Arbeidsnotat

Forecasting Cash Use in Legal and Illegal Activities

by

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Abstract

A general econometric model is developed and used to estimate the share of cash in consumer point-of-sale transactions in Norway over 1980-99. The share of cash fell from 90% during the 1980s to 50% in 1999, primarily due to debit card growth. Additional data from banks, stores, and elsewhere give an estimate of the total use of cash in legal activities. The stock of cash that is unaccounted for is an estimate of cash used in illegal activities. This totals 10% of GDP and has risen by 63% over 5 years. Projections of future cash use are also made.

Key words: Cash, Money, Tax evasion

JEL Classifications: E41, H26

Introduction

        While almost everyone uses cash, there is almost no direct information
about how much is used in various activities, particularly those beyond the law.
Yet cash is part of the money supply and inferences on its use are a factor in
monetary policy. In addition, cash provides seigniorage revenues for the
government. These revenues are substantial: it only costs about .04 Euros to
print a 100 Euro note (giving an initial benefit/cost ratio of 2,500 to 1). Finally, the
value of currency outstanding is an interest free loan from the public to the
government. For 16 countries in Europe, this "loan" (if recognized) would expand
the average current level of government debt by over 7%.
        If cash use were to fall absolutely, as could occur if it is replaced by
noncash payment methods, seigniorage revenues would be lost and part or all of
the entire interest free loan would need to be repaid. Although the real value of
this loan declines with inflation, its redemption would require significant
expenditures from current tax revenues. Our purposes are to estimate the value
of cash used in legal activities and, from this and knowledge of the stock of cash
outstanding, determine the use of cash in illegal and hoarding activities as an
unexplained residual. While we focus on cash use in Norway, the methodology
employed is general and can be usefully applied to other countries.[1]
        The current tradeoff between electronic payments and cash holdings is
shown in Figure 1 for 11 European countries plus Canada, Japan, and the U.S.
The average share of electronic payments in all noncash transactions for these
14 countries is 76%
while the average ratio of cash outstanding to GDP is 4.4%.[2] Over time, most
developed countries have been moving up and to the left in Figure 1, reflecting
the fact that electronic payments have been replacing both paper-based noncash
payments as well as cash. Retailers and personal experience tell us that debit
and credit cards have been the main payment instruments that have substituted
for cash at the point-of-sale (POS). And, according to some, use of cash at the
POS may be almost completely replaced in the future if "cash-in-a-chip" cards
become popular. Yet the value of cash outstanding in most countries continues
to rise. While many developed countries have good information on the POS use
of cards and a reasonable estimate of POS check use, there is very little direct
information on the use of cash at the POS.
        Legal cash use essentially includes cash use by consumers, stores,
banks, and public authorities. These are not independent since cash use by
consumers determines the need for stores and banks to hold cash. In recent
times cash is primarily, if not almost solely, restricted to POS transactions. The
use of cash for bill payments and disbursements, which was common 50 years

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[1] Determining and forecasting the share of cash used in legal activities has been done in
Snellman and Vesala (1999) and Snellman, Vesala, and Humphrey (2000).

[2] Figure 1 has been adjusted for the estimated 60% (35%) of cash thought to be held outside of
the U.S. (Germany).

ago, has in most developed countries typically been replaced by giro, check, or automated clearing house (ACH) payments.

Consumer cash use is not known directly but can be inferred by subtracting the value of debit and credit cards and the estimated value of checks at the POS from aggregate consumer expenditures where cash is currently used. It can also be estimated using an econometric model. Fortunately, both approaches yield very similar results. A turnover ratio transforms the estimate of legal consumer use of cash into a currency stock measure. This stock measure, augmented with other legal uses of cash, is subtracted from the value of currency outstanding and gives an estimate of the stock of currency used for illegal activities and--because we can not separate it out—some hoarding as well. Income and sales tax evasion are thought to be by far the largest component here, followed by the drug trade, prostitution, and smuggling (while hoarding is believed to be small, at least in Norway).

Forecasts of future cash use by consumers, which drives cash use by stores and banks, are obtained using Logistic and Gompertz growth or "S-curves". S-curves have been applied to forecast telephone adoption and use, the adoption of robots in automobile manufacturing, the spread of ATMs in banking markets, and are an accepted method to gauge the spread and adoption of innovations in industry. They are used here to gauge the adoption of card technology and spread of terminal availability that are among the primary determinants of the growth of payment methods that substitute for cash in legal activities.

As will be seen, the use of cash in legal activities is surprisingly small. So small that significant change in our methodology would have little effect on our estimate of the stock of cash used in illegal activities. In the future, as the share of cash used in illegal activities continues to rise, it will become more obvious that governments face the unpleasant notion that seigniorage revenues and the benefit of having an interest free loan from the public is brought about almost entirely by providing cash for illegal activities. In one sense, this may be viewed as an indirect "tax" on illegal activities. In another, it will mean that policies which raise revenues by reducing tax evasion will also reduce them to a different branch of government (but likely with a net gain: Rogoff, 1998).

In what follows, Section 1 contains our estimate of cash use in legal activities in Norway over 1980-1999. Consumer use of cash, which is the main component, is determined two ways: from an economic model and by direct calculation. In Section 2, this information is used to estimate cash use in illegal activities over the same period and as a percent of GDP. Section 3 presents forecasts of cash use in legal and illegal activities using S-curves and other procedures. Our results are summarized in Section 4 and some implications for future government policy are noted.

1. Estimating Cash Use In Legal Activities.

An Econometric Model Of Consumer Use Of Cash. Our analysis covers 1980-1999 and our focus is on cash use at the POS. While in the past it was not uncommon to use cash for bill payments, wage disbursements, and some large

value financial transactions, this practice has since the 1950s been largely replaced in most developed countries by safer and more convenient giro, check, or ACH payments. As a result, the use of cash since 1980 has been primarily restricted to consumer POS transactions (POSsales) where cash, debit and credit cards, and checks are the typical payment method. For our purposes, POSsales include purchases at retail stores, hotels, restaurants, and for transportation (gasoline, car rental, train, bus, subway, and taxis).[3]

Traditional money demand analysis has been concerned with how the stock of currency outstanding (as part of the money supply) is affected by the level of economic activity and the interest rate. Our analysis, based on Snellman, Vesala, and Humphrey (2000), extends the money demand literature in two directions. First, we estimate the flow of cash being used by consumers using changes in the stock of currency outstanding along with traditional determinants of changes in this stock (economic activity and the interest rate). Second, as cards and (to a lessor degree) checks can substitute for cash at the POS, the value of these payments and the diffusion of the technology that influences this substitution are incorporated directly into the analysis. Specifically, growth in the availability of EFTPOS terminals allows card payments to replace both cash and checks at the POS while the concurrent expansion of ATM terminals and the possibility of receiving "cash back" from a POS transaction without incurring an ATM fee have made it easier to use cash. A force in the background has been the pricing of many payment transactions and the assessment of ATM fees.

Our basic model is expressed in three equations. The first is almost an identity and states that changes in the value of all consumer payments where cash, cards, and checks typically occur (ΔPOSsales) equals the sum of changes in the value of cash, card, and check payments:

(1) ΔCASH + ΔCARD + ΔCHECK = φ ΔPOSsales   flow to flow

If we have correctly collected our data, the parameter ϕ should be close to 1.0. The value of consumer use of cash (ΔCASH) is unknown while good information exists for the value of card payments (ΔCARD). The value of checks used at the POS (ΔCHECK) is not known but is approximated by multiplying the average value of a card payment (around 60 Euros) by the volume of all checks written (which is typically small and falling in Europe).[4]

The second equation states that changes in the stock of coin and currency (ΔCURR) are due to changes in cash use at the POS and the interest rate (Δr):

(2) ΔCURR = α_1 ΔCASH + α_2 Δr   stock to flow

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[3] In Norway, automobile purchases, housing expenses, insurance, and most air transportation costs are typically paid by giro--not by cash, card, or check--and so are excluded from this total.
[4] The actual value of all checks written can not be used as it is strongly dominated by a relatively small number of large value business checks.

Of course, not all changes in currency stock are associated with legal activities and we try to ensure that the parameter α_1 relating to consumer cash use for legal activities is locally well identified. This brings us to the third equation and the final specification of the model.

Solving (1) and (2) for $\Delta CASH$, setting them equal to one another, expressing the result in terms of the use of cards (since cards substitute for both cash and checks), and adding a variable reflecting the availability of ATMs, the final equation estimated is:

(3) $\Delta CARD = \alpha_0 + \beta \Delta CURR + \beta \Delta CHECK + \phi \Delta POSsales - \alpha_2 \beta \Delta r + \alpha_3 ATMPOP + \varepsilon$

To help identify that portion of the change in currency outstanding which is associated with legal activities, α_1 in (2) is specified as a function of year-to-year changes in the number of EFTPOS terminals per person since $\beta = (\beta_0 + \beta_1 EFTPOP) = -1/\alpha_1$ in (3). This shift in EFTPOS terminal availability (through β) also affects the substitution of cards for checks. The number of ATM terminals per unit of population (ATMPOP) is added to (3) to allow for a similar terminal availability influence favoring cash use. Once (3) is estimated, the change in consumer use of cash for legal activities can be determined from $\Delta CASH = - \Delta CARD - \Delta CHECK + \phi \Delta POSsales$.

The parameter estimates are shown in Table 1. The fact that $\phi = .996$ suggests that the computed value of POSsales does indeed cover those activities where cash payments compete with cards and checks.[5] The value of β reflects the substitution of cards for currency (and, indirectly, cash) and checks at the POS. As seen in Table 1, β falls over 1981-99 and is negative over 1988-99, which is when EFTPOS terminals started to expand rapidly and the growth in ATM terminals had flattened out. This is also the time period when the share of cash in POS payments from the econometric model, shown in Column 1 of Table 2, starts to fall from around .92 in 1988 down to .50 in 1999.

However, the terms that determine $\beta = (\beta_0 + \beta_1 EFTPOP)$ are not significantly different from zero. Nor is the interest rate term (α_2). This result is due to the fact that POSsales very accurately represent actual expenditures made with cash, cards, and checks. If we had poor information on this variable and used the value of GDP instead (as was done in Snellman, Vesala, and Humphrey, 2000), then β would be significant, α_2 would be negative and significant, and ϕ would fall to .337. Even so, the resulting cash shares would be relatively unaffected (yielding a cash share of .53 in 1999). The cash share results are also robust to possible simultaneous equation bias since lagging $\Delta CURR$ in (3) by one period gives .50 as the cash share for 1999.[6]

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[5] In initial work, we had not included a number of activities that are now covered in POSsales. The value of N estimated then was 1.10, suggesting that we had understated POSsales (because the model assigned a more than proportional effect associated with the then lower POSsales value).

