Gold (Counter)factuals

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Outline

- Motivation
- Model
- Data

Questions

- there are various forms of money, used singly or jointly:
  - coins (gold or silver)
  - notes (backed or unbacked)
  - deposits (narrow or not)
- we want to think about the policy choices governing these objects
- We are motivated by an array of questions:
  - what if Bryan had won in 1896?
    - switch from gold to silver
    - a form of narrow banking
  - was there enough gold for the gold standard?
  - what happens when a country goes on/off gold/silver?
- we want to think of the price level implications
  - we're structural guys
  - we need a plausibly parametrized model of commodity money
  - we will apply to the 1800–1913, but first we fit to 1500–1800 (Price Revolution)

Model with one metal

- consumption good x_t, in exogenous supply
- metal stock Q_t, also exogenous
  - metal can be held in nonmonetary form (jewelry) d_{t+1} or in the form of money
  - a firm transforms money into jewelry (melts) or jewelry into money (mints)
- representative agent's preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(x_t, d_{t+1})$$

- constraints:

$$\begin{aligned} p_t x_t + q_t h_t &\leq m_t \\ m_{t+1} &\leq \Pi_t + m_t - p_t x_t - q_t h_t \\ d_{t+1} &= d_t + h_t + Q_{t+1} - Q_t \end{aligned}$$

  given initial stocks m_0 and d_0.
- firm's profits:

$$\Pi_t = p_t x_t + n_t - \mu_t + q_t h_t$$

- the firm's problem yields:

$$q_t \geq 1, n_t = 0 \text{ and } \mu_t = m_t \text{ if } q_t > 1$$

Steady State

$$\begin{aligned} h &= 0 \\ m &= px \\ q &= 1 \\ m &= Q - d \\ u_d &= \frac{1}{p}(1-\beta)u_x \end{aligned}$$

which can be written as an equation in d

$$(Q - d) = (1-\beta)\frac{u_x}{u_d}x$$

and the price level is

$$p = (1-\beta)\frac{u_x}{u_d}$$

Simple cases

- $u(x,d) = x^{1-\alpha} d^{\alpha}$

$$\begin{aligned} d &= aQ \\ p &= (1-a)\frac{Q}{x} \end{aligned}$$

price is linear in Q/x

- $u(x,d) = ((1-\alpha)x^{\rho} + \alpha d^{\rho})^{1/\rho}$

$$\begin{aligned} (\frac{d}{x})^{1-\rho} &= \frac{1-a}{a}(\frac{Q}{x} - \frac{d}{x}) \\ p + \tilde{a}p^{\sigma} &= \frac{Q}{x} \end{aligned}$$

with $\sigma = 1/(1-\rho)$, $\tilde{a} = (\frac{a}{1-a})^{\sigma}$; p is increasing but nonlinear function of Q/x

Introducing token money

- cash-in-advance constraint is

$$Q - d + e\bar{m} = px$$

  where e is quantity of silver per "dollar"
- bound on the silver value of token money:

$$e\bar{m} \leq (1 - \beta)\frac{u_x(x, Q)}{u_d(x, Q)}x$$

- below the bound
  - metal and token coexist at the rate e, $p \sim u_x/u_d$
  - d is endogenous: $d = a(Q + e\bar{m})$, $p = (1 - a)(Q + e\bar{m})/x$
- above the bound
  - all metal is in jewelry (price of metal is at its minimum), the dollar price level is $p = \bar{m}/x$
- in an open economy, the metal is exported, the world price of metal may fall
- Hawtrey effect

Bimetallism

- modify preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(x_t, d_{1,t+1}, d_{2,t+1})$$

(with 1:gold, 2:silver) and cash-in-advance constraint:

$$e_t m_{1t} + m_{2t} = p_t x_t$$

where e_t is a free parameter (in oz silver / oz gold)

- steady-state equations are

$$\begin{aligned} (Q_1 - d_1)\frac{v_{1d}}{v_{2d}} + Q_2 - d_2 &= (1-\beta)\frac{u_x}{v_{2d}} \\ e &= \frac{v_{1d}}{v_{2d}} \end{aligned}$$

- two equations in three unknowns (d_1, d_2, e)
- government can set e subject to bounds derived by imposing $d_1 = Q_1$ or $d_2 = Q_2$
- solution method:
  - pick e and solve for d_1, d_2
  - if one $d_i \geq Q_i$ then set $d_i = Q_i$ and solve for d_j, $e = v_{1d}/v_{2d}$
- these are "tight" bounds: they can be made looser by adding costs of converting metal $\leftrightarrow$ money (seigniorage, transport costs)

Simple cases (2)

- $u(x, d) = x^{\gamma} d_1^{\alpha_1} d_2^{\alpha_2}$
  - the bounds are
$$\frac{\alpha_1}{\alpha_2 + \gamma} \frac{Q_2}{Q_1} \leq e \leq \frac{\alpha_1 + \gamma}{\alpha_2} \frac{Q_2}{Q_1}$$
  - within the bounds, $d_i = a_i(eQ_1 + Q_2)$, $p \sim (eQ_1 + Q_2)/x$
- $u(x, d) = (\gamma x^{\rho} + (\alpha_1 {d_1}^{\epsilon} + \alpha_2 {d_2}^{\epsilon})^{\rho/\epsilon})^{1/\rho}$

$$\begin{aligned} (\frac{d_2}{x})^{1-\rho} &= b(\frac{Q}{x} - c\frac{d_2}{x}) \\ p &\sim \frac{d_2}{x} \end{aligned}$$

Data

- we need data on p, Q, x (per capita), e
- for this kind of history:
  - quantities are heavily reconstructed/guestimated
  - prices are relatively plentiful, but with lots of holes
- cheap way to aggregate unbalanced panel of price time series $\{y_{it}\}$:
  - model y_{it} as an observation on a latent factor z_t

$$y_{it} = \lambda_i z_t + \epsilon_{it} \quad (1)$$

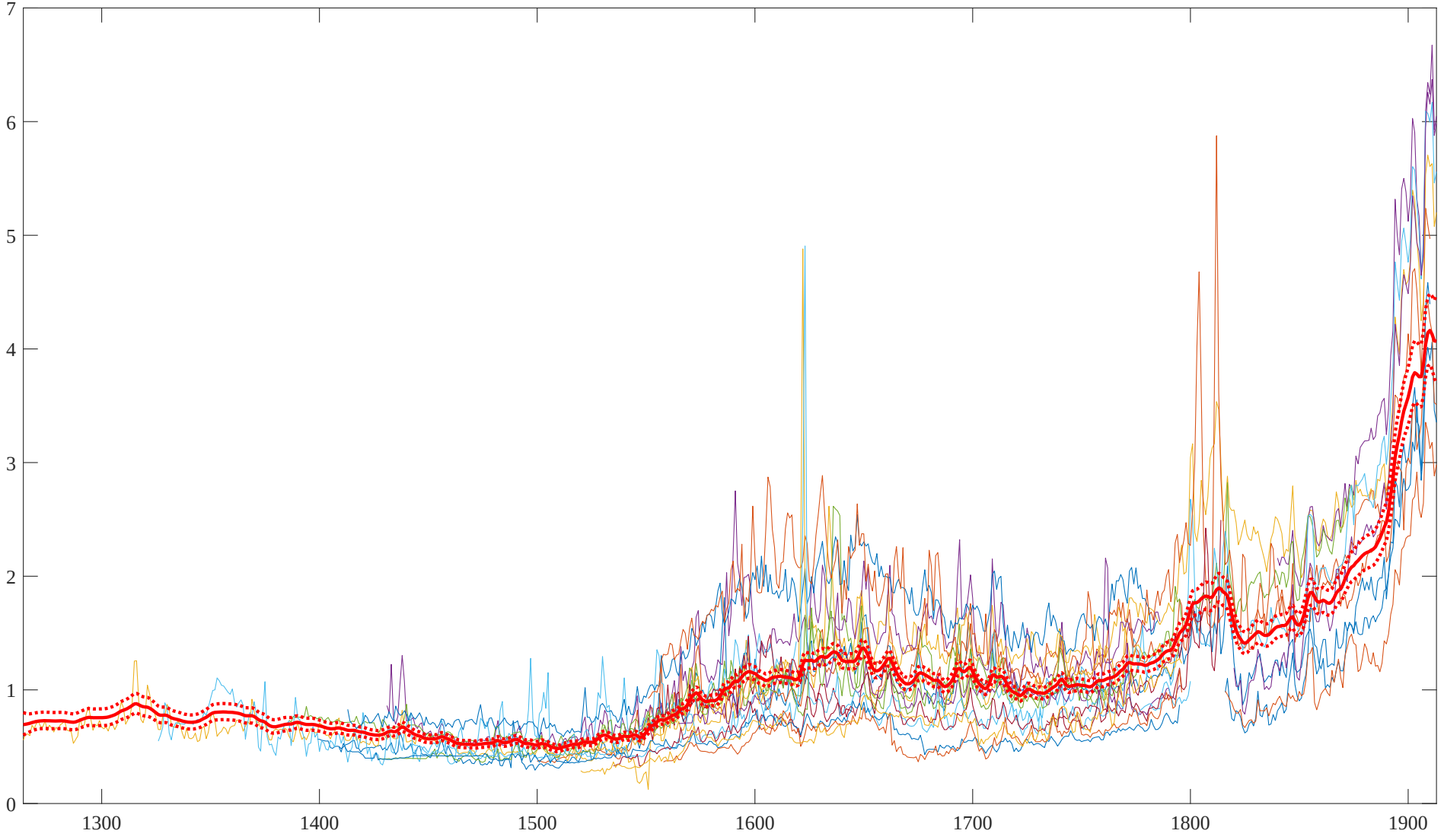
$$z_t = z_{t-1} + \eta_t \quad (2)$$

  - estimate λ_i, $E(\epsilon^2)$, $E(\eta^2)$ with MLE and Kalman filter

Prices

- Robert C. Allen's CPI series from iisg.nl
  - Antwerp, Amsterdam, London, Paris, Strasbourg, Florence, Naples, Valencia, Madrid, Augsburg, Leipzig, Munich, Vienna, Gdansk, Krakow, Warsaw, Lwow
  - from 1264 to 1913 (not for all cities!)
  - intended to be silver prices

