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Reconstruction of Money Supply Over the Long Run: The Case of England, 1270-1870

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RECONSTRUCTION OF MONEY SUPPLY OVER THE LONG RUN: THE CASE OF ENGLAND, 1270-1870[1]

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Abstract

I provide a time-series series for coin and money supply estimates for six hundred years of English history. I propose two main estimation methods. The first (the direct method), is used to measure the value of government-provided, legal-tender coin supply only. I propose two varieties of the direct method. Additionally, I propose an indirect method which relies on a combination of information about nominal GDP with an assumption regarding the evolution of velocity in time, and which can be used to calculate coin supply and M2. Both methods rely on benchmark values known for certain years, but no particular benchmark is determinant for the results. The new methodologies which I set out here may serve as a blueprint for a similar reconstruction of coin and money supply series for other economies for which analogous data is available.

Keywords: monetary history, historical money supply

JEL codes: E01, E40, E51, N13

I

In this paper I provide the first annual time series of coin and money supply estimates for about six hundred years of English history. I present a baseline set of estimates, but also consider a variety of alternative scenarios and provide several robustness checks. I concentrate on carefully setting out the details for the data construction, rather than on analysis, but the hope is that these new estimates – the longest such series ever assembled, for any country – will open new vistas to help us understand the complex interaction between the real and the monetary sides of the English economy, at both business-cycle and long-run frequencies. Furthermore, the new methodology which I set out here may serve as a blueprint for a similar reconstruction of coin and money supply series for other economies for which the analogous required data is available.[2]

I propose two new estimation methods. The first, which I call the "direct method", is used to measure the value of government-provided, legal-tender coin supply only. In this method, I do not consider broader forms of money such as banknotes, deposits, inland bills of exchange, government tallies, exchequer paper or private tokens, which became increasingly important from the seventeenth century onwards. Additionally, I propose an "indirect method" which relies on a combination of information about nominal GDP with the value of coin supply or M2 known at certain benchmark periods. This permits estimating the volume of a broader measure of money supply over time.

The paper is organized as follows. In section II, I discuss how the English monetary system differed from that of today, both in terms of what constituted money, and how monetary policy was conducted. In section III, I describe my "direct" estimation method for coin supply. In section IV, I describe my "indirect" estimation method, which can be used to estimate both coin supply and a broader measure of money supply. I also compare the resulting series from both methods, generate a broader money supply measure which can be compared with coin, and consider some robustness checks.[3] Finally, in Section V, I conclude.

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[2] Flandreau, *The Glitter of Gold*, pp. 75-96 and 220-225 discusses a related method, which requires a different kind of data and makes other types of assumptions.

[3] I show (at the end of section IV) that no benchmark is determinant for the general pattern of my results.

II

I start by discussing the role of mints in providing liquidity in the English context. In modern economies central banks issue fiat currency and engage in monetary policy. In early modern economies including England central banks with these functions did not exist. The Bank of England was created in 1694, but it was a private institution and not a central bank in the modern sense, although it did gradually began to play a public role by providing liquidity to the economy, in particular to other banks and to the government.

Yet to say that central banks officially endowed with modern functions did not exist is not the same as saying that governments did not engage in monetary policy. In a nutshell, monetary policy for premodern economies can be helpfully identified with mint policy. Agents were free to take precious metals to the mint and the government chose at which rate these were exchanged for coin, whether to charge a mint fee[4], and which denominations to issue.

Given both the mint price and the market price of precious metals, the public decided how many coins to mint and how many to melt or export. In terms of circulation value, there was a premium in low denomination coins due to both cost, since lower denominations were proportionally more expensive to produce, and convenience, since lower denominations had proportionally higher value due to additional convenience as small change.[5] Coins were valued not just proportionally to their precious metal content but by tale (number), that is, according to their face value.

Since central banks in the modern sense did not exist during this period, money cannot be defined as liabilities of central banks and credit institutions towards the public. An alternative, if close, definition for M0, M1 and M2 is required. The main point to be realized is that these are progressively less liquid assets, defined as such both in terms of divisibility and general acceptability as well as how quickly redeemable they are.

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[4] This brassage cost was in addition to the seigniorage fee which is the difference between the market value of the precious metals and the cost to produce the currency which was given in exchange. In England, mint charges were abolished in 1666, with the exception of small fees for the assayer and porter; Craig, *Mint.*

[5] Sargent and Velde, *Small change*, p. 322. Acceptance by tale was also normal for larger denominations, while there were some restrictions on the numbers of coppers enjoying "legal tender" status. See Desan, *Making Money,* on the rule of payment by tale in England, and Fox and Ernst (eds.), *Money,* for Europe as a whole.

I use the term *coin* referring to official (legal tender) bullion-based coin, regardless of whether it was circulating by tale or not.[6] One major distinguishing characteristic of legal tender coin was that, measured in value, the "intrinsic" component was an important part of the overall value, that is, much of it was composed of silver or gold coins.[7] As for private tokens and other fiat money, these are conceptually part of currency (even M0) but are not here defined as "coin".[8] Hence my definition of coin supply is a subset of M0.

Thus coin supply differs from currency supply; it excludes bills of exchange, tokens, and notes in circulation.[9] To avoid confusion, I avoid the term M0 altogether.[10] It is important not to place too much emphasis on anachronistic classifications such as M0 and M2. What for the present purpose does matter is to separate coin (for practical purposes, "quasi-M0") from "everything else", that is, all other assets sufficiently liquid to be potentially classified as "money".

III

The baseline estimation method relies on information about the value of the coin stock which is known for certain periods. When the type changed (e.g. 1279), or when the hammered coins were demonetized (1696), all the previous coinage still in circulation was called in and we know the value (and the distribution) of the total coin stock quite precisely. In other periods, only earlier coins of good weight would have yielded a profit on recoinage,

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[6] Circulation was almost always by tale, with no discount for weight or fineness deficiencies: see Munro, 'Coinage Debasements'. Nevertheless, the Great Debasement period may have been an exception; Rolnick et al, 'Puzzle'.

[7] There were also some copper and tin issues of small denominations. The data shows that mint output for these was usually zero, but there were times in the seventeenth and nineteenth centuries in which the quantities minted were far from negligible.

[8] Capie, 'Money', for instance, defines the monetary base as including banknotes and bank balances at the Bank of England, but also recognizing that "privately issued tokens were at times widespread" (p. 225)

[9] In modern terms, it is usually made clear that only money in circulation counts, that is, we do not include those in the hands of central banks and in the vaults of depository institutions. Since no reserve requirements existed in the period under study, however, no such proviso is necessary. While it is possible that under some periods some currency was being hoarded, such quantities should count, just as today cash in the hands of families does.

[10] Unlike what would be true for a modern economy, notes were less liquid than currency, since until quite late they were only issued in high denominations. It was only in the last decade of the eighteenth century that £5, £2, and £1 notes were issued by the Bank of England. Only then were the latter low enough to pay a laborer's monthly wage; Schwarz, 'Standard of Living'. As time went by, banknotes became increasingly closer substitutes to coin, even for small payments, so the boundaries became fuzzier.

but painstaking work by monetary historians has led to several secure values for the stocks at several points in time (Table 1).[11]

My goal is to estimate the volume of coin circulating in England (and Wales). This cannot be identified with sterling because sterling also circulated (to a varying degree) in Scotland, Ireland, and the Isle of Man during the eleventh to late fourteenth centuries.[12] However, many of the current estimates for in England in the Middle Ages in fact reflect estimates more properly applicable to the whole of Britain and Ireland. Consequently, I apply to the existing estimates a correction factor of 70% up to 1290, 83% up to 1377 and 90% until 1422.[13]

Evidently, some estimates are more secure than others.[14] The most secure estimate is that of 1870[15], but earlier figures that are based on either full or even partial recoinages can also be safely trusted. An example of the latter is the "Great Recoinage" of 1696: it was a partial recoinage because gold was not subject to it, but together with complementary information it leads to what is almost certainly a good approximation.[16]

Still reasonably secure are the figures marked as "proxies" in Table 1. These cases are inferred by indirect evidence. The first form of such evidence comes from the dies used to produce the coinage. Coins were struck to completion by placing a blank between two dies and hammering. Surviving coins individually identify their corresponding dies, allowing the number of dies used to estimate the volume of coinage (Allen 2001, p. 597). Another form of indirect evidence used have been archaeological evidence for finds of coins (hoards). The English civil war produced many coin hoards as a side-effect, which have been put to use in

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[11] When only a rage of figures is given for a certain year, I take the midpoint as the preferred figure which I use to produce my annual estimates. In the data file which accompanies this article, I additionally provide lower and higher bounds by using the corresponding figures in the range.