[6] As an additional check, we recomputed the value of consumer POS sales using household consumption data from the national accounts (POScons). These data were very similar to the POSsales data used above derived from business sales statistics. The national account data

The cash share values shown in Table 2 are obtained from cumulating the estimated ΔCASH values from the model over time, starting with an estimate of the level of cash use in 1981. If this level estimate is under- or overstated, then the cash shares themselves--but not their falling pattern--will be under- or overstated as well. As shown next, our estimate of the initial (1981) level of cash use is derived by direct calculation.

Direct Calculation Of Consumer Cash Use Consumer use of cash for POSsales (CASH) can be inferred directly by subtracting the value of debit and credit card purchases and the estimated value of checks at the POS from the value of POSsales: CASH = POSsales - CARD - CHECK. This is just equation (1) in levels form with $\phi = 1.0$. It gives us both our initial estimate of the level of cash use in 1981 (used to derive cash shares from the econometric model) and provides an alternative estimate of the evolution of the share of cash in total POS payments (i.e., CASH/POSsales).

Direct calculation of the cash share is shown in Column 2 in Table 2 and closely follows the level and pattern derived from the econometric model. This is not surprising since the estimate of φ was so close to 1.0 (Table 1). In sum, it is seen that the econometric model and the alternative of direct calculation give very similar results for the time pattern of consumer use of cash in legal activities.

Data Stationarity. Estimation of equation (3) with first differenced data from either business sales statistics (POSsales) or household consumption from the national accounts (POScons—not shown) yielded Durbin-Watson statistics that indicated a degree of positive autocorrelation, although it was marginal for POSsales. As well, unit root tests (Weighted Symmetric and Dickey-Fuller) suggested that some first-differenced variables were not stationary. Second differencing of the data yielded stationarity with a single lag but re-estimating (3) generated a cash share of .29 for 1999. As our first differenced results are supported by the directly calculated cash shares, these are the results we report and rely upon.[7] With this basis, we now estimate the total use of cash in legal activities. To do this, additional sources of cash use have to be accounted for.[8]

Total Legal Use of Cash. The value of consumer cash use and the cash shares reported in Table 2 are flows, not stocks. To be comparable to the stock data on other uses of cash in legal activities, the consumer cash use estimate (CASH) needs to be divided by a turnover ratio. As explained in our Appendix, consumers on average replenished their stock of cash holdings around every 12 days prior to 1992, giving a turnover ratio of 30 (= 365/12).

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yielded an estimated cash share of .59 for 1999 while the corresponding directly calculated value was .53.

[7] Taking first differences of logged variables yielded even less stationarity while re-estimation of (3) gave a cash share of .35 for 1999. This, too, differs significantly from the directly calculated share of .50.

[8] These values and a deeper discussion of the methodology used here and elsewhere in the paper are contained in our Appendix.

After 1992, it was possible to receive "cash back" from a transaction at a retail store and not incur an ATM cash withdrawal fee. This increased convenience, greater availability, and lower cost of obtaining cash meant that consumers could make more withdrawals for smaller amounts and decrease their average cash balances. After cash-back, we estimate that consumers on average replenished their stock of cash around every 5 days, giving a turnover ratio of 73. These two time-dependent turnover ratios are used to deflate CASH, giving a time-series estimate of the stock of cash held by consumers.

Other holdings of cash are by stores, banks, public authorities, private firms, foreign visitors who have returned home, consumer hoarding reported on tax returns (and subject to a tax), and a small precautionary value assumed to be held by consumers at the time they replenish their stock of cash.[9] Figure 2 shows each of these cash stock estimates over 1980-1999. The results suggest that the total stock of cash used for legal activities (LCURR) reached its highest level around 1987 as the number of ATMs approached market saturation. From there, LCURR remained relatively flat until 1992 when it started to fall as EFTPOS terminals expanded beyond 25% of their current level and cash-back was implemented at retail stores.

Limited information also exists for cash bill payments through the giro system (e.g., for rent, utilities, etc.). Although these cash payments have fallen by 46% over the 1994-1999 period for which they are observed, they are still sizeable. After being deflated by the same turnover ratio used above for consumer POS cash flows, the resulting stock of cash associated with giro cash payments was added to LCURR, giving LCURR*. The dashed line in Figure 2 shows the effect of this increase in cash stock used for legal activities.

2. The Unexplained Residual: Cash Use In Illegal Activities.

Subtracting our estimate of the value of the stock of cash used in legal activities (LCURR or LCURR*) from the total value of cash outstanding (CURR) gives an estimate of the stock of cash used in illegal and hoarding activities (ILCURR).[10] As seen in Figure 2, cash used in illegal activities--income and sales tax evasion, smuggling, the drug trade, etc.--has far exceeded legal uses of cash over either 1980-1999 or, when giro cash payments are included, over 1994-1999. It has also expanded considerably during the 1990s. The stock of cash associated with illegal and hoarding activities was 54% of the total outstanding in 1980, fell to a low of 44% in 1987, and then rose to 71% by 1999.

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[9] For example, after 1992 consumers are assumed to run down their stock of cash to only NOK 100 (about 12 Euros), rather than zero, before they replenish their stock of cash.

[10] If an individual holds—hoards—more than NOK 3,000 (around 300 Euros), it has to be reported on their tax form and is taxed. The total amount reported to tax authorities (60-80 million Euros) is included in our estimate of cash held for legal activities. However, the value of the residual stock of cash will include non-reported cash holdings above and below the NOK 3,000 cutoff. Non-reported cash hoarding above this limit is tax evasion (and is appropriately included in the residual) while values below this limit represent legal hoarding. Although we do not know the actual figure, if each adult held around half the cutoff value (which would be legal), it would comprise about 7% of the stock of cash.

Including giro cash payments reduces this share to 67% in 1999.[11] These values are so large that significant changes in our methodology in estimating the value of legal cash use would not have much effect on the results.

As noted in the literature, cash used in illegal activities relies heavily on large denomination currency (e.g., Boeschoten and Fase, 1992; Rogoff, 1998). In Norway, the largest denomination note is NOK 1,000 (about 115 Euros). This denomination is essentially only available by direct withdrawal from banks. It is not available from ATMs, it is very infrequently used in POS transactions and, since most stores do not stock them to make change, it is rarely available from cash-back at the POS. The value of these notes in the total value of currency outstanding has been rising steadily from 44% in 1980 to 62% in 1999. This gives a reasonable approximation to the possible size of the stock of cash used in illegal activities. In addition, there apparently is a good correspondence between changes in the estimated share of cash used for illegal and hoarding activities (ILCURR) and changes in the share of large value notes in total cash outstanding[12]. Over 1980-1999, the share of ILCURR in total cash rose by 17 percentage points while the share of NOK 1000 notes rose by 18 percentage points. Thus changes in the value of the very largest currency denomination(s) outstanding seem to be a reasonable indicator of changes in the value of illegal activity in a country, especially if they are infrequently seen in day-to-day transactions.

The Value Of Illegal Activities As A Percent Of GDP. Determining the value of illegal activities as a percent of GDP is difficult. It requires that the stock of cash associated with illegal activities (ILCURR) be multiplied by a turnover ratio for illegal activities before it is expressed relative to GDP (which is a flow). The size of this turnover ratio in previous work has been taken to be the ratio of GDP to M1 (Schneider and Enste, 2000).

The stock of cash associated with illegal and hoarding activities[13] *is* multiplied by an average GDP/M1 turnover ratio (4.26 over 1994-99) using recently revised M1 data. The value of illegal activities was 8.8% of GDP in 1994 and 10.4% in 1999. While this 1.6 percentage point rise seems small, it is a 63% increase in the value of illegal and hoarding activities over a 5-year period.

Comparison With Other Estimates. Using survey information for 1980 and 1983, Isachsen and Strøm (1985) estimated that tax evasion activities in Norway accounted for 4% to 6% of GDP.[14] The Norwegian tax authorities came to a similar conclusion as tax evasion was estimated to amount to 5% to 6% of GDP in the 1980s while other illegal activities (drugs, smuggling, prostitution, gambling) were thought to raise this value by around one-fourth. More recently,

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[11] As noted in the previous footnote, if the value of legal cash hoarding was 7%, then 60% of the stock of cash would be associated with purely illegal activities in 1999.

[12] See also Appendix 2.

[13] From CURR – LCURR*, which includes giro cash payments.

[14] The surveys also suggested that during a one year period around 35% of the adult population participated in a transaction whose purpose was to hide income or escape sales taxes.

the Tax Directorate has suggested that the current value of illegal activities may be twice as large as the earlier estimate (Skattedirektoratet, 1999). However, no new survey was undertaken and the suggestion remains a conjecture.

A recent survey of estimates of the size of shadow, gray, or underground activities across countries suggests that in 1996-97 these activities amounted to 19% of GDP for Norway, 19% for Sweden, 15% for Germany, 15% for Canada, 27% for Italy, and 9% for the U.S. (Schneider and Enste, 2000, Table 7). These estimates use a currency demand approach in which the ratio (value of cash holdings)/(bank deposits or M2) is related to a weighted average tax rate, an interest rate, per capita income, and the share of wages and salaries in national income during a period in the past (say 1960) when the value of illegal activity was thought to be small (at 1.5% of GDP).[15] Explanatory variables for the current period are used to evaluate this estimated relationship and yield a predicted ratio of cash to deposits which is presumed to also reflect a similarly low level of illegal activity. Comparing the predicted ratio with the ratio observed in the current period provides an estimate of the size of (or more precisely the change in) the stock of cash associated with illegal activities. Multiplying this stock figure by an assumed turnover rate for illegal activities (taken to be the ratio of GDP to M1) gives a value flow, which is then expressed as a percent of GDP.[16]

The Schneider and Enste (2000) 19% estimate for Norway was multiplied by average GDP in 1996-97and divided by the average GDP/M1 ratio (2.42) available at that time (which was before the current revision). The resulting implied stock of cash used for illegal activities is 2.1 times the size of the actual total stock of cash outstanding. If the entire stock of cash were used in illegal activities (we estimate "only" 67% to 71% are) the maximum value of illegal activities in GDP would be 14% in 1999 (using the revised turnover ratio of 4.26). Thus it appears that the currency demand model used by Schneider and Enste (2000) and others before them may overestimate the value of illegal activities.[17] Our approach does require more detailed data to be estimated but, fortunately, such data are often available for developed countries (although not for others).

