Is Cash Becoming Technologically Outmoded? Or Does it Remain Necessary to Facilitate "Bad Behaviour"? An Empirical Investigation into the Determinants of Cash Holdings

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I) Introduction

The initiative for this quantitative empirical exercise arose in response to two papers by eminent economists (one of them also Deputy Governor of the Bank of England), claiming that the future demand for cash could wither in the face of on-going technological innovation[1], e.g. plastic card payments, e-commerce and e-purses, (King 1999, B. Friedman 1999). Several of these technological developments already have been under-way in advanced countries for many years, so if technology was to be a serious threat to cash usage, one might expect to find some signs of this in the data by now. So the first priority of this empirical exercise was to examine whether technological variables could be found that had significant effects on cash holdings.

Perhaps the best published paper on cash usage in recent years is by Rogoff (1998). This was primarily written in response to, and to criticize, the ECB decision to issue large value euro-notes. The theme of his paper was to argue that note-holding, especially the use of large notes, is largely driven by the desire to avoid government control, especially the requirement to pay taxes. So the issue of large value euro-notes would be akin to a subsidy to criminals, (Rogoff, pp. 280/1). The three main variables in his equations were interest rates, the ratio of taxes to

[1] They also agreed that, if this was so, it might lessen, perhaps eliminate, the ability of a Central Bank to operate monetary policy to influence nominal magnitudes, e.g. the price level. In a companion paper, Goodhart (2000), we suggest that this latter argument is invalid. But this latter debate is outside the scope of this paper.

GDP and a proxy for violent crime. The latter has an ambiguous sign, since criminals will tend to use cash as their preferred store of value and means of payment, but the threat of mugging will deter cash holdings among law-abiding citizens. So, a second factor potentially driving cash usage will be `bad behaviour', e.g. the gray or black economy domestically, but also bad economic behaviour by governments with bad inflation records causing substitution of cash issued by good government (e.g. US$ or DM) for domestic currency. Thus a second set of potential variables were those that might prove a measure of `bad behaviour', such as Rogoff's tax/GDP and crime proxy variables.

Besides technological and `bad-behaviour' variables, cash holdings, as a % of GDP, may be influenced by standard macro variables, interest rates representing the user cost of holding non-interest-bearing cash, and some measure of real income (to test whether the income elasticity of cash holding is greater or less than unity). Such `macro' variables provide a third set of possible variables.

The ratio of currency holdings to GDP in most (developed) countries in the last few years has been strongly trended, but the trends have gone in different directions (Figure 1 in the Appendix). If we were to explain currency holdings adequately, we reckoned that we needed to be able to give some explanation to the cross-country differential trends. So our basic econometric model has been a combination of cross-country and time-series, a panel approach.

Taking 1997 as an example, the overall average cash to GDP ratio in our sample is 5.3%. These numbers would appear to imply that each person on average would hold about $1635 in the US, and in Japan 418.200 Yen (≈ 3485 US$) if all such cash was held domestically. The picture is even more surprising if one looks at data for large notes outstanding. Figure 2 in the appendix shows that these represent a remarkably large proportion of all currency outstanding in many countries. According to the currency statistics each American should carry nine one hundred dollar bills, and each German at least one 1000 DM bill (≈ 625 US$) in 1997. These numbers are hardly congruent with common money holdings for day-to-day purchases. One commonly held view in the literature is that huge amounts of cash holdings are used in the black or grey economy for crime, tax evasion, prostitution, drug dealing, betting, etc. Furthermore, it seems clear that a lot of US$, Swiss Francs, German Marks and Japanese Yens are held abroad. Doyle (2000) finds in his recent study that roughly 30% of

the US currency and up to 77% of the Swiss currency is held abroad. Such huge foreign money holdings can be attributed to international criminal activity and also to "dollarisation" in countries with high inflation records and an unstable political environment. The impact of crime and "bad behaviour" is likely to be greater for large bank notes, as these facilitate storing and shipping of large sums of money.

Besides the likely different effects of crime and "bad behaviour" for large (rather than small) notes, we also expect that modern payment technologies like debit or credit cards would have a more pronounced effect on small notes. This should be the case as small notes are used for everyday transactions and might more easily be substituted by card payments. This might not be the case for large bank notes. Goodhart (2000) argues that for payments in the black and grey economy cash is most suitable. It is the least risky payment method as it is immediate and fully anonymous. In particular, anonymity cannot usually be guaranteed for electronic payments. Thus modern payment technologies are not such a close substitute for cash and especially large bank notes in the black economy.

Following Doyle (1999), we split cash outside central banks into large and small bank notes and run our different regressions for these series as well. We arbitrarily set the boundary for small notes at the local currency value of £50.[2]

The plan of the paper is as follows. In Section 2 we will describe the variables used and discuss our rationale for using them. In Section 3 we explain our methodological procedure. Section 4 discusses the results and Section 5 concludes.

II) Variables Used

To generate a comparable data set we had to restrict ourselves to annual data from 1980 to 1998 for 18 OECD countries.[3] Even so, for many variables, data were only available for parts of this period and for a sub-set of countries. We will indicate the set of countries and years in the discussion of each variable. In all regressions we used the biggest data set available.

[2] At the end 1999 exchange rate

The main variable of interest was cash holdings. We used as our main series, and dependent variable, the ratio of cash outside central banks over GDP (CGDP).[4] To generate the series for small and large bank notes we arbitrarily set the boundary at the local currency value of £50.[5] We then deflated both series by GDP, which gave SmallGDP and LargeGDP.

Our regressors can be roughly divided into three categories: general macroeconomic variables, technological variables, and "bad behaviour" variables. In the following we will discuss each set separately.

Macroeconomic Variables

1) Interest rate (i)

This is taken as the nominal overnight money market interest rate.[6] All countries are covered for the whole time period.

2) Real consumption per head (cons)

To construct this series we took the ratio of private nominal consumption over population and deflated the series by the consumer price index[7]. To achieve international comparable data, we converted each series into dollar values at the 1990 exchange rate.[8] For 5 countries[9] this variable could not be constructed for the year 1998. Otherwise the data set is complete.

3) Inflation (infl)

This is derived as the percentage change of the consumer price index.[10] Data are available for all countries over the full time period.

4) The ratio of consumption over GDP (consgdp)

We deflated private nominal consumption with nominal GDP.[11] All countries over the entire time period are covered.

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[3] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United States and United Kingdom.
[4] Source: International Financial Statistics.
[5] We want to thank K. Rogoff for providing us with important parts of this data series. We extended his series with data from BIS (2000, 1998 and 1996), EMI (1997) and ECB (1999). Data are not available for Australia, New Zealand and Norway and only for a sub-period for Austria, Belgium, Denmark, Finland, Italy, Sweden, Portugal, Spain and the UK.
[6] Source: International Financial Statistics.
[7] Base year for all countries is 1990.
[8] Source for population: World Development Indicators; all other series: International Financial Statistics.
[9] Belgium, Italy, Portugal, Spain and the UK.
[10] Source: International Financial Statistics.
[11] Source: International Financial Statistics.

Rationale

The choice of an interest rate and real consumption per head reflects theories of the demand for money. According to theory the interest rate should be negatively correlated with currency holdings. Real consumption per head is used as the proxy for real income per household. We used consumption rather than GDP, since the depended variable was deflated by GDP, so errors in estimating GDP would cause spurious correlation. This should be less so, when consumption deflated by population is used. Moreover, most cash is used for consumption goods (not for investment). The elasticity of income with respect to cash is normally found to be less than unity. Given our linear estimation with variables expressed as ratios, the coefficient for real income should therefore show a negative sign.

