p. 137), as does Loke (2001) for her set of countries (Table 5.3), though in virtually all cases the significance level is low. Such repeated findings are somewhat reassuring, but in several cases the researchers involved (including us) have been using an overlapping data set.

Table 7. Panel estimation of the best specification

	Aggregate currency per capita	Large bills per capita	Small bills per capita
Real GDP per capita	0.57***	0.47***	0.33**
Nominal interest rate	−0.004***	−0.004***	−0.006***
Tax-GDP ratio (current)	0.41***	0.49***	0.51***
Tax-GDP ratio (lagged)	−0.04	0.29*	−0.38***
ATMs	−2.6E−07	−1.0E−04	8.6E−05
EFTPOS	−1.9E−06	9.3E−07	−3.1E−06
Crime	−9.1E−06*	−1.50E−05	−9.64E−06
ECM	−0.29***	−0.31***	−0.53***
Country trends:			
Belgium	−0.09**	−0.27***	0.00
Canada	0.08***	0.15***	0.02
Denmark	0.03	−0.08	0.04
Finland	0.00	−0.04	−0.03
France	−0.07***	−0.17***	−0.03
Germany	0.005	0.001	0.05
Italy	−0.02	−0.10**	−0.02
Japan	−0.05	−0.05	−0.13**
Netherlands	−0.04***	−0.09***	−0.02
Austria	−0.04**	−0.13***	0.03
Portugal	−0.06**	−0.16**	−0.05
Spain	0.05	0.01	−0.05
Sweden	0.02	−0.04	0.08*
Switzerland	0.01	0.06	−0.04
UK	−0.04	−0.13***	−0.03
US	0.03	0.07	−0.03
R^2	0.55	0.43	0.53
R^2-adj	0.39	0.21	0.35

Notes: Dependent variables are logs of real Cash/Large/Small/GDP per capita. ***, ** and * indicate significance at the 1%, 5% and 10% confidence level, respectively.

Sources: see Web Appendix D.

What is less reassuring is that our maintained hypothesis was that card payments would be substitutes for small bill holdings and that the effect of EFTPOS on small bill holdings would be substantially different from the effect on large bills. As shown in Table 7, we found that there was indeed a negative effect on small bill holdings, which however turned out to be insignificant. Furthermore this coefficient is statistically not different from the effect of EFTPOS on large bill holdings.

The effects of ATMs are, in principle, ambiguous. On the one hand, ATMs should decrease the costs of transfers between currency and other (now often interest-bearing) bank deposits. According to the Baumol–Tobin theory of the transactions demand for money, this implies a decrease in money holdings. On the other hand, more ATMs imply that cash is more readily available, and so an easier substitute for non-cash payments. So it might increase the demand for money. Evidence for both hypotheses can be found in the literature. Snellman *et al.* (2001) find a significant negative relationship, whereas earlier studies (e.g. Boeschoten, 1992) show no significant, or

even a positive effect. Findings of such, relatively weak, positive effects have been further reported in Snellman *et al.* (2001), Table 3, and in Loke (2001), Table 5.3.

At least in this case the differential effect, comparing large and small bill holdings, is more nearly as we predicted. There is an insignificant (but negative) effect on large holdings, and a stronger (but not significant) positive effect on small holdings; both effects differ, however, significantly.[10] The set of panel equations that gave overall the 'best' results included real GDP per capita, the nominal interest rate, the error correction model term (ECM), the current and lagged tax ratios, Crime, EFTPOS and ATMs as the independent variables. The results are given in Table 7.

3.4. The findings of our empirical investigations

We draw the following conclusions from this exercise, several of which, as one would expect, simply reconfirm what other research workers in this field have already found.

