The international diffusion of an innovation: The spread of decimal currency

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The diffusion of an innovation: The spread of decimal currency

Abstract: This paper argues that decimalization of currency diffused as a consequence of all three forms of isomorphism: normative, coercive, and mimetic. Furthermore, it is ambiguous as to whether the normative isomorphism was well founded. The patterns of denominations show variety by country as a consequence of a number of factors, including cultural ones. These patterns tend to follow a powers-of-two (binary) principle for smaller denominations and a purer decimal principle for larger denominations, reflecting their utility for cash transactions and for store-of-value functions respectively.

“There are 10 kinds of people in the world. Those who understand binary and those who do not.”
—Anonymous

1.0 Introduction

Money, as institution, has evolved in the almost three millennia since the appearance of the first coins in the 6th Century, BCE. This evolution has affected money’s composition (e.g., paper or base or precious metals), the designs one finds on coins and notes, their shapes, and the system of denominations. Today almost all currencies use a system of denominations based on the decimal system, but this use is a relatively recent development.

In modern decimal systems money consists of a standard unit divisible into one hundred (for centesimal systems), or one thousand subsidiary units (for millesimal systems). Generally, most of the subsidiary denominations take the form of coins, and most of the superior denominations take the form of notes. Stable systems of denominations that encompassed the whole range of the currency from small change to large denomination notes did not really emerge until the 19th Century, when mints solved the “Big Problem of Small Change” (Sargent and Velde 1999, 2002). Weber (2009) argues that prior to the industrial revolution, merchants used an “index coin” – generally the official mint weight of a leading coin – as the unit of account, with all actual transactions taking place in circulating currency based on their metal content relative to the index.

During the Industrial Revolution, improvements in the quality of coins led to a fusion between money’s unit of account and the medium of exchange functions (Weber
Selgin (2003, 2008) argues that it was Birmingham’s button makers, especially Thomas Williams and Matthew Boulton, who solved the problem by producing fiduciary or token small change that was relatively counterfeit proof and that the manufacturers credibly promised to redeem in gold or silver coin produced by the Royal Mint, or in notes of the Bank of England. This period of the commercial coinage did not last long but it did show a way forward that governments soon followed.

Although decimal denominations of coins existed in Ancient China, and instances occurred among the ancient Greeks, Etruscans and Romans (Junge 1984), among others, the first modern decimal system with an unbroken history to the present arrived in 1704; Russia’s Peter the Great imposed a currency reform with a silver ruble of 100 copper kopeks as part of a general program of modernization (Muravljeva 2007). The second adopter, the United States of America, did not do so until 1786. The 19th Century saw the diffusion of the practice, and the United Kingdom, one of the last, and the largest holdout against the practice, succumbed in 1971 (Anon. 1971). The diffusion of decimalization accompanied the spread of national fiduciary money produced under government monopoly.

This paper is an analytic history. It neither proposes nor tests theory. Rather, it draws on theories from several disciplines to explain the phenomenon. In Section 2, the paper draws on literature in economics, operations research and psychology to assess the optimality of patterns of denominations, comparing the decimal system with alternatives both past and abstract. The finding that a decimal system does not unambiguously dominate alternative systems sets up the discussion of how the decimal system came nevertheless to predominate. Thus Section 3 turns to sociology and the theory of institutionalization to posit reasons for the widespread adoption of decimalization. Section 4 then applies this theoretical lens to the actual history, finding that the diffusion was a consequence of all three
forms of coercive and mimetic isomorphism, and not just normative isomorphism. Lastly, Section 5 uses the theory of economic evolution to discuss variation, selection, and retention among the denominations. These evolutionary mechanisms have had the effect of causing country-by-country differences in how decimalization is expressed. Section 6 is a summary and conclusion.

Each of the theoretical treatments uses examples and illustrations to make the abstract concrete. The justifications for the use of numerous examples are two. First, the examples constitute the rhetoric of the paper, its argumentation (McCloskey 1983). The paper takes its methodological inspiration from Max Weber, who too utilized exhausting, if not exhaustive, detail. Second, the examples come from many countries to situate the story of denominations in world history.

In the discussion below, the factual items having to do with dates for the introduction of decimal currency, or the names or patterns of denominations, come from a variety of sources, but primarily Crib et al., (2004) and Krause and Mishler (c.1995).

2.0 A basic history of denominations

Before the arrival of decimalization, the two predominant systems of denominations were the binary or power-of-two system, and the Carolingian system of pounds, shillings and pence, which readily permits binary subsidiary denominations. The binary principle is a common one in currency. Coins with denominations in negative powers of 2 (1/8\textsuperscript{th}, ¼, ½; i.e. 2\textsuperscript{−3}, 2\textsuperscript{−2}, 2\textsuperscript{−1}), and positive powers (1, 2, 4, 8; i.e., 2\textsuperscript{0}, 2\textsuperscript{1}, 2\textsuperscript{2}, 2\textsuperscript{3} and so forth), predominate, at least until the last one to two hundred years.
The Augustan monetary system included the silver denarius, and its fractional coins, the *sestertius*, *dupondius*, and *aes*, worth $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{1}{16}$ of the *denarius* (Martinez Oliva 2007). There was also the *quadranum*, $\frac{1}{4}$ of an *aes*.

Udovitch (1979) reports that in Medieval Islamic accounts of banking “…we read of purses containing 308\ ¼ gold coins with a value of 300 dinars, or 122 gold coins with a value of 119 \ 3/8 dinars.” Some more recent examples come from the Sub-Continent and its sphere of influence. Burma, India, the Maldives, Muscat and Oman, Nepal, Pakistan, and Thailand, all used a binary coinage system until, in some cases, well after World War II. Prior to 1937, the Thai system consisted of $2 \ solos = 1 \ att$, $2 \ att = 1 \ sia$, $2 \ sia = 1 \ sik$, $2 \ sik = 1 \ fuang$, $2 \ fuang = 1 \ salung$, $4 \ salung = 1 \ babt$, $4 \ babt = 1 \ tamlung$, and $20 \ tamlung = 1 \ chang$. Prior to 1952, the traditional Burmese system consisted of $4 \ pyas = 1 \ pe$, $2 \ pe = 1 \ mu$, $2 \ mu = 1 \ mat$, $5 \ mat = 1 \ kyat$; later $8$ (heavy) $\mu = 1 \ kyat$. India’s system just before decimalization in 1957 consisted of $3 \ pies = 1 \ pice$ (paisa), $4 \ pice = 1 \ anna$ and $16 \ anna = 1 \ rupee$.