Prices



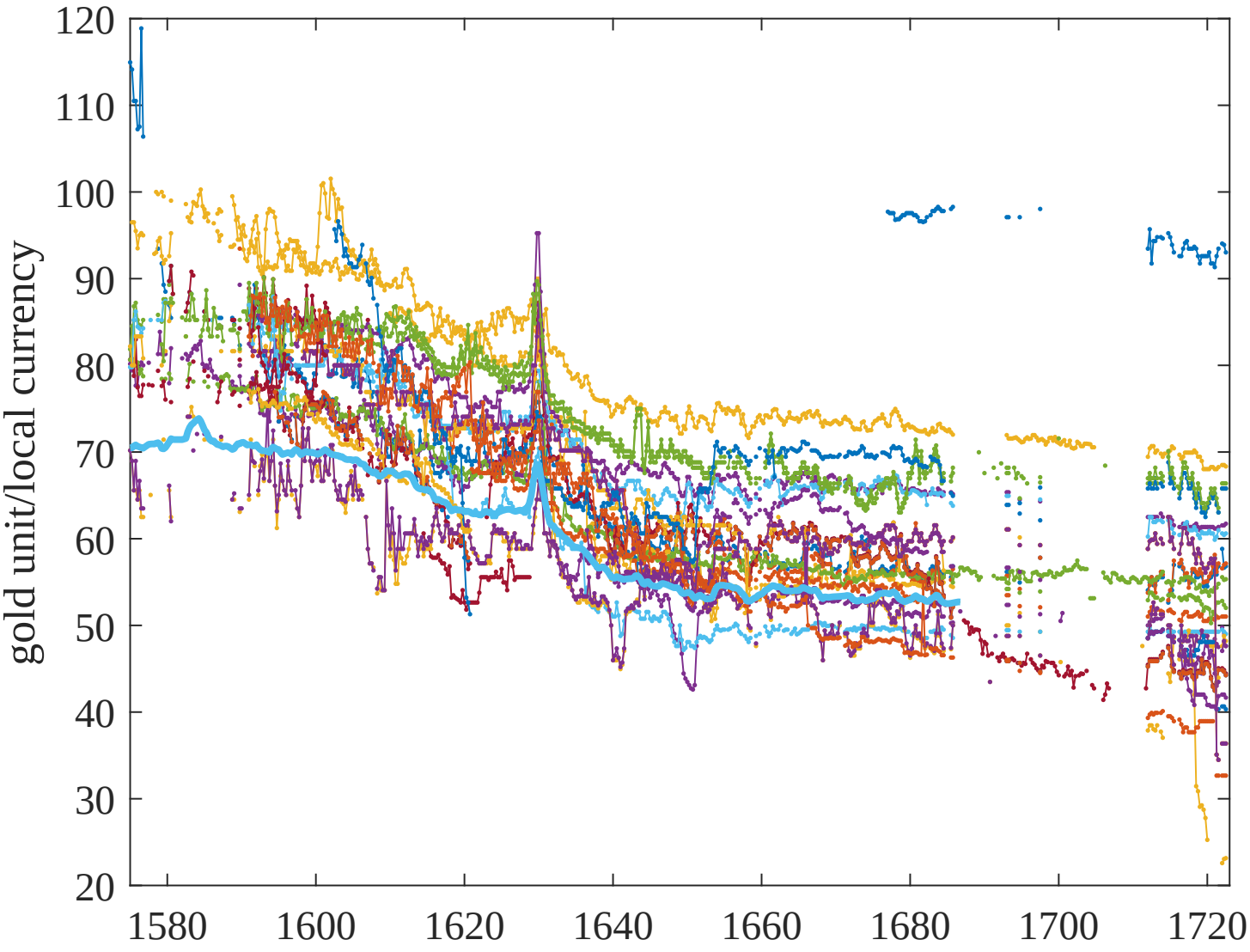
Gold-silver ratio

- classic Soetbeer (1879) series:
  - starts in 1687, derived from market value of gold coin in Hamburg
- before? Two approaches:
  - average legal ratios across countries
  - find market value of gold coin elsewhere

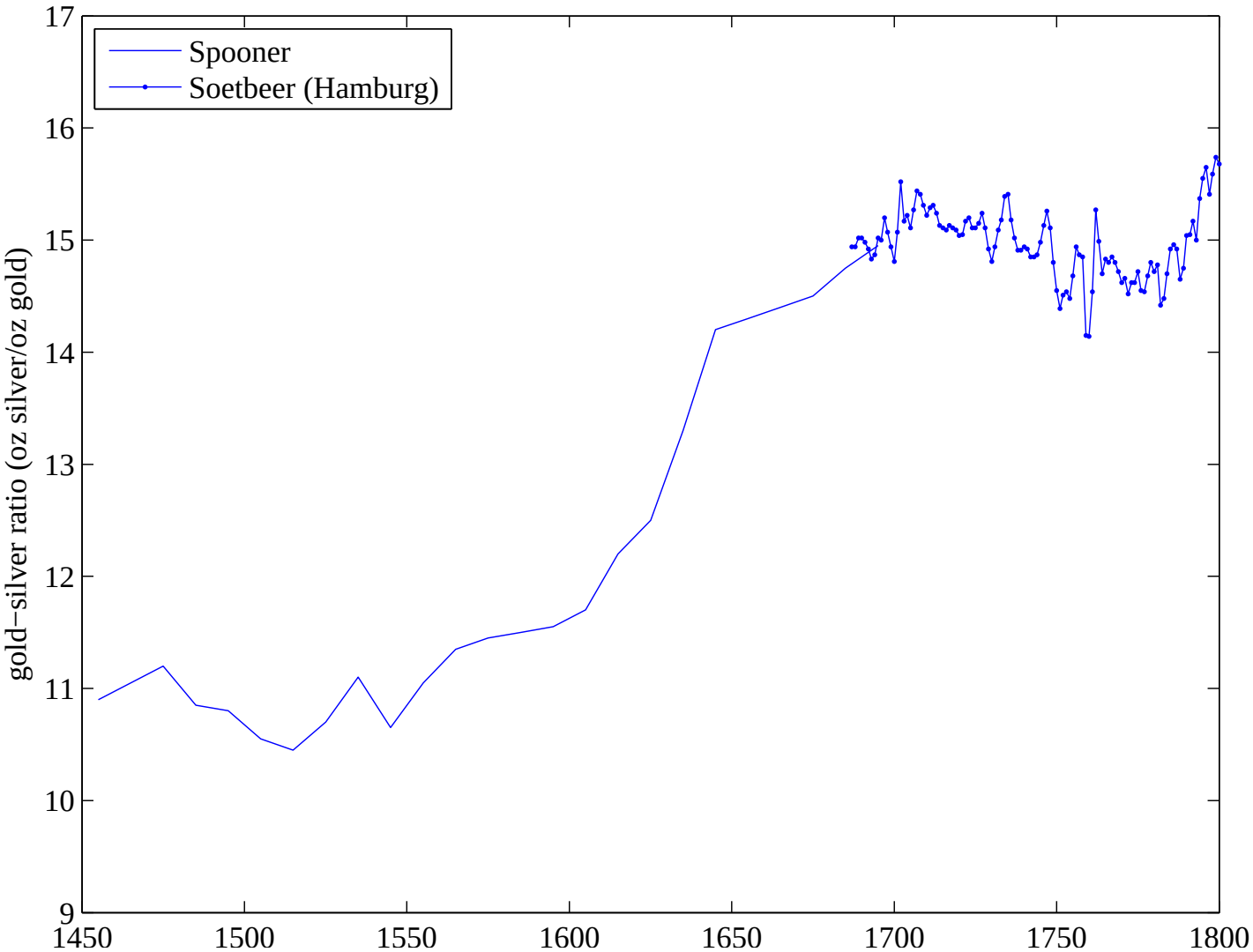
"Bisenzone" fairs

- Quarterly international netting, clearing and settlement meetings
- the Genoese merchants left Lyon in 1535, settled in Besançon (Bisenzone) and later Northern Italy
- records for exchange rates against mostly Spanish and Italian cities, but also Netherlands and Germany
- exchange rates expressed in terms of a gold-based unit per currency