The rationale for including inflation was to see if higher inflation decreases the demand for money. This should be the case as an increase rises the opportunity cost of holding cash and thus should lead to a decline in money holdings. Given that low inflation rates are already incorporated in the interest rate, no additional negative effects might be seen for this variable.
The variable Consgdp was used to measure cyclical effects. We believe that the use of cash should be more stable than GDP. Shopping for everyday necessities where lots of cash is used is not as hard hit by a recession as investment or export goods. The demand of cash in the underground economy might also be more stable.[12] A recession would thus imply that Consgdp is relatively high and the ratio of cash to GDP also increases. We therefore expect a positive sign for Consgdp on CGDP.

Technological Variables

1) The volume and value of cheque and card payments (chvol/cardvol and chval/cardval)

The series of the volume (value) of cheque and card payments are deflated by the population (GDP).[13] We were able to cover 10 OECD countries from 1991 till 1998. [14]

[12] In the black economy the demand for cash might even rise in a recession. Might it not be that crime rises during recessions?
[13] Source: BIS (2000, 1998 and 1996).
[14] Belgium, Canada, France, Germany, Italy, Netherlands, Sweden, Switzerland, UK and the US.

2) The number of ATMs and EFTPOs [15]

The series are both normalised to the number of ATMs and EFTPOs per million inhabitants.[16] Except for Australia, New Zealand and Norway, data were available from 1991 till 1998.

3) Internet hosts (intern)

The series was given as the number of internet hosts per 10,000 people.[17] All countries from 1994 till 1997 were included.

4) The number of telephone mainlines (tel)

The series is normalised to the number of telephone mainlines per 1,000 people.[18] It was available for all countries except Japan from 1980 till 1997.

Rationale

Initially one might expect that the effects of credit cards and EFTPOs would be to decrease money holdings. Are we not paying our shopping bills or underground ticket with a credit or debit card now, when we would have used cash ten or fifteen years ago? This casual observation appears to be supported by looking at cross-country differences (Figure 3 and 4 in the Appendix). A negative linear relationship between cardpayments / EFTPOs and CGDP seems quite apparent for 1997. This has been found in the literature. E.g. Snellman et al (2000) or Boeschton (1992)[19] found a significant negative relationship between these technological variables and the use of cash.

The effects of ATMs might be ambiguous. On the one hand, ATMs should decrease the transaction costs of money holdings. According to the Baumol-Tobin theory of the transaction 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. Thus it might even increase the demand for money. The latter argument gets some support by a cross-country scatter plot for 1997 (Figure 5 in the Appendix). Evidence for both arguments can also be found in the literature. Snellman et al (2000) finds a significant

[15] EFTPO is the shortcut for electronic funds transfer at the point of sale; ATM stands for automated teller machine.
[16] Source: BIS (2000, 1998 and 1996), EMI (1997) and ECB (1999).
[17] Source: World Development Indicators.
[18] Source: World Development Indicators.

negative relationship, whereas earlier studies (e.g. Boeschton (1992)) show no significant or a positive effect.

The latest development in payment technology is the advance of internet banking. Some, for example Friedman (1999), even forecast that this, combined with other modern payment technologies, might threaten the existence of cash in the future altogether. We tried to see if there were already some significant effects over recent years. We were, however, unable to find data series for internet banking. We therefore used the number of internet hosts in each country form 1994 to 1997 as a proxy. Looking at a cross-country scatter plot for the year 1994 (Figure 6 in the Appendix), one thinks that there might indeed be a negative relationship between CGDP and this variable.

The last technological variable we considered is the number of telephone mainlines. This is used as a general proxy for technological change. We hope that this is also related to technological progress in the banking sector. We are not too convinced that it is a very good proxy. It is, however, attractive as the available data covers the entire time period and is available for nearly all countries. It should have a negative effect on cash holdings.

"Bad Behaviour" Variables

1) Crime

The total number of assaults or major assaults was normalised by population.[20] A consistent data set could only be constructed for 10 countries[21] from 1980 till 1997.

2) The ratio of total tax revenue over GDP (RGDP)

Total government revenue was deflated by GDP. We were able to obtain these data for all countries.[22] Data for the entire time period was, however, only announced for 5 countries.[23]

[19] Boeschton did not look at the effects of card payments.
[20] Source: UNCJIN
[21] Austria, Canada, Denmark, Finland, Italy, Japan, Spain, Sweden, Switzerland, and the United Kingdom
[22] Source: International Financial Statistics
[23] Data was complete for Germany, Italy, Sweden, Switzerland and the US.

3) The ratio of the total value of the highest value note outstanding to the total value of currency outstanding (hnrel)

This series was constructed by taking the ratio of the total value of the highest value note outstanding to the total amount of cash outside central banks. The same restrictions for years and countries included apply as for LargeGDP and SmallGDP.[24]

4) The five year and ten year depreciation of the local currency with respect to the dollar (5/10)

This is defined as the percentage change of the local currency relative to the dollar exchange rate at date t and t-5 (t-10).[25] All countries are covered for the whole time period.

Rationale

Our variable "crime" is used as a proxy for criminal activity. Rogoff (1998) argues that the effect of an increase in crime on cash holdings is ambiguous. On the one hand, it should be negative as the likelihood of getting robbed increases and thus people carry less cash. On the other hand, it should increase the demand for cash in the criminal fraternity. As argued in the introduction, using cash is within the nature of crime. More crime thus could lead to a higher usage of cash. Rogoff (1998) finds in time series regression for 16 different countries that crime enters with a negative sign for 14 countries and is mostly significant.

Tanzi (1982) first argued 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. According to him this should be the case as citizens try to evade taxes by shifting part of their economic activity to the black or grey economy, in which paying with cash is the common practice. Other studies confirmed this result.[26] Using cointegration methods, Doyle (1999) challenges these findings as his results for 15 industrialised countries indicate that the amount of taxes either have no significant, or a negative effect, on currency holdings.

As mentioned earlier, paying and storing large sums of money in cash is in the nature of crime. This is much easier with high value notes. Given other criteria, international crime

[24] See footnote 5.
[25] Source: International Financial Statistics.
[26] See Rogoff (1996) or Sprenkle (1993) .

should prefer currencies with a higher value of the highest note outstanding.[27] Moreover, the domestic demand for the largest bank note might be higher, the more crime there is. We used hnrel to try to capture these effects. A higher ratio of the total value of the highest value note outstanding to the total value of currency outstanding should thus increase the total demand for money.

In the above discussion on small and large bank notes we suggested that a vast amount of, for example, Dollars and Deutsche Marks outstanding is currently held not in the country of origin. Besides historical reasons and ease of acceptance, the demand for foreign money holdings might be attributed to a low inflation record. This effect should reinforce the domestic negative effect of inflation. Furthermore, the stability of a currency towards the "world" currency, the US dollar, should be an important determinant in foreign money holdings. We try to take these effects into account with the five and ten year depreciation of the currency with the respect to the dollar. Depreciation should generally weaken the demand for the currency. Given our definition of the exchange rate as the amount of home currency per US$, the sign should be negative.