[12] Allen, 'Sterling area'.

[13] Campbell, 'Benchmarking', pp. 919-21, Allen and Oddie 'Revised Estimates', pp. 255, Allen, 'Sterling Area', p. 13.

[14] There is a high level of scholarly consensus about most figures. The most controversial is perhaps that for 1319, where I follow Mayhew, 'Prices'; by contrast, Allen and Oddie, 'Revised estimates', suggest £1.88-2.41 million, while acknowledging that the figure for England and Wales might be only about 83% of that.

[15] Capie and Webber, 'Coin', pp. 192-202.

[16] Mayhew, 'Money supply', p. 251. Note that gold and silver coinage exhibited different wastage rates. Silver was typically more worn, as gold coins were of higher denominations and more likely to be held; see Velde, 'Evolution'.

this context, as they indicate which proportions of coin date from which periods.[17] Finally, the figures marked as "guestimates" are the least secure. There are based on historians' overall understanding of available quantitative and narrative evidence. Unfortunately, there is a concentration of these during the Tudor period.

While the figures discussed so far provide a static snapshot of the value of coin for given years, mint output data provides much useful information about the flows for years between the stocks in Table 1.[18] Detailed annual estimates exist for the Tower of London mint output (Figure 1) and up to the 1840's it is safe to say that these would have gone directly into circulation.[19] However, simply summing up mint output over time to any given stock from Table 1 would lead to numbers which overestimate the amount of coin in circulation, and hence are inconsistent with the following corresponding stock also observable from Table 1. This is because using that method coin melted down but subsequently again minted is double-counted. Furthermore, much coin was carried abroad in the context of war, diplomatic payments, or trade, and this means that total coin supply at each given moment differed from the accumulated sum of mint output. Finally, in years of recoinage, much coin would have been withdrawn. Since the true value of coin supply is known at relatively regular intervals, however, it is possible to partially correct for such biases by manually adjusting the residual for key years. The precise way in which this is done is what distinguishes the "direct method A" from the "direct method B", the latter corresponding to the best estimates.

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[17] Mayhew 'Money Supply', p. 241, 246-7, Mayhew, 'Prices', Besly, 'Hoards', Besly, *Medals.*
[18] All stocks are end-of-period stocks (when necessary appropriately annualized to the year on which the majority of the period refers to; after 1660 all variation corresponds exactly to the civil year).
[19] Capie and Webber, 'Total Coin'; Capie and Webber, *A Monetary History.* I also consider provincial mints below.

Year	Coin stock value (preferred estimate)	Implied V of coin stock	Type of estimate	Year	Coin stock value (preferred estimate)	Implied V of coin stock	Type of estimate
1279	0.46	8.7	Full recoinage	1549	1.92	4.35	Guestimate
1282	0.58	7.85	Proxies	1551	2.02	5.71	Guestimate
1290	0.81	4.73	Proxies	1560	1.71	6.89	Guestimate
1299	1.04	5.26	Proxies	1561	1.45	8.82	Elizabeth's recoinage
1310	1.41	4.63	Proxies	1600	3.5	6.65	Proxies
1319	1.70	3.23	Proxies	1643	10.0	3.91	Proxies
1331	1.41	3.81	Proxies	1670	12.0	3.90	Proxies/Guestimate
1351	0.64	7.20	Partial recoinage plus proxies	1688	10.0	5.14	Proxies
1377	1.58	2.73	Proxies	1700	10.75	7.07	"Great Recoinage" of 1696-9
1422	1.62	2.29	Proxies	1750	18.0	5.06	Guestimate
1470	0.85	4.53	Full recoinage	1790	44.0	3.88	Guestimate
1526	1.40	3.5	Guestimate	1833	49.68	7.76	Guestimate
1546	1.45	5.98	Guestimate	1846	46.56	11.08	Guestimate
1548	1.76	3.97	Guestimate	1870	95.0	10.80	Proxies*

Table 1. Benchmarks for the value of English nominal coin supply and implied velocity, 1270-1870. Sources: For 1279-1470, see Mayhew, 'Prices', who in part relies on Allen, *Mints*. The partial recoinage leading to the figure for 1351 is discussed in Mayhew, 'Money and Prices', and the full recoinage leading to that of 1470 is discussed in Mayhew, 'Monetary Background', and further improved by Challis, Hastings, p. 195 and Mayhew, 'Money supply', p. 245. A correction factor for outside circulation has been applied; this corresponds to 70% up to 1290, 83% up to 1377 and 90% until 1422. For 1526 to 1700, see Mayhew, 'Prices', pp. 26-29, where 1551 corresponds to an average of the two available estimates for that year. For 1643, civil war coin hoards were used; Mayhew, 'Money supply'; Mayhew, 'Prices'. For 1688-1750, these are the estimates of Cameron , 'England', endorsed by Mayhew, 'Prices', p. 30. For 1790, see Capie, 'Money', p. 222-225. For 1833, the figure is an adjustment (explained below) based on Huffman and Lothian, 'Money', p. 170; for1846 the figure is an adjustment (explained below) based on Collins, 'Growth', p. 384. For 1870, see Capie , 'Money', pp. 222-225), which in the latter case relies on Capie and Webber, *A Monetary History* , pp. 192-202, which in turn largely rely on Jevons, 'Condition'. *Despite being based on proxies, the 1870 benchmark is quite secure; see the discussion in Capie and Webber *A Monetary History*.
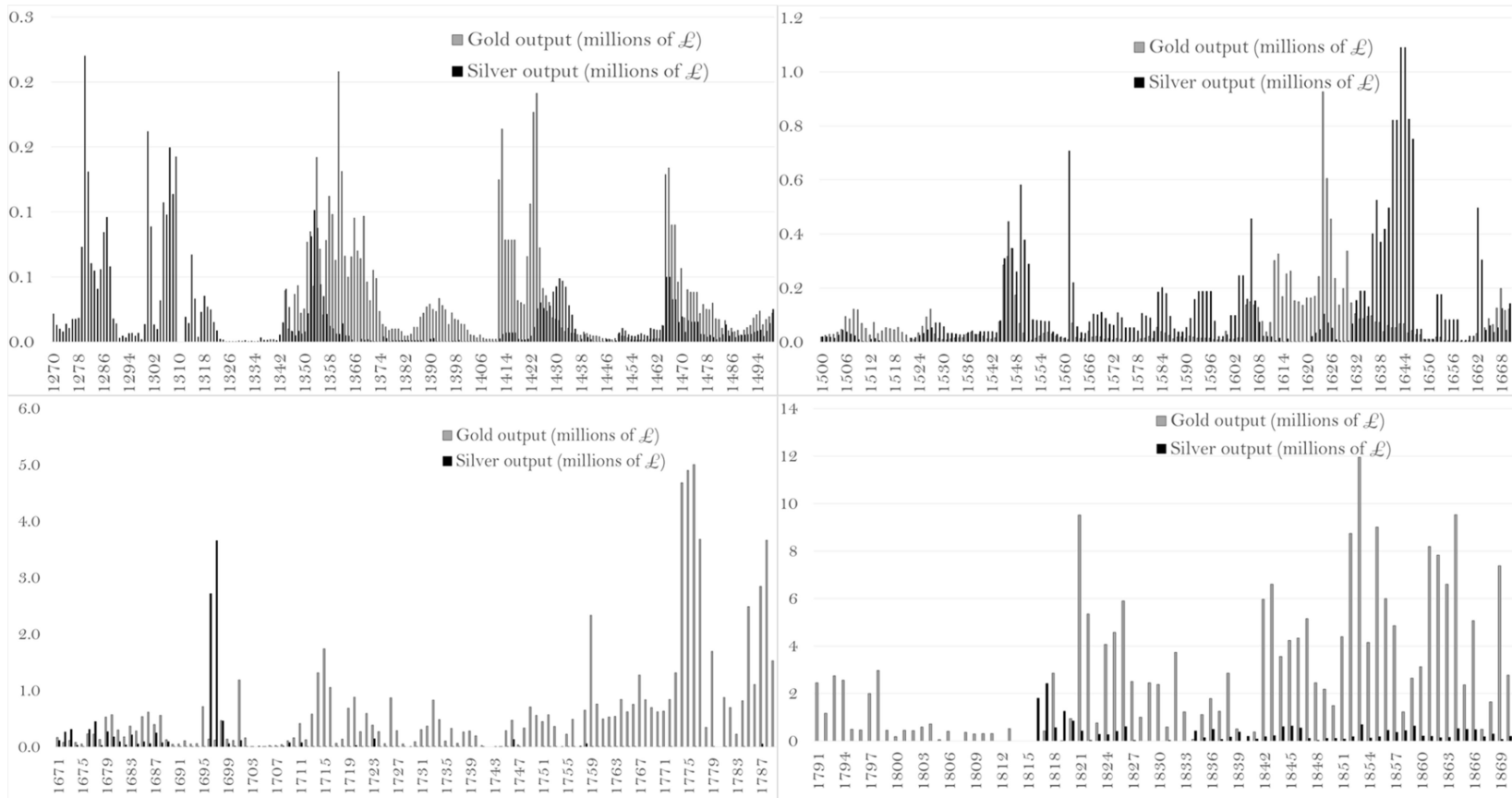
Figure 1. Gross mint output, 1270-1870. Peaks often correspond to recoinages and mint price changes. Source: Challis, *Hastings*.

