ELIMINATING THE PENNY FROM THE U. S. COINAGE SYSTEM:

AN ECONOMIC ANALYSIS

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INTRODUCTION

With the introduction of the new dollar coin in early 2000, and reported "shortages" of pennies during 1999 and 2000, questions have again been raised about the desirability of considering a further restructuring of the coinage system in the United States. More specifically, some members of Congress and others have called for elimination of the penny. It is ironic, indeed, that arguments calling for eliminating the penny and rounding prices are occurring as we are in the process of moving away from the rounding implicit in quoting stocks in fractions (eighths and sixteenths for example) and toward decimal trading in the expectation that this will yield substantial savings for investors.

The purpose of this paper is to examine the major economic consequences of removing the penny from circulation. The major findings are easily summarized:

- Removing the penny from circulation will have significant adverse direct effects on consumers. The resulting need to round prices will generate a rounding tax of no less than $600 million a year. Moreover, the "rounding tax" is likely to be regressive, affecting the poor and other disadvantaged groups disproportionately.

- The inflationary impact of rounding will probably be small. However, even a small effect will cumulate over time to a considerable sum. Utilizing the results of simulations of the degree of rounding likely to occur, and Congressional Budget Office estimates of the effects of higher prices on Federal government outlays, show that removing the penny would raise government outlays by about $950 million in 2005 and by $2 billion in 2010.

- Rounding could also have significant negative effects on firms, given the narrow profit margins in convenience stores and supermarkets, the possible adverse effects on theft deterrence, the costs of training cashiers and associated productivity losses, and the high costs associated with non-cash mediated transactions. Such considerations point toward changes in the structure of prices designed to take advantage of rounding and thereby raise prices overall.

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- The government's net earnings on penny production and distribution (about $25 million in 1999)—seigniorage—and the Mint's focus on continuing productivity gains and cost control suggest that the penny will remain a profit center for the government for some time to come.

THE NET EFFECT OF ROUNDING PRICES TO THE NEAREST 5-CENT INCREMENT

It has long been recognized that removing the penny from circulation would require that cash purchases be rounded to the nearest nickel. The most commonly mentioned scheme (which appeared in H.R. 3761, "The Price Rounding Act of 1989") specified that if the total, including tax, of a cash purchase ended in a 3,4,8, or 9, the resulting sum would be rounded up to the nearest nickel, while if the total ended in 1,2,6, or 7 the resulting sum would be rounded down to the nearest nickel. For example, a total bill at the cash register of $2.34 would be rounded up to $2.35, while a total of $2.36 would be rounded down to $2.35. Payments by check, credit or debit card would not require any rounding.

Many advocates of removing the penny assume that the net effects of such a rounding scheme will be close to zero—on average, the number of transactions leading to rounding up will be roughly offset by the number leading to rounding down. Even the aforementioned GAO study offered no evidence on the issue, suggesting, at least implicitly, that such an assumption was not unreasonable; " In theory, rounding could be designed to be fair so that one-half of the transactions would be rounded up and one-half rounded down" [1996, 11]. A moment's thought suggests such a "theory" is predicated on the distribution of the final digits of prices of individual goods, and, more to the point, the distribution of the final digits of sales at the cash register, being relatively flat, with the proportion of prices/sales ending in each digit from "0" to "9" being roughly 10 percent.

To move away from the world of assumption and speculation, I present a set of data and methods for getting at the direct, indirect, distributional, and dynamic (over time) effects of such a change in our payments system.

Direct Effects

I begin with a careful experiment designed to simulate the net effects of rounding on consumers. I was able to obtain, on a confidential basis, the "price book" for a typical convenience store in a large chain of such stores in the mid-Atlantic region. Focusing on just such a class of stores makes sense since most of their transactions (ignoring gasoline) are in cash. Table 1 shows the distribution of the final digits for the prices of the 3,585 separate items sold in the typical store. (Data were gathered in January 2000.) As is obvious and has been documented for a long time [Twedt, 1965], the overwhelming proportion of prices end in 9.