III) Methodology

A battery of Phillips Perron and Augmented Dicky Fuller tests revealed that the individual time series of CGDP, LargeGDP and SmallGDP are trended. We thus estimate the panel in first differences. To circumvent the problem of correlation between the error and the first lag we use the second lag as instrument for the first lag.[28]

There is no theoretical model which specifies which variables should be included and which not. We, therefore, worked our way from a general to a specific parameterisation of the demand for cash.

As most of the data series are not available for the entire period and for all countries, we could not include all variables in the general regression. Furthermore, the loss in degrees of freedom would have been too high if we would have started with all variables. We thus did

[27] We wanted to include the dollar value of the highest note outstanding in our regressions. As we have to estimate our model in differences it would however have dropped out.

some preliminary testing to get a general feeling for the possible significance of each regressor. As real income and the interest rate are an integral part in every specification for the demand for money, we ran regressions of CGDP, LargeGDP and SmallGDP on the i, cons and then every other variable separately (Tables A1 to A3 in the Appendix). This should give some indication of the importance of each of the variables. These regressions are, however, prone to the effects of omitted variables. This implies that the estimated standard deviation are biased upwards. For our general to specific specification, we include all variables with a t-statistic greater than one in these preliminary regressions.

According to Tables A1 to A3, all variables except crime showed this degree of significance in at least one of the regressions on CGDP, LargeGDP or SmallGDP. We would have liked to introduce crime into the general equation as well, in order to compare it with Rogoff (1996), but this would have limited the sample size to under 20.

The most general specification we estimated in first differences was thus CGDP / SmallGDP / LargeGDP on its lag, the interest rate, real consumption, inflation, consgdp, the value of cheque and card payments over GDP[29], EFPOS, ATMs, internet, Tel, RGDP, Hnrel, and the 5 year depreciation [30].

We used two criteria for the elimination of variables: the first was whether that variable had a low t-statistic; the second was whether it most limited the size of our sample to fewer countries and years. Amongst the possible ones we chose those with the lowest t-statistic. Due to theoretical reasons the interest rate and real consumption were never eliminated. Our data set and this process imply that the results are not nested from one equation to the next. We still worked with this procedure to maximise the number of observations in order to get more reliable estimates. As we will show later in our discussion of the results, this might have some effect on the level of significance, but less on the general impact of each variable. The order of deletion does actually not matter as long as the variables in our two "best specifications" are left in.

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[28] For a technical reference see Baltagia (1995) or Maddala (1983).

[29] Due to multicollinearity, we could not test card- or chgdp and card- or chpop in the same regression. The initial regression was also tested with the volume of cheque and card payments over population to see the difference. As this did not make any difference, we concentrate only on chgdp and cardgdp.

The order of deletion was: internet, cheque and card payments over GDP, Tel and inflation. This left us with Specification I, with nine independent variables, each of which was significant and correctly signed in at least one of the equations.

Specification I:

(1a) $CGDP = a_{1c}\,CGDP(-2) + a_{2c}\,i + a_{3c}\,cons + a_{4c}\,consgdp + a_{5c}\,AMT + a_{6c}\,EFTPO + a_{7c}\,rgdp + a_{8c}\,hnrel + a_{9c}5$

(1b) $SmallGDP = a_{1s}\,SmallGDP(-2) + a_{2s}\,i + a_{3s}\,cons + a_{4s}\,consgdp + a_{5s}\,AMT + a_{6s}\,EFTPO + a_{7s}\,rgdp + a_{8s}\,hnrel + a_{9s}5$

(1c) $LargeGDP = a_{1l}\,LargeGDP(-2) + a_{2l}\,i + a_{3l}\,cons + a_{4l}\,consgdp + a_{5l}\,AMT + a_{6l}\,EFTPO + a_{7l}\,rgdp + a_{8l}\,hnrel + a_{9l}5$

As we had to estimate in first differences and had data for ATMs and EFTPOs from 1991 till 1998 for 16 countries, we had only about 70 data points from 1992 till 1998. For the effects of payment technologies, these results are the best we can present. The results can be seen in Table 1.

The omission of ATMs and EFTPOs will enlarge the sample to over 130 data points from 1981 till 1998. This gave us Specification II

Specification II:

(2a) $CGDP = b_{1c}\,CGDP(-2) + b_{2c}\,i + b_{3c}\,cons + b_{4c}\,consgdp + b_{4c}\,rgdp + b_{6c}\,hnrel + b_{7c}5$

(2b) $SmallGDL = b_{1s}\,SmallGDP(-2) + b_{2s}\,i + b_{3s}\,cons + b_{4s}\,consgdp + b_{4s}\,rgdp + b_{6s}\,hnrel + b_{7s}\,5$

(2c) $LargeGDL = b_{1l}\,LargeGDP(-2) + b_{2l}\,i + b_{3l}\,cons + b_{4l}\,consgdp + b_{4l}\,rgdp + b_{6l}\,hnrel + b_{7l}\,5$

Our estimates are shown in Table 2.

[30] We only included the five year depreciation as 5 and 10 are highly correlated, but the effects for 5 were more pronounced.

Table 1

Specification I

Consgdp	EFTPO	ATM	RGDP	hnrel	5		R^2	adj R^2
0.11091	9.1E-08	-1E-06	0.01438	0.02035	0.00079		0.38655	0.31105
0.025555***	3.01E-07	5.09E-06	0.005777**	0.009112**	0.002447			
0.02524	6.2E-07	-1E-05	0.0987	0.03399	0.00181		0.67525	0.63335
0.040327	4.89E-07	8.47E-06	0.009463***	0.015223**	0.004145			
0.04333	-4E-07	1.3E-05	0.00622	-0.0195	-0.0038		0.41013	0.33401
[redacted]**		3.7E-6***	0.004169	0.006711***	0.0018**			

CGDP and LargeGDP. Its level of significance, however, depends on the years taken into account. For SmallGDP, not only the significance but also the sign changes with fewer years. This weak result for small notes is not so surprising. We assumed that they are used for everyday transactions. Small changes in the interest rate should not alter standard everyday transaction habits drastically.

Real income enters negatively as predicted. This result is more robust to changes in years taken into account than the interest rate. The demand for large bank notes never appears to be an important determinant. This, again, is not unexpected as we assumed that large bank notes are used primarily for ”bad behaviour”.

Our cyclical variable enters with a positive sign and is significant for SmallGDP and CGDP. For LargeGDP, no significant effect can be shown. This might indicate that the black and grey economy, and with it the demand for large bank notes, is as cyclical as GDP. Looking at Tables 1 to 6 it can be seen that the effects of the cyclical variable are highly robust to changes in the data set.

Resume:

In our estimations we find the standard effects for macroeconomic variables on the demand for cash. We additionally showed that cyclical effects are an important determinant for money holdings relative to GDP.

Technological Variables:

ATMs and EFTPOs are the only technological variables we found significant in any specification. Given our results (Table 1) it seems that both have only pronounced effects on the demand for small bank notes.

The impact of EFTPOS is only significantly negative for SmallGDP. This, at first disappointing, result is, however, not at odds with our discussion in the Introduction. There we argued that progress in payment technology should have a more distinct effect on small bank notes. As these are mostly used for everyday transactions, they are more easily replaced by electronic payment methods. We also assumed that large bank notes are held mainly in the black and grey economy and predicted, therefore, no great impact of modern payment

technologies on the demand for them. This, indeed, seems to happen and the insignificant effect for large bank notes drives the effect on the overall demand for cash. We thus can only partly confirm the results from the literature.[31] For small bank notes, we get the known significant negative effect. For large bank notes, however, no significant effect can be detected. Given the seen increase in the proportion of large bank notes in total bank notes outstanding (Figure 2 in the Appendix), it might explain why we do not find a significant effect for CGDP in contrast to the literature.