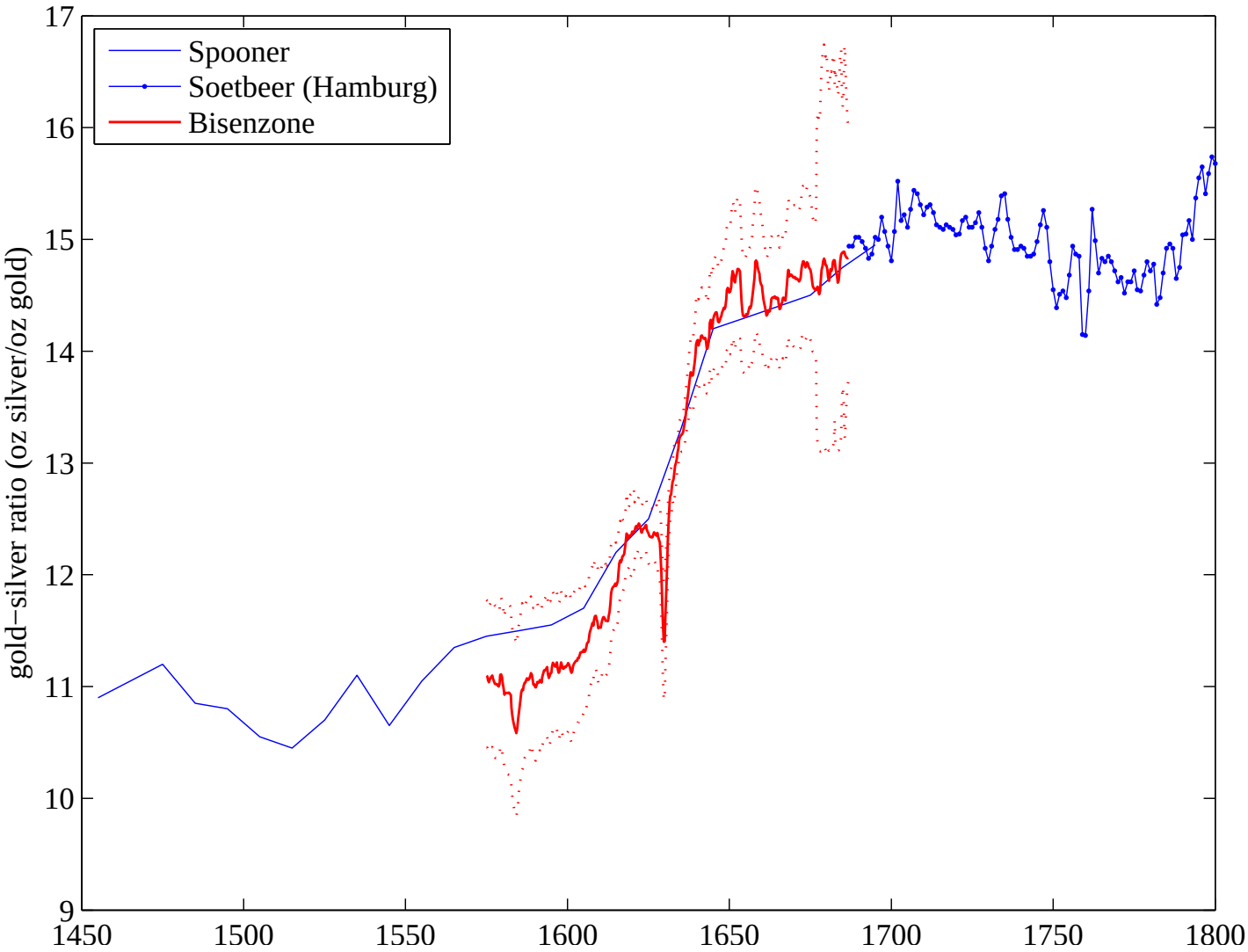
Bisenzone


gold unit/local currency
120
110
100
90
80
70
60
50
40
30
20
1580
1600
1620
1640
1660
1680
1700
1720

Ratio


Spooner
Soetbeer (Hamburg)
gold−silver ratio (oz silver/oz gold)
17
16
15
14
13
12
11
10
9
1450
1500
1550
1600
1650
1700
1750
1800

Ratio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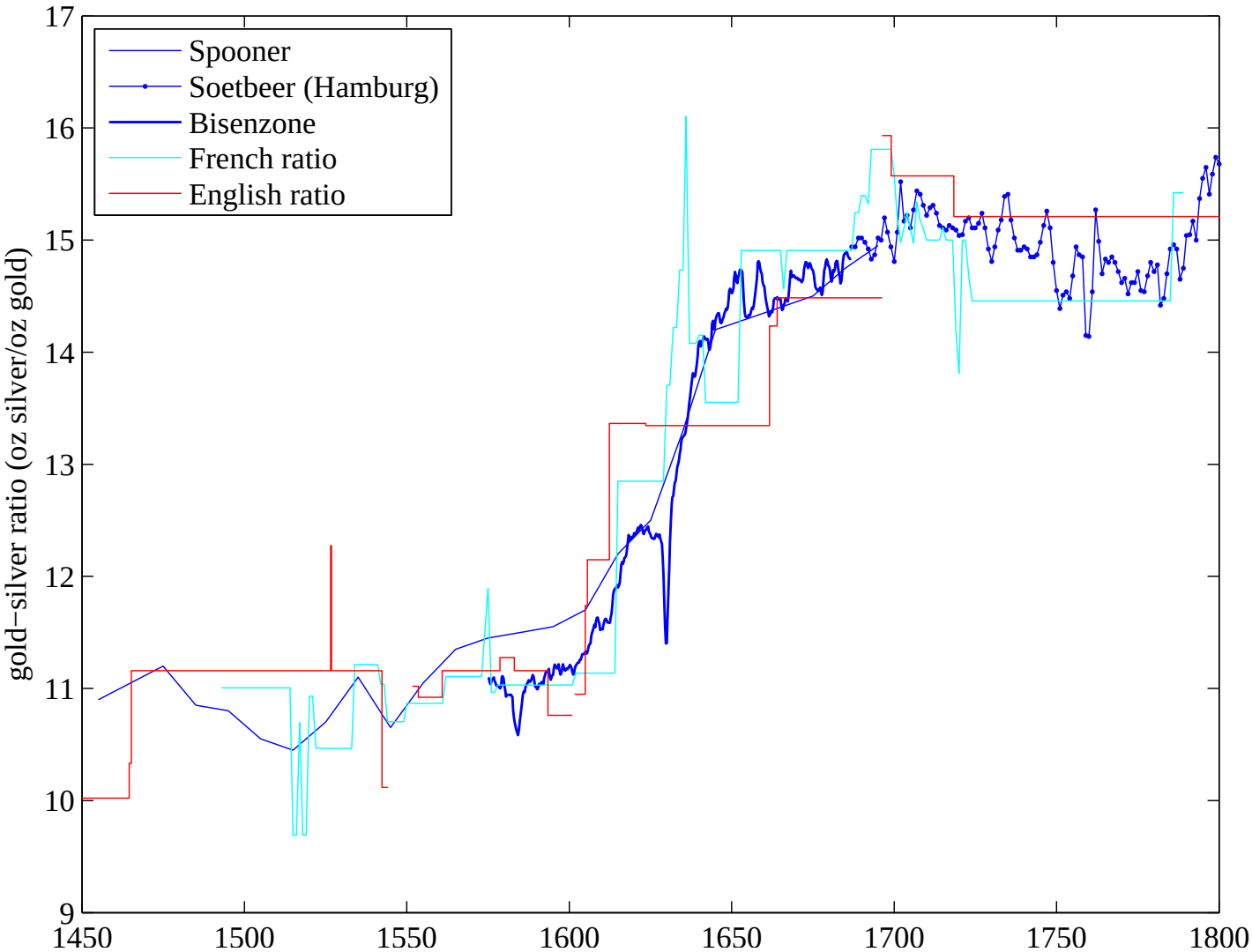
Spooner
Soetbeer (Hamburg)
Bisenzone
French ratio
English ratio
gold−silver ratio (oz silver/oz gold)
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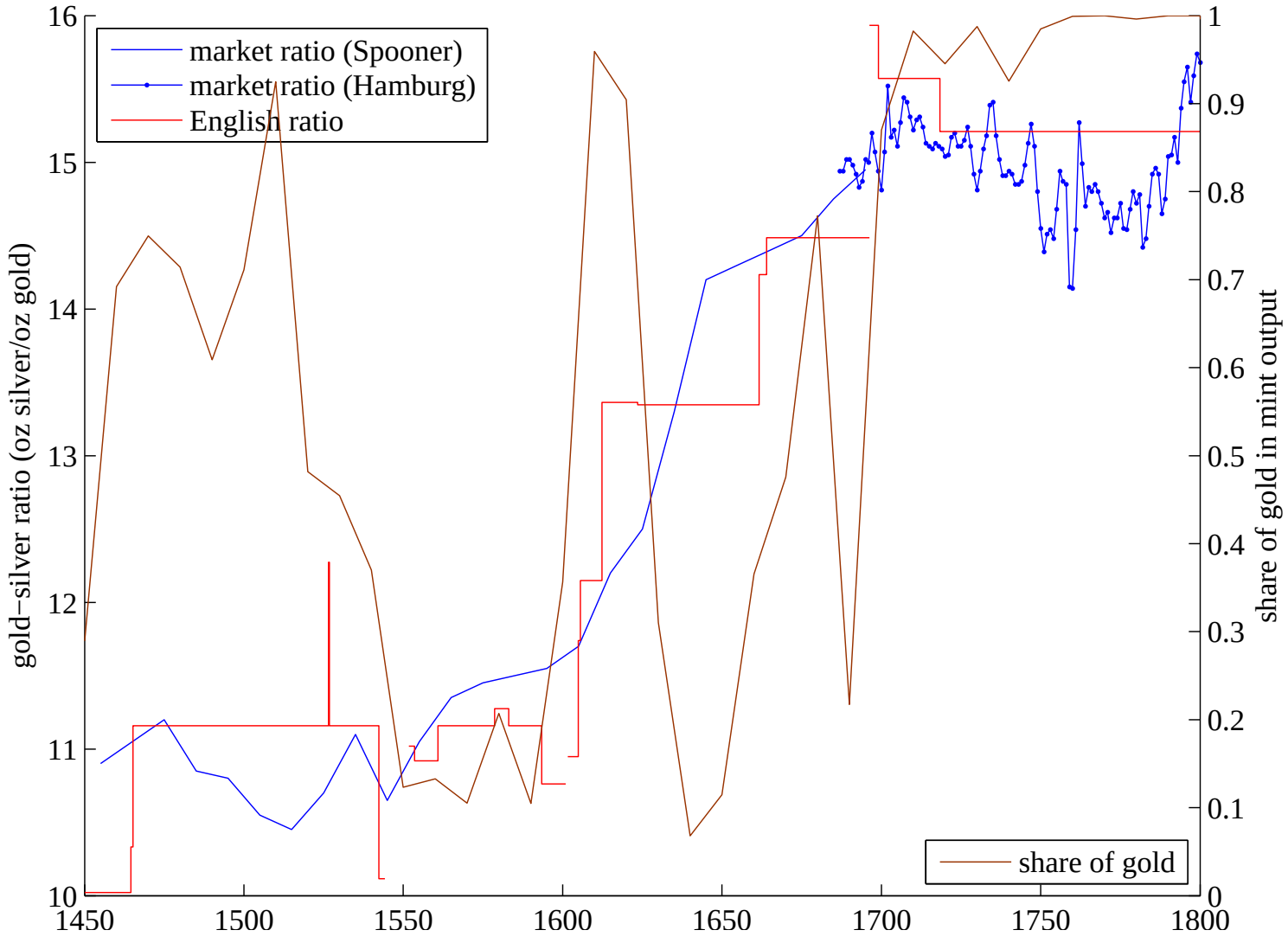
1550
1600
1650
1700
1750
1800