The names of many currencies reveal the commodity origin of money (e.g., *drachma*, *lira*, *livre*, *mark*, *peso*, and pound). We may infer that the binary principle originated in weighing a vehicle commodity (Powell 1996). Four thousand years ago, the Harappan civilization knew that a binary system of weights gives the optimal solution to the problem of determining the smallest number of weights to use with a two-pan balance if the weights and the object one is weighing must go in separate pans (Telser 1995). Morrison and Morrison (1996) report the discovery in the city of Mohenjo-Daro of a set of weights in the pattern 1,1,2,4,8,16….

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1 The *denarius* lives on in the Macedonian *denar* and the Middle Eastern *dinar* or *dirham*. Older derivatives of the name include *denero*, *denier*, *dinero*, and *dinheiro*. *Denarius* comes from the Latin *deni*, which means “by tens” or “consisting of ten” because the original silver coin was equal in value to ten copper *asses*. 
“The binary scale used by the Harappan people ... is realized through an unworked but by no means unstudied set of small weights. The intrinsic twofold, bilateral symmetry of the equal-arm balance expresses itself in the visible identities \(1+1=2\), \(1+1+2=4\), and so on. It is addition without mathematics.”

Interestingly, Fairservice (1992) suggests that Harappan and Vedic cultures may have used a base 8 counting system for some purposes.

Before 1933, the U.S. dollar was a commodity-based monetary system. In this system two \(\frac{1}{4}\) gold Eagles (each US$2.50), for instance, weighed as much as a \(\frac{1}{2}\) gold Eagle (US$5, and all three together weighed as much as one gold Eagle (US$10). Any merchant could use an equal-arm balance readily to identify clipped or counterfeit coins by comparing them to genuine coins.

The economics literature on the binary principle begins with Hentsch (1973 & 1975) and continues through Caianiello et al. (1982), Van Hove and Heyndals (1996), and Van Hove and Vuchlen (1996). These authors argue that a binary system permits an economy to transact its business using the smallest number of coins. This has lead Van Hove (2001) to refer to the binary principle as the “principle of least effort”.

There are also practical and cognitive reasons why people might wish to use a binary system. One practical reason comes from bargaining. Bolton (1997) used lab experiments to examine why bargaining so frequently results in 50-50 splits. He argued that the 50-50 split is the unique limit evolutionary stable outcome when bargainers can use a signal to discriminate among partners. Fairness — splitting equally — is a coordinating convention that has survived an evolutionary process that selects against waste. Ellingsen (1997) pointed out that when the size of a pie is certain, equal splitting is the unique outcome of bilateral bargaining. A binary system can more readily accommodate such bargaining than can a decimal system. These arguments provide an explanation for Grigerenzer’s (2004)
observation that splitting the difference is a “fast and frugal” heuristic or rule of thumb that humans use for making decisions.

The New York Stock Exchange, the world’s largest, used binary “ticks” in pricing shares, in this case 1/8th subdivisions of the dollar, until 2000-1, when it phased in decimal ticks. US bond and commodity markets also used binary ticks. The NYSE began in the same year that the US adopted a decimal currency but the incongruity of paying in decimal currency for transactions accomplished in powers-of-two survived for over two hundred years. Many accounts of the practice attribute it to the circulation of Spanish (Mexican) dollars (the peso of eight reales, aka piece-of-eight) in the US and this surely was a factor, but the practice outlived the 1857 demonetization of foreign monies.

In the modern era, England and its colonies were the chief users of the Carolingian system of 20 shillings to the pound and 12 pence to the shilling, commonly abbreviated as £sd, the “d” descending from the denarius. The first use of the word penny occurs in the laws of King Inc (688-726) of Wessex. King Offa of Mercia set the weight of the silver penny equal to “32 wheat corns in the midst of the ear” (Anon. 1961). Pepin the Short (751-68), the father of Charlemagne (768-814), introduced a system based on a pound of silver (the Livre tournois). He divided this pound into 20 solidi, each of 12 deniers, giving 240 deniers to a pound of silver. The solidus was purely an accounting device for recording values such as a "solidus of grain", that is, the amount of grain that one could purchase for twelve deniers (Scott 1964, p.40); the livre too was purely a unit of account. The 12 deniers to the solidus retained the Roman duodecimal system while the 20 solidi to the livre may have reflected the Celtic vigesimal counting system. In England, the shilling as a name came in 1504, and derives from the Old English “settling” meaning cutting or slicing (Anon 1971), with the first shilling being minted in 1508 under Henry VII (1487-1509; Chown 1994, 23). Prior to
its revolution, France also used the *écu* made up of six *livre tournois*, with the *solidus* becoming the *sol* or *sou* (Miskimin 1967). Rather than *sol* though, France produced coins of 15 and 30 *deniers*, i.e., denominations of a sixteenth or an eighth of a *livre* of 240 *deniers*.

The Carolingian system adapts readily to a binary system of subsidiary denominations. The English pound has long been available as a coin, especially in the form of the gold sovereign; there was also a gold half-sovereign. The next lower fractions of the pound were the silver crown (5 shillings or quarter of a pound) and half-crown (2½ shillings or an eighth of a pound). The silver shilling gave rise to the silver sixpence (½ shilling) and threepence (three pence or a quarter-shilling). The florin (two shillings or a tenth of a pound) represents an early 19th Century move towards decimalization rather than a doubling; the coin survived, but decimalization had to wait (Kindleberger 1983). Dyer (1994) discusses the mixed rationale that led to the short-lived (1887-1891) double florin (a fifth of a pound).

The copper penny gave rise to the copper tuppence (2 pennies), groat (four pence and also a third of a shilling), ha’penny (½ pence) and farthing (¼ penny). Multiples of the pound, however, have been more decimal. Here one finds 2 and 5 pound coins and 5, 10, 20, and 50 pound notes. British West Africa provides a different example of the combination of the £sd system with decimal denominations; from 1907 to 1957, it also used a coin worth a tenth of a penny. This may have represented a substitution of a coin for the cowry, which the Sierra Leone company had once valued at a mille (see below).

In addition to these two basic patterns—the binary and the Carolingian—other more cultural influences played a part as well. In many Muslim or Ottoman countries the pre-decimal coinage included a 40 denomination. For instance, in Egypt prior to 1886, 40 *paras* equaled 1 *qirsh* (*piastre*). In Turkey as late as the mid-20th Century, 40 *para* equaled 1 *kuruş*,

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with 100 *kuruş* equaling 1 *lira*. The number “forty” occurs throughout the Bible and the Middle East. (Examples include “forty days and forty nights”, “wandered for forty years”, “Ali Baba and the Forty Thieves”, etc.) My understanding is that the word for 40 and the word for “very many” were similar in the languages throughout the region.