- Currency and GDP are both strongly trended. There is a strong cointegrating relationship between them, so that if the long-run relationship is disturbed, currency holdings adjust in order to return to the long-run norm. A common cointegrating factor for all countries cannot be rejected.
- The demand for currency, whether in large or small bills, is significantly, and generally affected by (nominal) interest rates.
- The demand for currency per capita rises as real expenditures rise but the effect is quite variable between countries.
- The tax ratio variable has a generally positive effect on currency usage, but this effect again differs between countries. In those countries where foreign currency holding is thought to be important, the tax ratio has no apparent effect. In the remaining set of countries the effect is much stronger, and especially, as expected, for large bills.
- As found elsewhere (using similar data sets), EFTPOS has a weak, but significantly negative, effect and ATMs an even weaker positive effect on currency usage. There is, therefore, some statistical evidence of card payments reducing the demand for cash, but it appears to remain a fairly weak interaction.

The evidence, therefore, from this and other econometric research in this field is that plastic card usage, via EFTPOS, has indeed reduced cash usage. Even so, the competitive impact has so far been limited, partly as a consequence of ATMs making

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[10] Including crime as a regressor limits our sample slightly. In a test regression, where crime is dropped, the effect of ATMs on Small is significant at the 10% level. A Wald test also rejects the hypothesis at the 1% level that the effect on small bills is equal to the effect on large bills, which is negative and insignificant. The coefficient for EFTPOS turns out to be negative and significant at the 10% level for large bills in the test regression without crime. It cannot be rejected, however, that EFTPOS have the same effect on large as on small bill holdings.

As the country specific constant in the differenced estimation is similar to a country specific trend in the non-differenced series, it is interesting to note that the unexplained trends in our estimations are particularly due to trends in large bill holdings. One can observe only in Spain and Japan significant trends in small bill holdings.

cash more attractive as a means of payment. Moreover, with 'bad behaviour' (and foreign hoarding) an ever-present feature of our lives, all the evidence to date is that cash is not about to disappear.

4. CONCLUSIONS AND PUBLIC POLICY ISSUES

If the last twenty years are any guide to the future, then cash is *not* an endangered species. On our evidence, the effects of modern payment technologies on the demand for cash have not been strong. ATMs tend to increase and EFTPOS to decrease the demand for currency, though neither effect is highly significant. The institutional, anecdotal and direct empirical work available suggests that competition from existing electronic retail payments' products, primarily plastic credit and debit cards, focuses mostly on small to medium-sized purchases. (The average size of card payments in the EU is €60 for debit cards and €91 for credit cards.)[11]

Currently, there are few signs, nor much likelihood, of past or current electronic products displacing holdings of large value currency bills as a result of ordinary commercial developments. The various characteristics of cash remain superior for the purposes for which they are largely held ('bad behaviour', local and foreign hoarding), and the business prospects for e-money to compete in this market look slim, as described earlier.

Nevertheless, as Van Hove and Vuchelen (1996) and Rogoff (1998) emphasized, the availability of large value notes facilitates such 'bad behaviour'.[12] The simplest step would be for (all) central banks to stop issuing any new notes with a face value higher than, say, $100. Concern for seigniorage and an unwillingness of central bankers to admit to past wrong decisions may make any such suggestion a non-starter. Nevertheless, the horrific events of 11 September 2001 have focused attention on all those aspects of financial activity, for example 'money laundering', that facilitate terrorism, an extreme version of 'bad behaviour'. Although the inconvenience of having to obtain and handle larger bundles of smaller value notes is hardly going to deter the determined terrorist, drug-runner, etc., at the margin it could help.

Alternatively, and perhaps more likely than just withdrawing large notes, the government could intervene to try to make e-money more attractive, compared to cash.

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[11] The work of Loke (2001) suggests (see Chapter 5) that in some countries, especially with widespread ATM networks and low interest rates, cash usage for retail payments is not only holding, but may even be regaining, share. The ten-year forecasts made in Snellman *et al.* (2001: Figure 4, p. 142), suggest that the share of cash in POS payments will remain fairly constant in Italy, Germany and the UK, at around 90/95%, and in Denmark and Belgium, at around 60%. Only in Switzerland and Netherlands do they see a significant drop (of around 10%). So, even where electronic means of payment have been in use, and competitive, for some time, there is no sign of currency usage disappearing.

