

Appendix 2: Tables

Table 1: Estimated Univariate Models for First Log Differences of Yearly Price Data: (gr.Ag/liter)
ARMA structure

Sample	Variable (Mnemonic)	AR(2)		Properties AR(2) Factor		MA(1)	DCD ⁽¹⁾	$\hat{\sigma}_a$ (%)
		$\hat{\phi}(B) =$ $(1 - \hat{\phi}_1 B - \hat{\phi}_2 B^2)$		Period (years) (s.e)	Damp. Factor (s.e)	$\hat{\theta}(B) =$ $(1 - \hat{\theta}B)$	$H_0 : \theta = 1$ (90%, 95%) (1.0, 1.9)	
		$\hat{\phi}_1$ (s.e)	$\hat{\phi}_2$ (s.e)			$\hat{\theta}$ (s.e)		

Table 1.A Grains Europe in XVIII Century (Wheat)

1703-1815	London (L)	.56 (.12)	-.20 (.10)	7.0 (1.9)	.45 (.11)	.80 (.07)	13.3	21.1
	Arevalo (A)	.75 (.10)	-.22 (.09)	9.8 (4.2)	.47 (.10)	.90 (.05)	8.3	31.5
	Holland (H)	.70 (.13)	-.23 (.10)	8.3 (3.2)	.48 (.11)	.82 (.10)	10.7	16.7
	Milan (M)	.61 (.18)	-.55 (.08)	5.5 (.6)	.74 (.06)	.26 (.22)	24.1	13.1
	Strasbourg (S)	.50 (.20)	-.41 (.10)	5.4 (.8)	.64 (.08)	.50 (.22)	14.1	16.2
	Gdansk (G)	.66 (.17)	-.39 (.09)	6.2 (1.1)	.62 (.07)	.60 (.18)	10.8	15.4
	Vienna (V)	.69 (.11)	-.17 (.10)	10.4 (6.7)	.42 (.12)	.86 (.06)	12.0	21.6

Table 1.B Grains America in XVIII Century

1720-1815	Pennsylvania/ Wheat (PW)	.58 (.14)	-.38 (.10)	5.8 (0.5)	.62 (.08)	.67 (.13)	20.1	16.9
	Pennsylvania/ Corn (PC)	.41 (.14)	-.35 (.11)	5.2 (0.6)	.59 (.19)	.69 (.14)	23.4	18.0
1703-1815	Mexico/ Corn (MC)	.63 (.10)	-.20 (.09)	7.9 (2.3)	.45 (.10)	.88 (.08)	7.9	32.4

Table 1.C Grains Europe and America in XIX Century (Wheat)

1867-1896	L	.17 (.26)	-.51 (.19)	4.3 (0.6)	.71 (.13)	.37 (.28)	5.9	9.0
	H	.44 (.39)	-.30 (.20)	5.4 (2.1)	.54 (.18)	.50 (.39)	1.9	9.9
	PW	.14 (.24)	-.55 (.17)	3.8 (0.5)	.74 (.11)	.28 (.25)	8.3	9.1

Notes:

(1) By the Generalized Likelihood Ratio Test of Davis, Chen and Dunsmuir (1995) test (DCD) we can reject the null hypothesis of noninvertibility, since the likelihood ratio is, much taller than the cut-off value, except one case, for confidence level of 95%. I(1) is thus confirmed.

Table 2: Estimated Univariate Models for the Log of Relative Price Data: ARMA structure

Samp.	Ratio	AR(p)		SF ⁽¹⁾⁽³⁾	DCD ⁽²⁾	Mean $\hat{\mu}$ (%)	SDSI (St.dev.) $\hat{\sigma}_a$ (%)
		$\phi(B) = (1 - \phi_1 B - \phi_2 B^2)$		$H_0 : \phi_1 = 1$ (90%, 95%)	$H_0 : \theta = 1$ (90%, 95%)		
		$\hat{\phi}_1$ (s.e)	$\hat{\phi}_2$ (s.e)	(1.1, 1.8)	(1.0, 1.9)		

Table 2.A Grains Europe in XVIII Century

1703-1815	A/L ⁽³⁾	.71 (.09)	-.24 (.09)	-	0	-.42 (.06)	34.6
	H/L	.38 (.08)	-	45.9	1.9	-.20 (.03)	22.8
	M/L	.68 (.07)	-	17.2	0	-.23 (.07)	22.8
	S/L	.68 (.07)	-	17.3	.5	-.44 (.07)	24.1
	G/L	.59 (.07)	-	23.3	2.7	-.51 (.05)	23.6
	V/L	.57 (.08)	-	24.0	0	-.72 (.06)	26.7