The next step is to simulate 5,000 transactions of from one to three items each across the full spectrum of 3,585 items. (I also conducted simulations with 1,000 and 10,000 transactions; the results are virtually identical to those reported below.) Each transaction represents, in effect, a single customer, purchasing a random set of one to

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TABLE 1
Distribution of Prices in a Representative Convenience Store

Last Digit of Price	Number of Items	Percent of Total
0	8	0.2 %
1	2	0.1
2	6	0.2
3	19	0.5
4	323	9.0
5	134	3.7
6	103	2.9
7	4	0.1
8	27	0.8
9	2,959	82.5
Total	3,585	100.0

three items from among all those available in the store. The bill is calculated for each transaction and the rounding scheme described above is applied to the total. The results show that *between 60 percent and 93 percent of the transactions result in rounding up*, with the lower figuring resulting when up to three items are purchased and the higher figure resulting when one or two items are purchased. These results are not surprising given the distribution of prices in Table 1. With available research showing the average value of a cash transaction in year 2000 dollars to be in the $5-6 range [Humphrey, 1994, 61], and the data available from the chain of convenience stores supplying the price data, I am confident that focusing on 1-3 transactions per customer captures the representative range of cash transactions in such venues.[1]

The last step in the simulation is to arrive at the total number of cash transactions in the economy in a given year and apply the above percentages to estimate the range of net rounding in dollar terms. As a wise sage once said, easier said than done. Hancock and Humphrey put it this way, "data on cash transactions represent estimates from one-shot surveys or expert guesses and are woefully inadequate compared to data for noncash transactions" [1998, 1576].

Proceeding with the appropriate degree of caution and appreciation for the lack of precision inherent in any calculation, I utilize data provided by the American Bankers Association which itself is drawn from the widely used "Nilson Report" produced by HSN Consultants of Oxnard, CA. For the year 2000, the number of transactions by consumers is estimated at 106 billion. Hancock and Humphrey report that estimates of the proportion of total transactions, which are in cash, range from 50 percent to 83 percent [1998, 1576]. Table 2 applies this range for cash transactions to the range for the proportion of cash transactions rounded up from the simulations above to arrive at an estimated upper and lower bound for the dollar value of rounding for the economy as a whole.

As is shown, the estimated range for the direct effect is $318 million to $818 million, with a midpoint of $598 million. (The use of a range is appropriate given the underlying imprecision mentioned above.) I consider the estimates in the table conservative since transactions totals ending in "3" or "8" are rounded up by two cents rather than the one cent assumed for all transactions in the underlying calculations

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TABLE 2
Net Rounding: Direct Effects

Proportion of Cash Transactions Rounded Up	Cash Transactions as Proportion of Total Transactions 50 percent	83 percent
60 percent	53 billion transactions × .6 = 31.8 billion × $.01 = $318 million	88 billion transactions × .6 = 52.8 billion × $.01 = $528 million
93 percent	53 billion transactions ×.93 = 49.3 billion × $.01 = $493 million	88 billion transactions ×.93 = 81.8 billion × $0.1 = $818 million

Based on estimate of 106 billion consumer transactions in 2000 [Nilson Report]; assumes rounding of only one cent per occurrence.

and I have not assumed any change in pricing behavior by retail outlets to take advantage of the rounding scheme.

To provide some intuition and context for the estimates, if each of the 200 million U.S. residents aged 16 and over experienced a penny of net rounding up per day, this would amount to $700 million dollars per year (200 million persons × $.01 × 350 days per year).

These calculations illustrate a basic premise—even a seemingly trivial effect per individual per day adds up to a nontrivial "tax" on consumers in the aggregate.[2]

Indirect Effects

By definition, the rounding tax estimated above would raise the overall price level, as measured, say, by the Consumer Price Index. The effect would be quantitatively small. With consumer spending in current dollars at $6.5 trillion in 1999, the $598 million midpoint of the rounding tax range would represent an increase in prices of about 1/100 of one percent ($598 million/ $6.5 trillion = 0.000092).[3]

While the effect on the CPI would hardly be noticeable, in dollar terms, even such a seemingly small effect could cumulate over time to a considerable sum given that virtually all government outlays (for example, social security benefits, welfare payments, interest on the public debt, and items procured) and many private sector costs, such as wages and salaries, are indexed or tied, formally or informally to the CPI.

To illustrate, the Congressional Budget Office [2000, Appendix C] estimates that an increase of one percentage point in the annual rate of inflation beginning in January 2000 would raise total outlays by $103 billion by 2005 and $219 billion by 2010. Thus, if the rounding tax pushes up prices by 0.92/100 of one percent, Federal government outlays would be about $948 million higher in 2005 ($103 billion × 0.0092 = $948 million) and by $2 billion in 2010 ($219 billion × 0.0092 = $2.01 billion).