3. Forecasting Cash Use.

Logistic And Gompertz Forecasts Of Consumer Use Of Cash. Logistic and Gompertz growth or S-curves have been used in a variety of situations to forecast the adoption and dispersion of technologies in industry. They are used here to forecast changes in the share of consumer use of cash at the POS over 2000-2015 resulting from the dispersion of card payment technologies. In a

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[15] Schneider and Enste, 2000, Table 3.

[16] Other estimation methods exist and are covered in Schneider and Enste (2000) as well as Giles (1999) and other papers in the June, 1999, issue of the Economic Journal.

[17] Their 19% estimate for the ratio of the value of illegal activities to GDP in Sweden appears to be overstated by some 70%, since the implied value of the stock of cash used for illegal activities is 1.7 times the value of total cash outstanding in Sweden.

detailed empirical comparison, Meade and Islam (1995) have shown that the standard logistic and Gompertz S-curves outperform more complicated models.[18] The logistic and Gompertz models used to forecast consumer cash shares (S_t) as a function of time (t) are:

(4)   Logistic (linear, symmetric) $\ln(S_t/(1 - S_t)) = a + b\,t + \varepsilon_t$

(5)   Logistic (non-linear, symmetric): $S_t = S_t^*/(1 + c\,\exp(-b\,t)) + \varepsilon_t$

(6)   Gompertz (non-linear, asymmetric): $S_t = S_t^*(\exp(-c\,\exp(-b\,t))) + \varepsilon_t$

where S_t^* is the estimated saturation (or end) share value at time t, b is the coefficient of diffusion or the slope of the S-curve, and c is a scaling coefficient which determines the vertical position of the curve.[19]

In the linear logistic model (4), the pattern of initial cash replacement is used (via symmetry around its inflection point) to predict the remaining pattern of replacement. As well, the predicted end share should approach one (or, in our case, zero). The non-linear logistic model (5) is more general since it permits the data to determine the end share (S_t^*) but still uses symmetry around an inflection point to predict the remaining pattern of cash replacement. The non-linear Gompertz model (6) is the most general of the three as it can be asymmetric about its inflection point.

The predicted consumer cash shares from the non-linear logistic and Gompertz S-curve estimations are shown in Table 2, along with their adjusted R^2. The linear logistic model (not shown) had an R^2 of .75 and a predicted cash share of .166 in 2015 and so is closest to the Gompertz result with an end period share of .154. The linear logistic model, which imposes the most "structure" on the data (i.e.,symmetry and an end cash share that should approach zero) could be directly estimated. Estimation of the non-linear logistic and Gompertz models, with less imposed "structure", required a grid search.[20] While cash shares associated with search results with the highest adjusted R^2 are presented in Table 2, the R^2 values changed only slightly as the end cash shares were varied between .10 and .01. Figure 3 illustrates the pattern of actual (1980-99) and forecasted (2000-15) consumer cash shares from the symmetric, non-linear, logistic model. Parameters for all three models are in Table 3.

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[18] This is largely because more complicated models have more parameters to estimate and the data available typically can not support the increased complexity.

[19] In implementation, since the end cash share is expected to fall while (4)-(6) estimate a relationship which can approach 1.0, S_t is actually measured as (1 - cash share). After estimation, $1 - S_t^*$ gives the predicted ending cash share which may be a small percentage amount.

[20] The search process stipulated values for S_t^* between .01 and .99 in (5) and (6), permitted the free estimation of parameters b and c, and the result with the highest R^2 was selected.

New data on cash shares over the next few years can improve the accuracy of these forecasts since the inflection point should become better defined. At this point in time, however, consumer use of cash in legal activities is projected to keep falling from its current level of 48% to 50% in 1999-2000 and may reach very low levels--from 5% to 15%--in 15 years. These results suggest that cash used in legal activities may become so small in Norway that government seigniorage revenues may be due almost solely to providing the means of payment for illegal activities. In contrast, the cash share projection for Finland appears to be leveling off at close to 60% (Snellman and Vesala, 1999). The likely reason for this difference is that the value of card use in Norway is one-third larger than that in Finland (even though Finland's population is 17% larger).[21]

Simple Forecast Of Cash Use In Illegal Activities. The S-curve forecasts for cash use at the POS were possible because a relatively long (20 year) time-series was available. When giro cash transactions (for bill payments) are combined with POS cash transactions, the time-series covers only 6 years (1994-1999) so S-curves can not be employed. Over this shorter period the overall rise in the value of cash outstanding was 19%. The stock of cash associated with legal activities fell by 23% while the (residual) stock of cash associated with illegal and hoarding activities rose by 63%.

Taking the absolute changes experienced over these 6 years and projecting them forward for a similar period suggests that the total value of cash outstanding could rise by 16% (0.8 billion Euros). The share of the stock of cash used in legal activities would then fall from 33% in 1999 to 20% in 2005. Correspondingly, the share attributed to illegal and hoarding activities could rise from its current level of 67% to fully 80% of cash outstanding.

4. Summary, Conclusions, And Policy Implications.

Using an econometric model of consumer cash use at the point-of-sale (POS), we have estimated how the use of cash has fallen as a share of POS cash, card, and check payments for Norway over 1980-1999. The results are robust to alternative specifications and are very similar to cash shares derived by direct calculation with available data.[22] The share of cash in consumer POS payments for legal activities has fallen from .91 in 1980 to .50 by 1999. All of the decline has taken place during the 1990s as card payments expanded rapidly in response to the increased availability of EFTPOS terminals and (as shown in Humphrey, Kim, and Vale, 2001) from direct and differential pricing of different payment instruments and ATM use.

Cash share estimates over 1980-1999 are used in three logistic and Gompertz growth or S-curve models to forecast future cash shares over 2000-

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[21] Another consideration is that the last observed cash share for Finland was for 1996. In that year, Norway's cash share was 69%, which fell to 50% three years later. More recent data for Finland would indicate whether their cash share remains in the 60s (as projected) or if it starts to fall again.

[22] The model and procedures are general and can be applied to determine cash use in other countries.

2015. All three models give broadly similar results. As averages of the two models with the highest R^2s, cash shares at the POS will continue to fall, although at a slower rate, and may be .30 in 2005, .18 in 2010, and .10 in 2015. These are tentative projections that can be improved in a few years when the inflection point in the cash share time-series data becomes more prominent.

We estimated the value of cash used by consumers, banks, stores, and public authorities in legal activities at the POS as well as that for bill payments through giros. Subtracting this value from the value of total cash outstanding provides an estimate of cash use in illegal and hoarding activities. Most of these activities are believed to be associated with sales and income tax evasion, especially after 1992 when sales and income tax rates were raised substantially in an effort to reduce taxes on capital. Other activities concern the drug trade, smuggling, and prostitution while legal hoarding is believed to be small. As a total, these activities accounted for 49% of the value of cash outstanding in 1994, rising to 67% in 1999. The value of illegal and hoarding activities ranged from 8.8% to 10.4% of GDP over 1994-1999 and are somewhat above the percentages estimated using survey procedures during the 1980s. While the 1.6 percentage point rise here seems small, it is associated with a 63% increase in nominal value over the period.

Other researchers, using a different modeling framework, have suggested that the value of illegal activities to GDP is 19% (Schneider and Enste, 2000). Unfortunately, this estimate also implies that the stock of cash used in illegal activities exceeds the total value of cash outstanding by 105%. Although only 67% of all cash is used in illegal activities, if all cash were so used the ratio to GDP would be 14%. Fortunately, if no other information is available the value of the largest denomination notes in circulation may be used as a reasonable approximation to the level and (better yet) the rate of change in illegal activities in a country (if this note is infrequently or rarely seen in legal transactions).

Looking ahead, the projected share of the stock of currency used in illegal activities may rise from its current value of 67% to 80% by 2005. If the government continues to passively issue currency, new seigniorage revenues over this period may total around 0.8 billion Euros. From a currency printing perspective, this forecast suggests that some portion of low denomination currency may have to be retired from circulation while new issue of large denomination notes can continue to expand. Facilities used to inventory, examine fitness, and distribute currency can be reduced and consolidated since cash in general circulation--that is, the smaller denomination notes used in legal activities--should continue to fall. In terms of monetary policy, while the overall stock of cash should continue to increase its usefulness as an indicator of transactions captured in the national accounts will be reduced as the transactions being financed will increasingly be illegal and unreported.

Overall, our results suggest that cash used in legal activities may become so small in Norway that government seigniorage revenues are likely to be due almost solely to providing the means of payment for illegal activities. This is a dubious position for a government to be in. In the future, should all but the smallest denomination currency be withdrawn from circulation as legal use of

cash continues to contract? Should all currency be withdrawn and coins (a cost-effective substitute for notes due to their long lifetimes) be substituted for the smallest denomination currency? Would these actions be effective in curbing somewhat illegal activities when large denomination currencies of other countries still circulate? Could the redemption of all or just large denomination currency stock over a short period of time be implemented without raising taxes?

These questions will likely frame the debate in the future. In particular, governments may find it feasible to withdraw over time all but coins from circulation in order to reduce the incidence of underreported sales tax and business cash income as consumers continue to shift to card and electronic purse payment methods. While large value substitute currencies from other countries would then be employed in international-based criminal activity (e.g., smuggling), these currencies would not be legal tender where the domestic currency was retired and so would be difficult to easily obtain and use by (mostly) law-abiding citizens. Paired with enhanced sales and income tax enforcement, such a policy would likely raise tax revenues by more than the decrease in seigniorage.

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Table 1

Determinants of Consumer Use of Cash: Norway, 1980-1999

_____

$$\Delta CARD = \alpha_0 + \beta\Delta CURR + \beta\Delta CHECK + \phi\Delta POSsales - \alpha_2\beta\Delta r + \alpha_3 ATMPOP + \varepsilon$$
_____

		Value of $\beta = \beta_0 + \beta_1 EFTPOP = -1/\alpha_1$	
α_0	= -19273*		
β_0	= .22409	1981	.224
		1983	.206
β_1	= -.00019	1985	.183
		1987	.099
ϕ	= .99580*	1989	- .075
		1991	- .336
α_2	= 2070.7	1993	- .591
		1995	-1.291
α_3	= 47.255*	1997	-1.790
		1999	-2.285

$R^2 = .62$ (R^2 adjusted = .47)
Number of observations = 19

_____

* Significantly different from zero at the 99% level of confidence.