Table 2.B Grains America in XVIII Century

1720-1815	PW/L	.45 (.09)	-	28.5	0	-.46 (.04)	20.4
	PC/L	.53 (.09)	-	23.5	0	-1.06 (.05)	21.6
1703-1815	MC/L ⁽³⁾	.57 (.09)	-.13 (.10)	-	0	-.35 (.06)	35.0

Table 2.C Grains Europe and America in XIX Century

1867-1896	H/L	.38 (.16)	-	8.3	-	.0022 (.0219)	7.6
	PW/L	.49 (.16)	-	5.5	-	.031 (.020)	5.6
	PW/H	.23 (.24)	-	11.7	-	.030 (.024)	9.6

Notes:

- (1) Shin and Fuller (1998) statistic (SF). It test whether an AR(1) operator is non-stationary.
- (2) Though stationary seems clear, an additional check is carried out in this case: an ARIMA(2,1,1) is estimated. By DCD we cannot reject the null hypothesis of noninvertibility, except two cases, since the likelihood ratio is, much smaller than the cut-off value, for confidence level of 95%. CI(1,1) is thus confirmed.
- (3) Notice that, in the case of an AR(2) with imaginary roots operator, the non-stationary test SF it not justified. In this case, to control for a non-stationary AR(1) we use (2).

Table 3: Estimated Univariate Models for the Log of Relative Price Data: ARMA structure (Subsamples)

Samp.	Ratio	AR(p)		SF	Barlett	Mean $\hat{\mu}$ (%)	SDSI (St.dev.) $\hat{\sigma}_a$ (%)
		$\phi(B) = (1 - \phi_1 B - \phi_2 B^2)$		$H_0 : \phi_1 = 1$ (90%, 95%)	$H_0 : \sigma_{a1}^2 = \sigma_{a2}^2$ (90%, 95%)		
		$\hat{\phi}_1$ (s.e)	$\hat{\phi}_2$ (s.e)	(1.1, 1.8)	(2.7, 3.8)		

Table 3.A: Grains Europe in XVIII Century

1703-1792	A/L ⁽¹⁾	.67 (.10)	-.26 (.10)	-	5.9	-.42 (.06)	32.9
1703-1757		.67 (.13)	-.29 (.09)	-		-.45 (.08)	36.6
1758-1792		.62 (.17)	-.36 (.17)	-		-.35 (.06)	25.9
1703-1792	H/L	.30 (.10)	-	36.0	3.3	-.17 (.03)	22.5
1703-1757		.35 (.13)	-	18.5		-.18 (.05)	24.8
1758-1792		.11 (.17)	-	17.7		-.17 (.03)	18.1
1703-1792	M/L	.61 (.08)	-	16.7	2.6	-.18 (.06)	21.5
1703-1757		.65 (.10)	-	7.8		-.15 (.09)	23.4
1758-1792		.40 (.16)	-	9.2		-.22 (.05)	17.5
1703-1792	S/L	.62 (.08)	-	16.1	3.2	-.37 (.07)	24.2
1703-1757		.67 (.10)	-	6.8		-.35 (.10)	26.5
1758-1792		.41 (.15)	-	3.2		-.42 (.05)	19.2
1703-1792	G/L	.33 (.10)	-	33.1	.4	-.45 (.04)	19.8
1703-1757		.31 (.14)	-	19.5		-.41 (.04)	20.5
1758-1792		.28 (.17)	-	11.5		-.49 (.04)	18.1
1703-1792	V/L	.59 (.09)	-	17.7	10.9	-.71 (.06)	25.4
1703-1757		.55 (.11)	-	10.9		-.75 (.08)	28.9
1758-1792		.70 (.14)	-	1.9		-.60 (.10)	18.3

Note: (1) By DCD we cannot reject the null hypothesis of noninvertibility, CI(1,1) is thus confirmed.

(Cont...:)

Table 3: Estimated Univariate Models for the Log of Relative Price Data ARMA structure (Subsamples)

Samp.	Ratio	AR(p)		SF	Barlett	Mean $\hat{\mu}$ (%)	SDSI
		$\phi(B) = (1 - \phi_1 B - \phi_2 B^2)$		$H_0 : \phi_1 = 1$ (90%, 95%)	$H_0 : \sigma_{a1}^2 = \sigma_{a2}^2$ (90%, 95%)		(St.dev.)
		$\hat{\phi}_1$ (s.e)	$\hat{\phi}_2$ (s.e)	(1.1, 1.8)	(2.7, 3.8)		$\hat{\sigma}_a$ (%)