[12] Why did the ECB agree to the introduction of such large value notes? The ECB was constructed in the image of the Bundesbank, and the German Central Bank had issued 1,000 and 500 DM notes. So, the main reason was, somewhat thoughtless, mimicry of the Bundesbank's prior practice. A subsidiary reason may have been the desire to increase seigniorage. Although some may now recognize that this decision was a mistake, face-saving considerations suggest that such large notes will not be withdrawn. In this respect the Fed has behaved much better; it has refrained from issuing notes larger than $100, despite the likely strong demand for them.

Indeed there is now a reverse public-policy issue that merits discussion, which is that the provision of e-money, especially e-purses, may well fail to become viable, *unless* the authorities provide a helping hand. If they so wanted, they could provide such help in a number of ways:

(1) By providing technological standards for, and ensuring the inter-operational nature of, competing private sector e-moneys.
(2) By either issuing, or guaranteeing and insuring, such e-money themselves.
(3) By providing such e-money facilities in conjunction with various other electronic functions, e.g. identification, health records, social security benefits, etc.
(4) By making e-money legal tender.
(5) By mandating the use by all retail outlets of electronic payments devices.
(6) By abolishing the use of cash, which would require the universal provision of electronic wallets to allow person-to-person transfers, and arrangements to allow tourists, and others, to purchase e-funds with foreign currency.

Van Hove (2001) reports the extent to which various authorities have already moved in this direction. The most ambitious development is that in Singapore, where the Board of Commissioners of Currency Singapore (BCCS) is apparently planning to make electronic money legal tender by the year 2008, probably in conjunction with the Network for Electronic Transfers, Singapore (NETS). So Singapore appears to be taking steps (1) through (4); whether, and when, they might move to (5) and (6) remains uncertain.[13]

There are, of course, costs and benefits related to each step. Step (1), i.e. the provision of standards and inter-operability, may be necessary to allow for network economies, but also would involve public sector intervention in a rapidly evolving technological field in which officials and politicians would have no special expertise. Step (2) would involve a comparison, by the relevant authorities, of the costs and benefits of issuing e-money alongside, or in place of, currency. Providing guarantees, and/or insurance, to private sector issuers would either require difficult pricing issues, or would involve (potentially unbounded?) costs for no fiscal benefits. Steps (3), (5) and (6) might be highly efficient, and might well reduce tax evasion and crime, but their effects on the right to privacy, even privacy for bad behaviour, need serious consideration. Step (5) would impose costs on all retail outlets, e.g. taxis, pubs, etc., as well as shops. Depending on the costs of the equipment, this would provoke considerable opposition, unless the government was to pay for its installation in some way.

It is, in principle, possible to create anonymous e-money schemes. But, such schemes are unlikely to emerge. First, users have to trust that these systems really are

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[13] Although the BCCS does plan to make electronic money legal tender, this will apparently *not* imply that merchants will be *obliged* to accept e-money. Today, while traditional cash is legal tender in Singapore, merchants are free to set payment conditions – and will apparently remain free to do so once e-money has been made legal tender. We are grateful to Van Hove for this information.

anonymous. Since they would have difficulty in checking this on their own, trust may be a big problem. Secondly, security would be a major problem for issuers. Finally, government regulation, for instance anti-money-laundering rules, may stunt the development of truly anonymous e-money. So cash is always likely to have an advantage in terms of anonymity.

The advent of the new IT technologies raises questions of the weight to be given to privacy and freedom on the one hand, versus efficiency and the reduction of anti-social behaviour on the other. For example, all cars could be (compulsorily) fitted with electronic devices that automatically transmit information on their location *and speed* to a central computer. Fines for speeding could then be automated and time weighted[14] (and charged to the owner's e-money balance). Moreover, a comprehensive DNA register, plus a requirement that each individual carry an implanted chip, could enable the exact whereabouts of everybody to be ascertained on a continuous basis.

The equivalent in the economic context would be to try to ban the use of cash and force everyone to make all payments via e-money transactions, which could then be centrally recorded. The improvement in information flows, and possibly in economic efficiency would be large. Of course, criminals and tax evaders would seek alternative means of payment (foreign currency, gold, drugs), but the extra transactions' costs would reduce anti-social behaviour.