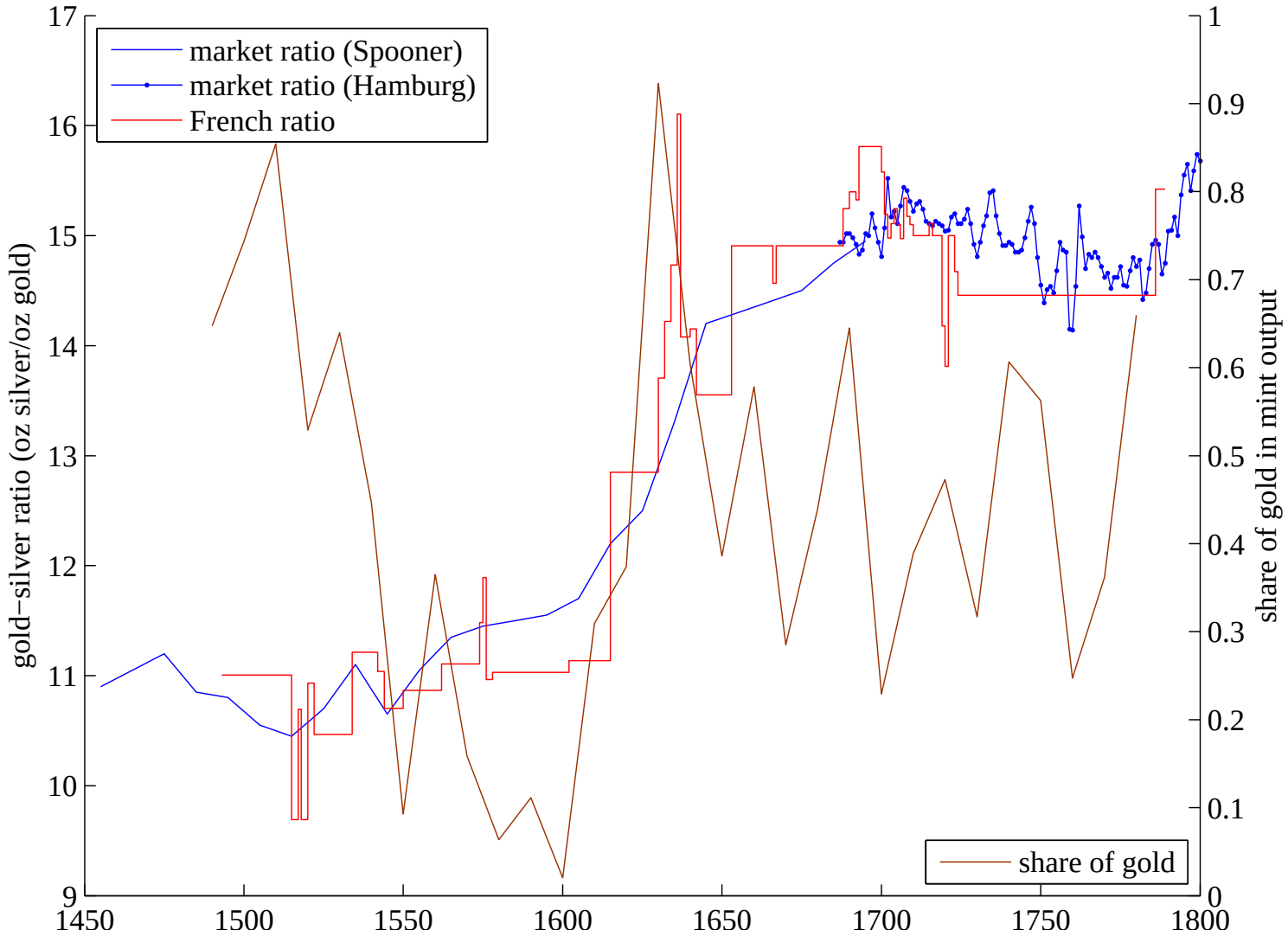
Dynamics of gold-silver ratio

- recall that, in the model, e is arbitrarily chosen but must reside within bounds
- changes in metal stocks move the bounds
- the English and French ratios illustrate the dynamics

Legal ratios and minting



Legal ratios and minting



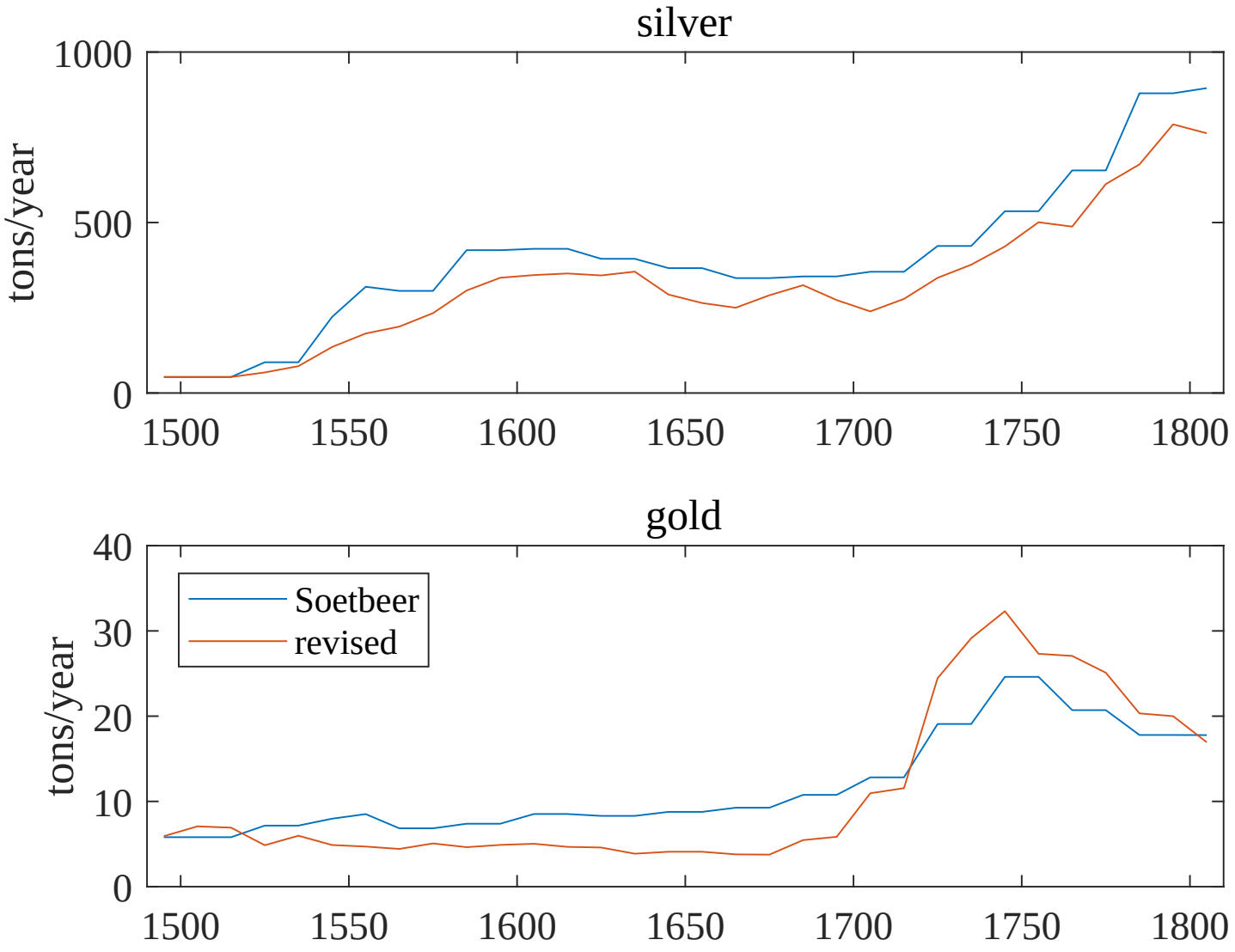
Catch-up

- 17th c.: countries are trying to keep pace with rising relative price of gold
- why? To induce minting of gold, but why do they care? (our model is silent)
- by 1720, England gives up and stays on gold
- France continues and stabilizes the ratio for Europe until 1873 (14.5 until 1785, 15.5 after)