Table 2

Estimated Share Of Cash In POS Payments: Norway, 1980-2015

<u>Observed Period:</u>

<u>Projection Period:</u>

Year	Econometric Model	Direct Calculation	Year	Symmetric Non-Linear Logistic	Asymmetric Non-Linear Gompertz
1980	---	.909	2000	.483	.531
1981	.909	.909	2001	.432	.495
1982	.904	.904	2002	.382	.460
1983	.898	.898	2003	.334	.427
1984	.890	.890	2004	.290	.395
1985	.911	.911	2005	.250	.365
1986	.928	.928	2006	.214	.336
1987	.921	.921	2007	.182	.310
1988	.917	.918	2008	.154	.285
1989	.914	.914	2009	.130	.261
1990	.909	.909	2010	.109	.240
1991	.880	.880	2011	.092	.220
1992	.868	.868	2012	.077	.201
1993	.847	.847	2013	.065	.184
1994	.792	.793	2014	.055	.168
1995	.736	.736	2015	.047	.154
1996	.685	.686			
1997	.626	.627	R^2 adjusted	.93	.87
1998	.567	.568			
1999	.502	.503			

Table 3

Results of Forecasting Consumer Cash Use: Norway, 2000-2015

_____

S-Curve Model:	Equation Estimated:	R^2 adjusted
Logistic (linear, symmetric)	$\ln(S_t/(1 - S_t)) = -3.245 + (.1349)\ t$	.75
Logistic (non-linear, symmetric):	$S_t = .99/(1 + 76.43\ \exp(-.2107\ t))$	.93
Gompertz (non-linear, asymmetric):	$S_t = .99\ \exp(-6.615\ (\exp(-.1039\ t)))$	.87

_____

All estimated parameters are significantly different from zero at the 99% level of confidence. The end cash share value in the non-linear logistic and Gompertz models is .01 (= $1 - S_t^* = 1 - .99$) and was pre-specified in a grid search and thus not freely estimated.

The results reported above rely on the directly calculated cash shares from Table 2. Almost identical results were obtained using cash shares from the econometric model.

Figure 1: **Electronic Payments and Cash Holdnings by Country, 1990-1998**
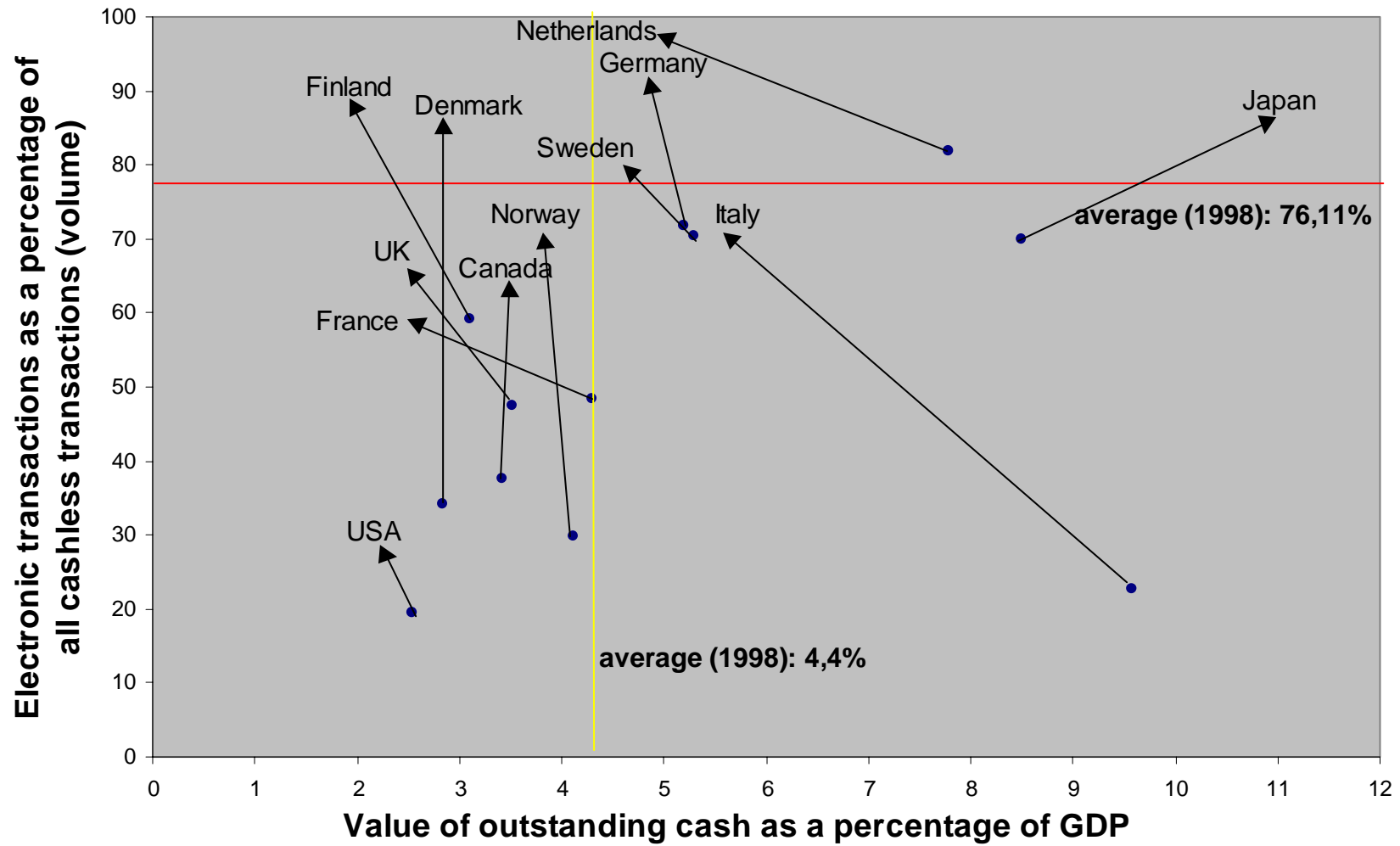
Figure 2: **Estimates of Stocks of Cash Held by Various Groups**

1. Cash stock held by the public for POS transactions
2. Cash stock held by banks and other credit institutions
3. Cash stock held by public authorities, public and private firms, declared and idle cash, and cash held overseas
4. Cash stock used for illegal activities and hoarding (determined as a residual)

Cash stock held for giro payments
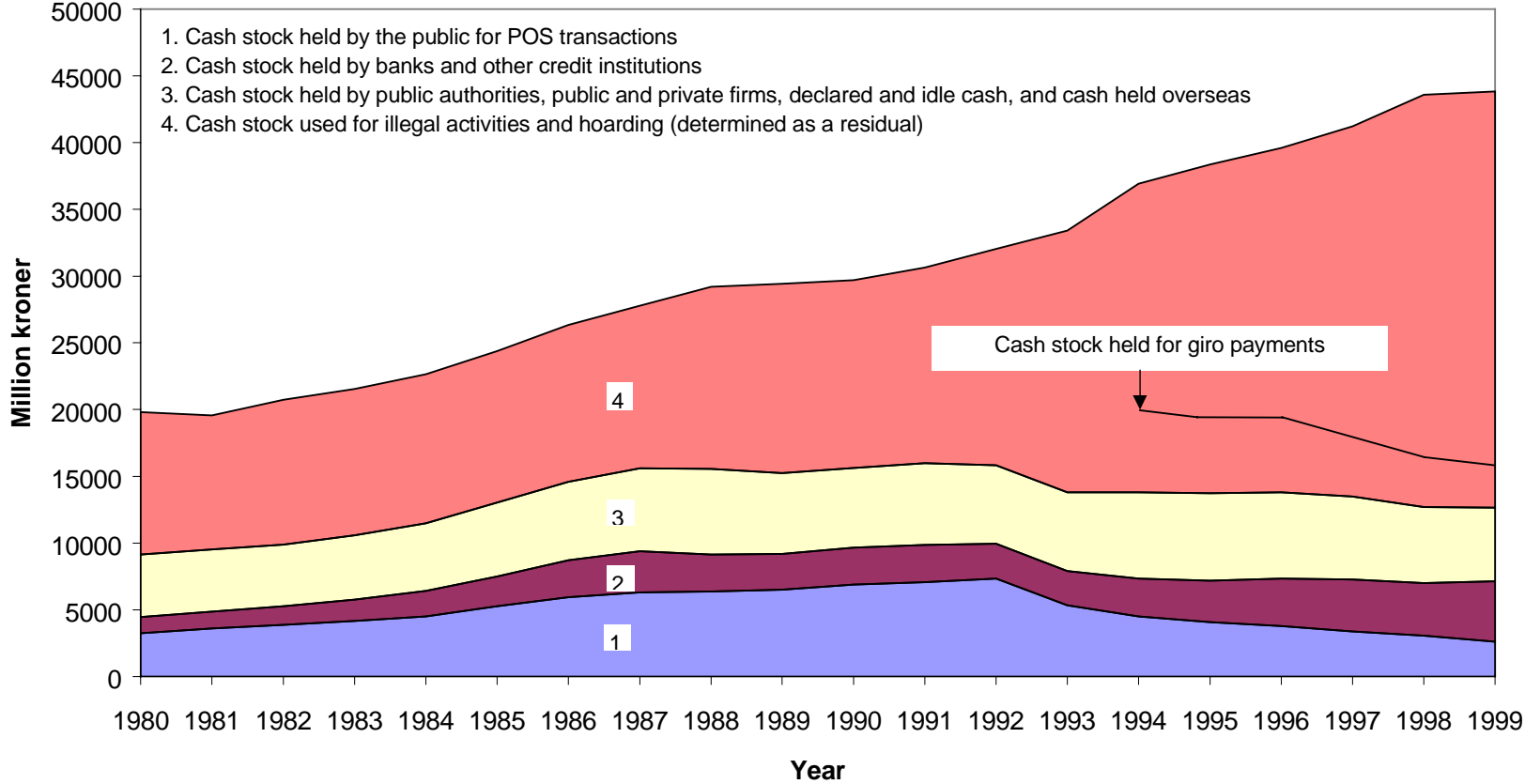
Figure 3