Strikingly, the binary and Carolingian systems persisted for hundreds of years after the discovery of zero. Although the decimal system’s ease of use in performing arithmetic is well known, in the years before the advent of pocket electronic calculators people used the abacus or like instrument to perform addition, subtraction and multiplication, but not division, and then wrote down the results (Stone 1972). At least from the time of Rome to the Renaissance in Europe, and longer in the Orient, the abacus was the common counting device, and it used a place system based on decimals even before the creation of a symbol representing zero. [The Roman abacus used columns of 1000 (M), 500 (D), 100 (C), 50 (L), 10 (X), 5 (V), and 1 (I); (Stone 1972).] In Europe, until well into the 15th Century and even after the introduction of double-entry bookkeeping, clerks kept records using Roman numerals (*Bulletin* 1930). Thus what had developed were binary systems of denominations for transactions, with calculation and record keeping using a more decimal system. ²

The advent of decimal money reconciled the system of denominations with counting. However, as Leibnitz demonstrated in the 17th century (Kula 1986; p. 82), the essence of the decimal system rests in the invention of zero, not in the use of base 10. One could imagine the reconciliation between counting and transacting taking the form of the adoption of a base 8 counting system. Unfortunately, as Ifrah (1983) and Kula (1986) point

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² Although the colonial powers stopped accepting cowries early in the 20th Century, cowries continued to function as money in parts of West Africa until the 1970s (Şaul 2004).

³ One can speculate that decimal arithmetic only became common when paper became cheap enough that one could use it for calculations and other ephemeral uses, not just record keeping (Bloom 2001).
out, all our counting systems take as their starting point the human body (5 fingers, 10 fingers, 20 digits, or 60=4 hands and feet times 14 +1 knuckles), which provides a rather forceful though usually unremarked demonstration of path dependency.

Most economies find that a system of denominations of 0.01, 0.10, 1, 10, 100, etc., provides too few denominations for transacting business. Therefore modern systems generally augment the decimal denominations by denominations that double or halve the decimals (e.g., 0.02, 0.05, 0.20, 0.50, 2, 5, 20, 50, etc.). Interestingly, within the decimal system we also see some denominations that are quarter of another denomination, a topic we will return to later.

Doubling and halving brings us to cognitive factors supporting a binary system. Albers (2001, 297) refers to the sequence (.01, .02, .05, .1, .2, .5, 1, 2, 5, 10, 20, 50, 100) as one of “the prominent or full step numbers…i.e., the powers of ten, their halves and their doubles.” He argues that halving and doubling are basic mental processes for comparison of numerical data, a contention that is consistent with their frequent appearance in customary weights and measures (Linacre 2007). Whynes et al. (2007) cite Albers (1998) to the effect that the process of halving and doubling is fundamental to the way in which humans make quantitative comparisons. Albers (2001) acknowledges that the pure binary system more perfectly satisfies the principles of halving and doubling, but states that “Our culture selected the decimal system.”

Caianiello et al. (1982) argue that a “module” (ratio of adjacent denominations) of $3\sqrt{10}$ (approximately 2.15) reconciles the binary principle with decimals. However, the ratio of adjacent denominations is not constant within currencies. Instead, Tschoegl (1997) and Wynne (1997) found that the average for all subsidiary denominations across a number of
currencies is close to 2.6, the result of the ratio fluctuating between 2 and 2.5, especially among the small denominations.

Among notes, the patterns of denominations tend to be sparser. The US had banknotes of US$500 and US$1000. The US took these of circulation in 1969 as it became apparent that the denominations were too convenient for drug smugglers and the like (Allison 1998). The euro is still available in 100, 200 and 500 euro denominations, and Switzerland has 100, 200, and 1000 franc notes. In their study of payments in The Netherlands, Boeschoten and Fase (1989) report a high degree of hoarding of large denomination banknotes.

Telser (1995) argues that a system of denominations based on powers-of-three (1, 3, 9, 27, 81…), would require fewer denominations than a binary system. Such denominations do occur, but they are rare. For example, 15th century Britain issued the gold Noble (a third of a pound) and the half-Noble, but this was a short-lived experiment.

Recently, Bounie and Houy (2007a) have argued that a system based on the fractional power 1.53, which yields denominations of (1, 2, 3, 5, 8, 12, 19, 30, 46, 70, 108, 165), is more efficient than either powers-of-two or powers-of-three. They use simulations based on an empirical distribution of prices in France, and find that such a system would use 2.5 percent fewer coins than using the euro requires. However, they acknowledged that such a system would pose cognitive obstacles and so are not surprised that it has not emerged in practice. Between 1851 and 1879 the U.S. came close to having such a pattern with coins of 1, 2, 3, 5, 10, 20, 25, 50, 100, but by 1889 the 2¢, 3¢, and 20¢ denominations had disappeared (Tschoegl 2001).

The powers of 1.53 and the 1851 to 1879 U.S. system both have a number of redundant denominations, that is, denominations that are not at least twice as large their
predecessors in the sequence, with the result that they contain a denomination is smaller than the sum of its predecessors (Carothers 1930). A system with too many denominations also poses a different cognitive problem, that of recognizing and sorting the coins in a transaction.

Shallit (2003) shows that the substitution of an 18¢ coin for the 10¢ would cause a 17 percent increase in efficiency, defined as a reduction in the number of coins a change maker would have to tender on average, under the assumption of a uniform distribution of prices. Bounie and Houy (2007b) criticize this recommendation on the grounds of cognitive complexity. Instead, they advocate the introduction of an 80¢ coin into the euro’s system of denominations. They argue that this would decrease the average number of coins needed in the economy by about 16 percent. However, denominations such as 18¢ or 80¢ are not a prominent number (Albers 1998) and violate the principles of halving and doubling (Albers 2001).

3.0 Diffusion

Meyer and Rowan (1977) introduced the term institutional isomorphism to describe how imitation could give rise to convergence in the practices of organizations. They suggested (Meyer and Rowan 1977, 349) that isomorphism provided protection to an organization “…from having its conduct questioned. The organization becomes, in a word, legitimate.” Later, DiMaggio and Powell (1983) argued that isomorphism could originate in three different mechanisms: the normative, coercive, and mimetic.

Normative isomorphism results from considerations of what is the proper course of action (Boxenbaum and Jonsson 2008). One set of norms in the economic realm focus on efficiency or effectiveness. Diffusion results from each adopter independently deciding that
the new practice represents an objective improvement over current practice. This was the argument of the first advocates for decimalization. Some of the early adopters (e.g., Russia, the US, and France) appear largely independently to have adopted decimal coinage as a modern advance.