Previous estimates

In a related piece of work, Mayhew acknowledges the need to target successive known stocks by estimating annual coin supply by deducting estimated wastage from known output, alternatively using 2% or 4% assumptions on annual wastage.[20] Notwithstanding the usefulness of Mayhew's attempt, I use a different approach, with the objective of arriving at estimates for which much less true variation is lost. Annual variation in wastage can be estimated with much additional precision for two reasons. First, some components of wastage can be accounted for from annual data, as explained in detail below. Second, even after this is controlled for, instead of assuming fixed percentage wastage rate levels over the remainder, it is possible to let these vary endogenously at an arithmetic rate, such that wastage is whatever it needs to be annually such that we arrive at the following available coin supply benchmark as discussed below.

General methodology

Changes to the value of coin supply are given by:

$$dC_t = O_t + P_t + X_t$$

Where dC_t is a flow variable corresponding to the change in the value of coin supply (C_t), O_t stands for net mint output for that year, P_t corresponds to melting of coin, and X_t is a residual. I now discuss each of these right hand side variables in detail.

O_t is expressed in net terms because gross mint output overstates the annual change in the money stock in years of recoinage or those of net outflows of specie.[21] Hence,

$$O_t = new\ coinage_t - recalls_t$$

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[20] Mayhew, 'Quantity theory'.
[21] As Glassman and Redish, 'New Estimates', p.32 notice, when discussing the French case, that 'Balance of payments surpluses were recorded in mint output, at least when settled in coin taken to French mints. Balance of payments deficits, however, caused specie exports not recorded in mint output'.

Because I estimate the value of coin supply in circulation (assumed to be circulating by tale), I do not need to explicitly consider clipping or sweating.[22] However, one limitation to the estimation of O_t from mint output data by using the Tower records is that these only cover the Royal mint, but until 1553 other mints were in operation in several English towns.[23] I have applied a partial correction for this by using the additional information in Munro (1983, p. 127-37), but it must be recognized that much variation in provincial mint output remains unaccounted for at an annual level. However, notice that this will not lead to systematic biases over the long run since the stocks in Table 1 above have already corrected for this by using estimates adjusted to the output of provincial mints (Allen 2001, 2012).

The presence of P_t, the change in melted coin, is required because the proportion of precious metals which finds its way into the monetary base changes as agents change how much is hoarded as bullion (in a strict sense or in bars) or held in plate.[24] Notice that precious metals melted to be used as plate leave circulation but not those hoarded as coin; when savings in the form of cash increase and people are hoarding currency the circulating fraction of money supply decreases, but in an aggregate model this simply corresponds to a decrease in velocity. We know both the value of silver hallmarked by the London Company of Goldsmiths, which had the monopoly over hallmarking of silverware and jewelry as well as gold, and that of exports from the East India company.[25] Nevertheless, it is not clear that all quantities hallmarked or exported annually correspond to quantities of decreased coin, since they could also correspond to changes of quantities of bullion held by the public.

Finally, X_t denotes a "wastage" residual that includes coin melted down[26] or exported. Allen (2012) provides estimates based on information from the distribution of finds in coin hoards. Until the early modern period, the residual X_t includes undocumented provincial

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[22] In the words of Mayhew, *Sterling*, p. 79: 'in England practical experience showed that all but the most grotesquely butchered money in fact passed at face value'. Furthermore, weight loss per unit of time has an approximately constant mean, as shown by Velde, 'Evolution', a fact well-captured by my methodology.

[23] The Tower's mint output data is reproduced in Challis (ed.), *A New History*. Regional mints opened during some exceptional periods of the early modern period such as the Civil War when a Royalist mint was briefly set up and the Great Recoinage; Challis (ed.), *A New History*, includes supplementary information for these periods, which I include in my calculation.

[24] Mayhew, 'Silver in England'. The period of the dissolution of the monasteries has one of the lowest subsample residuals in my results, which is consistent with dishoarding, i.e. the melting down of newly available plate; Challis, *Tudor Coinage*, p. 154.

[25] Mayhew, 'Silver in England'.

[26] i.e. the specie is turned back into bullion to be sold in the market or exported.

and ecclesiastical mint output from the Bristol, Bury St. Edmunds, Calais, Canterbury, Chester, Coventry, Durham, Lincoln, Norwich and York mints. In the earlier periods, the unrecorded outputs of provincial mints could be substantial – more than one third of total estimated output in three periods between 1279 and 1351 (Allen 2012, p. 312). Hence during the medieval period the money supply must have grown faster than what would be suggested by looking at the (Royal mint) Tower records only. But using my baseline method, the residual between benchmarks will automatically absorb this bias, and only some of the short-term variation associated with between-benchmarks variation in provincial mint output will be lost. Furthermore, this lost variation is always limited since as previously mentioned Tower mint output was never less than two thirds of total mint output, and usually it was a good deal more.

Direct method A: the naïve direct method

Since for some years we know the value of the stock of coin in circulation (Table 1), it is possible to calculate the annual residual as an annually uniform "whatever it needs to be" in the intervening period between benchmarks so that the estimated coin supply at the next period for which we observe it matches the predicted value, that is, after all the intervening $\{O_t\}$ and $\{P_t\}$ have been accounted for.[27] I call this the "direct method A". The resulting annual estimates are shown in the broken grey line of Figure 2.