Metal stocks

- the same Soetbeer (1879) estimated worldwide annual output rates of gold and silver from 1492
- since then, much research has tried to refine:
  - Hamilton (1934) counted flows coming into Spain
  - Morineau (1985) counted flows reported in European newspapers
  - many historians have used New World archives (Bakewell 1971, Brading and Cross 1972...)
  - new estimates for Brazil, Russia

Annual output



From flows to stocks

- we need estimates of stocks in 1492
- but we have reliable ones!

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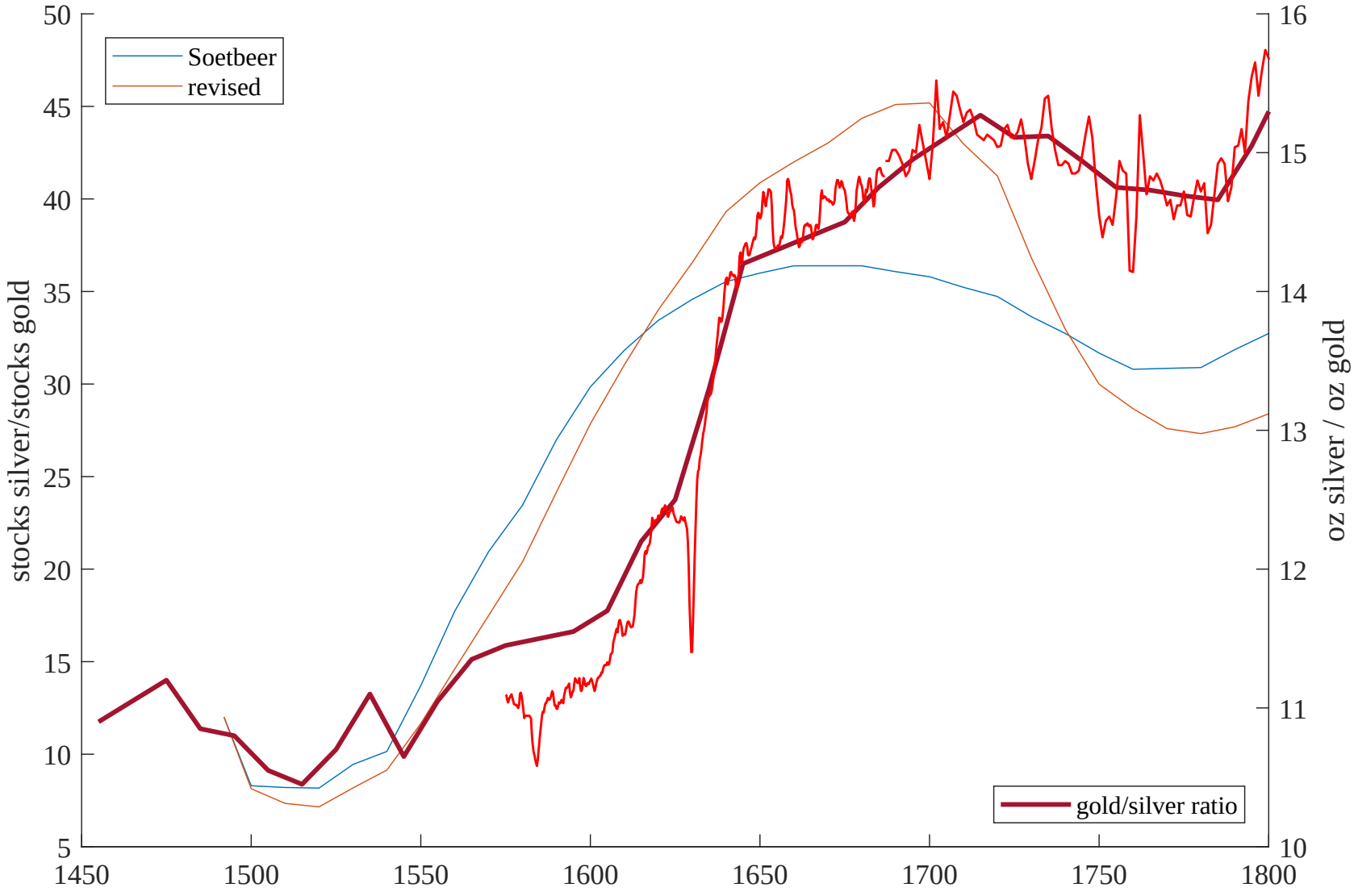
above the 297 tonnes reported by Velde and Webber. Given the research capabilities available to Velde and Webber in their positions in the Federal Reserve System, and given that other independent analyses have produced similar results, it is reasonable to rely upon their estimate that the total stock in 1492 was 297 tonnes.

Stocks and the Ratio



Population, GDP

- classic Maddison (2001) data
- can be updated with lots of recent work on England, Holland, Northern Italy, Germany, Spain, France
- De Vries (2003) for population and urbanization

Population

	1400	1450	1500	1550	1600	1650	1700	1750	1800
	1400	1450	1500	1550	1600	1650	1700	1750	1800
England and Wales	2.2	2.2	2.6	3.2	4.4	5.6	5.4	6.1	9.2
Scotland	0.7	0.7	0.8	0.9	1.0	1.0	1.0	1.3	1.6
GB	2.8	2.9	3.4	4.1	5.4	6.6	6.4	7.4	10.8
Ireland	0.8	0.9	1.0	1.1	1.4	1.8	2.8	3.2	5.3
UK	3.7	3.8	4.4	5.2	6.8	8.4	9.2	10.6	16.1
Holland	0.2	0.2	0.3	0.3	0.5	0.8	0.9	0.8	0.8
NL									
Holland	0.6	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.3
Netherlands	0.8	0.9	1.0	1.2	1.4	1.8	1.9	1.9	2.1
Italy (CN)	5.3	6.0	6.6	7.2	8.3	7.0	8.5	9.6	10.8
Italy (S)	3.1	3.5	3.9	4.2	4.8	4.3	4.8	5.7	7.0
Italy	8.4	9.5	10.5	11.4	13.1	11.3	13.3	15.3	17.8
Spain	3.4	3.8	4.2	5.3	6.4	6.8	7.1	8.2	11.1
Belgium	1.1	1.3	1.4	1.7	1.6	2.0	2.0	2.2	2.9
Germany	5.8	7.3	8.7	12.0	15.4	9.5	13.4	17.4	21.6
Scandinavia	1.2	1.4	1.5	1.7	2.0	2.6	2.9	3.6	5.0
France	11.6	14.0	16.4	19.5	19.6	20.5	22.6	24.6	28.2
Portugal	0.7	0.8	0.9	1.4	1.9	2.0	2.3	2.4	2.9
other Europe	4.4	5.1	6.7	7.4	8.7	8.1	8.6	10.7	13.9
Total Europe	41.0	47.7	55.6	66.7	76.9	73.0	83.3	96.9	121.6

GDP/capita

	1400	1450	1500	1550	1570	1600	1650	1700	1750	1800
England	1090	1055	1114	1135	1143	1123	1100	1630		
Scotland	818	791	836	851	857	842	825	1201		
GB	1059	993	1053	1072	1080	1071	1058	1563	1710	2080
Ireland	526	526	526	571		615		715		840
UK	885	887	909	909	909	862	792	1282	1421	1748
Holland	1245	1432	1483	1697	1783	2372	2171	2403	2440	2617
NL										
Holland	934	1074	1112	1273		1779		1802	1510	1218
NL		1172	1217	1395		2002	2041	2080	1900	1752
Italy (C+N)	1761	1943	1537	1545	1511	1391	1566	1486	1614	1486
Italy (S)	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Italy	1601	1668	1403	1381	1337	1244	1271	1350	1403	1244
Spain	885	889	889	940	990	944	820	880	910	962
Belgium		900	929	1043	1089	1073	1203	1264	1375	1497
DE		1100	1332	1113		894	1130	1068	1162	1140
SE		900	1000	1100	1368	1076	1303	1691	1255	1175
France	985	981	935	860	804	901	963	992	992	1045
Portugal	615	615	615	615	829	863	1033	914	1197	1022
total		1129	1101	1040		996	1057	1154	1191	1225