Coercive isomorphism results from power relationships and politics (Boxenbaum and Jonsson 2008) and represents pressures to conform originating in standards, regulations, and the like. For coins and currency, the primary source of coercive isomorphism would have been colonialism with the colonial power imposing the home system. Today, although decimalization has become almost universal, there is no body with the power to force sovereign states to adhere to the standard.

Samoa provides a nice example of coercive isomorphism. From 1900 to 1914, it was a German colony and used the German Mark, a decimal currency. Then, at the outset of World War I, New Zealand seized the colony; under New Zealand’s rule Samoa switched to the NZ pound, which followed the British (Carolingian) system. Although Samoa achieved independence in 1962, because of its extensive ties to New Zealand it retained the NZ pound as its currency until 1967. In 1967, when NZ adopted a centesimal dollar, then Western Samoa adopted its own centesimal dollar.

Not all coercive actions led to an isomorphism, or at least, to a complete one. In 1878, Britain took over the administration of Cyprus. The Ottoman coinage nominally consisted of a variety of coins, including a lira or pound of 100 gros, kurus or silver piastres, with coins of 100, 50, 20 (a mejidie), and 1.5 gros, with the silver piaster being worth 40 copper paras, with coins of 5, 10, 20 and 40 paras (Zapiti and Michaelidou 2008, 212-3). However, debasements had resulted in complications such that there was also copper piastres, and the terms piastre and para could mean any of several different values (Pridmore 1974, 14).
The British introduced a Cyprus gold pound equal in value to the English pound, made up of 20 shillings, consisting of 9 piastres, for a total of 180 copper piastres to the pound because this essentially reconciled the value of the British gold sovereign with the Turkish gold lira (Pridmore 1974, 16). The choice of 180 piastres to the pound was a response to an arbitrage that involved selling Ottoman lira for Ottoman piastres and then using the piastres to buy English pounds. The British further countered by creating their own piastres that approximated the value in Cyprus of the Ottoman though underweight in terms of its copper content (Pridmore 1974, 16).

The new system moved the currency away from something that was somewhat decimal, to a system that was neither decimal nor fully Carolingian. Initially, the British issued copper coins of ¼, ½ and 1 piastre. In 1901, the British introduced silver coins of 3, 4½, 9, and 18 piastres, the last two being referred to as the shilling and double shilling. (In 1928 the also issued a silver 45 piaster to commemorate 50 years of British Administration.) Although not fully Carolingian in form, the Cypriot currency retained a strong element of doubling and halving.

Lastly, mimetic isomorphism arises most often under conditions of uncertainty (Boxenbaum and Jonsson 2008) where an actor’s response is borrowing and imitation. It can result from what economists such as Bikhchandani et al., (1992 & 1998) have called informational cascades. In an informational cascade every subsequent actor, having observed the accept/reject decision, but not their predecessors’ information or reasoning, makes the same choice. Each subsequent actor rationally chooses to favor the weight of the evidence of the prior decisions over their own private information, if any.

Early in the process of standardization, isomorphic mimeticism may combine with normative mimeticism. As Avant (2004) points out, one state’s adoption of a practice that
subsequently appears successful may cause the practice to become an international model, making it more likely other states will copy it. Once a practice becomes an international model, the practice provides a new commonsensical starting point. Reformers then use the model as the basis for their own reform proposal and appeal to the practice’s perceived success as part of their strategy of getting reform in their own countries. Consistent with the logic of Gourevitch’s (1978) “second image reversed”, the international model influences the domestic conditions necessary for its adoption. At some point though, there may be an international tipping point (Finnemore and Sikkink 1998) when domestic conditions no longer matter and the international model becomes automatic, i.e., isomorphic mimeticism dominates.

Recently, Polillo and Guillén (2005) sought to explain the international adoption of central bank independence. Following the world-system, world-society, and neo-institutional perspectives in sociology, they assumed that states compete with each other in the cultural, political, and economic realms. From this they argued that to maintain their position and status, the states adopt organizational forms and practices that make them isomorphic with their environment. More generally, as Dori (2008) argues, globalization is the cross-national diffusion of universal norms or models.

Decimalization diffused at the same time as the creation of national currencies, but more slowly. Cohen (1998) argued that the Treaty of Westphalia (1648) initiated the diffusion of the idea of the sovereign state, and with it its symbols of an army (Avant 2000), a flag and a currency. Actually, as Helleiner (1997, 1998 and 2003) pointed out, the creation of national money as the sole legal tender within the national territory really developed only in the 19th Century and became almost universal only in the 20th. Nationalism gave rise to
national money because nationalists saw currency as a medium for the dissemination of national symbols (Helleiner 1998).

Some countries never really adopted national money (the most noteworthy example is Panama, which has used the U.S. dollar since 1904), and today countries such as the members of the European Monetary Union are abandoning it (De Grauwe 2007). Recently El Salvador and Ecuador have given up their own currencies and adopted the US dollar as a response to the inability of their political systems to reduce inflation.

The colonial powers applied the idea of national money to their colonies. By World War I, Britain, France, Germany, and Italy sought to replace hodge-podges of trade currencies and commodity-based “primitive money” (e.g., Maria Theresa thalers, Mexican silver dollars, gold sovereigns, cartridges, cowries, salt, and manilas) with their own currency, or local variants. The colonial powers’ motives were many. One was the dissemination of imperial symbols (e.g., the imperial monarch) while linking them together with local images (Mwangi 2002). Another was a sense of a civilizing mission that included the introduction of a more modern monetary system. Lastly, the authorities surely wished to capture any possible seignorage. Because of the network externalities involved in the circulation of money, the effort to introduce local currencies frequently required the coercive power of the state (Ofonagaro 1979).

As the governments in Asia, Africa, and Latin America created national money they commonly adopted the decimal system in replacing colonial or indigenous patterns of denominations, though sometimes the process took two steps. The first step was to create national money; the second step, some years or even decades later, was to adopt decimalization. Ethiopia provides one example of this; the Sub-Continent others.
4.0 The spread of decimalization

The Arabs brought the zero and the decimal system from India to the West in the late Middle Ages, though as we have noted above, something like place value counting existed with the abacus. The mathematician Leonardo Fibonacci of Pisa in 1202 C.E. proposed the adoption of Arabic numerals in his book, *Liber Abaci (The Book of the Abacus)*, but their use did not become widespread until at least the 15th century.