Taken together, the direct and indirect effects on the government and private sectors would be no less than $1.5 billion over five years and $2.5 billion over a decade. I say "no less than" because I view the estimates as conservative and static, making no allowance, for example, for strategic adjustments in firms' pricing practices.

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Distributional Effects

In a caring and pluralistic society, estimates of aggregate, economy-wide effects need to be accompanied with an analysis of the incidence of the potential "tax" on consumers. More specifically, we need to examine whether the aggregate effects will fall disproportionately on any particular segment of society. Unfortunately, available data suggest that those least able to shoulder such costs will bear a disproportionate share of the overall burden.

Recent Federal Reserve surveys [Kennickell, et al., 2000, 9; Hogarth and O'Donnell, 1999] indicate that 9.5 percent of American families do not have checking (transactions) accounts—a total of nearly 10 million households. The vast majority of these families (82.6 percent) had incomes of less than $25,000 and were nonwhite or Hispanic (57.1 percent).

Since only cash transactions will be subject to rounding, it follows that removing the penny from circulation will impose a regressive tax on those making a disproportionate share of their transactions in cash—the poor and under-represented minority members of our society. Regrettably, this implies that the existing regressivity of the sales tax will be reinforced by the rounding tax.

Dynamic (Over Time) Effects

The direct and indirect effects enumerated above are essentially static in nature, implying that all other factors driving pricing decisions are held constant. In moving to an assessment of the dynamic reactions of firms which will govern the financial effects of removing the penny over time, some have suggested that firms might round down to attract customers or, at a minimum, that firms would not arrange their prices in a way to take advantage of the rounding scheme. Such contentions fly in the face of basic microeconomic principles which are based on the fundamental premise that the behavior of firms, that is, their employment, production, advertising, and pricing decisions, are guided by a straightforward objective—the desire to maximize profits.

In a recent study for the National Bureau of Economic Research, Besley and Rosen examined the effects of sales taxes on firms' pricing decisions. Their findings:

> For some commodities, we cannot reject that taxes are shifted on a one-for-one basis. For others, commodity taxes are over shifted—a ten-cent increase in the revenue extracted from the sale of these commodities leads to an increase in their prices of more than a dime. The finding that some commodities exhibit over shifting . . . is consistent with the predictions of certain theoretical models of imperfect competition that seem like reasonable characterizations of the retail sector. [1998, 26-27][4]

These findings suggest such taxes are even more regressive and burdensome than conventionally thought. Moreover, as the discussion below makes clear, they apply directly to the "rounding tax" under examination here.

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In discussing the possible removal of the penny at the 2 December 1998 committee meeting, members of the National Association of Convenience Stores were told that the net profit on an average transaction in a convenience store is only 3 percent or 6 to 7 cents. Comparing the two-cent difference in rounding up a penny versus rounding down a penny, it was stated that such a difference "accounts for over 30 percent of that net profit and, therefore, all prices in the convenience store would have to be raised" [National Association of Convenience Stores, 1998].

This observation—a simple, straightforward statement about shifting—is critical, because it has been contended by proponents of removing the penny that price structures would not respond in an unfavorable (to the consumer) fashion to a rounding scheme. What evidence there is suggests we will get a rounding tax *and* pricing adjustments by firms to both shift and take advantage of the tax.[5]

Some have contended that removing the penny from circulation would save worker productivity lost in conjunction with handling pennies when making change, thereby permitting rounding down. Such claims of improved efficiency are vacuous in the absence of evidence bearing on the issue. At the same meeting of the NACS, it was reported that "the offset in cost of handling the penny does not even compare to the 30 percent..." [ibid.] of the net profit which could be lost from rounding down.

Reinforcing the possible negative effects of rounding on profit margins, in the absence of adjusting the price structure, are the net costs associated with any induced shifts of payments from cash to non-cash media. Table 3 [Hancock and Humphrey, 1998, 1613] provides evidence on the average cost of accepting different payment instruments at supermarkets in the United States.

As they note, "the costs include the time it takes to complete a transaction, the wage and fringe benefits of the various accepting/verifying/accounting employees, armored courier costs (for cash), check and other fraud expenses, bank charges, electronic network transaction fees, and credit card fees" [1998, 1612, n.68]. Whether based on sales value or per transaction, cash is always cheapest, and by a wide margin!