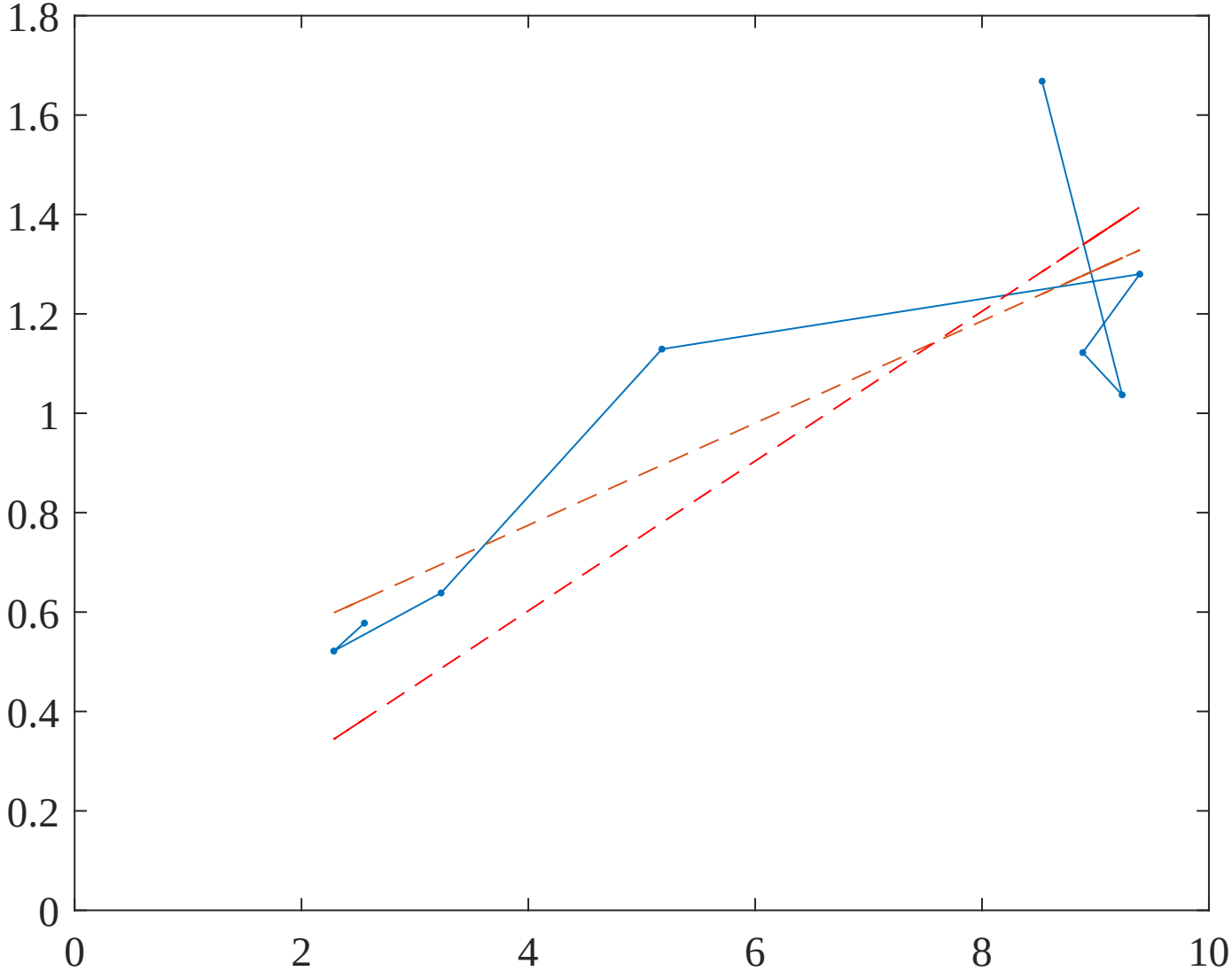
Data

	1450	1500	1550	1600	1650	1700	1750	1800
ratio	10.90	10.55	11.05	11.70	14.30	15.10	14.77	15.54
population	47.7	55.6	66.7	76.9	73.0	83.3	96.9	121.6
GDP	53.8	61.2	69.3	76.7	77.2	96.1	115.4	148.9
GDP/capita	1.13	1.10	1.04	1.00	1.06	1.15	1.19	1.22
prices	0.58	0.52	0.64	1.13	1.28	1.12	1.04	1.67 (1.47)
gold (t)	280	356	653	890	1113	1341	2426	3624
silver (kt)	3.50	4.02	7.71	20.1	37.0	50.9	67.5	98.1

What we do with the data

- Preference parameters θ, exogenous variables: Q, x, e
- Endogenous variables: d_i (we don't observe), p (we do)
- Given $\{Q, x, e\}$ find θ to minimize $\sum_t (\hat{p}_t - p_t)^2$
  - warning: we don't have that many observations

Cobb-Douglas preferences



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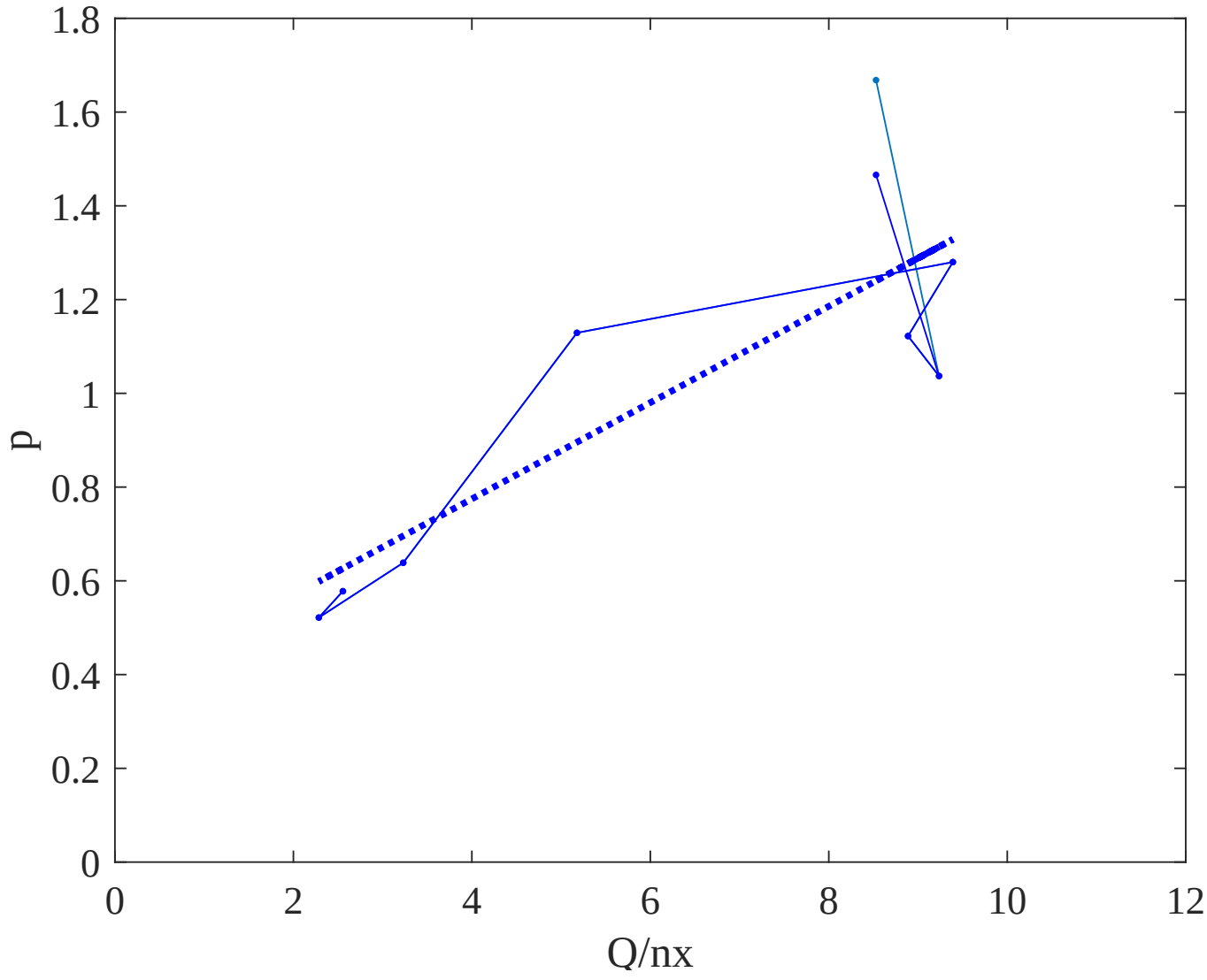