Actual and Forecasted Shares of Consumer Use of Cash in POS Payments

Norway: Estimated Share of Cash in POS Payments

Actual (1980-1999)

Forecasted (2000-2015)

Non-Linear, Symmetric
Logistic S-Curve (by grid search)
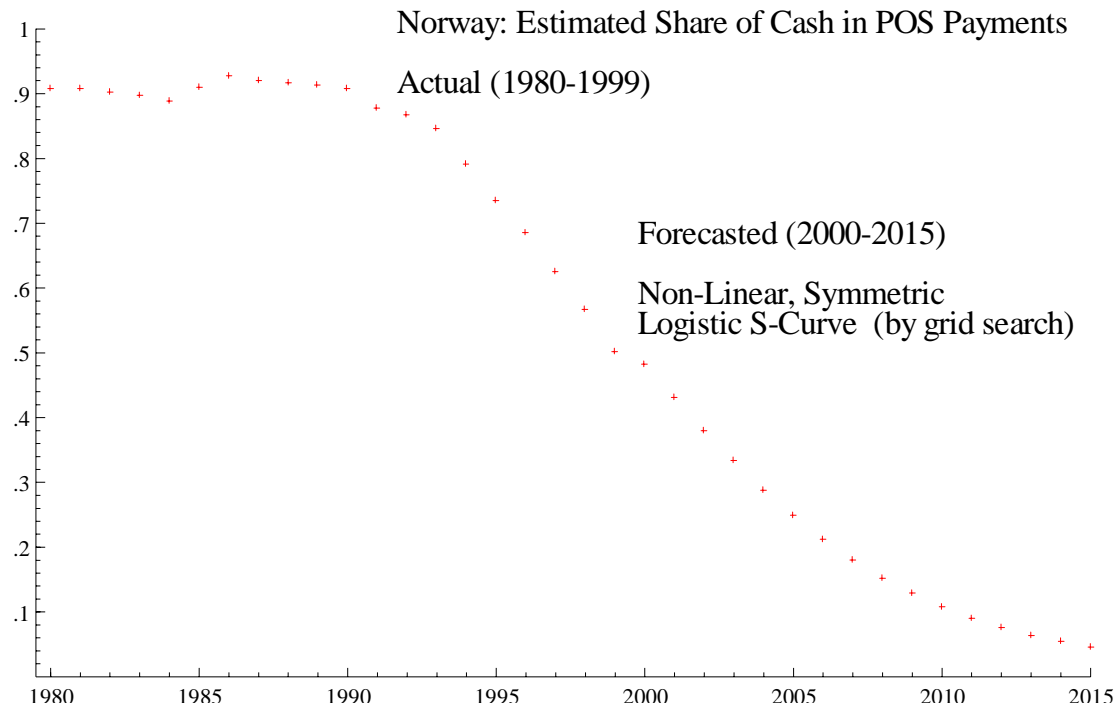
Appendix 1

In this appendix we present a detailed account of the data and methods used to develop estimates of cash use in Norway. Table 1 displays two alternative methods to approximate consumption at the point of sale (POS) in Columns 1 and 2 and contrasts these values with total household consumption in Column 3.

Table 1: Calculation of the value of the consumer POS sales (million krones)

Year	Consumer POS sales (business statistics of Norway - retail sales, hotel and restaurants, transport) (1)	POS household consumption (National accounts) (2)	Total household consumption (National accounts) (3)
1980	103 070	99 883	138 913
1981	115 057	113 049	157 007
1982	124 370	123 614	176 154
1983	134 629	135 441	194 651
1984	146 933	148 217	213 751
1985	168 028	170 558	248 471
1986	187 652	192 375	278 346
1987	202 665	209 846	297 092
1988	207 869	220 412	308 211
1989	213 292	227 273	320 913
1990	226 611	239 765	338 236
1991	240 255	257 031	356 054
1992	253 078	271 666	373 649
1993	274 943	283 664	389 987
1994	293 327	299 996	410 536
1995	308 032	315 307	435 247
1996	323 806	332 352	465 695
1997	346 251	354 316	495 077
1998	365 473	380 636	525 488
1999	378 701	399 962	550 315

Source: Statistics of Norway

Consumer POS sales (Column 1) are derived from statistics on retail sales (varehandel), hotels and restaurants, and transport provided by Statistics of Norway.   This data series is calculated as:
- Retail trade excluding motor vehicles (code 52 in NACE classification)
- Retail sales of gasoline and lubricating oils (code 50.05), maintenance and repair of motor vehicles (code 50.2), sales of parts and accessories of motor vehicles (code 50.302), and maintenance and repair of motorcycles (code 50.403)

- Sales in hotels and restaurants
- Sales in forwarded goods, car rentals, parking, etc.
- Sales of consumer railway services (passenger transport total), regular coastal trade (ruteinntekter), tramways and suburban railways (trafikkinntekter), scheduled road transport (trafikkinntekter), and taxis.

We included VAT for those sales and services subject to VAT regulation. Sales of consumer airline services (passenger receipts) has not been included since the vast majority of airline tickets in Norway are believed to be paid by giro, not cash.[23]

POS household consumption (Column 2) shows an alternative way to calculate Norwegian consumption at POS based on the data on private consumption in the national accounts. This data series is calculated as the value of household consumption including foreigners' consumption in Norway. However, it excludes the value of consumption typically paid for by giro, such as:

- House rent
- Purchase of motor vehicles for private use and car insurance
- Consumption of electricity and heating
- Purchase of postal and telecommunication services and
- Education expenses.

Figure 1: Comparison of the three data series on Norwegian consumption at POS

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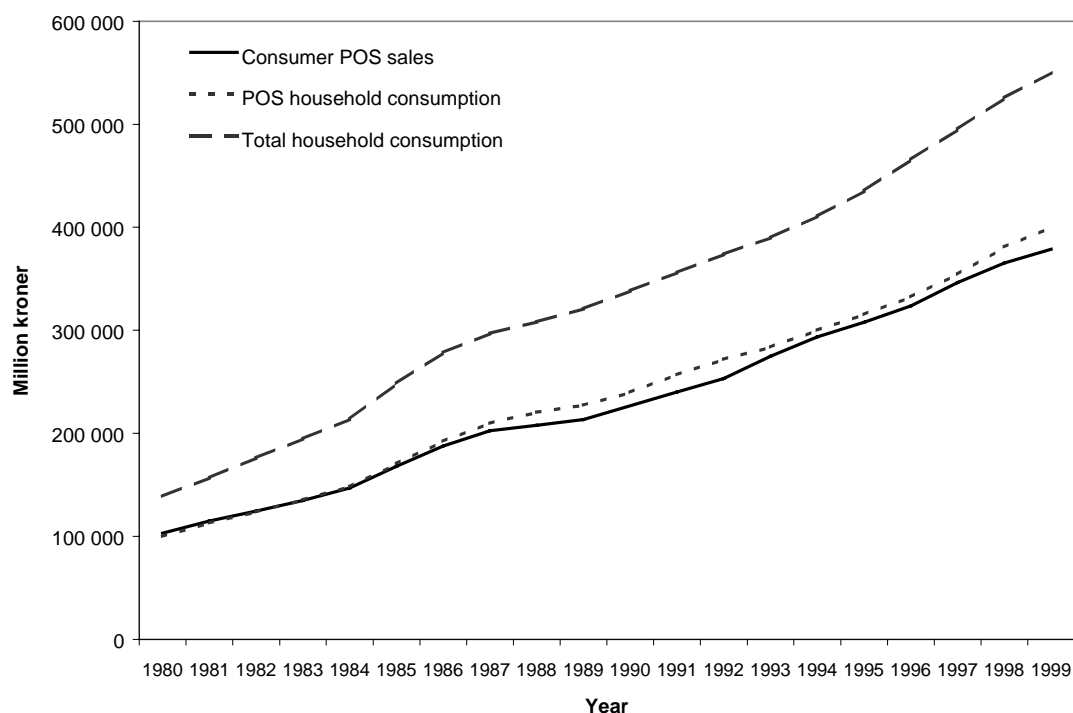
[23] According to a telephone interview with Luftsfartsverket and SAS on 4th August 2000.

21

Total household consumption (Column 3) is based on quarterly data on private consumption in the national accounts and is calculated as the sum of all household consumption including foreigners' consumption in Norway. This data series would overstate Norwegian consumption at the POS using only cash, cards, or checks since giro payments (typically not made at the POS) would be included.

Figure 1 above shows the relation between the three series presented in Table 1. It is clear that the difference between Consumer POS sales (solid line) and POS household consumption (dotted line) is very small. We conclude that these two data series are effectively equivalent for purposes of our analysis.

The data on 'Consumer POS sales' (Column 1, Table 1) has been chosen for estimating consumer use of cash at POS (called POSsales in the text) over 1980-1999. Consumer use of cash at POS is calculated as the value of Consumer POS sales (Column 1 in Table 2) minus the value of debit and credit card transactions (Column 2) and minus the estimated value of checks used at POS (Column 3). The resulting value of consumer cash use at POS is shown in Column 4 of Table 2.

Table 2: Calculation of consumer use of cash at POS (Million kroner)

Year	Consumer POS sales (1)	Card value at POS (2)	Check value at POS (3)	Consumer cash use at POS (4) = (1) - (2) - (3)	Cash replenishment frequency (days) (5)
1980	103 070	203	9 191	93 676	12,6
1981	115 057	282	10 208	104 567	12,6
1982	124 370	392	11 578	112 400	12,6
1983	134 629	544	13 179	120 907	12,6
1984	146 933	754	15 360	130 820	12,6
1985	168 028	1 047	13 908	153 072	12,6
1986	187 652	1 453	11 959	174 240	12,5
1987	202 665	2 017	13 906	186 742	12,3
1988	207 869	2 800	14 328	190 741	12,2
1989	213 292	4 400	13 920	194 972	12,2
1990	226 611	6 780	13 800	206 031	12,2
1991	240 255	16 210	12 650	211 395	12,2
1992	253 078	22 360	11 096	219 622	12,2
1993	274 943	31 620	10 400	232 923	8,4
1994	293 327	50 130	10 582	232 615	7,1
1995	308 032	70 450	10 802	226 780	6,6
1996	323 806	93 080	8 670	222 056	6,2
1997	346 251	122 380	6 773	217 098	5,7
1998	365 473	153 040	4 770	207 663	5,4
1999	378 701	184 860	3 276	190 565	5,0

Statistics on the values of card payments at EFTPOS (Column 2) and on the volume of checks issued (used in part to compute Column 3) were taken from the annual reports 1987-1999 on Payment Systems of the Central Bank of Norway. However, data are not available for values of card transactions for the period 1980-1986. The missing observations for the value of card payments were estimated by assuming a constant growth rate (going backwards) equal to the growth of card payments from 1987 to 1988 (28 per cent). As the observed value of card payments in 1987 (2017) is only 1.1% of the observed value in 1999, the missing values would be even smaller. Thus, during the early years of EFTPOS infrastructure growth, the estimated value of card use is very small. As a result, our estimation method should have little effect on our overall results.[24]

The value of checks at POS (Column 3 in Table 2) is estimated as the average value of card transactions multiplied by the annual volume of checks. This assumes that the average value of a check written at the POS is similar to that for card use. It is probably somewhat higher but we do not know by how much.[25] There were missing values for the average value of card payments over 1980-1986. These figures were estimated as the CPI adjusted average value of card transactions in 1987, going backwards.