Theft Deterrence

Lest one underestimate the set of issues surrounding what happens at the cash register, it is important to note that the high incidence of prices ending with a "9" in Table 1 is no accident:

> Department stores first started the (odd) pricing method to eliminate shrinkage at the cash register caused by the pocket-bookkeeping method among sales personnel. Even-priced merchandise often would be paid for in exact amount direct from the shoppers' purse. The clerk would then serve another customer or two before ringing up a sale. When prices were changed to odd amounts, making change from pocket became obvious and correct change usually required a trip back to the register. [Department of the Treasury, 1979, 2; see also Twedt, 1965]

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TABLE 3
Costs of Receiving Different Payment Instruments for U.S. Supermarkets

	By Transaction Volume		By $100 of Sales Value	
	Unit Cost	Percent (%)	Cost	Percent (%)
Cash	$0.07	57	$0.52	35
Debit card[a]	$0.30	2	$0.94	3
Check[b]	$0.43	33	$1.20	49
Credit Card	$0.81	3	$2.27	5
Other[c]	—	5	—	7

Food Marketing Institute [1994]. a. Refers to an on-line debit, with settlement through the ACH. b. A verified check reduces fraud losses and its cost per transaction (per $100 of sales) is somewhat lower at $0.37 ($1.05). c. Primarily food stamps, a government-sponsored food welfare program.

The National Association of Convenience Stores website (http://www.cstorecentral.com) is filled with stories on the rising volume of employee theft and its link to what happens (or doesn't happen) at the register. One would expect strong underlying support for anything that helps control employee theft and forces cash transactions through a register. The accounting, tax, and profit implications are significant for both the public and private sectors. Eliminating the penny from circulation obviously moves in the opposite direction.

Cashless Society?

Lastly, some have contended that ongoing technological advances will mean that electronic payments will increasingly displace cash transactions, perhaps eliminating them all together in the foreseeable future. This contention ignores the increasingly wide availability of ATMs [Weiner, 1999], which makes it more convenient from a consumer's perspective to acquire and utilize cash than otherwise. Furthermore, the costs of cash vs. alternative payments media, shown in Table 3, suggest that profit-seeking firms would be rather hesitant to behave in a way that resulted in a significant decline in the number of cash transactions unless and until the relative costs of cash vs. other payments media are much more favorable.

REMOVING LOW DENOMINATION COINS FROM CIRCULATION: AN HISTORICAL AND COMPARATIVE PERSPECTIVE

It is an undeniable fact that the real value of the Lincoln penny today is about 1/20 of its value when introduced in 1909 and that inflation reduces the use and usefulness of low-denomination coins [Goldin, 1985]. Interesting though these facts are, they do not, by themselves, tell us anything about the effects of removal. In an ideal world, historical evidence and the experiences of other countries might help to pin down the major economic effects of removing the penny from circulation. Proponents of removal often cite the fact that over the last twenty years several countries (France, Spain, the Netherlands, Australia, New Zealand, and the United Kingdom) have re-

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moved their lowest denomination coins from circulation (the equivalent of a ½ cent coin or the penny) with no discernable economic effects. I have conducted an extensive search of the relevant archives in these countries and cannot find a study of the subsequent economic effects. Proponents, I presume, would equate the absence of a careful study of the effects within these much smaller economies (Australia's GDP, for example, is eight percent of GDP in the United States) with the proposition that the effects were in fact negligible, and hence would be in the United States. Such an approach strikes me as a weak platform on which to base a significant change in our coinage system; the absence of evidence does not equal zero impact. A good example is provided by the fact that the Army stopped using pennies in European commissaries and exchanges (non-profit-seeking entities) in 1980; those proposing removal of the penny cite the alleged lack of problems as evidence that the effects would be negligible for the economy as a whole. In its deeper excavation of the contention, the GAO reported to the Congress that: "the facilities often rounded down to minimize complaints" [1996, 10].