Are these findings robust? To get a significant effect for EFTPOs on the demand for small bank notes, Spain has to be included. We re-estimated Specification II without Spain. The results in Table 3 show that the coefficient for EFTPOs remains negative, but is not significant anymore. We doubt that this is a matter of the number of data points, e.g. dropping the US and the UK doubles the negative effect of EFTPOs.

The results for ATMs throw some more light on the theoretical discussion in Section II. Even though its impact on LargeGDP and CGDP is not significant, it shows a negative sign. In contrast to that, the demand for small bank notes appears to be significantly and positively related to the number of ATMs. What thus might be happening is that people decrease overall cash holdings, and go more often to the cash machine to get small amounts of money, implying an increase in the demand for small bank notes. This effect for ATMs is, however, also not robust to changes. For example, in a regression in which we dropped RGDP[32], then ATMs looses its significance even for SmallGDP (Table 3).

[31] See Snellman et al (2000) or Boeschton (1992).
[32] Including RGDP limits our data set in the late 90s and, as we will see later, that its effect is very volatile with respect to the exact specification of countries included.

Table 3

Specification I, without Spain or the US and the UK

	Lag	I	Cons	Consgdp	EFTPO	ATM	RGDP	hnrel	5		R^2	adj R^2
excluding Spain												
SmallGDP	-0.1013	0.00014	-1E-06	0.04509	-3E-07	1.4E-05	0.0073	-0.0177	-0.0038		0.42215	0.34245
	0.103772	0.000137	7.85E-07	0.017994**	2.35E-07	3,8E-6***	0.004282*	0.006995**	0.0018**			
excluding the UK and the US												
SmallGDP	-0.0511	3.2E-05	-9E-07	0.04111	-6E-07	1.3E-05	0.00503	-0.022	-0.003		0.4503	0.36732
	0.09981	0.000143	8.01E-07	0.018313**	2.5E-7**	4E-6**	0.004323	0.00726***	0.001897			

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level,

Table 4

Specification I, with all countries but no RGDP

	Lag	I	Cons	Consgdp	EFTPO	ATM	RGDP	hnrel	5		R^2	adj R^2
SmallGDP	-0.008	-1E-04	-4E-07	0.02761	-4E-07	4.4E-06		-0.0262	-0.0021		0.25827	0.19254
	0.107361	0.000132	7.65E-07	0.018439	19E-7**	3.68E-06		0.006064***	0.0018			

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level,

Table 5

Specification I, excluding Austria or the Netherlands

	Lag	I	Cons	Consgdp	EFTPO	ATM	RGDP	hnrel	5		R^2	adj R^2
excluding Austria												
CGDP	0.33001	-0.0004	-2E-06	0.09694			0.00423	0.03134	-0.0031		0.32239	0.28934
	0.075878***	0.000132***	6,3E-7***	0.022***			0.012719	0.010394***	0.0013**			
excluding the Netherlands												
CGDP	0.31678	-0.0004	-2E-06	0.09158			0.01101	0.02256	-0.0025		0.29601	0.25991
	0.076471***	0.00013***	6.4E-7***	0.022***			0.006347*	0.009705**	0.0013**			

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level,

Table 6

Specification II, excluding only Germany, Japan, Switzerland and the US

	Lag	I	Cons	Consgdp	EFTPO	ATM	RGDP	hnrel	5		R^2	adj R^2
all countries excluding Germany, Japan, Switzerland and the US												
DCGDP	0.25218	-0.0003	-3E-06	0.0648			0.00496	0.02228	-0.0009		0.22189	0.14894
	0.105487**	0.000137**	8.4E-7***	0.025**			0.012515	0.009979**	0.00137			
only Germany, Japan, Switzerland and the US												
DCGDP	0.43975	-0.0005	-2E-06	0.1612			-0.0157	0.06738	-0.007		0.47358	0.41284
	0.118236***	0.000257*	9.6E-7**	0.039***			0.028004	0.023866***	0.002388***			

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level,

Resume:

Taking the evidence for technological variables altogether, they did not appear to have an important determinant for the demand for cash in the last 10 years. The only significant influence could be shown for ATMs (positive) and EFTPOs (negative) on the demand for small bank notes under certain specifications.

"Bad Behaviour" Variables

From the 4 proposed "bad behaviour" variables, all, except "crime", have an impact on money holdings.

In accordance with results in the literature, we find a positive effect of taxation on the demand for money. The effect on holdings for small notes is less than for large ones, which is not surprising.

One has, however, to be very cautious with this result. The significance level of RGDP is highly dependent not only on the time period covered, but also on the countries included. One can see the effects of the inclusion of different years by changes in the estimates from Specification I to Specification II (Tables 1 and 2). More worrying is how volatile the result is to the exact countries included. In Table 5, we re-estimated Specification II without Austria. This small change has a drastic consequence for the significance level of RGDP. Its t-statistic drops from 1.81 to just over 0.33. The positive sign, however, remains. This is again not just due to the elimination of data points. Estimating Specification II with Austria but without the Netherlands, for example, (Table 5) still yields significant estimates for RGDP. At present we are not quite certain why this is the case.

The effects for hnrel are amongst the most robust ones in our exercise. The higher the ratio of the total value of all the highest value notes outstanding to the total value of notes outstanding the more cash there is relative to GDP. This is exactly what we expected. This effect is reversed for small bank notes. It seems that the use of the highest value note has a negative effect on the use of small bank notes. Being critical, one could argue that hnrel is not entirely exogenous, and that this is the reason behind our results. Nevertheless, we may be picking up the two different effects of crime, since we expected hnrel to be a proxy for cash use in "bad

behaviour". There we noted two effects: it lowers money holdings, as the likelihood of getting robbed increases (the effect on small bank notes). On the other, hand it increases the demand for cash as one needs large sums of cash to ship and store value (effect on large bank notes and ultimately CGDP). Unfortunately, our data set for the variable "crime" was too small to investigate these effects more thoroughly with another proxy for criminal activity. Some future research might help to clarify this issue.

The five year depreciation with respect to the $US shows the assumed negative influence on the demand for cash in Specification II with the most data. The sign and the significance level are, however, highly year and country dependent (Tables 1, 2 and 6).[33] Given the discussion in Doyle (2000), that mostly German Mark, Japanese Yen, Swiss Franc and $US are held as a substitute for local currencies in countries with high inflation records, the results in Table 6 are not so startling. Depreciation with respect to the $US is not an important determinant for currencies which are mainly held domestically. The 5 year depreciation is, however, highly significant (Table 6) for an estimation where only data from Germany, Japan, Switzerland and the US are taken into account.

Resume:

"Bad behaviour" seems to have an important impact on the demand for cash balances. We found that national and international dimensions of "bad behaviour", like RGDP, hnrel and the 5 year depreciation, are driving forces for cash holdings. The signs of these variables are quite robust. For RGDP and the five year depreciation, the t-statistic is "however" very volatile. They depend highly on the set of countries and the time period covered.