The last column in Table 2 shows the estimated number of days consumers wait before they replenish their cash stock for transaction purposes. Based on value and volume data on cash withdrawals from ATMs, cash back at stores, and withdrawals over the counter (OTC) at bank/post branches,[26] we calculated the average number of cash withdrawals per adult (persons over the age of 18) for our only observation period 1996-1999. A simple linear relationship was specified between these withdrawals and the number of cash access points over the same period. This linear relationship was then extended backwards to 1980 using the number of cash access points observed for these years. Overall, the greater the number of possible cash access points, the greater will be the average annual number of withdrawals per adult. The annual number of withdrawals represents a POS cash turnover ratio (not shown).

Dividing the number of days in a year (365) by this POS cash turnover ratio yields the average number of days consumers wait before they replenish their inventory of cash for transaction purposes over 1980-1999 (Column 5, Table 2).

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[24] The introduction of EFTPOS terminals in the retail sales sector in Norway began in 1982 with the installation of the first EFTPOS terminals in Shell and ESSO gasoline stations. Among the approximately 2500 gasoline stations at the time, 600 had already installed 900 EFTPOS terminals by 1985. The second wave of EFTPOS infrastructure growth started in 1986 with the introduction of the first EFTPOS terminals in retail stores (Source: Den norske bankforening, Notat 1/86). Prior to 1982, EFTPOS was manual rather than fully electronic.

[25] The actual average value of a check in Norway is very high and directly reflects the high values of a relatively small number of business checks. Therefore, the actual average value of a check could not be used in our analysis.

[26] Details on data sources and calculation methods of OTC cash withdrawals over 1996-1999 are presented in the internal working paper of the Central Bank of Norway, FIBE internt notat (2000), "Om korrigert beregning av kontantuttak i skranke", Norges Bank.

The frequency of cash replenishment was once every 5 days in 1999, meaning that the associated turnover ratio for 1999 was (365 days)/(5 days) = 73. That is, the average adult withdrew cash 73 times per year (or once every 5 days).

There was a large and important shift in the estimated cash replenishment frequency during 1992-1993. This is a consequence of our initial assumption of a linear relationship between the number of consumer cash access points and the average number of withdrawals per adult. It reflects the fact that from 1992 onwards access to cash was greatly expanded by the introduction of cash back services at stores. This increased the number of cash access points by 18,460 EFTPOS terminals which were already in operation that year.[27]

Table 3 below shows the different components of the use of cash we can account for. Given data availability and our estimation process, results for the 1990s are expected to be more accurate than those for the 1980s.

Column 1 (Consumer POS stock of cash) shows the estimated stock of cash used by consumers for transactions at the POS. It is calculated from 'Consumer cash use at POS' (a value flow from Column 4, Table 2) divided by a cash transaction turnover ratio (365 days divided by the cash frequency replenishment times in Column 5 of Table 2), giving a cash stock estimate. As seen, Consumer POS stock of cash falls after 1992. This reduction is primarily due to the rise in the estimated POS cash transaction turnover ratio and the corresponding fall in the number of days people wait before they replenish their cash holdings. The main factor here was the introduction of cash back at stores in 1992, allowing for more frequent cash withdrawals with a lower value being withdrawn each time. This permitted consumers to reduce their average inventory of cash holdings, which, in turn, reduced their share in the total stock of cash outstanding. Data on the value of the stock of cash held by banks and credit institutions (Column 2) and on the stock of cash held by public authorities plus the stock of cash held by public companies (Column 3) are taken from the FINDATR1 database at the Central Bank of Norway.

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[27] In 1992 commercial and saving banks introduced cash back services through EFTPOS terminals for their cardholders with 500 kroner as an upper limit. Concurrently, the Postbank (Postsparebanken) introduced cash back (and cash out) services for their cardholders the same year. The Postbank clients could use their cards also at Shell and ESSO gasoline stations (Source: Payment system report, 1991, 1992). However, it is uncertain how many of the EFTPOS terminals actually offered cash back services in the first years after 1992. Furthermore, it is more realistic to posit that the actual decrease in the number of days consumers waited before replenishing their cash holdings after the introduction of cash back services was likely smoother than the one presented in Table 2. Ideally, estimation of cash transaction turnover ratios after 1992 should apply some lag structure which would allow for a gradual use of the cash back opportunity.

Table 3: Calculation of cash stock held for legal transactions (Million kroner)

Year	Consumer POS stock of cash (1)	Cash stock held by banks and credit institutions (2)	Cash stock held by public authorities, municipalities and public companies (3)	Estimated cash stock held by private firms (4)	Declared, idle and overseas stock of cash (5)	Cash stock for legal transactions (6)
1980	3 234,0	1229,5	1236,25	1883,1	1551,3	9 134,2
1981	3 603,4	1259,8	1283,13	1824,9	1549,7	9 520,9
1982	3 868,9	1385,5	1336,63	1743,6	1557,8	9 892,5
1983	4 164,0	1595,0	1531,75	1716,9	1580,9	10 588,5
1984	4 505,0	1903,5	1725,43	1771,3	1588,6	11 493,8
1985	5 264,8	2232,5	1986,23	1948,0	1600,8	13 032,3
1986	5 947,6	2768,1	2162,85	2102,9	1614,4	14 595,8
1987	6 303,5	3075,3	2393,93	2164,6	1652,4	15 589,7
1988	6 385,6	2768,1	2536,10	2215,7	1662,4	15 567,9
1989	6 517,4	2662,0	2108,58	2294,4	1663,9	15 246,2
1990	6 887,6	2761,2	1971,10	2330,1	1665,8	15 615,8
1991	7 079,6	2792,9	1921,88	2520,5	1672,4	15 987,4
1992	7 356,3	2592,3	1902,95	2647,4	1340,1	15 839,1
1993	5 346,9	2553,0	1748,28	2784,9	1356,8	13 789,9
1994	4 503,1	2838,0	1967,58	3124,4	1381,4	13 814,4
1995	4 074,0	3103,2	2017,20	3159,6	1391,4	13 745,4
1996	3 780,0	3565,8	1817,58	3228,1	1400,0	13 791,5
1997	3 389,5	3877,6	1531,10	3265,6	1427,1	13 490,9
1998	3 052,1	3945,1	1124,15	3328,7	1260,7	12 710,7
1999	2 613,3	4524,0	962,48	3283,1	1267,9	12 650,8

The FINDATR1 database also provides information on the value of cash held and demand deposits owned by private firms (joint-stock companies). While no information is available on cash holdings of personal proprietorships, charity organisations, or free professionals, demand deposit data for these three categories of firms are available in FINDATR1. In order to estimate the likely value of the stock of cash held by personal proprietorships, charities, and free professionals, we multiplied the ratio of cash holdings to demand deposits for joint-stock companies by the value of demand deposits for these three types of organisations over 1980-1999. This gives an estimate of the cash stock held by personal proprietorships, charities, and free professionals which is summed with the cash stock values for joint-stock companies. The end result is shown in Column 4 as "Estimated cash stock held by private firms".

The cash stock values in Column 5 of Table 3 represent the sum of three additional (but minor) components of the stock of cash. First, the tax authorities require individuals holding more than 3000 kroner at the time of their tax filing to

report the value of these cash holdings on their tax statement.[28] Second, based on information from Statistics of Norway, the stock of cash held abroad by tourists who had previously visited Norway was estimated to be 0,7 per cent of the total value of cash outstanding over 1980-1999. Third, we estimate the stock of idle cash held in individuals' wallets just prior to their obtaining additional cash. As people typically do not run their cash balances down to zero before they replenish their inventory of cash, we assume that over 1980-1992 adults carried an average of 200 kroner as idle cash in their wallets prior to obtaining additional cash. Due to the increasing number of ATMs and EFTPOS terminals after 1992, and especially with the implementation of cash back at stores in 1992, we reduced the 200 kroner value to 100 kroner over 1993-1999. These two values are multiplied by the number of persons over the age of 14 in each year, giving an estimate of the stock of idle cash in wallets over 1980-1999. Finally, summing over Columns 1 to 5 in Table 3, we obtain an estimate of the total stock of cash used for legal activities at the POS (Column 6).

In Table 4 below, the value of the stock of cash for legal activities at the POS (Column 2, from Column 6 of Table 3) is subtracted from the observed value of cash outstanding (Column 1). The resulting residual and "unexplained" value is our estimate of the value of the stock of cash used for illegal and hoarding activities (XCURRENCY in Column 3). Hoarding is believed to be small in Norway. Thus XCURRENCY will primarily reflect illegal activities, the largest of which is believed by tax authorities to be income and sales tax evasion. The last column in Table 4 expresses XCURRENCY as a percent of total cash outstanding. While some small, but unknown, portion of XCURRENCY may have been destroyed over time, the fact that 54% to 71% of the stock of cash outstanding is not used for reasons we can reasonably account for is striking. Large amounts of unaccounted currency have also been found in other countries (e.g., the Netherlands--Boeschoten and Fase, 1992; the U.S.—Porter and Judson, 1996).

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[28] All currency above 3000 kroner has to be reported in Norway. The Norwegian tax authorities provided us with data on reported currency for the years 1996, 1997 and 1998. We assume that consumers held a constant reported amount of cash over 1980-1995 equal to the one reported in 1996 and that in 1999 consumers reported the same amount of cash holdings as in 1998. These are strong assumptions but the values are small.