How far would we want to go down the road of giving up privacy (and anonymity) to enhance efficiency and crime prevention? Not far. We agree that governments should not wilfully encourage 'bad behaviour', and hence we agree with Rogoff that the issue of 'large value' notes is undesirable. But any attempt to force a complete shift to electronic transfer, and to try to ban, or to prevent, the domestic use of cash would in our view be appallingly illiberal. But then no government is seriously thinking of going as far as that. It can also be argued that the availability of cash transfers on the grey/black economy may limit the ability of governments to raise taxes to excessive levels, since such taxes can then more easily be evaded. Moreover, the potential use of foreign cash, for example US dollars, lessens the pain to the people and the incentive to governments of policies that threaten hyperinflation.

In the absence of efforts by the authorities positively to promote e-money usage, and at the authoritarian limit to withdraw (ban) all currency issues, we see the prospects of e-money competing with small notes as limited, and of competing with large note issues as negligible. Renowned economists such as B. Friedman or M. King have worried whether currency and central banks can survive the IT revolution. Many other financial intermediaries may disappear, or change their role dramatically, but currency and central banks are among the safer financial institutions to survive the new millennium. Indeed, the legalization of drugs could make a much bigger dent in the demand for currency than competition from e-money.

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[14] We thank H. Leinonen for this particular idea.

If the private sector (unaided) attempt to introduce an e-money payment system is, as we have sought to demonstrate, faltering badly, should the public sector step in to revive this exercise? While we ourselves are sceptical, others are more in favour of such an approach, e.g. Van Hove. But this we would claim is the real public policy issue for the immediate future.

Discussion

Michele Boldrin
University of Minnesota

A long-standing theoretical question economists like to investigate is: 'Why do people use currencies?' More precisely: 'Why do people use fiat currencies, instead of some commodity money or, more recently, some sophisticated record keeping device?' Such questions, surprising and somewhat amusing to laypeople, have produced interesting answers and substantial theoretical advances in the field of monetary theory. Investigating the reasons for our usage of currency has also been instrumental in our understanding and designing of financial systems and monetary policies. The paper by Drehmann, Goodhart and Krueger (DGK) is a useful addition to this body of literature coming, as it does, in the year in which the Euro makes its physical appearance and after a decade of developments in IT technology and Internet commerce. The question they ask is not so much 'Why do we use currency?' but a more prosaic and practical one: 'Will currency still be an important means of transaction in advanced economies in the next few decades?' The answer provided is a clear, and admittedly not surprising, 'Yes, it will.' I agree with their answer, which does not come as very much of a surprise.

What is interesting in this paper, then, is not so much the answer provided but the motivations adopted to justify it, together with the positive and normative views of the role of currency that the authors appear to favour. I will concentrate my brief discussion on this aspect of the paper.

Basically, there is just one reason for which, according to DGK, currency is and will be widely used. While they articulate this reason in a number of forms, give it different motivations and look at it from various angles, the main point of the paper boils down to an, admittedly well-known, old piece of wisdom: *pecunia non olet* (that is, money doesn't smell). First, our authors discuss the preservation of economic privacy, which in turn bifurcates into (1) the right of carrying out privately and inconspicuously legal economic transactions, and (2) the desire of rendering illegal transactions hard to observe and monitor by enforcing agencies. Next is the relative inefficiency of alternative means of transaction for carrying out small everyday exchanges: credit and more generally 'smart' cards as well as e-money are still relatively primitive and too costly for a large number of small daily transactions. Also in this case, though,