V) Conclusion:

An important finding is the dependence of the estimates on the precise specification. It is a common problem in econometrics that the significance level of estimates depends on the time period covered. What we found additionally is that, especially in the case of RGDP, the precise set of countries determines the t-statistics for the estimates in a powerful way. This finding gives some indication that the demand for cash is not so much explained by common

[33] Again, the change in the level of significance for RGDP should be noted.

factors as maybe by cultural and country-specific reasons. It also implies possibilities for a researcher to obtain a significant specification, even though the underlying structure of the system is more ambiguous. It is difficult, and perhaps dangerous, to try to reach firm conclusions. However, we do not want to be too negative. From our work we feel able to conclude that precise estimations of significance are not reliable, but that the general direction of most variables is more solid. Future research might be able to get more insights into this problem.

So what about an answers to the question in the title? If the last twenty years are a guide to the future, then we are quite confident that cash is not an endangered species. On our evidence, the effects of modern payment technologies on the demand for cash are not that strong. We could only find a significant negative effect for EFTPOs on the demand for small money balances. This, however, is quite powerful. If we assume an average annual growth of EFTPOs of 20%[34] and the estimated linear relationship, then it would only take 15 years until no small bank notes would be held in the US anymore. However, the advance of ATMs seemed to increase the demand for small notes. Given these opposite forces,[35] it seems that technology is not crowding out small bank notes entirely. For large bank notes and overall cash balances, this seems anyhow the case. Furthermore, "bad behaviour" variables show very strong positive effects on the demand for small and large bank notes. Even though politicians always announce they want to be tougher on crime, we are sure that they will not succeed entirely. Black and grey economies will persist in the future. This implies a powerful source for the demand for cash balances.

[34] The overall average increase in our sample was 33% and in the US even over 50%.
[35] and the estimated linear relationship, which is unlikely to hold once demand for EFTPOs and ATMs is saturated.

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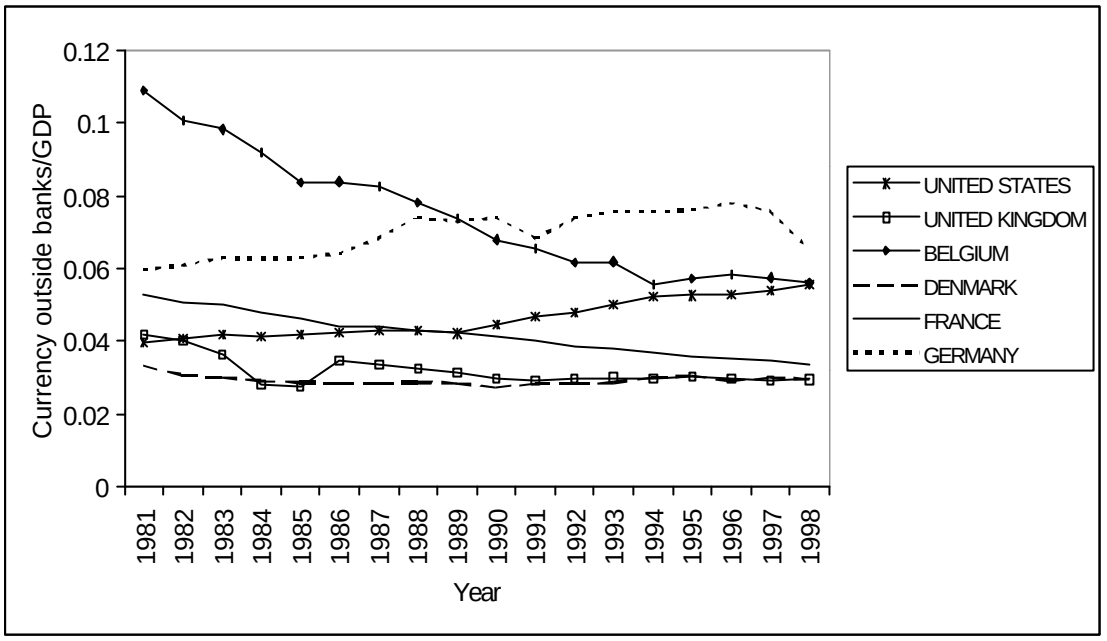
APPENDIX

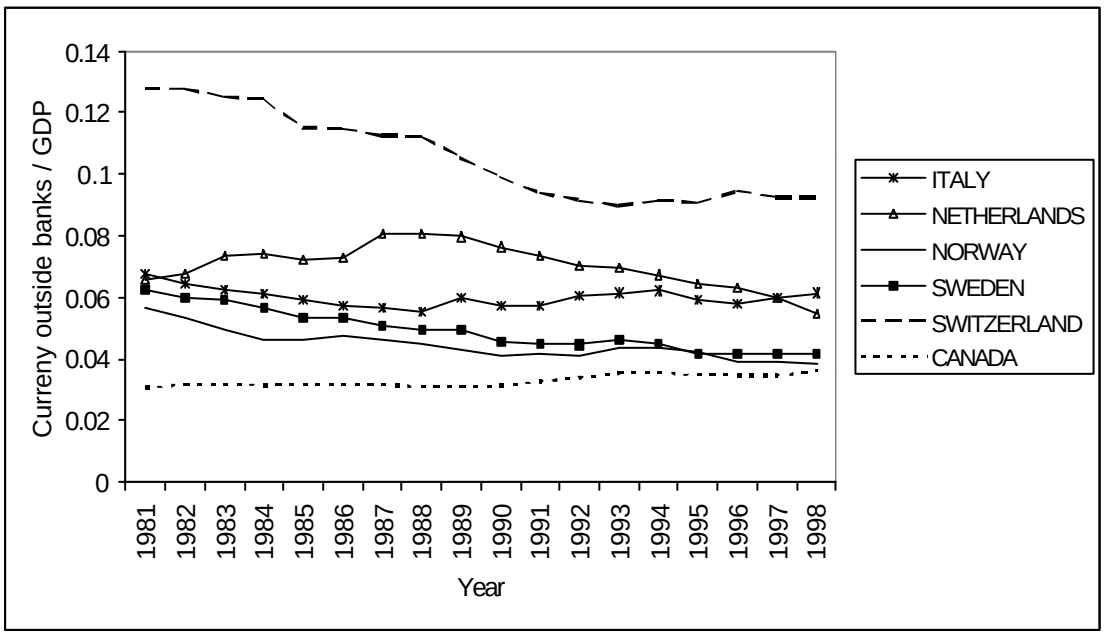
Figure 1

Currency outside central banks over GDP



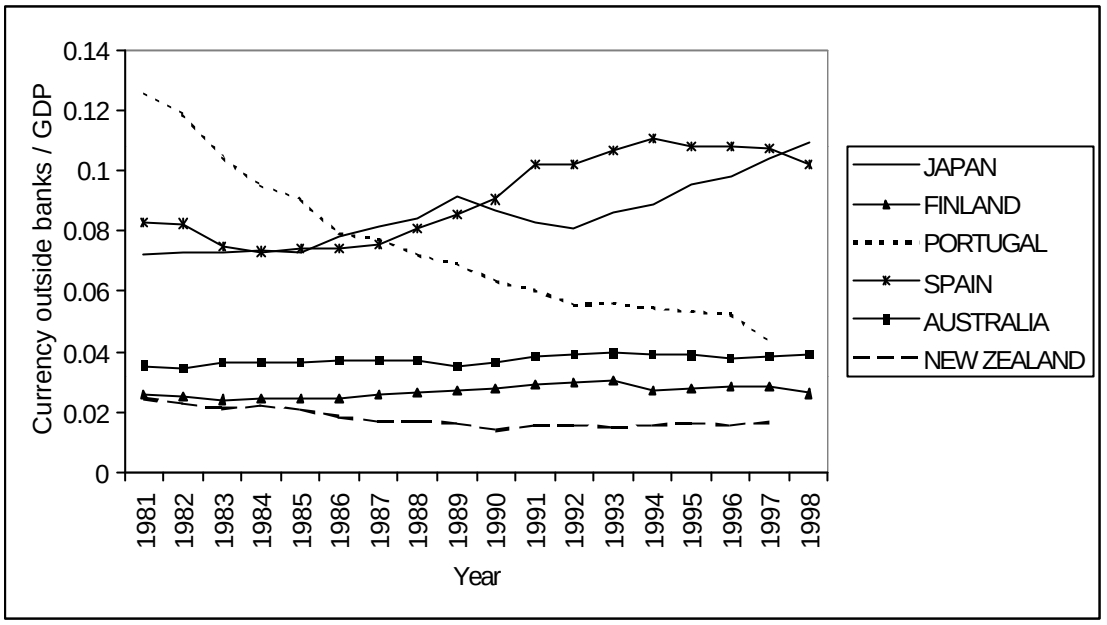
Source: see text

(a)