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[27] Hence notice that while this residual is unobserved at an annual level, the information contained in stocks which we observe force it to be "correct on average" between these.
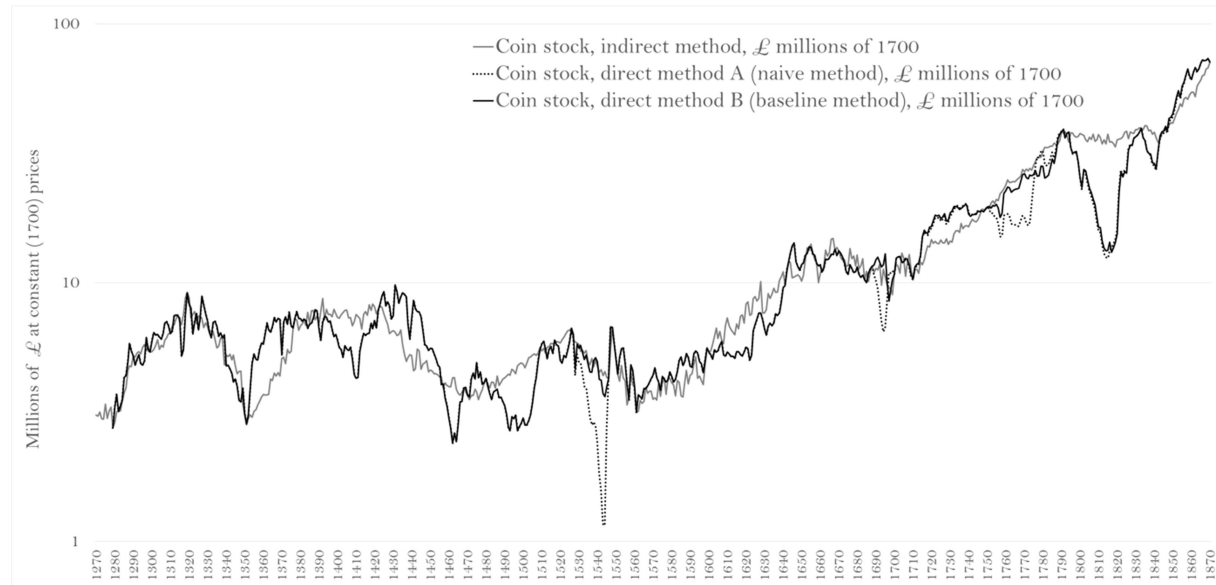
Figure 2. English nominal coin supply, 1270-1870 (log scale of base 2). The periods when direct method A cannot be seen means it coincides with the baseline method (aka direct method B). Source: my calculation based on a series of sources; see text for details.

Direct method B: the baseline direct method

Direct estimates A implicitly assume that recalls were uniformly distributed between the known stocks. This was not the case: recalls were often concentrated in time. They usually happened in the context of recoinages associated with devaluations[28], and ignoring this would lead to misleading estimates, with predicted (but spurious) peaks of coin supply, due to double-counting, at the time of recoinages, such as the 1690's and the 1770's, clearly visible in Figure 1. Hence the estimates can be further improved upon by paying close attention to each of the "suspect" periods which can be identified both from the narrative literature and from informal comparison with the indirect estimates which will be discussed in section IV, and making appropriate adjustments as necessary.[29] I now discuss the periods for which I have done so to improve the credibility of the resulting baseline estimates.

The Tudor debasement period. The Tudor debasement (and devaluations) period (1542-1560)[30] constitutes an important period of monetary disruption.[31] The bullion content of the pound sterling fell by 25% in gold and 83% in silver.[32] In 1551 after the worst issues of that year, Edward resumed fine silver issues, devaluing the base issues but leaving them in circulation. This situation continued under Mary. However, Elizabeth did demonetize all the earlier base issues, when she re-established fine silver as the only legal issues. In that sense, hers was the only proper recoinage, providing an indication of the size of the money stock.[33] Even once the fineness was partly restored during Elizabeth's reign, the bullion content of English coin was 25% less than it had been before Henry VIII's Great Debasement.[34] In practice, this would have meant that more coin was minted than otherwise would have been

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[28] Hotson, 'Stabilizing', p. 6-7.

[29] Since velocity only changes very slowly at best over the long run, a prolonged deviation of the direct estimates from the indirect is a red flag.

[30] There is some debate in the literature concerning wherever the Great Debasement started 1544 or at an earlier date (see Challis, *Tudor Coinage*, and Munro, 'Henry VIII'. But it only became (gradually) discovered by the public after 1544; Mayhew, *Sterling*, p. 45.

[31] Following a series of debased issued under Henry VIII and Edward VI, there was no formal recall of the earlier better coins, but there was profit to be had recoining better coins into more (but baser) new coins.

[32] Ling-Fan, 'Bullion', p. 75.

[33] Gould, *The great debasement*, Challis, 'Hastings', Mayhew, *Sterling*.

[34] Ling-Fan, 'Bullion', p. 88.

possible, but this is automatically accounted for by assuming that money circulated by tale (even when not full-bodied) and accounting for money supply in sterling, as I am doing here.[35]

Henry VIII's aggressive debasement was launched on the public in May 1544, and once this was the case people could gradually find out that they were being fooled by assaying the coins.[36] Accordingly, successive devaluations were required to sustain the debasement policy: the mint price increased once in 1545 and twice in 1546.[37] I assume that, due to these changes plus the operation of Gresham's law, £0.5 million was reminted (or hoarded) in 1545 and another £0.5 million in 1546.[38] This leads outflows during 1527-1544 to be £0.09 million per year, followed by the £1 million concentrated in those two years which – despite the uncertainly in the numbers – is surely more realistic than assuming a constant outflow of £0.13 for 1527-1556, as is done using direct method A. No such ad-hoc adjustment is required for the following years because we have successive benchmarks for the coin stocks in 1548, 1549, 1551, as shown in Table 1.

The great recoinage of 1696-8. The great recoinage was caused by a number of factors including the need to substitute the badly worn out (and clipped) coinage. All existing coins were demonetized, and could be reminted for free as long as they were surrendered within certain time limits.[39] The intellectual debate surrounding the recoinage has been studied in detail and does not need to be repeated here.[40] It is, however, important to understand that because the Locke-Newton position prevailed *vis a vis* that of Lowdes, the money supply may have fallen by up to 40%. About £9.6 million in face value was retrieved for recoingae, £4.7 million of which was accepted in face value, being that the rest was only accepted by weight.[41] Clancy writes that "[t]he vast majority, in the region of 10 million, of the old currency was

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[35] Some coins must have occasionally circulated at a discount, despite proclamations threatening punishment to those refusing to accept coinage at face value; but it is difficult to know the extent to which this happened. At the same time, if Gresham's law was operating at this time, is it more likely that sellers faced with incomplete information about coin quality (and who did not have the instruments or did not want to pay the cost to assay the coinage) would have simply raised prices; there is, indeed evidence that price rises started from the time of the onset of debasement (Mayhew 1999, p. 50).

[36] Mayhew, *Sterling*, p. 45.

[37] Challis, *Tudor Coinage*, p. 171.

[38] This is consistent with the view that at the outset of debasement, new coin could be got rid of easily, and the Crown could rely on higher mint prices to ensure an adequate mint output, a strategy which would have worked best early on, while the public did not suspect it was getting back debased coinage (Challis 1978, p. 182)

[39] Horsefield, *Experiments*, p. xvi.