DGK insist mostly on the lack of privacy of these instruments and on the fact that transactions carried out through them are very likely to leave a trace behind, i.e. they lack the anonymity that cash provides. These arguments are backed by empirical evidence, showing the slow speed of penetration of alternative means of payments in various countries during the last decade and their still higher cost of adoption and usage. On the basis of this analysis and of the international data reported, DGK estimates a simple (and rather traditional, I would say) equation of the demand for currency. The estimation *per se* does not yield any surprising result. At the same time, it is very hard for me to understand in what sense a simple estimation of this kind may be able to shed any light on the future evolution of the aggregate demand for currency. To the extent that we are, as the authors admit, in the middle of a period of major innovations in the set of available transaction technologies, that new ones may be introduced and already existing ones highly improved and that the experience of the last five or ten years is better seen as the starting period of a long 'learning-by-using' curve, one should not feel very comfortable in using such estimates in making predictions about the future. While the estimated equation may be a reasonable or even good rationalization of what has happened so far, it may easily break down in front of future technological changes. The authors themselves do stress the 'networking' nature of many of the alternative means of payments: any reasonable modelling of network dynamics is bound to yield some threshold effect. Threshold effects have, precisely, the implication that small changes in the underlying parameters or level of the state variables bring about large and sudden changes in behaviour. I see no reason why we should not expect to see something similar applying to currency. Hence, if it is definitely too early to prepare the funeral of currencies it is also way too early to brand all alternative means of transactions as ineffective and bound to failure.

What remains, then, is the partly positive and partly normative assertion that currency is and will be used because it preserves anonymity and it guarantees that illegal transactions cannot be easily monitored and uncovered. Commenting on such a position is quite challenging as it forces us to a continuous distinction between normative and positive analysis, between the design of an 'ideal' economy and the realities of those we live in. Indeed this theme would have been, had the authors developed it extensively, the most interesting and provocative one among the many they touch upon in this paper. Unfortunately, I do not believe they do a particularly good job at separating the normative from the positive side of the issue, the costs of excess taxation from the gains of an equal distribution of the costs of public goods, the preservation of privacy and liberty from the prosecution of socially damaging activities, etc. Hence, in concluding, I will limit myself to pointing out the intrinsic conflict underlying the theme.

On the one hand, free and open societies should always minimize the extent to which 'big brothers' (be they large private conglomerates or public authorities) intrude in the life of their citizens. Maintaining currency and preserving its value should therefore be a central goal of public policy. Further, we are all quite aware of

the social risks associated with letting the 'predatory temptations' of the state run unchecked. To the extent that the availability of cash puts some restraint on the taxing power of the state and allows valuable and socially useful economic transactions to take place even in the black or grey markets, keeping trustworthy currencies alive is socially good. On the other hand, allowing criminal and illegal behaviours to be carried out at low cost is, especially in the aftermath of the tragedy on 11 September, most certainly not a goal of public policy. By the same token, basic and fairly intuitive criteria of social justice require all citizens to share equally in the cost of global public goods. The different degrees to which different economic activities can be monitored and, in the specific case, can make use of cash in carrying out transactions generate an unacceptable form of unequal distribution of the social burden of public goods. These and other arguments along very similar lines suggest that we should advocate a policy that does not allow currency to be easily used to such ends. How feasible is it to make these two goals (privacy on the one side, social justice on the other) truly compatible by properly designing the issuance, circulation and redemption of currency? Are there alternative means of transactions that would potentially perform better than currency along this particular trade off? This, I believe, is the crucial policy question that this paper raises but, unfortunately, does not address.

Andrew Rose
University of California, Berkeley

Drehmann, Goodhart and Krueger have set themselves an interesting and potentially important task. They are interested in finding out whether the new economy poses a threat to the use of currency. Their answer is a definitive 'No!' a result which I personally find convincing.

Their evidence is strong. As they note, most digital cash schemes have either vanished, or are struggling. As stated in Section 2.2, there are few countries with non-trivial e-money activity. Given that e-purse use is stagnating or declining, the evidence seems more than enough to answer the question posed by the title without further analysis. The authors are at pains to show that costs of e-money – especially the risk of fraud, and the costs of continuously improving encryption technology to forestall counterfeiting – are likely to remain high, placing e-money at a competitive disadvantage vis-à-vis cash for the foreseeable future.