Source: see text

(b)

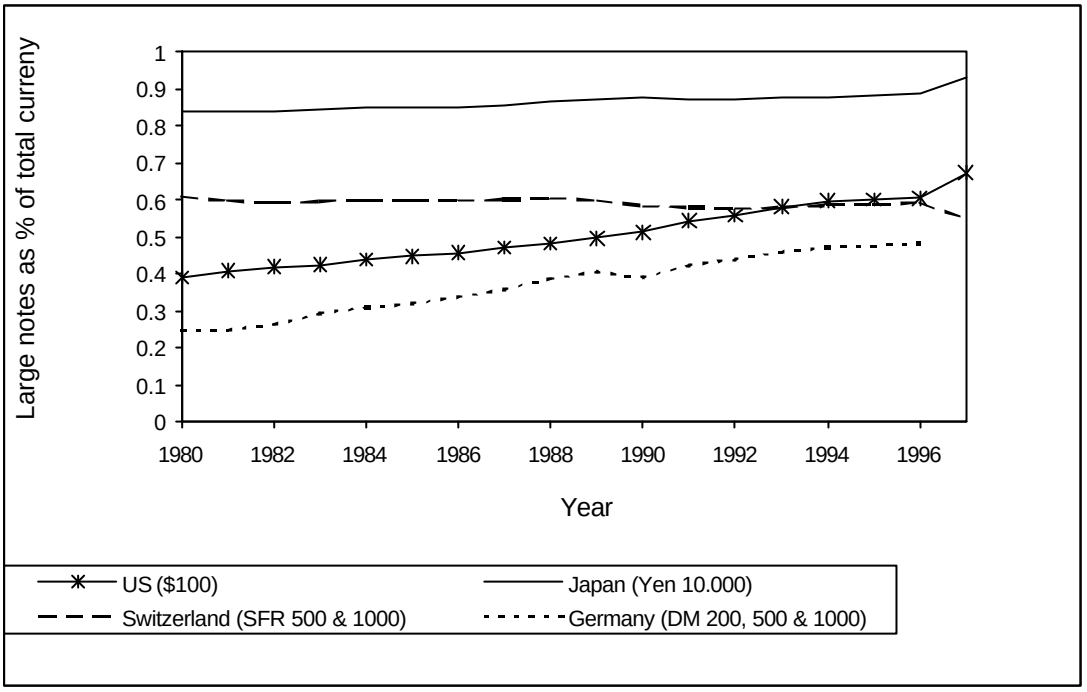


Source: see text

(c)

Figure 2

Large notes as a percentage of total currency outstanding



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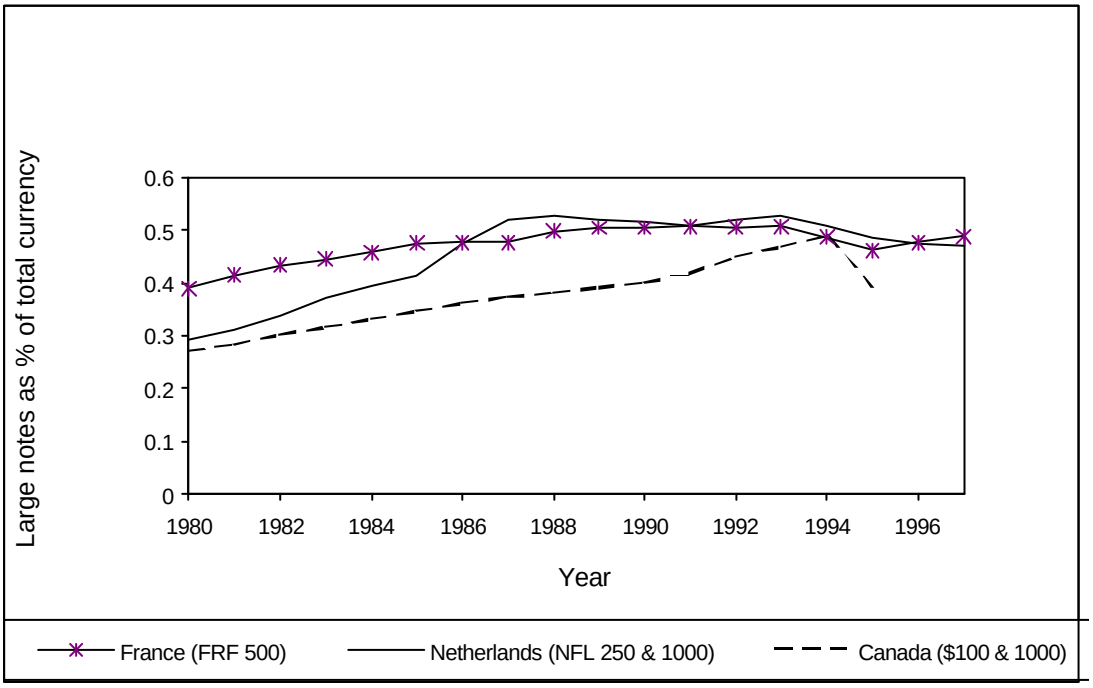
(a)



Source: see text

(b)