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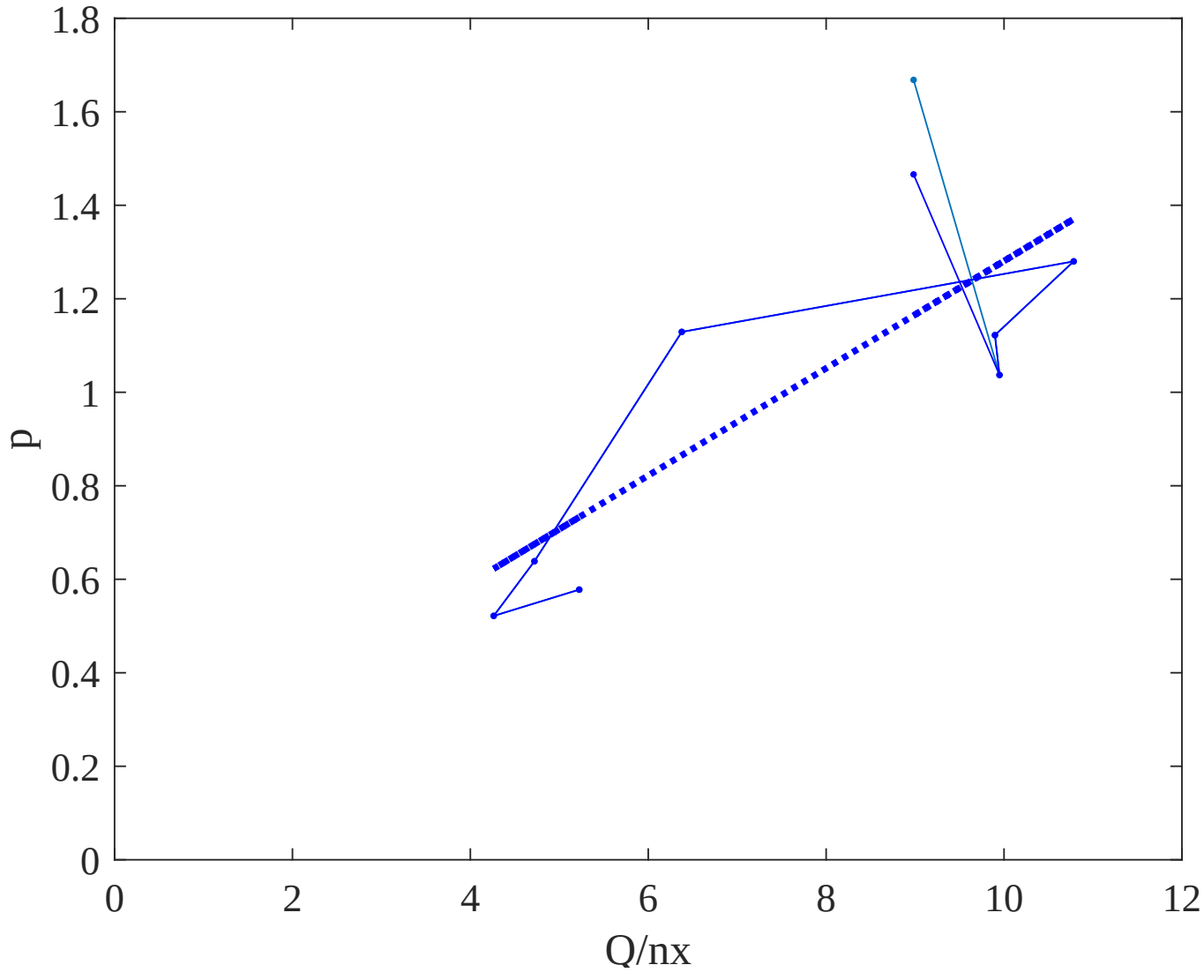
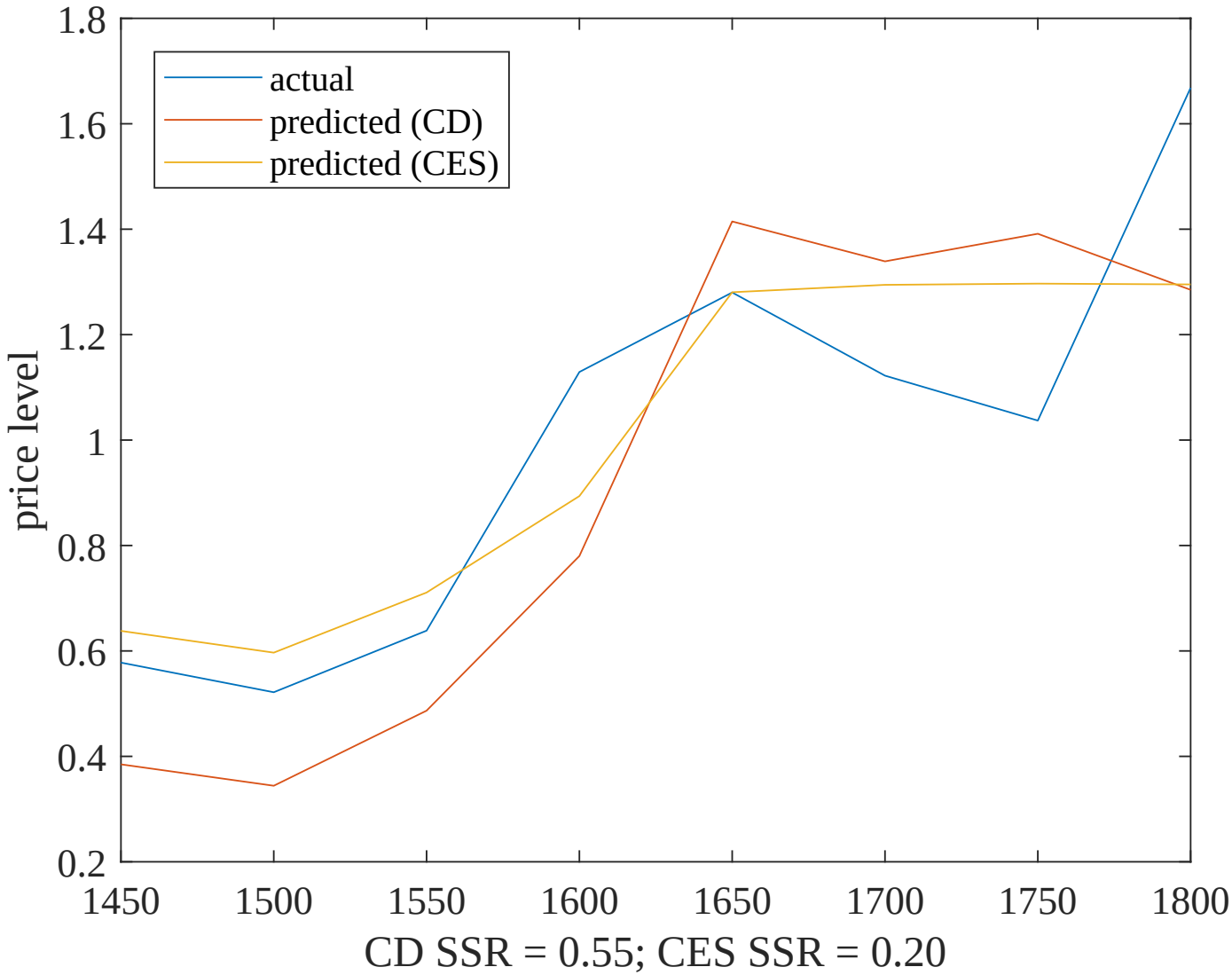


CD vs. CES preferences



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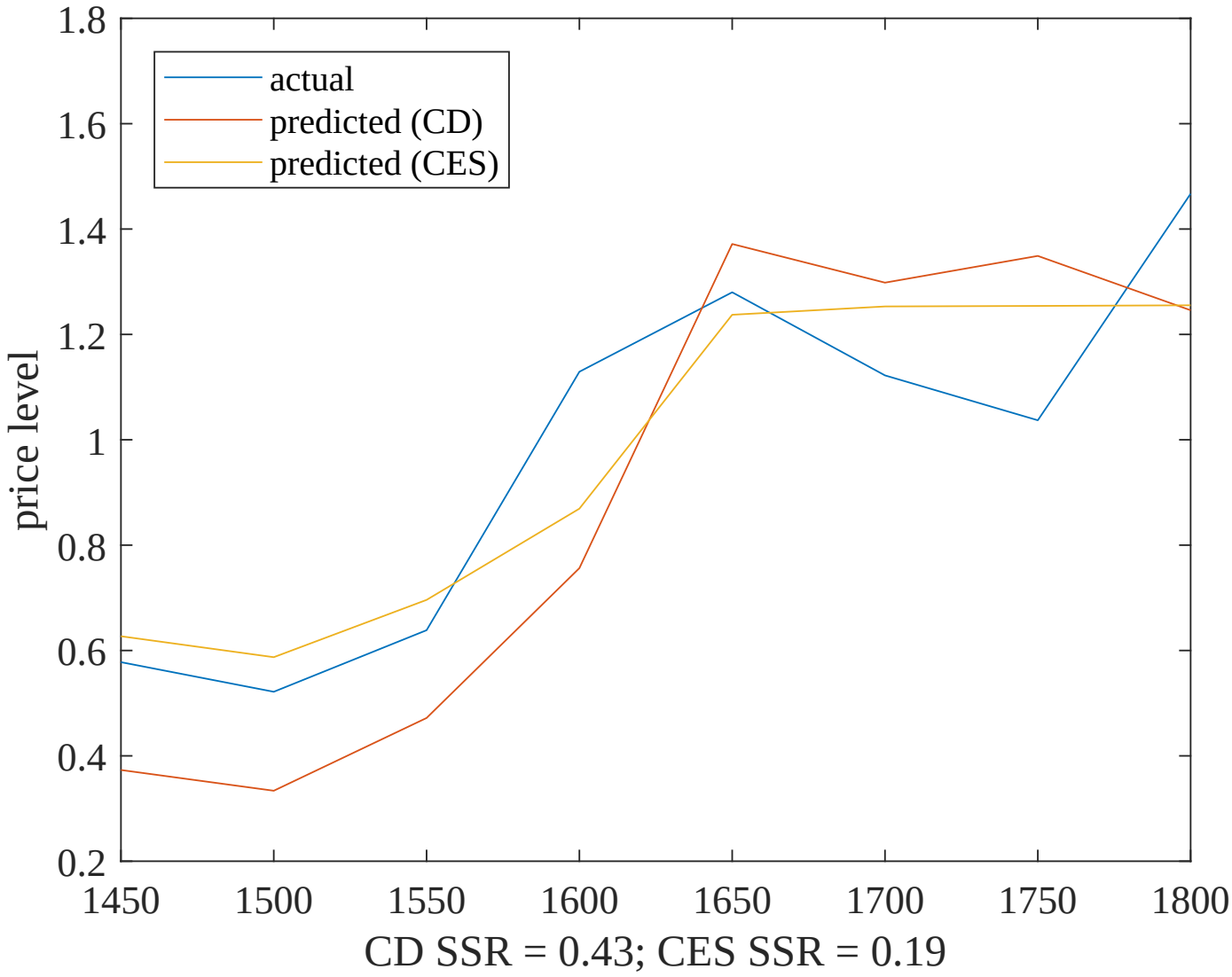