The first modern proposal for decimal arithmetic dates to Simon Stevin van Brugghe, called Simon Stevinus, and the book that he published in 1585; the publisher issued a French translation at the same time and an English translation appeared in 1608 (Breen 1988). A second French translation appeared in 1634, and Breen suggests that it is this edition that became familiar to the French Encyclopædists.

An early step towards a modern decimal coinage occurred in 1642 when Phillip IV of Spain devalued the peso from 8 *reales* to 10. Although this did not give rise to a full decimal system, it did give rise to a 2 *real* coin known widely as the *pistareen*, which contributed to the development of decimal money in the US (Kleeberg 1998). Later, the architect Sir Christopher Wren made a plea for decimal measures in the UK in 1666 (Anon. 1966); in France the Abbe Gabriel Mouton followed in 1670.

However, the first modern decimal currency emerged in Russia in 1700-1704 (Maksimov 1968). In 1468 there is a record of a *ruble* of ten *grivna*. By 1490 this had evolved into the Novgorod *ruble* of ten *grivna*, each of ten *denga*. In 1533 the regent for Grand Duke Ivan IV Vasileivich (later known as Ivan the Terrible), his mother Elena Glinskaya, introduced a currency reform that did away with the *grivna*, creating a ruble of 100 *denga*, which came to be known as *kopeks*. 
Then in 1704 Peter the Great, as part of a general program of modernization that ranged from calendar reform through architecture, imposed a currency reform that created a new silver ruble of 100 copper kopeks; even so, he later introduced a half, quarter, and one-eighth kopek (Muravljeva 2007). Between 1697 and 1698 Peter had traveled to Latvia, the Netherlands, and Great Britain. While in London he visited the British Mint on four separate occasions (MacGregor 2004). The Mint had introduced horse-powered rolling mills and hand-operated screw presses in 1662 and in 1696 had engaged in a comprehensive recoinage to replace the old hammered coinage, which had been vulnerable to clipping. Russia’s coinage was seriously in need of reform and in 1700 mints in Moscow started turning out machine-struck round coins, including the first kopeks in 1701. Peter’s far-reaching monetary reform helped to finance the army’s rearmament, the creation of a navy, and the building of canals and harbors.

From 1736 to 1739, Peter van Havan, a Dane, worked in Russia as a tutor in a wealthy Russian family (Maksimov 1968). On his return to Copenhagen he published a book on his travels in which he argued that the Russian system was the most rational and scientific because it was decimal, and so well-suited for arithmetic. He went to argue that the decimal system should extend to all weights and measures.

In 1780 the Hapsburg government approved a plan by the Milanese jurist Cesare Beccaria to introduce uniform weights and measures in Lombardy. In his report, Beccaria advocated a universal system based on decimal reckoning (Maestro 1980). The mathematician Paolo Frisi, who had helped Beccaria with his calculations, helped in the transmission of these ideas to France through his friendship with the mathematicians Condorcet and Lagrange. At around this time the Americans Benjamin Franklin, John Adams, Gouverneur Morris, James Madison, James Monroe, and Thomas Jefferson all
visited France. Jefferson in particular became a proponent of decimal weights and measures as well as currency (Hellman 1931).

In what would become the United States, in the 1770s decimalization was already under discussion and in 1782, Gouverneur Morris, then Assistant Superintendent of Finance, proposed a decimal American dollar (based on the widely used Spanish or Mexican dollar) as the country’s new unit of account. Two years later Congress appointed a committee to study the matter. Thomas Jefferson was a member of the committee and he proposed a system consisting of a gold ten dollars, a silver dollar and tenth of a dollar (the disme – c.f. dixieme), and a copper hundredth of a dollar (Jefferson 1784; 1953). The committee proposed three more silver coins, a half-disme, a double disme, and a half-dollar. Congress adopted the centesimal system in 1785, with this law apparently introducing the first modern use of the term “cent” (Vice 1983). Congress then contracted with private individuals for the coinage of the Fugio cents, the first U.S. decimal cents (Breen 1988). In 1792, Congress finally passed the Mint Act, creating the basis for the present US currency system. The Act authorized denominations of ½¢, 1¢, 5¢, 10¢, 25¢, 50¢, $1, $2.50, $5, and $10. It also defined the mille (mil) as one one-thousandth part of a dollar, though the U.S. never issued mille coins. The ½¢ and 1¢ were to be of copper, the denominations from 5¢ to $1 silver, and the denominations over $1 gold. It is not clear why Congress chose to split the [0.10, 0.50] interval at 0.25 rather than at 0.20 as Jefferson’s committee had proposed.

Despite the passage of the Mint Act, during the late 18th Century and the first half or so of the 19th Century, shortages of coins led merchants, cities and banks to create tokens or private issues of notes in small and large denominations (Barnard 1917, Bodenhorn 1993, and Falkner 1901), and some of these retained binary denominations. For instance, Barnard shows one issued in Philadelphia in 1814 having a value of 6¼¢, i.e., 1/16th of a dollar, and
redeemable for groceries or Philadelphia banknotes at the premises of the merchant John Thompson. The 6¼¢ was equal to a ½ real; this was not a problem as the Mexican real was then still legal tender.

The year after the U.S. adopted a centesimal currency, the East India Company commissioned the Calcutta Mint to produce currency for use at its settlement on Prince of Wales Island (now Penang, and part of Malaysia). The new copper coins were cents, defined as the 100th part of a Spanish dollar (Pridmore 1955). The history of the early coinage in the Straits Settlements and Sumatra is complex because of the multiplicity of coins of various origins circulating in the area (including merchants’ tokens), the Company’s establishment of the rupee in India, and a variety of other factors. In 1845 the Company started minting cents, half-cents, and quarter-cents for use in the Straits Settlements, comprising Penang, Malacca, and Singapore (Pridmore 1955).

The fourth adopter of decimalization was also a private company. In 1791 the Sierra Leone Company introduced a currency for its colony comprising a silver dollar, 50, 20, and 10 cent, and a copper cent (Vice 1983); Matthew Bolton’s Soho Mint produced a million or so coins for the Company (Selgin 2008, 117). In 1796, the Company moved towards a millesimal system, declaring that it would value cowries at 1 mil. The Sierra Leone Company was not profitable and in 1808 Sierra Leone became a Crown Colony. The new government immediately replaced the decimal coinage, which smacked of Republicanism, with English pounds, shillings and pence.