Big and small

Much of the paper is focused on differentiating between the demands for large as opposed to small bill usage. The idea is that small bills are used by the salt of the earth for medium of exchange purposes, while larger bills are used by the criminal class, mostly as a store of value. The authors imply (though they do not rigorously show with simple statistical tests) that different bill sizes are associated with different money demand functions. They find weak results, especially for the effects of ATMs

and EFTPOS, but also for crime. I'm not sure what I take away from it all. Time-series econometrics like this rarely seems to shed much light on tricky issues like the introduction of new technologies, especially when the variables of interest have strong trends. Even with the panel dimension I guess I'm not surprised that the overall results are so weak.

Indeed, it is not obvious to me that one should only focus on holdings of currency. Perhaps new technologies will allow me to maintain my holdings of cash but reduce my M1 by reducing my use of cheques. I now pay essentially all my recurring bills by direct transfer over the Internet. In the past, I would have paid all these bills with cheques. If I were offered e-money at a lower cost than my cheque facility, I would probably try it. Traditional monetary aggregates include increasingly antiquated concepts like cheques but exclude e-money. Even if cash withstands the challenges of e-money, conventional monetary aggregates may not. Central banks have an interest in the stability of monetary aggregates above and beyond those of currency.

Even if e-money eventually does drive out currency, it is not clear whether this is very important to monetary policy. As other authors have noted, bank-issued e-money would continue to be a claim to base money. Since the latter consists of currency plus commercial bank reserves held on deposit at the central bank, the elimination of currency might simply mean an increase in reserves. (Indeed, the central bank could guarantee this by appropriate reserve requirements for e-money.) Of course it is likely that the successful introduction of e-money would shrink the monetary base and thus seigniorage. Still, as Rogoff and others have pointed out, seigniorage is small, and might easily be swamped by other benefits (in Rogoff's case, a reduction in currency-assisted crime; in the case of e-money, a more efficient monetary mechanism).

And yet

While I was totally convinced by this article that cash is here to stay for at least a while, forever is a long, long time. So let me do the following thought experiment. The argument here is that cash is safe as a medium of exchange since cash is cheaper, safer and more anonymous. Fair enough. But the same was true – even more so – when the cheque was introduced hundreds of years ago. Party B cannot use cheques from party A without being deposited and cleared through a bank. Party B does not know whether the cheque is good without independent verification. And cheques are certainly not anonymous. Yet the cheque manifestly overcame its disadvantages and is now a substantial part of M1, and a liquid medium of exchange in most countries.

One can go much further along the same line of reasoning. While the stock of credit associated with credit and charge cards is not yet a formal part of narrow money, it is most certainly a money substitute in the present. Going back in time, paper money would have suffered many of the same disadvantages vis-à-vis specie as e-money does today vis-à-vis cash. It behoves us to recall that the confidence we feel

about cash now would have been matched in the past by those sceptical about cheques, credit cards, and even paper money.

This scepticism seems especially relevant when we consider how rapidly technology seems to progress. Perhaps there is some equivalent to Moore's law for e-money; e-money may also prove more popular with technology convergence facilitated by, for example, Bluetooth. And it is important to remember that electronic funds transfer now accounts for the vast majority of payments in the OECD, when judged by value. Is it really impossible to imagine the wiring of money so commonly used by businesses will eventually come down to the retail level? The incentive for banks to offer digital currency is large, since the float provides an interest-free loan from customers. To quote an authority in the area:

> 'Today, there continue to be incentives for private businesses to recapture seigniorage from the federal government. Seigniorage profits are likely to be part of the business calculation for issues of prepaid payment instruments, such as prepaid cards . . . a diversion of seigniorage may be an inevitable byproduct of creating a more efficient retail payment system in the long run.' (Alan Greenspan, 'Fostering Financial Innovation: The Role of Government')

E-money may be down now, but I doubt it is out for the count.