[40] See for instance, Horsefield, *Experiments*, p. 51-52 or Sargent and Veld, *Small change.*

[41] Craig, *Royal Mint*, p. 193.

withdrawn over the course of several years and what remained unaccounted for was in any case demonetised in January 1698 ... 6.8 million was produced to replace the hammered money, which meant that the resulting silver circulation was reduced by 38 per cent".[42]

Hence I input that in the 1696 and 1697 years the residual has to be Clancy's 10 million (by assumption divided evenly between 1696 and 1697), and otherwise I follow the usual methodology as in the previous subsection. This leads to an important – and much more historically realistic – result when compared with the direct A (naïve) estimates of the previous subsection. (The practical difference is illustrated in Figure 3.) Hence my direct B (baseline) estimates indicate that the value of the coin stock fell in real terms from 12.4 million in 1695 to 10.2 in 1696 and 9.0 in 1697.[43] Then, it restarted growing.
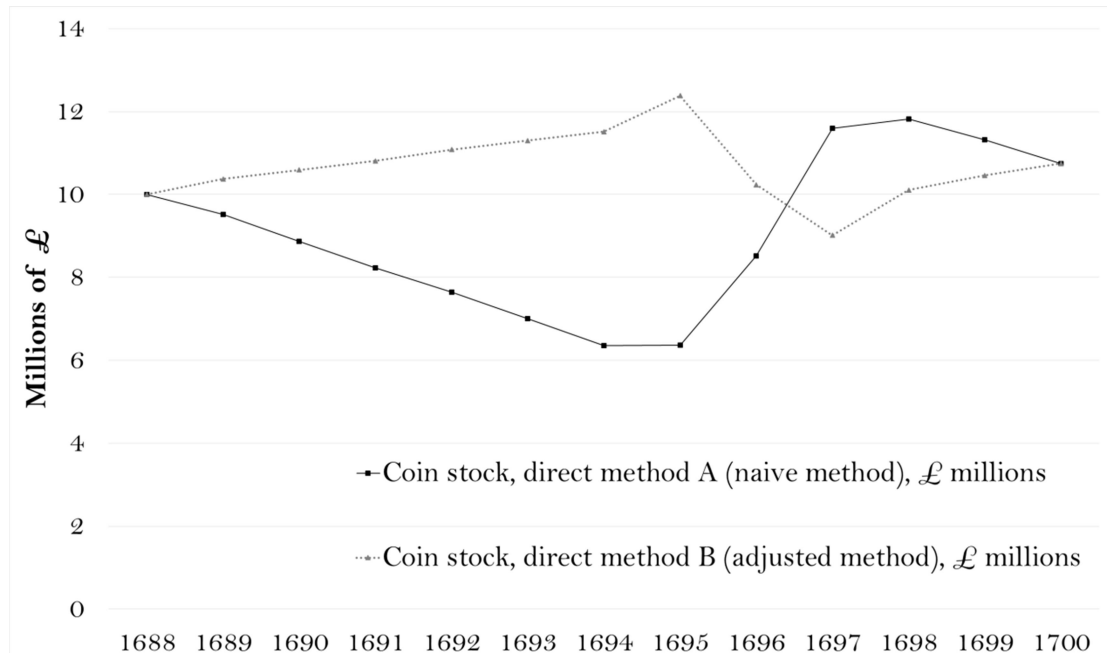

Figure 3. Recalls correction made for the Great Recoinage period.

The 1733-4 recoinage. Challis mentions a partial gold recoinage in these years of "more than 15,500 lb of old hammered coins", which were withdrawn and recoined. Since Newton's 1718 indenture, one troy lb corresponded to £46.725; hence an average of about

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[42] Clancy, *Recoinage and Exchange*, p. 15
[43] See Horsefield (1960, p. 256) for comparison with contemporary estimates.

£362 thousands per year will have been recoined in those two years.[44] These are the additional outflows I assume for those two years in the baseline estimates. (In addition to the 207 thousands estimated residually.)

The 1773-7 recoinage. Once the quality of coinage began to be threatened, a gold recoinage took place in the 1770s.[45] Challis suggests the £16.5m in gold minted then represented about 75% of the total gold coin supply.[46] Also according to the same source, the recoinage took four years to complete, 1773-7. I hence assume an additional outflow of £4.125m per year over this period in the baseline estimates. Adding the regular residual then increases the total to £4.397m over these four years.

The 1790-1870 period. It is harder to give precise estimates for coin supply over this period than for earlier periods. One difficulty is that after the creation of the issue department of the Bank of England with the Bank Charter of 1844, royal mint coin output can no longer be considered to go directly into circulation. It hence becomes more difficult to infer precisely the timing of coin supply increases from mint output data. But we at least know where to end: the year 1870 is the first for which we have relatively certain data. Table 2 compares the existing competing estimates for the stock in 1870 (Table 2). Annual estimates for both coin and M2/3 under circulation which go as far back as 1833 are available.[47] However, as emphasized by Capie and Webber, a key element underlying both is Sheppard's coin circulation figures for 1880, which Capie and Webber argue persuasively to have been an overestimate – hence the earlier estimates would have been too small.[48]

[44] Challis, 'Hastings', p. 439.
[45] Hotson and Mills, 'London's market', show that silver prices drove gold prices from 1721 to 1773.
[46] Challis, Hastings, p. 440.
[47] Huffman and Lothian, 'Money', Collins, 'English Banking'.
[48] Capie and Webber, *A Monetary History*; Sheppard, *Financial Institutions*. See also Adie, 'Deposits', and Collins, 'Deposits', for a flavor of some of the conceptual difficulties from estimating important elements of the money supply during the 1790-1870 period.

	Huffman and Lothian (1980)	Collins (1983) (1866-1870 mean of end-of-year figures)	Capie and Webber [1985, tables I(1), I(4) and I(9)]	Capie (2004, p. 222, 224)
Coin stock	95.4	87.5	85.449	95
Monetary Base/High-powered money (M0 or H)	153.4	128.4	134	141.4
Money stock (M2/3)	-	379.7	540	540

Table 2. Value for the several monetary aggregates circa 1870, as proposed by several authors. Unit: £ millions.

Accordingly, I have inflated Huffman and Lothian's 1833 figure of £41.4 million by an admittedly arbitrary 20%, and I have done the same with Collins's estimate for £38.8 million for 1846 – which leads to £46.56 million, similar to Huffman and Lothian's £46.2 million for the same year (Figure 5).[49] The Capie-Webber critique suggests this is preferable to taking the original figures, but the resulting estimates for this period surely carry a greater margin of uncertainty than for others.

Although the Capie-Webber critique is not unsubstantial, it needs to be put under some perspective. First, since these series are nonstationary, for many econometric applications the series will need to be used in first differences (should different subsamples be found to have a unit root). This means that divergences about the exact stocks at each moment are much less important that the timing of growth rates, which we can indeed estimate with a reasonable degree of accuracy.[50] Second, there is agreement about the broad magnitudes at stake, and the divergence is not as large as one might think (Table 2). Indeed, Capie's more recent estimate for both coin and M0 has moved closer to that of Huffman and Lothian.[51] Third, as before, informal comparison with the indirect method can ensure that the absolute level of the direct method estimates do not fall too much out of line.[52]

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[49] Huffman and Lothian's 'Money', p. 170, Collins, 'English Banking', p. 384.
[50] Though of course, the absolute levels will still matter if cointegrating or error-correction relationships are involved.
[51] Capie, 'Money'.
[52] This is where the usefulness of the indirect estimates most clearly comes to light – they put discipline on the long term trends of the direct estimates.

In any case, there is no question that the period after 1790 is one for which there is more fundamental uncertainty about the true value of coin and broader forms of money supply, until the light is turned on again in 1870. Figure 2 illustrates the "double-dip" divergence which results from the baseline and indirect estimates for this period. As expected, major divergences in the results obtained by different methods occur at times of known monetary disturbance, most notably c.1542 and 1820, for which we only have incomplete information.