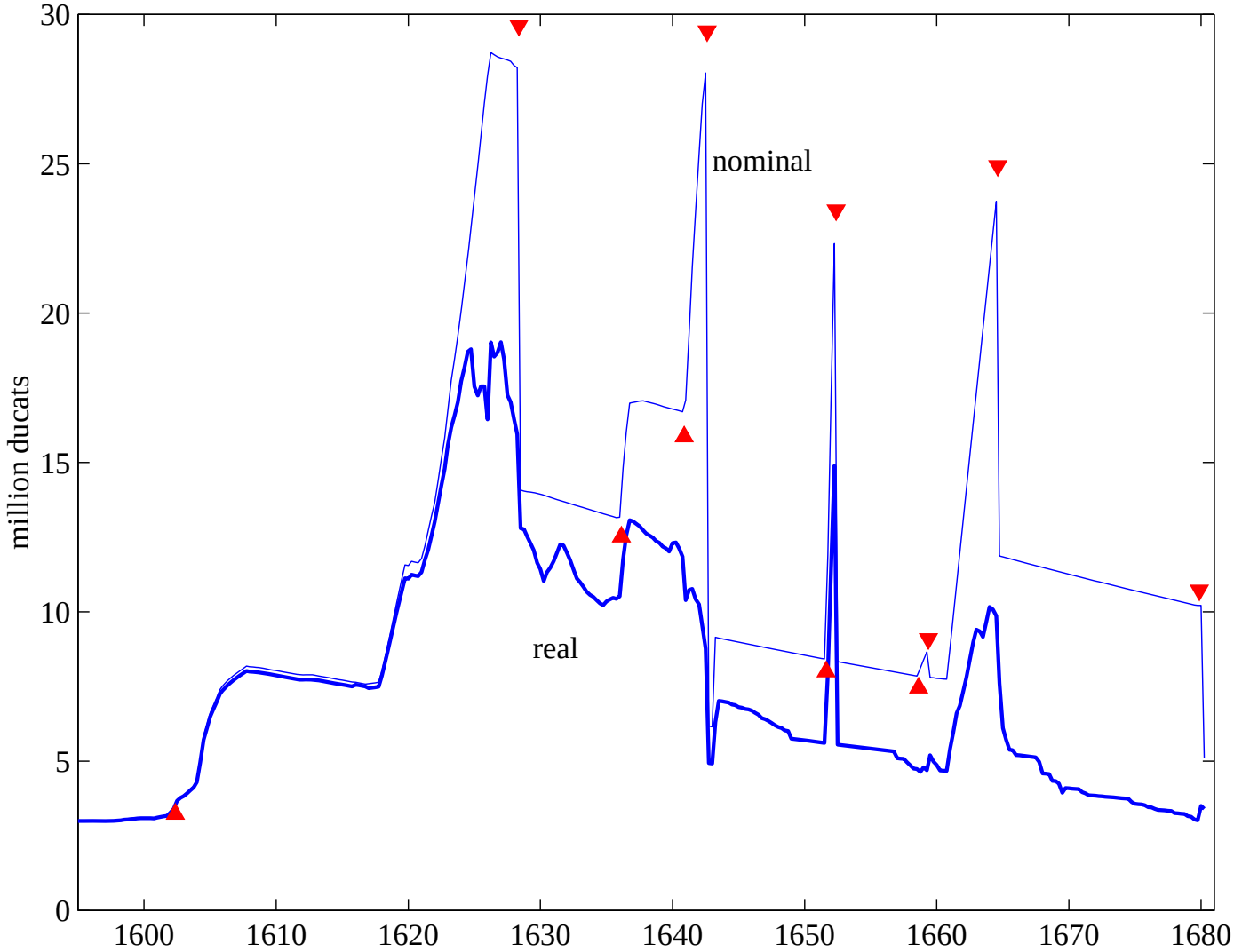
Next steps

- the Price Revolution literature has suggested other factors
  - urbanization $\rightarrow$ higher velocity
  - financial changes (private and public banks, circulating liabilities)
  - do we need these additional factors?
- the minting data might provide further tests of the bounds
- once we're happy with our parameters, we move on to the 19th c.!

An early Hawtrey effect

- around 1600 Spain began to issue token money (copper)
- copper drove out silver by 1628
- the government started manipulating the currency and demand collapsed

An early Hawtrey effect



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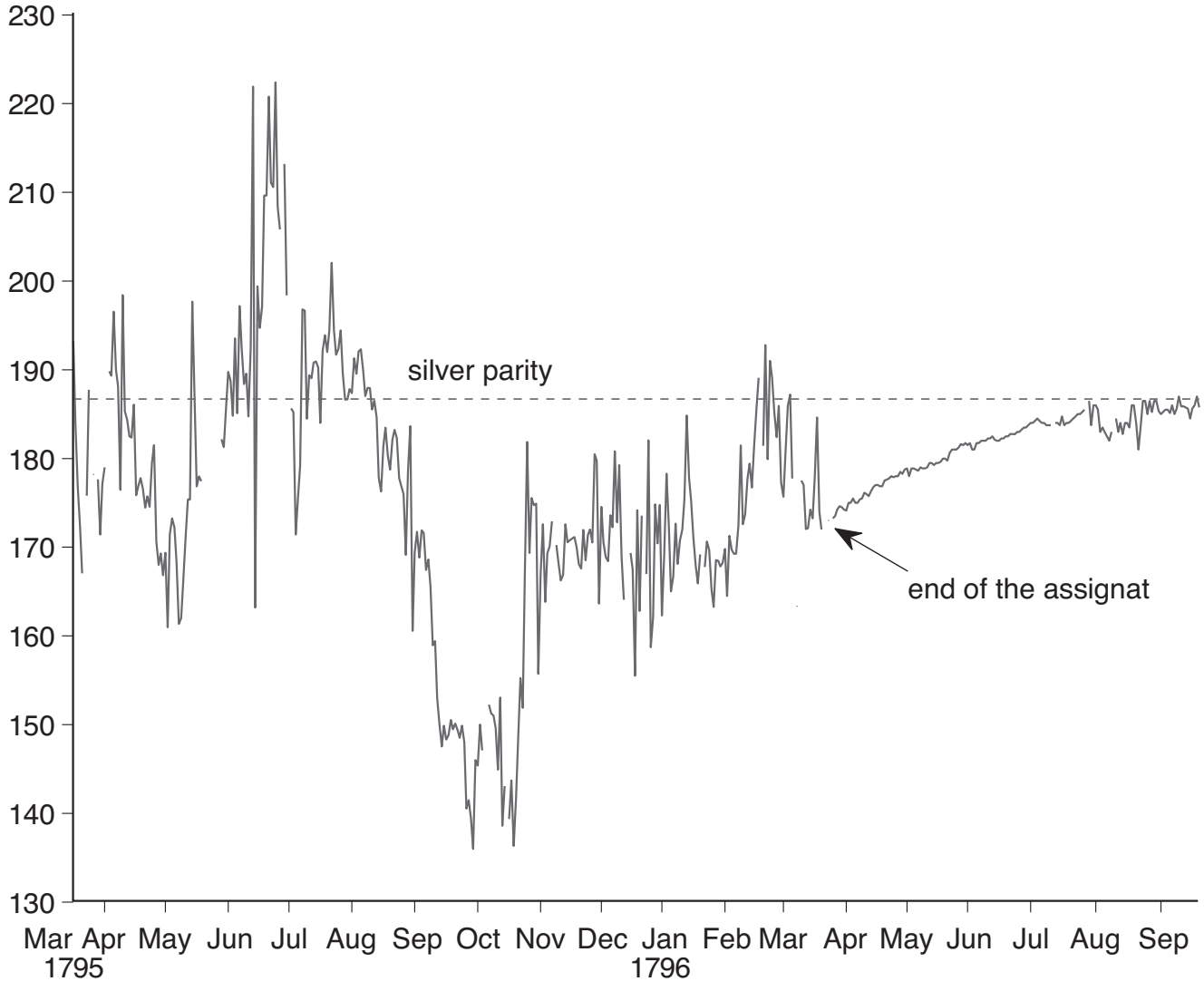

An early Hawtrey effect