Panel discussion

Phillippe Bacchetta pointed out that it is necessary to distinguish between cash holdings and cash transactions, e.g., individuals might hold a precautionary amount of cash to avoid the risk of not being able to buy goods or services should the debit or credit cards not be accepted. However, the amount of cash transactions might be substantially smaller. Kai Konrad asked why large bills would be actually issued, if they were used mainly for 'bad behaviour'. He proposed an alternative explanation based on excessive taxation and the related time consistency problem of the government, i.e., in order to pre-commit not to overtax, the government facilitates grey or black economy activities by issuing large bills. Paul Seabright added to the debate of privacy and liberalism that the consumer would retain the choice and externalities of this choice would eventually make the case for government intervention. He provided anecdotal evidence for the foreign use of currencies such as the dollar to avoid tax payments. Malte Krueger replied that the foreign circulation of cash might very well have positive externalities, e.g., dollars were used in countries of monetary chaos and that irrespective of the value of the bill.

Paolo Mauro questioned that the use of e-money could reduce crime. He argued that the substantial amount of money laundering through banks would suggest that the loss of anonymity resulting from non-cash transactions is small. Moreover he

stressed that there are other motivations for holding large bills than just 'bad behaviour' such as tourism. Patrick Weil stressed that cash would be subject to much of the same problems as e-money, since it could be counterfeited and privacy would not be complete for cash in the case of currency reforms and updates. Georges de Ménil noted that in the current political environment the question of how to trace cash transactions seemed to be particularly relevant. If terrorist activities were financed all in dollars, it would be necessary to search people at borders or to let them fill out currency declarations. Charles Goodhart replied that indeed recently there have been efforts to regulate the Bureau de Change.

Jacques Drèze mentioned that the fact that national currencies are going out of circulation soon as a result of EMU provides an experiment which could be used to get further insights on the hypothesis that large bills are mainly used for 'bad behaviour'. The Central Bank of the Netherlands had reported that 30% of large bills did already come back to the bank. Furthermore, the bank would have data when these bills would have come back last to the bank before. As to his knowledge this data would not have been analysed so far. Charles Goodhart replied that the hypothesis has been put forward already by Sinn and Westermann who had claimed that the weakness of the Euro was partly due to the smaller demand for cash for 'bad behaviour' as the third phase of EMU approached. They had asked the Bundesbank to collect data in order to provide evidence on this hypothesis. Richard Portes noted the Bundesbank had actually found no evidence in support of their hypothesis so far.

Michael Moore questioned the econometric methodology. He did not quite believe that in the regression of money on income the residuals would not be autocorrelated. Moreover, he doubted that income would be weakly exogenous in the error-correction specification and, hence, would not play any role for the adjustment to equilibrium. Charles Goodhart disagreed with Moore in that it seemed implausible to him that the cash-income ratio should reach its equilibrium via income adjustments. This would be particularly implausible, because of the use of end-of-the-year data. Mathias Drehmann defended the econometric results.

Patrick Honohan mentioned that resulting from the recent political pressure to clean up the money-laundering scheme, banking secrecy was no longer considered a good thing. He reported that the British government withheld subsidies to firms which did not comply with transparent enough accounting standards. Instead of most of the proposed anti-liberal measures, stigmatization of those who performed large cash transactions would be likely to be more effective against money laundering. Jochen Kluve pointed out that the positive effect of ATMs on cash holdings of small bills reported might be due to the fact that ATMs are loaded with small bills.

In response, Charles Goodhart agreed with Andrew Rose's discussion that e-money was unlikely to have an effect on central banks' monetary policy and that the main substitution would be between e-money and cheques and not cash. Malte Krueger agreed that the data quality is problematic since it was not on an audit base. He claimed that the data on retailers' cash holdings were most reliable compared to

those provided by the national payment association. Concerning the data on cash transactions he argued that using consumption data is not promising because consumption includes transactions that are not done with cash such as rent and water bill payments. To justify the chosen sample period he argued that credit card transactions did not play a big role in Europe where debit cards became much more popular only in the 1980s. Moreover, it would be very difficult to obtain data for earlier years. He agreed with the discussants that it is difficult to predict how future developments affect the demand of cash versus e-money. He mentioned computing power as an example that on the one hand would make more sophisticated encryption feasible, but on the other hand would also facilitate cracking the encryption code.

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