Figure 3

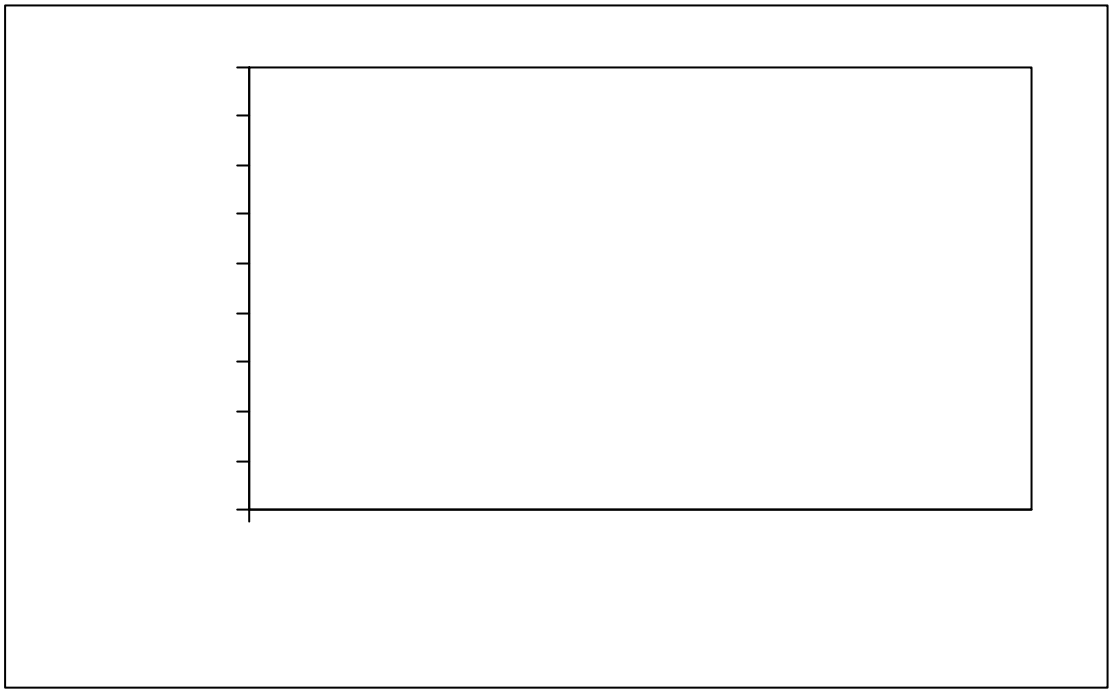


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Figure 4

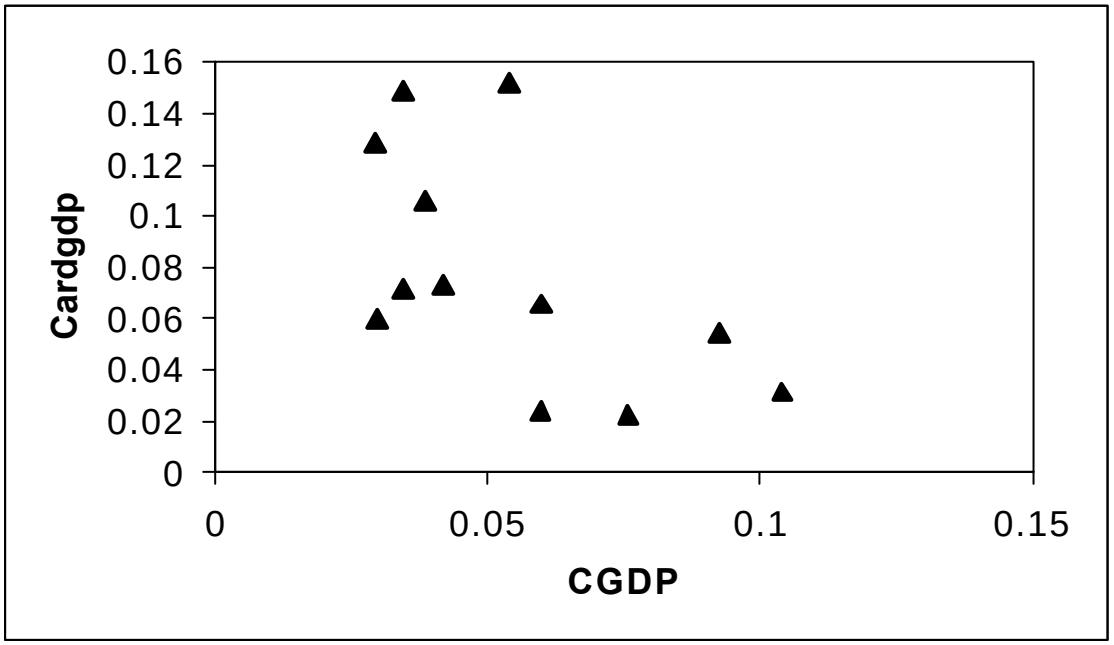

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Figure 5

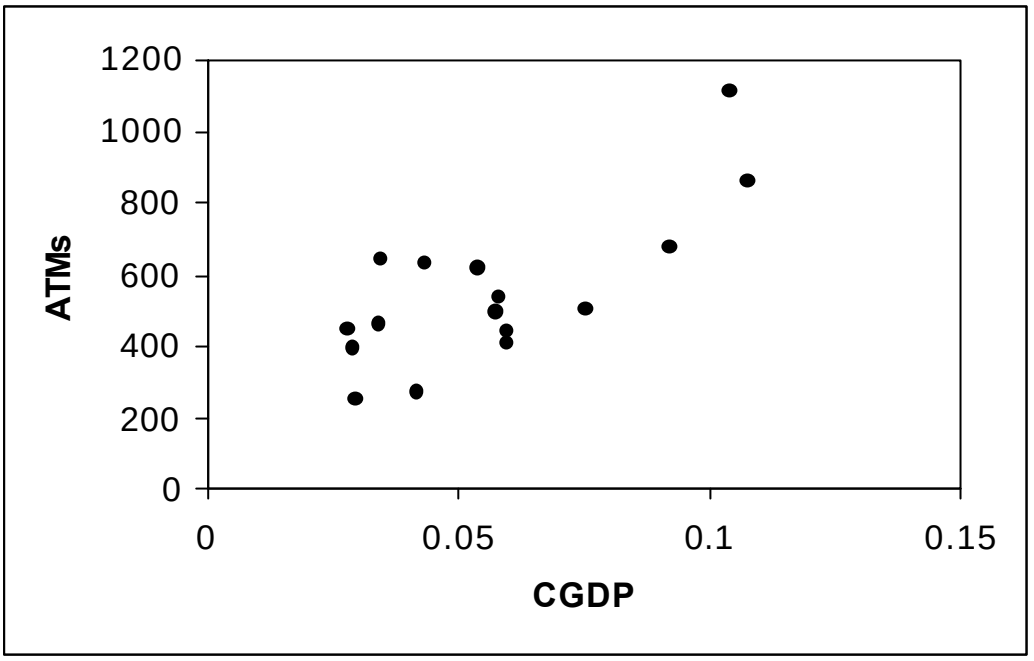

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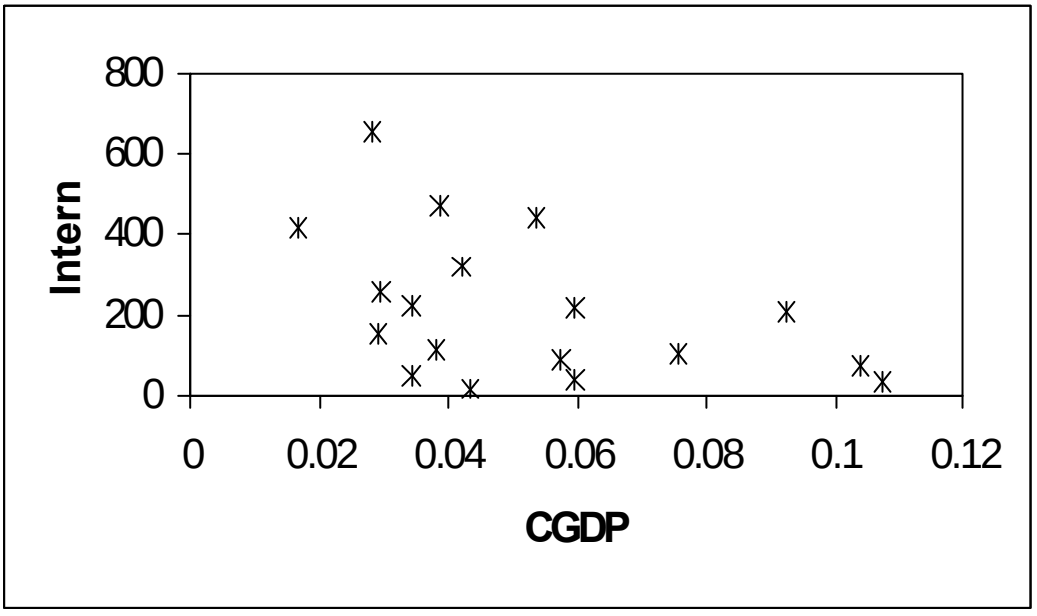
Figure 6