France was thus only the fifth adopter of a decimal currency. In 1790, M. de Talleyrand-Perigord, Bishop of Autun, proposed the decimalization of weights, measures, and money to the National Assembly. On 7 October 1793, the French revolutionary government introduced the franc of 100 centimes to replace the Carolingian system, but with
franc representing only a name change for the livre. (The five centimes piece was called a sol or sou, and the two sou piece was known as a décime.) The government also implemented a short-lived attempt (about 12 years) to decimalize the calendar (12 months of three ten-day weeks plus extra days) and the clock (10 hours per day of 100 minutes each). Napoleon’s armies helped the concept of decimalization diffuse further throughout Europe, though the Low Countries, for instance, dropped his system after his defeat. Doty (1982) points out that for many years France was the only European country with a decimal currency.

After independence in 1832, Belgium tied its currency to the French Franc, as did Switzerland in 1848, and Italy in 1861. Portugal decimalized in 1839, and Spain in 1848. When Spain switched the reform provided for a silver real divided into copper coins: the half-real, two tenths of a real, one tenth of a real, and one half of one tenth of a real. The silver real also appeared as the half peseta of two reales, the peseta of four reales, the half-duro of 10 reales, and the duro or peso fuerte of 20 reales. Lastly, there was the gold centén or doblón, worth 100 reales (Tortella Casares 2006).

The Vienna Coin Treaty of 1857 and the Latin Monetary Union (Willis 1901), of which France was a key member, helped spread the decimal system in Europe (Hallock and Wade 1906). In 1865, France, Italy, Belgium, and Switzerland formed the Union following earlier de facto agreements to stabilize exchange rates between them. They signed a formal treaty that established uniform weights and denominations for silver coins of 5, 10, and 20 (national) units and for gold coins of 1, 2, and 5 (national) units (Junge 1984). Greece subsequently adhered to the terms of the Union in 1868, though it did not join formally until 1876. Although they were not members, Spain (1868), Rumania (1868), Bulgaria (1880), Serbia, Venezuela (1891), as well as Austria, Montenegro, San Marino and the Papal States too conformed to the policies of the Union (Willis 1901). The Union disbanded in 1927,
some years after it had ceased to have any practical significance (de Cecco 2007). The slightly later Scandinavian Monetary Union also adopted the decimal system. By 1880, most of Europe had centesimal currency.

In the Americas, Canada adopted a centesimal system in 1857, with denominations that duplicated those in the US. (In 1854, Canada and the US had joined in a free-trade agreement that lasted until the U.S. withdrew in 1866.)

When the former Spanish and Portuguese colonies in Latin America achieved independence, they initially continued the colonial binary. From the mid-1800s on, the Latin American countries decimalized as part of general modernization inspired by the examples of the United States, Portugal, Spain and the Latin Monetary Union. Still, although El Salvador decimalized in 1889, in 1909 it issued a ¼ real coin as apparently usage of the old Spanish system still persisted in rural areas.

Mexico’s decimalization underwent a particularly tortuous path. The liberal government of 1857 onwards sought to decimalize but faced resistance. President Benito Juárez’s decree of 1861 established the decimal system, but implementation took place under the Regency (1864) and the Empire (1865), that is, under the French-sponsored government of Emperor Maximilian (1864-67). When the liberals finally overthrew Maximilian in 1867, they began to complete their original plan, but they came to one sticking point, the peso. The peso was the most widely used coin in trade with China (Andrews 1904; Von Glahn 2007), and exporters feared that the Chinese would discount the new coins. So from 1873 to 1898 Mexico reverted to the 8 reales denomination for the peso alone, although the rest of the coinage was decimal (Andrews 1904).

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4 Denmark and Sweden formed a monetary union in 1872 and Norway joined in 1875. The union lasted until 1924, but as with the Latin Monetary Union, dissolution followed de facto abandonment (Jonung 2007).
In Asia, Japan and China adopted the decimal system as part of their efforts at modernization. With the New Currency Act of 1871, Japan adopted a millesimal system consisting of a silver yen of 100 sen, each of 10 rin to replace what had been a binary system. It also introduced 1, 2, 5, 10 and 20 yen gold coins. China appears to have adopted the decimal system only with the Revolution in 1912. Before 1912, local monies reflected traditional practices, including some use of decimals, but also other bases.

In South Asia several countries used a binary principle well into the 20th Century. The Nawab of Radhanpur, an Indian Princely State in Gujarat, maintained his own mint until 1900 and from around 1867 to 1870 introduced a decimal currency of 100 fulus (or fulus) to the rupee, before returning to the binary system. Decimalization arrived in Nepal in 1932, Thailand in 1937, Burma in 1952, India in 1957, the Maldives in 1960, Pakistan (including what would become Bangladesh) in 1961, and Muscat and Oman in 1970. In the 1940s, Nepal briefly introduced a 1/4 and a 1/2 paisa (100 paisa = 1 rupee). In addition, several countries in India’s sphere of trading influence used the Indian rupee as their domestic money. Bahrain did so until 1965 when it introduced its own millesimal currency (1000 fils = 1 dirham).

Still, generally colonies used the same system as their colonizers. Belgian, French and Italian colonies used a decimal system that they maintained after they achieved their independence. British colonies and Dominions generally used the British system. However, Mauritius (1852), Hong Kong (1863), and Ceylon (1870), like Canada, all adopted decimal currency in the 19th Century while they were still British dominions or colonies. Cyprus decimalized in 1955. The former British colonies in Africa decimalized on independence.

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5 I am indebted to John Kleeberg for this information about Mexico’s to decimalization.
South Africa (1961), Australia (1966), and New Zealand (1967) were amongst the last large economies to decimalize.

Before it decimalized in 1971, the United Kingdom had debated decimalization for over a century and a half. William Gladstone said in 1845, “I cannot doubt that a decimal system of coinage would be of universal advantage in monetary transactions” (Anon. 1961). However, he also warned against any too hasty a change before “the subject has been thoroughly sifted and is well understood by the public”, an admonition the United Kingdom apparently thought it had taken to heart.

The slowness to decimalize may have stemmed from the absence of any revolution overthrowing an ancien régime, of a break with a colonial past, or, as the first country to undergo the Industrial Revolution, of a need to signal modernity. In 1966 the United Kingdom finally surrendered, deciding that decimalize would occur five years later (Anon. 1966). Ireland too decimalized in 1971. Thus did the British Isles unfortunately and prematurely give up an eminently sensible system that had served them well for centuries.  

Once the U.K. succumbed, the remaining holdouts, almost all British colonies or former colonies, followed. Malta, which had been independent since 1964 but which had stayed with the Carolingian system since 1855 when Britain made sterling legal tender there, in 1972 converted the Maltese pound to the Maltese lira, comprised of 100 cents, each of 10 mils. Nigeria appears to have been the last to decimalize, adopting a naira of 100 kobo in 1973. Today, only two countries do not have decimal systems: Mauritania divides the ouguiya into 5 khoums and Madagascar divided the ariary into 5 iraimbilanj (or francs). The denominations of the major unit follow the standard European pattern of 1, 2, and 5 times

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6 In a victory for customary measures, the European Union recently conceded that Britain might keep its imperial measures such as pints and miles.