Seigniorage

What discussion one does find in the popular press within the various countries is that "negative seigniorage"—that is, the cost of producing the low denomination coins exceeding their face value—did often operate as an important driving force, that is, as a necessary condition behind the subsequent elimination. In considering the U.S. case, the Mint reports that the full costs of production and distribution for the penny have been approximately eight-tenths of a cent in recent years. With penny production of nearly 12 billion in 1999, this implies positive seigniorage—that is, a net profit of about $24 million (12 billion pennies $\times$ 0.2/100 = $24 million). Given the Strategic Plan for the Mint (www.usmint.gov), which emphasizes continuing productivity gains and cost control, it would appear that penny production will remain a profit center for the Government for some time to come.[6]

A Case Study: The Euro Coinage System

In the context of the recent establishment of the European Monetary Union, participating governments and finance ministries had to confront the question of the structure of the accompanying coinage system. After careful reflection and consideration, it was decided to include a penny equivalent. The German Finance Ministry provided the following background and rationale:

> If a euro one-cent coin were not introduced, public opinion might regard this as a sign of weakness in the euro and confidence in the stability of the common European currency might suffer as a result....
> ... the purpose is to supply coins needed for monetary transaction. For this, minting the low-denomination euro coins is indispensable. Abolishing the low-denomination coins is out of the question for reasons of price policy as well. If such coins were no longer available, we would

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> have to pass regulations concerning pricing or rounding ... It would be hard to reconcile such government intervention in pricing with our economic principles. [Letter, 18 December 1998]

CONCLUSIONS

The 1996 GAO study of the economic effects of removing the penny from circulation concludes: "In analyzing these factors, we found no clear path that would lead either to a substantial benefit to the Federal government or a clearly expressed preferred course of action by the American public" [1996, 11]. In this more comprehensive study, I also could not identify any net benefits associated with price rounding and the removal of the penny. Admittedly, the calculations of the degree of rounding and the quantitative effects on the economy and Americans, although done carefully and conservatively, are subject to some unknown degree of error. To my way of thinking, such uncertainty reinforces the analytical arguments presented. Unless it can be demonstrated that the adverse effects will be negligible, then the benefits of removing the penny must be sufficiently large to outweigh a reasonable estimate of the adverse effects. I find the potential adverse effects considerable.

As the government's experience with the metric system, the bicentennial $2 bill, and various attempts to overhaul health care so poignantly demonstrate, the public must be convinced of a pressing need for and clear net benefits associated with changing anything that has become embroidered into the social and economic fabric of society. The evidentiary requirement for removing the penny from circulation does not yet appear to meet this standard. Of course, if and when seigniorage turns negative, inflation reduces the real value of a penny substantially further, and, more generally, the benefits of elimination (what might be called "convenience") rise relative to the costs, then removal will be more attractive. In the meantime, with the "decimalization" of equity prices leading to a substantial narrowing of spreads and accompanying reductions in trading costs to investors, it is clear that a penny here and a penny there, be it at the convenience store, supermarket or stock market, add up to a substantial sum that can either help consumers (decimalization) or tax them (eliminating the penny).

NOTES

The author wishes to thank the editors and referees of this *Journal* for helpful suggestions.

1. I also conducted simulations that allowed for sales taxes on a random proportion of the items composing each transaction. The results reported above were not materially affected. This is reasonable: first, the sales tax is itself routinely rounded up; second, in most jurisdictions food is exempt from sales taxes [Federation of Tax Administrators, February 2000]; hence, the majority of the items in a convenience store would not be taxable. As one referee has noted, however, if the distribution of prices shown in Table 1 was flatter, or the "average" consumer purchased 4-5 goods per cash transaction, the proportion of cash transactions rounded up would decline.
2. The same point has been vividly illustrated by the recent move on the New York and other stock exchanges involving pricing stocks in cents instead of fractions of a dollar. Pricing in fractions is, in effect, a kind of rounding scheme. The early evidence [Henry, 2000; Chakravarty and Wood, 2000a, 2000b] suggests the change is resulting in a substantial drop in trading costs for investors.

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3. For a compelling theoretical analysis, see Chen where he concluded, "A shortage or an absence of a desirable denomination would be inflationary" [1976, 183]. As he argues, the decline in money demand would result in a rise in velocity and prices.
4. See papers reviewed in Anderson [1990], which examine the relationship between grocery store prices or grocery store profits and market concentration. They find a positive relationship and conclude many local markets are imperfectly competitive.
5. And make no mistake, retail price books are geared to change prices rapidly and to set the final digits of prices with considerable precision; see, for example, Sisel and Lambert [1997] and Roberts and Sanquist [1997].
6. One referee correctly emphasized the important role of seigniorage and suggested that Sumner's analysis [1993] of privatizing the mint may yield some insights regarding a more optimal set of production and transactions arrangements.

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