Table 4: Calculation of stock of cash held for illegal and hoarding activities
(Million kroner)

Year	Total stock of cash outstanding (1)	Cash stock for legal transactions (2)	XCURRENCY: Residual cash stock (3) = (1) - (2)	%XCURRENCY of total stock of cash (4) = (3) / (1)
1980	19 801,3	9 134,2	10 667,1	53,87 %
1981	19 579,7	9 520,9	10 058,8	51,37 %
1982	20 736,2	9 892,5	10 843,7	52,29 %
1983	21 538,3	10 588,5	10 949,8	50,84 %
1984	22 640,7	11 493,8	11 146,9	49,23 %
1985	24 384,5	13 032,3	11 352,2	46,55 %
1986	26 328,4	14 595,8	11 732,6	44,56 %
1987	27 785,7	15 589,7	12 196,0	43,89 %
1988	29 208,9	15 567,9	13 641,0	46,70 %
1989	29 431,8	15 246,2	14 185,6	48,20 %
1990	29 700,7	15 615,8	14 084,9	47,42 %
1991	30 649,6	15 987,4	14 662,2	47,84 %
1992	32 028,8	15 839,1	16 189,7	50,55 %
1993	33 407,2	13 789,9	19 617,3	58,72 %
1994	36 925,5	13 814,4	23 111,1	62,59 %
1995	38 359,1	13 745,4	24 613,7	64,17 %
1996	39 588,4	13 791,5	25 796,9	65,16 %
1997	41 220,8	13 490,9	27 729,9	67,27 %
1998	43 577,5	12 710,7	30 866,8	70,83 %
1999	43 837,2	12 650,8	31 186,4	71,14 %

Illegal and hoarding activities in a country are known to rely almost exclusively on high value currency notes. The share of high value notes (or just the highest value note) in the total value of cash (notes and coin) outstanding for 13 countries is shown in Figure 2. For Norway, the share of the 1000 kroner note was 44% in 1980 and 62% in 1999. The 18 percentage point rise in this share over 1980-1999 is very close to the 17 percentage point increase in our estimate of the share of illegal and hoarding activity in cash outstanding (from 54% in 1980 to 71% in 1999 shown in Column 4 in Table 4). At present, and probably in the future as electronic payments continue to replace cash for legal activities, changes in the share of the 1000 kroner note in total cash outstanding will likely be a good indicator of changes in the size of illegal and hoarding activities in Norway.

The share of the 1000 kroner note in Figure 2 appears to be high relative to all countries except Japan and Italy. However, as shown in Figure 3, the Norwegian 1000 kroner note is actually relatively small in terms of purchasing power when converted into a standard unit of account such as the Euro. The 1000 unit notes

for Switzerland, Germany, the Netherlands, Italy, Belgium, and Finland all exceed the real value of the Norwegian 1000 kroner note.

Figure 2: Largest denomination in various countries as a percentage of total value of banknotes outstanding in 1998.
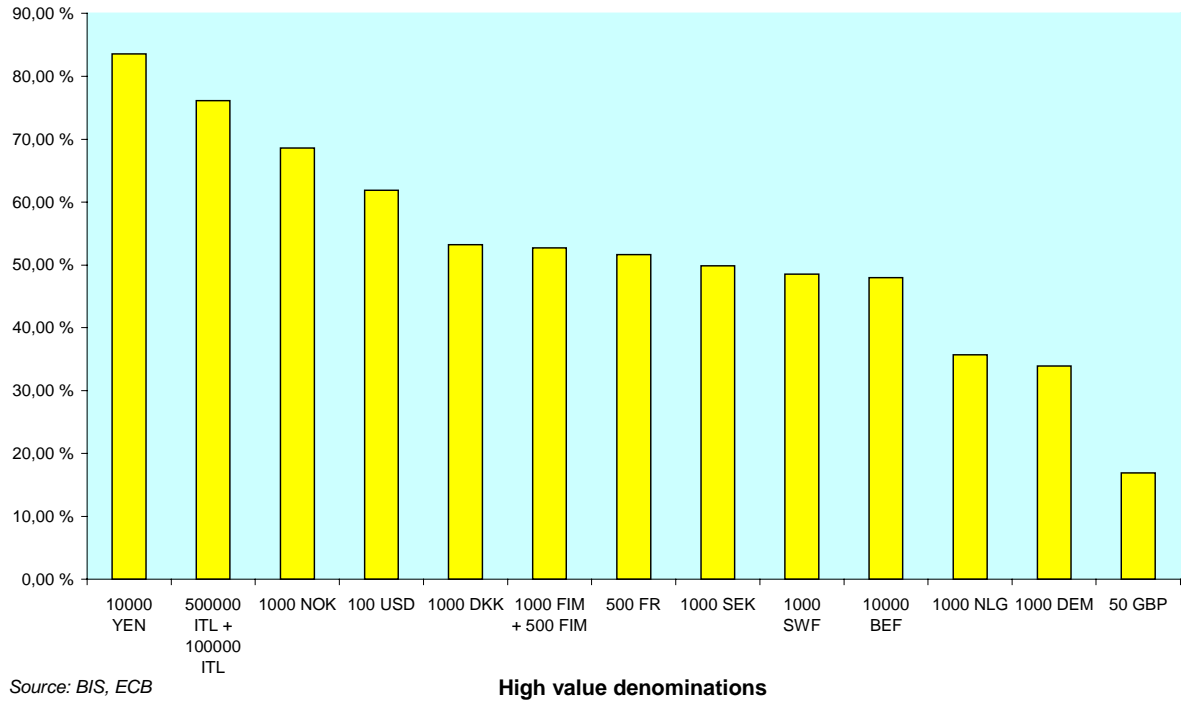

Source: BIS, ECB

High value denominations

Figure 3: Value of high value notes from various OECD countries (in EURO).

High value notes from various OECD countries

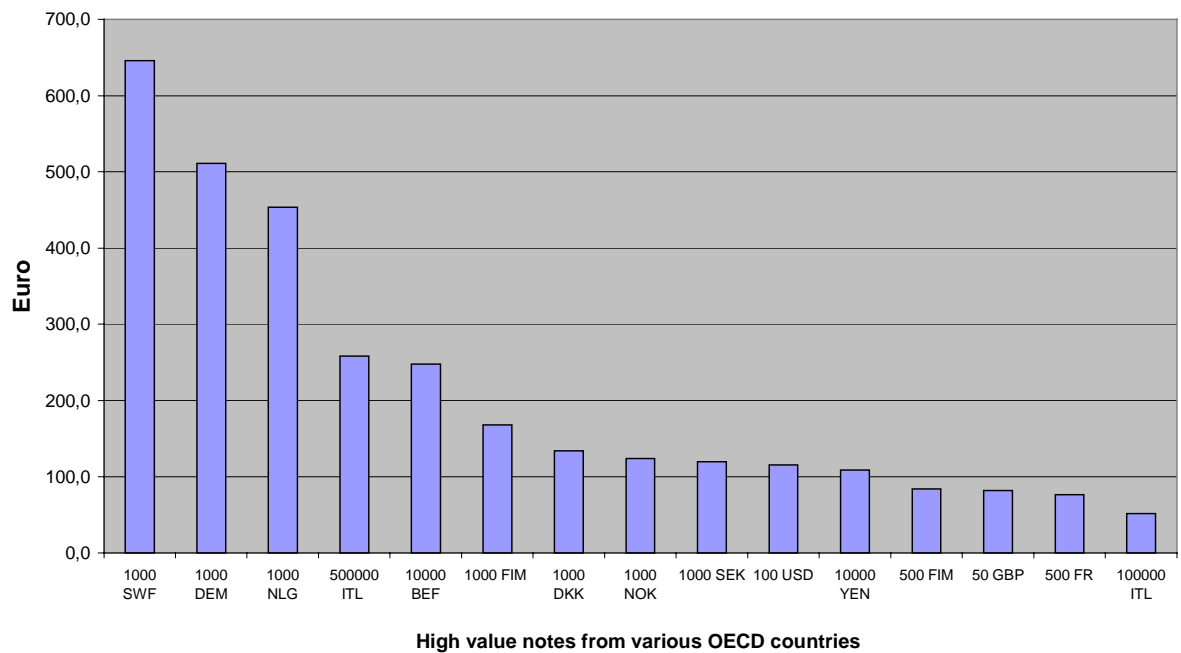*Currency rates: EURO Spot Closing 08. 09. 00 - (FT 11.09.00)*

Table 5: Comparison of the value of cash stock held for illegal and hoarding and the value of 1000-notes outstanding (Million kroner)

Year	XCURRENCY	Value of 1000-notes	XCURRENCY as % of total cash stock	Value of 1000-notes as % of cash stock	(5) = (2) / (1)
	(1)	(2)	(3)	(4)	(5) = (2) / (1)
1980	10 667,1	8 764,6	53,87 %	44,26 %	82,16 %
1981	10 058,8	8 868,7	51,37 %	45,30 %	88,17 %
1982	10 843,7	10 129,1	52,29 %	48,85 %	93,41 %
1983	10 949,8	11 154,3	50,84 %	51,79 %	101,87 %
1984	11 146,9	12 154,0	49,23 %	53,68 %	109,03 %
1985	11 352,2	13 674,8	46,55 %	56,08 %	120,46 %
1986	11 732,6	15 106,4	44,56 %	57,38 %	128,76 %
1987	12 196,0	16 244,5	43,89 %	58,46 %	133,20 %
1988	13 641,0	17 425,8	46,70 %	59,66 %	127,75 %
1989	14 185,6	17 727,6	48,20 %	60,23 %	124,97 %
1990	14 084,9	18 715,5	47,42 %	63,01 %	132,88 %
1991	14 662,2	19 571,1	47,84 %	63,85 %	133,48 %
1992	16 189,7	20 864,3	50,55 %	65,14 %	128,87 %
1993	19 617,3	22 009,8	58,72 %	65,88 %	112,20 %
1994	23 111,1	24 832,6	62,59 %	67,25 %	107,45 %
1995	24 613,7	25 522,1	64,17 %	66,53 %	103,69 %
1996	25 796,9	25 985,4	65,16 %	65,64 %	100,73 %
1997	27 729,9	26 711,4	67,27 %	64,80 %	96,33 %
1998	30 866,8	27 772,9	70,83 %	63,73 %	89,98 %
1999	31 186,4	27 290,5	71,14 %	62,25 %	87,51 %

In Table 5 below we investigate more thoroughly the relation between XCURRENCY and the value of 1000-notes for the period 1980-1999. The share of 1000-notes in the total stock of cash increased steadily from 44 per cent in 1980 to 62 per cent in 1999 (column 4).