Instead of the *iraimbilanj*, Madagascar now has a 0.2 and a 0.4 *ariary* coin, as well as a 4 *ariary* coin.

### 5.0 Evolution of the Denominations

As a standard practice diffuses it becomes subject to entropic tendencies. Frenken, Saviotti, and Trommetter (1999), in their study of aircraft, helicopters, motorcycles and microcomputers, point out that at the same time as a technology is diffusing, variation is also starting. Thus, there is a constant tension between the homogenizing, standardizing or centripetal force, and the heterogenizing, differentiating or centrifugal force. In evolutionary terms, there is a constant tension between selection and the generation of variation.

One can observe similar tendencies in denominations, where variation has arisen from three sources. First, countries differ in how they decimalize, with the two most common approaches being to divide the basic unit into 100 or 1000 parts. Second, there is a choice in the basic pattern of denominations and in the denominations of the subsidiary coins. Lastly, each country’s system is subject to an evolutionary process that exhibits both innovation and selection. As the issuers of money adapt to changing circumstances, they replace, add and remove denominations (Tschoegl 2001).

Although generally countries have opted for centesimal systems over millesimal systems, a number of Mediterranean and Middle Eastern countries, such as Bahrain, Cyprus, Egypt, Israel, Jordan, Kuwait, and the United Arab Emirates, adopted millesimal systems. In addition, in the 20th Century Portugal (until 1912), Brazil (until 1942), Malta (until 1994) and Uruguay (1959-1975) had millesimal systems that they then converted to centesimal. The millesimal systems come in two variants, of which the Egyptian system (10 *millims* = 1 *piastre*, 100 *piastres* = 1 pound) and the Kuwaiti system (1000 *fils* = 1 *dinar*) are representative.
Most of these are now centesimal as inflation has eroded the value of the mil denomination. (In Egypt, inflation has resulted in the smallest denomination now being 25 piastres, with the milliems having disappeared completely.)

The 1792 Act establishing the U.S. dollar provided for a millesimal system. In 1935, Pres. Franklin D. Roosevelt asked his Secretary of the Treasury to propose to Congress that it reintroduce the 0.5¢ denomination and introduce a 1 mil (0.1¢) coin. Illinois had issued mil tokens in 1933 and several states followed as the states introduced sales taxes denominated in mils. Though gasoline prices and property tax rates today still feature mils, Congress never authorized the coins as the states fairly quickly stopped issuing mil tokens.

There are two other, rare options. From 1897 to 1902, French Indochina used a system of 5 sapeque = 1 cent; 100 cents = 1 piastre. Bhutan, when adopting decimalization in 1957, opted for a system based on 10,000. The system apparently consisted of 100 naya paisa = 1 rupee, and 100 rupees = 1 sertum. Since 1974, the system has become centesimal with 100 chetrums or chhartum = 1 ngultrum.

A second source of initial differentiation took the form of the choice between splitting the interval between the $1*10^{k-1}$ (k an integer) and 0.5*10^{k} at 0.2*10^{k} or 0.25*10^{k}. The United States adopted a 25 cent coin, though Thomas Jefferson had advocated the adoption of a 20 cent coin. Both Canada and Panama imitated the US pattern in adopting a 25¢ (centavos) coin rather than a 20¢. Panama has fully paralleled the US only since 1930, when, inter alia, it did away with the 2.5 centavo coin. By contrast, the countries of the Latin and the Scandinavian monetary unions immediately opted for the 0.2*10^{k} denomination.

Not only have countries differed in their choices, several have gone back and forth or used both at the same time. For example, even in France, the government switched back and forth between a 25 and 20 centimes denomination several times after it first introduced
the 20 centimes in 1849, before settling on the 20 centimes shortly prior to the Vienna Coin Treaty. The Bulgarian banknote issues of 1929 and 1948 featured both a 200 leva and a 250 leva note, with the two circulating in parallel (Tschoegl 2004). The United States issued coins of 2¢ (1864-1873), 20¢ (1875-1878), 25¢ (1796 to the present), and $2.5 (1796-1929), and a US$2 note (Tschoegl 2001). Currently, Kuwait has coins of 50 and 100 fils, but notes of 250 and 500 fils, i.e., a quarter and a half dinar.

In recent years, in an example of a drift towards standardization, \(0.2\times10^k\) denominations have been superseding \(0.25\times10^k\) denominations. The euro follows the \(0.2\times10^k\) pattern, so when the Netherlands acceded to the European Monetary Union, it gave up its 0.25 and 2.5 guilder coins and 25 guilder notes.

At the same time, elsewhere heterogeneity has arisen as some countries, such as Japan and Korea, have done away with any subdivisions between \(1\times10^{k-1}\) and \(0.5\times10^k\). Japan had denominations of \(2\times10^k\) but gradually eliminated them. Furthermore, even in this sparse system, denominations of \(5\times10^k\) (e.g., ¥500 and ¥5000) are relatively unused (Kitamura 1997). Still, in 2000, Japan introduced a ¥2000 note to commemorate the year 2000 and Japan’s hosting of the G8 Summit in Okinawa.

The evolution of the system of denominations for a country’s currency is subject to both idiosyncratic and general influences. In the 1890s, the Banque des Iles Saint-Pierre et Miquelon issued banknotes with denominations of 27 and 54 francs as these were the counter value of US$5 and US$10 notes, the French collective territory of Saint-Pierre et Miquelon being 25 kilometers from Newfoundland, which was not yet a part of Canada. Myanmar provides another example of an idiosyncratic factor. In 1987, General Ne Win, the military dictator, implemented a redenomination program in which the government
issued banknotes with the denominations of 45 and 90 kyats. Both numbers are divisible by nine, which apparently is an astrologically auspicious number and General Ne Win’s favorite. A third case of an idiosyncratic denomination is the Russian 15 kopek (5 altyns; Muravljeva 2007), which has persisted from the Czarist era to the present, and has continued in the Ukraine as well. What makes the denomination anomalous is that both countries also issue a 10 kopek and a 25 kopek coin, making the 15 kopek redundant. From 1726 to 1990, Russia or the USSR also issued a 20 kopek coin (two grivens; Muravljeva 2007).