The bullion crisis period goes from approximately the period immediately preceding the bank restriction act (1797) to the formal establishment of the gold standard (1819-21). It could have turned into a full-fledged financial crisis and indeed it is one of the "crises which did not happen".[53] For the present purposes, this period is relevant because of the unusual levels of hoarding and bullion export. As suggested by the direct estimates in Figure 2, there was very little minting of coin during this period[54]; the bullion crisis was due to the sharp divergence of the market price from the official price of gold (Figure 4).
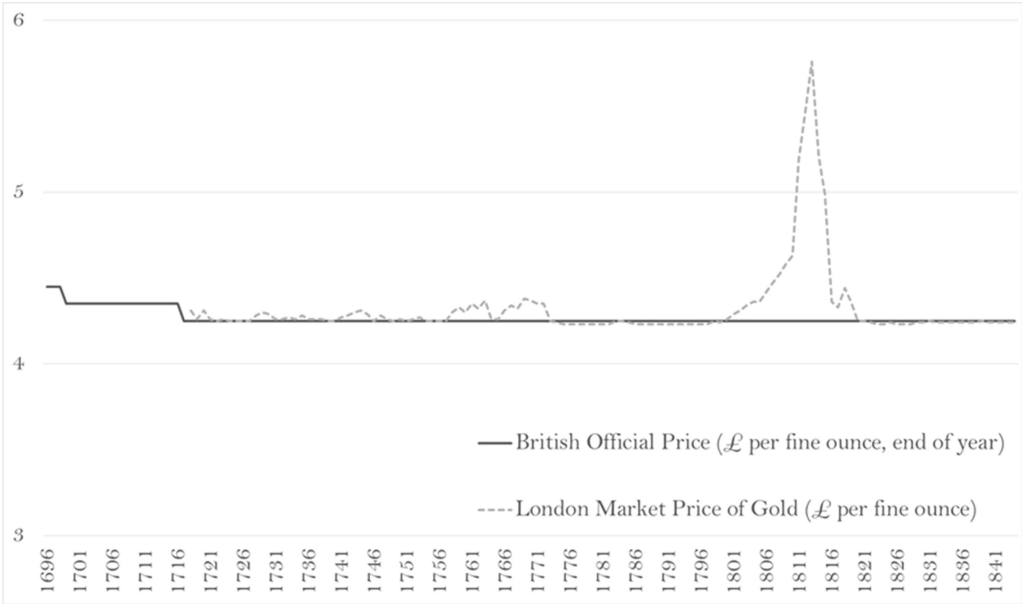

Figure 4. Official and market price of gold. Sources: Officer (2016)

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[53] These are too often ignored by economic historians for that very reason, though in principle we should all agree that from a policy perspective we can learn at least as much from them as from those that did turn sour. The reasons why this crisis did not turn into a full-fledged financial crisis are explored in O'Brien and Palma, *Old Lady*.
[54] Challis, *Hastings*.

A major recoinage and exchange took place during 1816-21. Its immediate motivation was the end of the Napoleonic war and the need to pave the way for the Bank of England to return to convertibility, which had been suspended with the restriction act of 1797. It is known that £12.6 million of old silver coin were withdrawn from circulation in 1817[55], and I have accounted for this in the baseline estimate. Still, the "double-dip" behavior of the baseline direct estimates visible in Figure 6 remains suspect, especially in light of the fact that the indirect estimates based on nominal GDP suggest no similar behavior, so there would have needed to have existed sharp changes in velocity at those times. It seems likely that the monetary stock around 1815 was much higher than is suggested by the direct method, and much more in line with what is suggested by the indirect method, due to the monetary experiments which resulted from the Napoleonic wars.[56] But without a good estimate of the stock from a source independent of income, the adjustment required by the baseline method cannot be made. The best hope for such a measure would be the 1816-17 "Great Recoinage", but unfortunately Clancy does not offer an overall figure for the amount withdrawn.

In future work it may be possible to refine method B by taking into account that mint price rises were used to induce people to bringing gold or silver to the mint, whether in the form of old coin, hoards, plate, or foreign bullion. Mint production was determined by mint prices offered for bullion (both in England and elsewhere), and how they compared with price of silver or gold in the open market, for export or as offered by the goldsmiths.[57] Mint price rises often eliminated the misalignment between the mint price and current market prices for precious metals. But availability of bullion to be coined could at times increase for reasons unrelated to mint price increases.[58]

IV

The indirect method estimates do not rely on tower output mint at all, and instead linearly interpolate implied velocity between the available benchmarks and exploit annual variation in nominal output to arrive at a measure of annual coin supply. Formally, coin

[55] Clancy, *Recoinage*, p. 22, 145, and 181-207.
[56] For a recent account see O'Brien and Palma, *Old Lady*.
[57] Mayhew 'Silver', p. 101. Under a commodity standard the official price also affects the market price, as people always had the option of brining bullion to the mint rather than selling it on the market.
[58] For instance, mint output increased considerably in the 1630s following to the Cottington treaty with Spain (signed 1630).

supply (here used as an example, but the same principle is true for M2) can be calculated by writing the equation of exchange as,

$$M = \frac{PY}{V}$$

where M stands here for coin supply, PY is nominal GDP, and V is the velocity of circulation of coin.[59] Then in order to arrive to a series for V, I proceed as follows. For the years in Table 1, I simply write the equation as V=PY/M and apply the figures for M known from the first column of Table 1.[60] I then linearly interpolate between those V's, which leads to a series that maps into a series for M.[61] The resulting estimates for V are shown in Figure 5. They suggest that velocity was at times volatile but did not exhibit a long-term trend.[62] So far I have described this procedure for coin supply, but this method can be likewise used for M2. I proceed in the same way to calculate the velocity to the (lower bound to) M2, using the numbers from Table A2 in the appendix. The resulting velocity is also shown in Table 5.
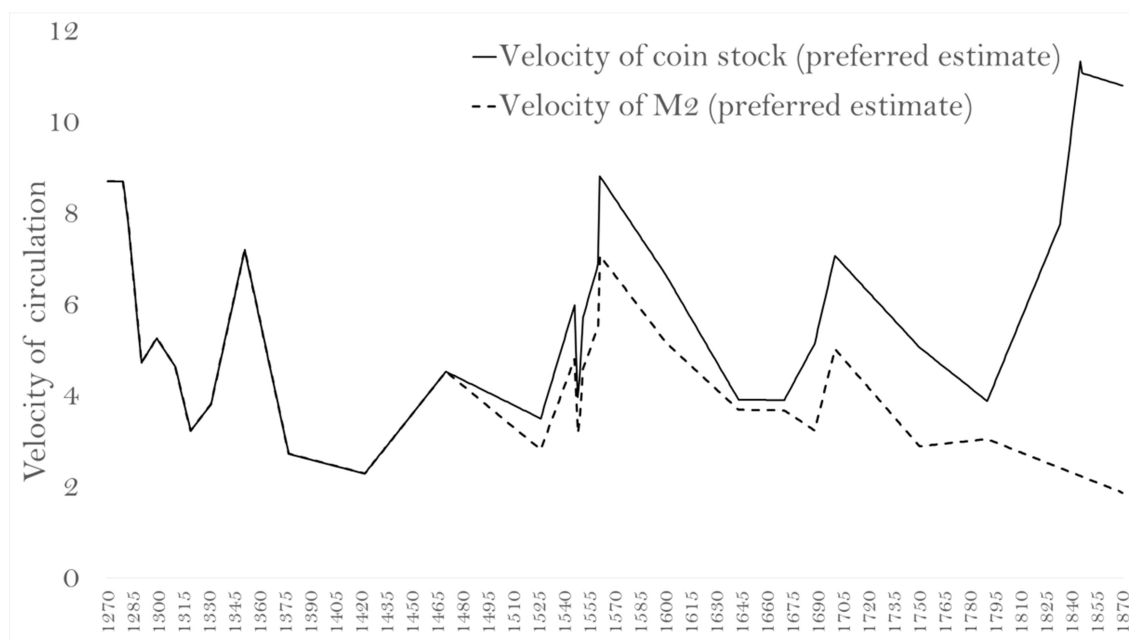

Figure 5. Benchmark velocity estimate used in the indirect method. Sources: see text.