Source: see text

Table A1

CGDP

LAG	I	Cons	Infl	consgdp	chgdp	chpop	cardg	cardp	EFTPO	ATM	intern	Tel	Crime	RGDP	hnrel	5	10	R^2	adj R^2
0.3965 0.054733***	-0.0003 8E-5 ***	-6E-07 4.89E-07	-6E-05 8.89E-05															0.159	0.15
0.4117 0.050666***	-0.0003 7E-5 ***	-3E-08 4.68E-07		0.0762 1,4E-2***														0.23	0.222
0.2376 0.102849**	2E-05 0.000144	3E-07 0.00000109			8E-05 0.000181													0.107	0.052
0.2127 0.105519**	-2E-05 0.000143	-4E-09 0.00000106				199.1 143.46+												0.142	0.091
0.2988 0.119321**	-0.0002 0.000142	-4E-07 0.00000115					3E-04 0.017296											0.09	0.051
0.2243 0.10061**	-9E-05 0.000116	2.9E-07 0.00000117						-58.69 67.9999										0.095	0.047
0.2893 0.090116**	-0.0002 0.000128	-3E-07 9.48E-07							-4E-07 2,4E-7+									0.121	0.093
0.3018 0.088021	-0.0002 0.000132	-8E-07 9.71E-07								-3E-06 4.76E-06								0.122	0.095
0.3415 0.15321**	-0.0003 0.000285	-4E-07 0.0000015									-2E-06 6.12E-06							0.091	0.031
0.3646 0.053314***	-0.0003 7,3E-5 ***	9.8E-08 5.57E-07										-3E-05 1,3E-58**						0.175	0.166
0.1459 0.081854**	-0.0002 0.000106	-5E-08 6.76E-07											-0.738 1.196088					0.038	0.013
0.3784 0.053996***	-0.0003 7,8E-5***	-6E-07 4.99E-07												0.007 6E-3+				0.153	0.143
0.3069 0.076986***	-0.0005 0.00014***	-2E-06 6,E-73*													0.032 1,E-2**			0.199	0.182
0.394 0.052745***	-0.0003 7,7E-5***	-8E-07 4.92E-07														-0.002 7E-4**		0.172	0.163
0.393 0.053027***	-0.0003 7,7E-5***	-6E-07 4.88E-07															-0.001 7E-4+	0.164	0.155

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level, + not significant but t-statistic greater than 1

Table A2

LargeGDP

LAG	I	Cons	Infl	consgdp	chgdp	chpop	cardg	cardp	EFTPO	ATM	intern	Tel	Crime	RGDP	hnrel	5	10	R^2	adj R^2
0.0548 0.081221	-0.0004 0.000254	7.9E-08 0.00000109	1E-05 0.000326															0.017	-0
0.0654 0.080358	-0.0003 0.000227	-2E-07 0.00000108		0.0727 0.0374**														0.041	0.022
0.1252 0.134543	0.0005 0.000336	-3E-07 0.00000205			9E-04 3,3E-4***													0.194	0.139
0.0658 0.150256	0.0004 0.000377	5.3E-07 0.00000222				515.7 285.5**												0.112	0.054
0.0974 0.134957	-0.0006 0.000319*	1.3E-07 0.00000187					-0.006 0.039703											-0	-0.05
0.1094 0.143977	0.0004 0.00035	2.7E-06 0.00000247						-214.3 133.5+										0.087	0.033
0.0529 0.106892	-0.0004 0.000403	-6E-07 0.00000237							-4E-07 5.44E-07									0.018	-0.02
0.0612 0.105802	-0.0005 0.000411	-4E-07 0.00000223								-1E-05 1E-5+								0.032	-0
0.1224 0.136375	0.0004 0.000433	3.6E-06 0.00000235									-1E-05 9,6E-6+							0.079	0.012
0.0678 0.088706	-0.0001 0.000243	2.2E-07 0.00000135										-2E-05 3.06E-05						0.005	-0.02
-0.0147 0.135931	-0.0002 0.000184	9.1E-07 0.00000101											-0.768 1.83277					0.053	0
0.0702 0.059683	-0.0002 0.000163	5.2E-07 8.04E-07												0.079 7,3E-3***				0.488	0.476
0.0969 0.082155	-0.0003 0.000159**	2.4E-08 7.72E-07													0.03 0.0116**			0.067	0.048
0.0547 0.081089	-0.0003 0.000226	1E-08 0.00000109														-0.001 0.002185		0.019	-0
0.0546 0.081198	-0.0003 0.000226	7.7E-08 0.00000109															-2E-04 0.002447	0.017	-0

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level, + not significant but t-statistic greater than 1

Table A3

SmallGDP

LAG	I	Cons	Infl	consgdp	chgdp	chpop	cardg	cardp	EFTPO	ATM	intern	Tel	Crime	RGDP	hnrel	5	10	R^2	adj R^2
0.0793 0.080541	-0.0002 0.0000904**	-1E-06 3,8E-8***	2E-04 1.1E-4+															0.031	0.011
0.086 0.079467	-0.0001 0.0000832	-2E-06 3,8E-7***		0.0284 0.013**														0.043	0.024
-0.0472 0.216398	0.0002 0.000272	-2E-07 0.00000166			0.001 2,7E-4***													0.26	0.209
-0.0575 0.242628	0.0002 0.000306	-8E-08 0.0000018				327.1 231.1+												0.047	-0.01
0.0186 0.19226	-0.0001 0.000144	-1E-06 8.06E-07					-0.014 0.016921											-0.01	-0.06
-0.0886 0.221323	0.0001 0.000267	2.8E-06 0.00000188						-282.4 102.4**										0.134	0.082
-0.0416 0.117351	-0.0002 0.000135	-7E-07 7.87E-07							-4E-07 1.7E-7**									0.055	0.021
0.0404 0.109876	-0.0002 0.000145	-1E-06 7.6E-7*								-1E-06 3.77E-06								-0	-0.04
0.0696 0.239912	0.0006 0.00035*	1.3E-06 0.0000019									-6E-06 7.72E-06							0.05	-0.02
0.0587 0.118082	-2E-05 0.000123	-9E-07 6.65E-07										-2E-05 1.5E-5+						-0.02	-0.04
0.0713 0.119227	-0.0001 0.0000705**	-6E-07 4.04E-07											-0.27 0.713483					-0.03	-0.1
0.0616 0.072051	-0.0001 0.0000744	-1E-06 3.5E-7***												0.013 0.0032***				0.124	0.103
0.1154 0.079924	-0.0002 0.0000793**	-1E-06 3.7E-7***													-0.018 0.0055***			0.088	0.069
0.0986 0.080485	-0.0002 0.000083*	-1E-06 3.7E-7***														-5E-04 0.000771		0.015	-0
0.1004 0.080969	-0.0002 0.0000831*	-1E-06 3.8E-7***															-3E-04 0.000867	0.014	-0.01

Standard errors are given as small numbers. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level, + not significant but t-statistic greater than 1