One influence, general in its frequency though idiosyncratic in its expression, has been experimentation, especially in the early days of a country’s decimalization. Thus before the British introduced their own currency to Malta, two local Maltese banks produced banknotes with denominations of 5, 10, 20, 30, 40, 100, 250, 300, 500, and 1000 scudi (Consiglio 2006). In this sequence the notes of 30 and 300 scudi were redundant. Redundant denominations of coins and notes have been more prevalent in the past and now tend to be uncommon, suggesting that the survival of a denomination depends in part on its relation to other denominations (Tschoegl 2001).

A common general influence has been inflation, which, together with the solving of the problem of small change (Sargent and Velde 1999, 2002; Selgin 2008), has led to the disappearance of the two-standard-units or three-standard-units currency systems. For instance, the post-World War II inflation in Japan (when the yen went from ¥4/US$ to the Bretton Woods rate of ¥360/US$) resulted in the disappearance of the rin and the sen, and the Bank of Japan took both denominations out of circulation in 1954. Now the Yen has

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7 As of mid-1999, banknotes with a denomination of ¥5000 accounted for less than five percent of all banknotes issued post World War II.
8 They set the value of the scudi at 12 per pound sterling, making each worth 20 pence.
only one standard unit and all coins and notes are decimal multiples of that unit. The same was true of the Italian lira until Italy adopted the euro.

Given sufficient inflation, the process can work in reverse when governments have redenominated to simplify record keeping. On 1 January 2005, the Turkish government introduced the New Turkish Lira (Yeni Türk Lirasi) of 100 new kuruş (yeni kuruş), with one new lira equaling one million old lira (Amado et al., 2007). This returned the kuruş to daily parlance where until then for many Turks it had been “a word out of history books and grandparents’ stories.”

Lastly, Durand (1961) remarked on the prevalence of round numbers in society, noting that that individuals quote prices and transactions occur disproportionately frequently at round numbers. Recently Knotek (2005) and Bounie et al., (2007), linked round prices to denominations. Knotek observed that often sellers charge prices that facilitate rapid, simple transactions. Often sellers set prices that coincide with common denominations; as a result transactions require few pieces of money or little change. Bounie and his co-authors applied estimation to a data set of representative French prices and found that rounding had a positive and significant influence on prices in the economy. Furthermore, buyers were more likely to use cash rather than other payment instruments for transactions involving round prices. The Knotek and Bounie et al., results suggest a symbiosis between prices and denominations. This may be a factor in the survival of redundant denominations when the redundant denomination coincides with the prices of some particularly common goods.

Tschoegl (2001) reports that in the U.S., the 1851 law that authorized the minting of the 3¢ also reduced the basic rate for mailing a letter from 5¢ to 3¢. Congress explicitly sought to make paying for postage stamps more convenient; one small coin of billon, a silver alloy,  

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9 I owe this evocative phrase to a Turkish former student of mine.
would replace three large copper cents. Papers in Lucassen (2007) point out other examples from various periods in the last millennium and in various countries as governments issued denominations that were convenient for paying wages.

6.0 Conclusion

Between 1700 and 1975, the world moved from a situation in which essentially no currencies followed a pattern of decimal denominations to one in which almost all did. The diffusion appears initially to have followed from normative isomorphism with decimalization appearing to be scientific and modern, and appeared first in Russia, the United States and Europe. In many cases coercive isomorphism played a role as colonial powers introduced their home practices to their colonies, replacing indigenous currency systems with systems modeled on home practice.

Mimetic isomorphism became operative as many independent countries came to adopt decimal currency as a sign of modernization when they created national money as part of a set of practices signaling nationhood. Similarly, countries achieving independence from colonial powers adopted decimalization of their new currencies to signal a break with the past in those cases where prior practice was non-decimal.

Whether countries adopted centesimal or millesimal systems was a consequence of cultural influences, as was the pattern of denominations. Factors such as idiosyncratic influences, learning, and experiences with inflation further brought both centripetal and centrifugal tendencies.

In all of this, the initial argument for decimalization was that it would make calculation easier. Yet the binary principle and the Carolingian system endured despite their supposed inferiority, suggesting that this argument was not compelling. Ironically, the
Carolingian system finally disappeared on the eve of the appearance of the electronic calculator that would have made moot the issue of ease of calculation.

When countries introduced the decimal system, they clearly recognized that a pure decimal system did not provide sufficient denominations to facilitate transactions, and they augmented it with denominations of $0.5\times10^k$ and $0.2\times10^k$ or $0.25\times10^k$. What emerges from this cross-sectional and diachronic study is the impression that binary currency is ideal for the medium-of-exchange function of money, i.e., pocket change and small bills for daily transactions, especially those involving bargaining, while decimal currency is better for the store-of-value function of money, i.e., easily countable denominations for squirreling away large sums.

How decimal currency came to supplant binary currency despite the lack of evidence for a clear superiority is an interesting question. The answer may rest in two factors. First, the inefficiency (in terms of the number of coins necessary to conduct the business of an economy) of a mixed system of decimals plus their halves and doubles relative to an entirely binary system is probably slight. Unfortunately, Nuño et al., (2005) do not estimate the average number of coins in a person’s pocket for a binary system. For the Euro they estimate the average as 14, versus 11 for the U.S., and 23 for the Yen.

Even a slight increase in efficiency would probably still be enough to result in the survival of binary currency over its decimal alternative, were it not that decimalization accompanied the rise of the nation-state, which took as one of its characteristics the monopoly of the provision of legal tender. Smith (1990, pp. 4-5), argues that this monopoly owed more to political motives and historical accident “than with any well-considered economic principle.” Quickly, monopoly “became a dogma which ... was accepted without question or comment in all the later foundations of central banks” (Smith 1990, p. 168).
With the advent of a monopoly supplier of money, decimal money did not have to compete with binary money. Furthermore, the slight inefficiency, if any, of decimal money simply increased the state’s seignorage, undermining any state’s incentive to undo it.

Selgin (2008, 149) quotes Herbert Spencer to the effect that:

So constantly have the ideas of currency and government been associated—so universal has been the control exercised by lawmakers over monetary systems—and so completely have men come to regard this control as a matter of course, that scarcely any one seems to enquire what would result if it were abolished. Perhaps in no case is the necessity of state-supervision so generally assumed, and in no case will the denial of that necessity cause so much surprise.

Spencer denied the necessity and argued that commercial coinage would result in good money driving out bad (Selgin 2008, 149). Such a situation would beg the question of whether a system of binary denominations might reappear. The question is, however, increasingly moot as electronic means of payment replace cash.
Bibliography


Smith, V. 1991. The Rationale of Central Banking, Liberty Press, Indianapolis, IN.