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[59] It is possible to define M is as coin supply rather than M2 as long as the definition of V is consistent with it.
[60] Nominal GDP is available from Broadberry et al, *British Economic Growth*.
[61] Note there is no circularity in this construction: the benchmark years are simply assumed, and all calculations are made for the intervening years only.
[62] See table A1 in the appendix for some comparative figures.

Using a series of available benchmark data points for the size of M2 (described in Table A2 of the appendix), the indirect method can be hence calculated annually for M2. The "indirect estimates" for both coin and M2 are shown in the solid black line (coin supply) and in the non-continuous line (M2) of Figure 6.
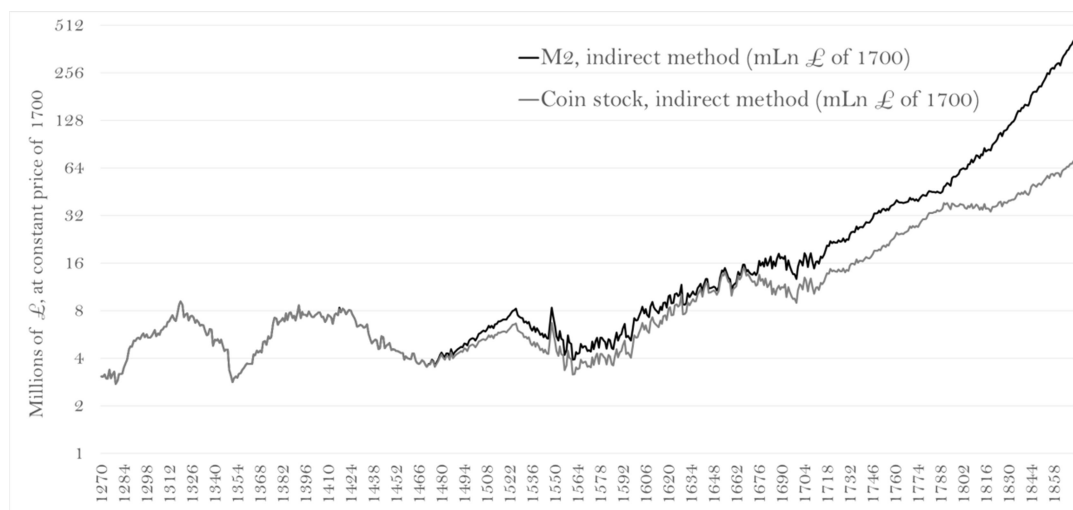

Figure 6. British per capita coin supply and M2 at constant prices of 1700 (log scale of base 2)

The most obvious disadvantage of the indirect method is that it relies on a linear interpolation of velocity between the observed benchmarks. So when calculating the annual estimate, the numerator – nominal GDP – does change in accordance to the "truth", but the volatility of the denominator between benchmarks is underestimated, and hence the estimates for the value of coin supply are more volatile than they should be. A second disadvantage is that by relying on income data for its construction, the indirect estimates for coin supply cannot be used in econometric applications which aim to explain variations in income itself. The indirect method does have the advantage that "on average and in the long run", it should be approximately right, since velocity only changes slowly under long horizons.[63]

I am now in a position to compare the baseline (or direct) estimates among themselves, as well as the growth of M2 relative to coin. The baseline estimates, shown in the solid grey line of Figure 2, direct method B, can be compared with the broken grey line, which shows the direct method A. In Figure 2 also show the indirect method, for coin, in grey. The comparison suggests that the direct method usually leads to considerable improvement over

[63] Bordo and Jonung, *Velocity*.

the indirect estimates, especially at the times where a correction has been applied, such as the late seventeenth century and the 1770's. The baseline estimates are also closer to the narrative evidence presented in Challis. In turn, comparison with the indirect method estimates in black suggests a smoother and also more historically realistic path, which further has the advantage of being independent of any income data in its construction. The fact that output data does not enter in any way in the construction of the direct estimates allows these estimates to be used in econometric work in which output is an outcome variable. However, the direct method estimates may be biased over a long period of time if no sufficient regular recoinage information is available. Hence, the indirect estimates can be helpful in identifying periods when the direct method estimates may need adjustment using supporting narrative evidence.

It is also possible to study the growth of M2 relative to coin, as shown in Figure 6. This method reveals that the ratio of M2 to coin supply is 1 until 1470 and 5.75 by 1870, which broadly parallels the growth of the per capita output of financial services, which increased in index terms from 109 in the 1500s to 685 in 1870.[64]

Finally, for whichever methodology is being used, how can we be sure that a single benchmark is not driving the entire results? In order to show that this is unlikely to be the case, I now perform the following robustness exercise. First, I ignore every odd benchmark year for which we do know the "truth" (for instance, 1290). I then apply my method between its two other surrounding benchmarks (in this example, 1282 and 1299). I can check if my method's prediction to the ignored benchmark choice of 1282 is close to the truth. This process can be repeated, ignoring the even benchmarks instead of the odd ones. The results, shown for the direct and indirect methods in Figures A1 and A2 of the appendix, suggest that no single benchmark was usually determinant: the estimates usually hold up well even when every other benchmark is ignored. They are likely to be even closer to the truth when every benchmark is used.

V

As usually in economic history, my estimates are subject to a high degree of uncertainty. I have detailed the assumptions underlying the construction of the series so that

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[64] Broadberry et al, *British Economic Growth.*

anyone can change these as preferred or as new information that I am not aware of may come to light. For the reasons set out in section III, my estimates for the 1790-1870 period carry higher levels of uncertainty than those for other periods, as they rely on stronger maintained assumptions. I have nonetheless linked my money supply estimates to those of Capie and Webber, which start in 1870, but it seems likely that the estimates for the 1790-1870 period can be considerably improved in the future.

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Appendix

	Bordo and Jonung (1987)	Capie and Webber (1983)	Capie (2004)	Mayhew (1995)	Mayhew (2013)
England 1300	-	-	-	-	4.91
England 1470	-	-	-	-	4.56
England 1526	-	-	-	-	3.61
England 1546	-	-	-	-	5.95
England 1561	-	-	-	-	8.73
England 1600	-	-	-	-	5.73
England 1643	-	-	-	-	3.81
England 1670	-	-	-	3.40	-
England 1688	-	-	-	-	2.65
England 1700	-	-	4	-	2.64
England 1750	-	-	3	-	2.23
UK 1790	-	-	2.5	-	-
UK 1870	2	1.75	-	-	-

Table A1. Estimates for velocity of circulation.