The last column in Table 5 shows the ratio of the value of 1000 kroner notes to XCURRENCY. Over 1980-1991, the value of these notes rose relative to the estimated stock of cash held for illegal and hoarding purposes (XCURRENCY). After 1991, this trend was reversed so that by 1999 the ratio moved back to where it was in 1981. This result reflects changes in the Norwegian payment system, specifically the increased use of cards at POS and the implementation of cash back at stores that lowered consumers' average cash holdings (as more frequent cash withdrawals reduce the average idle balance that needs to be held).

So far, our focus has been on the use of cash for transaction purposes at POS. However, data also exists (only for 1994-1999) regarding the use of cash to make giro payments over the counter (Norges Bank, 2000). Although these payments have fallen by 46% during this 5-year period, they are still sizeable and thus should be included in any analysis that tries to estimate the size of illegal and hoarding activities in GDP. This is done in Table 6.

Table 6: Calculation of the implied size of illegal and hoarding activities in GDP (Million kroner)

Year	Cash giro payments (1)	XCURRENCY* (2)	GDP/M1 (3)	Implied size of illegal use of cash (4)	Implied size as % of GDP (5)
1994	266400	17.954,0	4,59	76449,4	8,81 %
1995	260000	19.943,0	4,39	84918,7	9,14 %
1996	264600	21.292,8	4,45	90666,2	8,92 %
1997	235900	24.046,9	4,33	102393,5	9,34 %
1998	181400	28.200,7	4,03	120080,7	10,82 %
1999	143800	29.214,4	3,77	124397,2	10,43 %

Source: Norges Bank

The observed value of giro cash payments (a flow) is shown in Column 1 of Table 6. Deflating this value by 365 days divided by Column 5 in Table 2 gives an estimate of the stock of cash associated with these giro payments (not shown). This is the same procedure used to transform the flow of consumer cash use at POS (Column 4, Table 2) into a stock measure (Column 1, Table 3). Adding this new cash stock component to the existing cash stock for legal transactions (Column 6, Table 3) and subtracting this value from the total stock of cash outstanding (Column 1, Table 4), gives a new and somewhat lower estimate of the stock of cash used for illegal and hoarding activities. This new value (XCURRENCY*) is shown in Column 2 of Table 6. As seen in the last column of Table 4, the ratio of XCURRENCY (which reflects only consumer use of cash at POS) to the total value of cash outstanding was 71% in 1999. Including giro cash payments reduces this ratio to 67% in 1999 (as legal use rises and illegal and hoarding use falls).

The value of XCURRENCY* (a stock) needs to be expressed as a flow before it is divided by the value of GDP, in order to express the size of illegal and hoarding as a percent of GDP. It is accepted practice (Schneider and Enste, 2000) to use the GDP/M1 turnover ratio to do this, although this is largely because no other information is available that might be more accurate.

The M1 data used to obtain the GDP/M1 ratio in Table 6 reflects the recent revisions in the monetary aggregates for Norway. The main change is that "unutilised overdrafts and building loans" are excluded from the previous series

and the borderline between M1 and M2 has been redrawn to make M1 conform more closely to the standard transactions component of the money supply that can be used for direct payments without other costs in addition to ordinary transactions fees.

Multiplying XCURRENCY* by 4,26 (which is the average GDP/M1 ratio over 1994-1999 from Column 3) gives the implied value of illegal and hoarding activities over 1994 -1999 (Column 4). The reason for using the average GDP/M1 ratio is to smooth out year-to-year variations in this ratio that are unlikely to be associated with variations in illegal and hoarding activities. The resulting percent these activities are of GDP are shown in the last column of Table 6. As seen, our estimates range from 8,81% to 10,43% of GDP. The variation is a bit more than 1.5 percentage points. While this sounds small, it reflects an underlying growth in the nominal value of illegal and hoarding activities over just 5 years of 63% (using the stock values shown in Column 4).

Appendix 2

In this appendix we provide more detailed information on the stock of cash in Norway for the period 1991-1999. Table 1 shows the development of the various denominations of notes during the period. It is worthwhile to mention that the public adopted rapidly the 200-kroner note as a means of payment at POS after its introduction in 1994.

Table 1: Denominations of notes in circulation 1991-99. Yearly average value in NOKm

	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	**28.608,5**	**29.918,6**	**31.263,5**	**34.675,9**	**35.851,1**	**36.812,2**	**38.283,4**	**40.487,3**	**40.566,2**
1000-kr	19.571,1	20.864,3	22.009,8	24.832,6	25.522,1	25.985,4	26.711,4	27.772,9	27.290,5
500-kr	828,1	1.282,4	1.889,5	2.548,3	2.991,7	3.465,2	4.068,0	4.875,1	5.588,1
200-kr				105,5	1.025,1	1.771,2	2.629,7	3.649,5	3.949,2
100-kr	7.641,5	7.193,0	6.777,5	6.585,8	5.727,5	4.961,6	4.245,8	3.473,3	3.026,7
50-kr	567,8	578,9	586,7	603,7	584,7	628,8	628,6	716,6	711,9

Source: Norges Bank

The 200-kroner together with the 500-kroner notes are the denominations typically used in Norwegian ATMs. Lower denominations circulate among the public and through the cash back services, while access to 1000-kroner notes is possible primarily in bank branches (OTC).

Table 2: The rate of note circulation 1991-99 [1]

|	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	**4,47**	**4,77**	**4,87**	**4,84**	**4,93**	**4,90**	**5,17**	**4,71**	**5,28**
1000-kr	1,44	1,50	1,43	1,32	1,35	1,33	1,24	1,25	1,30
500-kr	4,36	6,35	7,74	8,01	8,63	8,66	8,74	8,38	8,73
200-kr				5,35	9,09	10,71	11,02	10,78	10,85
100-kr	5,62	6,11	6,32	6,43	6,33	5,93	5,68	4,37	4,88
50-kr	1,96	1,97	1,98	2,06	2,13	2,04	2,19	1,99	2,09

Source: Norges Bank

1) Average no. of times per year that notes pass through Norges Bank.

Table 2 shows the rate of note circulation, i.e. the average numbers of times per year that the various notes pass through the Norges Bank. The rate of circulation for the 1000-kroner note is slightly decreasing while the total value of cash in 1000-kroner denomination is increasing (see Table 1). Conversely, the rate of

circulation for the 500-kroner and 200-kroner notes increases and is about seven times higher than that of 1000-kroner note.

Dividing total value of cash of each denomination by its denomination value gives the number of notes outstanding. Multiplying this number by the rate of note circulation gives the value of cash circulating in and out from Norges Bank. This value is defined here as 'the circulation value' for the respective denomination. Figure 1 below shows the share of circulation value for each denomination as a percentage of total circulation value of all denominations.

Figure 1: Value of stock of cash circulating in and out Norges Bank per denomination. Percentages
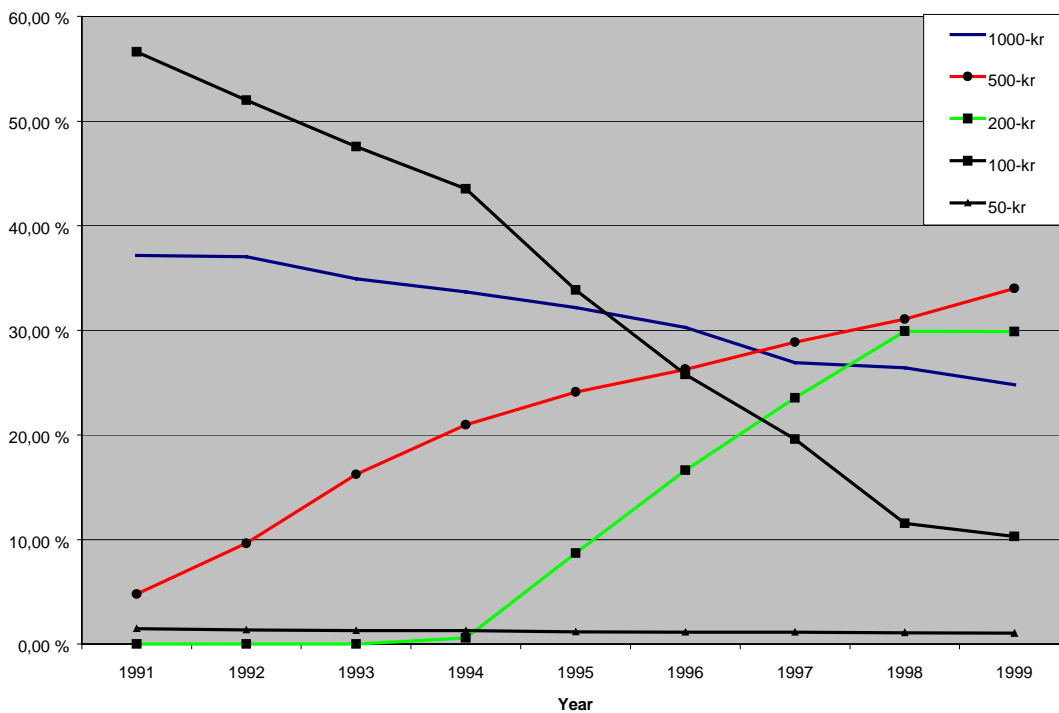
The share of circulation value of 100-kroner note fell rapidly during the period. This may be explained by the rapid increase of the share of the circulation value of the 200-kroner and 500-kroner notes. 100-kroner note is now circulating among the public and through cash back services. The share of circulation value of 1000-kroner note is falling. This is another indication that 1000-kroner note are into a lesser degree used as a means of payment for ordinary legal transactions. An increase of legal transactions paid with 1000-kroner in the stores or in banks should normally lead to higher rate of circulation and to an increase of the share of circulation value of 1000-kroner note. A falling share seen together with an increase of the nominal value of outstanding cash in 1000-roner denomination should than imply that 1000-kroner note is not used primarily as means of payment for legal transactions.

KEYWORDS:

Cash
Money
Tax evasion