	Coin supply	Coin supply (preferred estimate)	Implied V of coin supply (preferred)	M2	M2 (preferred estimate)	Implied V of M2 (preferred)
England 1279	0.5 − 0.8	0.6	6.09	0.5 − 0.8	0.6	6.09
England 1282	0.8 − 0.87	0.835	5.49	0.8 − 0.87	0.835	5.49
England 1290	1.0 − 1.3	1.0	3.31	1.0 − 1.3	1.0	3.31
England 1299	1.1. − 1.4.	1.1	4.37	1.1. − 1.4.	1.1	4.37
England 1310	1.5. -1.9	1.5	3.85	1.5. -1.9	1.5	3.85
England 1319	1.8. − 2.3.	1.5	2.68	1.8. − 2.3.	1.5	2.68
England 1331	1.5. − 1.9	1.2	3.16	1.5. − 1.9	1.2	3.16
England 1351	0.6 − 0.95	0.6	5.98	0.6 − 0.95	0.6	5.98
England 1377	1.42 − 2.39	1.92	2.27	1.42 − 2.39	1.92	2.27
England 1422	1.22 − 2.39	1.285	2.06	1.22 − 2.39	1.285	2.06
England 1470	0.75 - 0.95	0.9	4.53	0.75-0.95	0.9	4.53
England 1526	1.4	1.4	3.5	1.4 − 1.71	1.56	2.82
England 1546	1.45	1.45	5.98	1.45 − 1.77	1.61	4.80
England 1548	1.76	1.76	3.97	1.76 − 2.15	1.96	3.18
England 1549	1.92	1.92	4.35	1.92 − 2.35	2.14	3.49
England 1551	2.02	2.02	5.71	2.02 - 2.47	2.25	4.58
England 1560	1.71	1.71	6.89	1.71 - 2.09	1.90	5.52
England 1561	1.45	1.45	8.82	1.45 - 1.77	1.61	7.08
England 1600	3.5	3.5	6.65	4.5	4.5	5.17
England 1643	10	10	3.91	12.22 − 14.07	13.15	3.69
England 1670	12	12	3.90	14.67 − 16.88	15.78	3.68
England 1688	10	10	5.14	11.75 - 20	15.88	3.24
England 1700	7 - 14.5	10.75	7.07	8.5 - 21.75	15.13	5.03
England 1750	15 - 18	18	5.06	23 - 40	31.5	2.89
England 1790	44	44	3.88	56	56	3.05

Table A2. Benchmarks for English nominal money supply, 1270-1790. Sources: For coin supply 1279-1470, Allen, 'Silver', and Allen, *Mints*; coin supply from 1526 to 1700 is based on Mayhew, 'Prices', p. 26, where 1551 corresponds to an average of the two available estimates for that year; for the coin supply of 1700, see Mayhew 'Prices', p. 29. For the 1688-1750 coin supply figures, these are the estimates of Cameron, *England*, also endorsed by Mayhew, 'Prices', p. 30. Note that Mayhew's 1688 number in Table 3 of page 26 corresponds to Cameron's M1 estimate. For the M2 preferred estimates: 1279-82, 1377 and 1422 simply the average of both of Allen's bounds. For all other 1290-1470, Mayhew (2013)'s choices. With regards to the bounds to the broader measure of money (M2), the key is to realize Capie's 'Money' numbers are more conservative than those of Cameron, 'England'. For the upper bound during the period before 1600, I use Mayhew's 1600 relative numbers. This bound is hence tantamount to assuming bills of exchange were relatively used as much in the middle ages as in 1600. For sure, this bound should tighten the far back we go in time, but since we know credit was used in the middle ages but have no way to estimate how much of

it was transferable or its size, as this is an upper bound there is no harm to assume it all the way it back to 1270. Still in calculating the higher bound, for 1600-1688 I use proportionality with Cameron's 1688 relative M2/coin supply size, and for 1688-1750, Cameron's 1750 M2/ coin supply size. As for the lower bounds, for 1600-1700, use Capie's 1700 relative size (itself a lower bound, as it includes notes but not bills of exchange), and for 1700-1750 use Capie's 1750 relative size, for 1750-1790 use proportionality with Capie's 1790 relative M2/coin supply size.
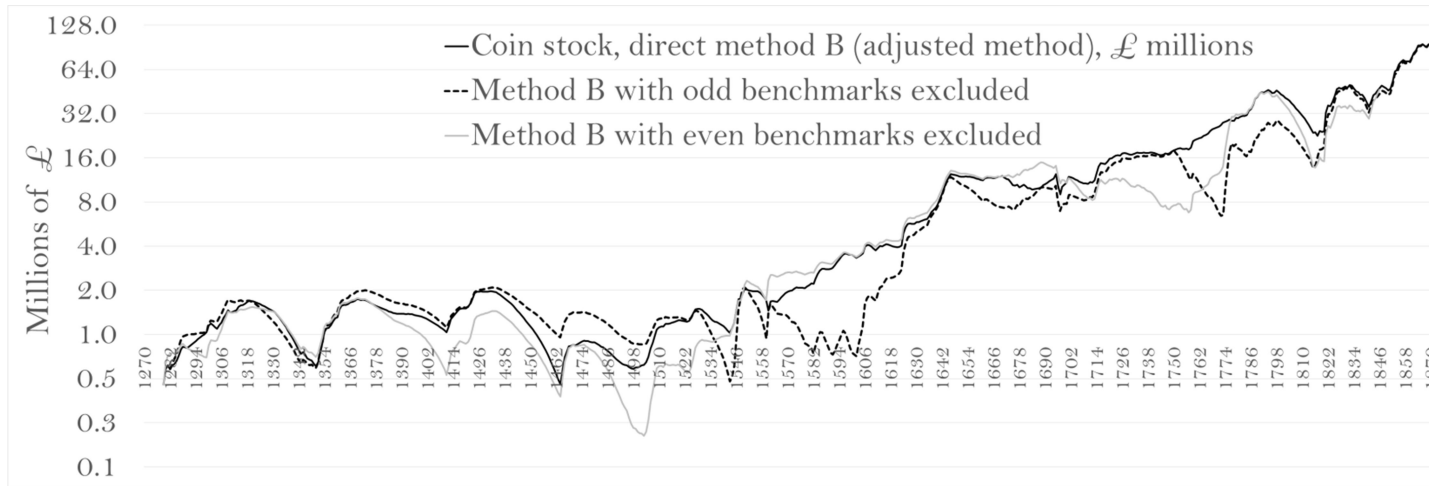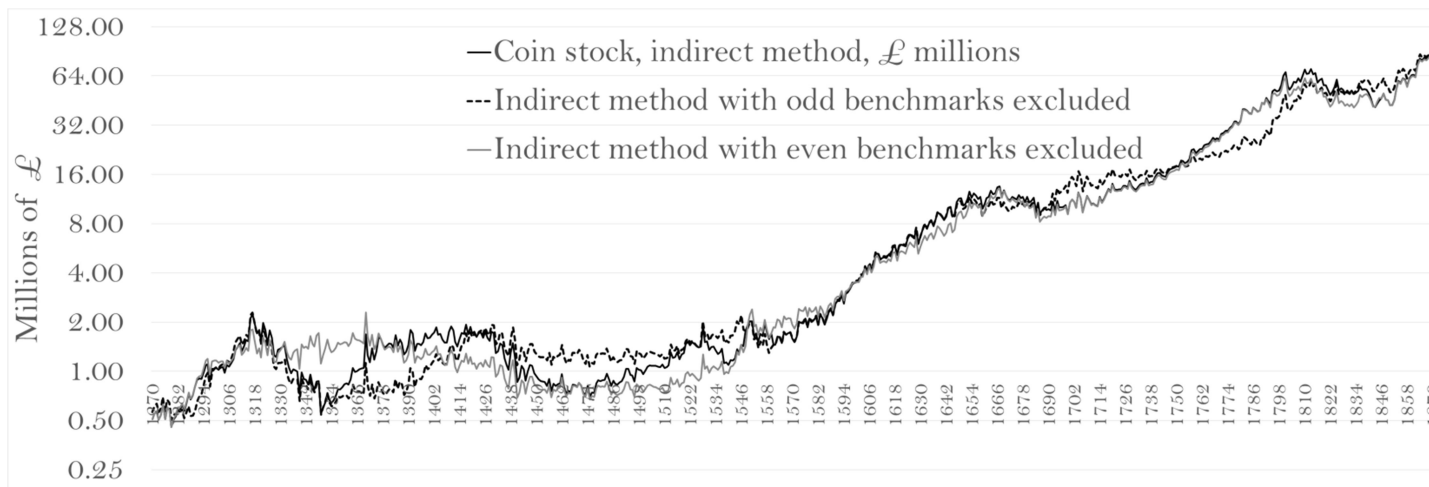
Figure A1. Robustness checks for the direct method

Figure A2. Robustness checks for the indirect method.