Table 3.B Grains America in XVIII Century

1720-1792	PW/L	.47 (.10)	-	20.0	.8	-.47 (.04)	18.6
1720-1757		.51 (.14)	-	7.1		-.53 (.06)	18.9
1758-1792		.35 (.15)	-	11.2		-.41 (.04)	17.5
1720-1792	PC/L	.55 (.10)	-	15.7	.6	-1.05 (.03)	20.0
1720-1757		.70 (.13)	-	2.42		-1.09 (.10)	18.3
1758-1792		.43 (.16)	-	8.2		-1.05 (.04)	21.2
1703-1792	MC/L ⁽¹⁾	.65 (.11)	-.19 (.11)	-	.9	-.31 (.07)	34.9
1703-1757		.60 (.14)	-.21 (.14)	-		-.24 (.08)	36.3
1758-1792		.70 (.17)	-.24 (.17)	-		-.44 (.10)	31.3

Note: (1) By DCD we cannot reject the null hypothesis of noninvertibility, CI(1,1) is thus confirmed.

**Table 4: Estimated Univariate Models for the Log of Relative Price Data:
(Currency Unit/Pence)
ARMA esturcture (Subsamples)**

Samp.	Ratio	AR(p)			SF	Barlett	Mean $\hat{\mu}$ (%)	SDSI (St.dev.) $\hat{\sigma}_a$ (%)
		$\phi(B) = (1 - \phi_{11}B)$ $(1 - \phi_{21}B - \phi_{22}B^2)$			$H_0 : \phi_1 = 1$ (90%, 95%) (1.1, 1.8)	$H_0 : \sigma_{a1}^2 = \sigma_{a2}^2$ (90%, 95%) (2.7, 3.8)		
		$\hat{\phi}_{11}$ (s.e)	$\hat{\phi}_{21}$ (s.e)	$\hat{\phi}_{22}$ (s.e)				

Table 3.A: Grains Europe in XVIII Century

1703-1790	A/L ⁽¹⁾	.60 (.16)	.12 (.17)	-.26 (.13)	11.0		-1.42 (.08)	33.7
1703-1757		.68 (.15)	.06 (.17)	-.33 (.15)	4.8	4.1	-1.54 (.12)	36.5
1758-1790		-.32 (.26)	.86 (.22)	-.36 (.17)	8.6		-1.30 (.05)	25.8
1703-1792	M/L		.63 (.08)	-	15.5		-2.23 (.06)	21.7
1703-1757			.68 (.10)	-	6.6	3.3	-2.22 (.10)	24.6
1758-1792			.32 (.16)	-	10.7		-2.25 (.04)	17.5
1703-1792	S/L		.50 (.09)	-	22.7		-2.69 (.09)	29.2
1703-1757			.52 (.11)	-	12.5	10.1	-2.70 (.09)	33.5
1758-1792			.40 (.16)	-	8.4		-2.69 (.06)	19.2
1703-1792	V/L		.63 (.08)	-	15.1		.12 (.07)	25.6
1703-1757			.55 (.11)	-	10.5	8.4	.049 (.086)	28.9
1758-1792			.74 (.14)	-	1.1		.31 (.08)	17.8

Note: (1) By DCD we cannot reject the null hypothesis of noninvertibility, CI(1,1) is thus confirmed.

(Cont...:)

Table 4: Estimated Univariate Models for the Log of Relative Price Data (Currency Unit/Pence) ARMA structure (Subsamples)

Samp.	Ratio	AR(p)		SF	Barlett	Mean $\hat{\mu}$ (%)	SDSI (St.dev.) $\hat{\sigma}_a$ (%)
		$\phi(B) = (1 - \phi_1 B - \phi_2 B^2)$		$H_0 : \phi_1 = 1$ (90%, 95%) (1.1, 1.8)	$H_0 : \sigma_{a1}^2 = \sigma_{a2}^2$ (90%, 95%) (2.7, 3.8)		
		$\hat{\phi}_1$ (s.e)	$\hat{\phi}_2$ (s.e)				

Table 3.B Grains America in XVIII Century

1720-1792	PW/L	.60 (.10)	-	12.0	1.6	-2.42 (.04)	18.2
1720-1757		.59 (.13)	-	5.2		-2.52 (.07)	19.0
1758-1792		.39 (.17)	-	8.0		-2.32 (.05)	15.3
1720-1792	PC/L ⁽¹⁾	.93 (.11)	-.46 (.11)	-	.1	-2.98 (.04)	18.2
1720-1757		.90 (.16)	-.32 (.17)	-		-3.06 (.07)	17.7
1758-1792		.96 (.17)	-.53 (.16)	-		-2.92 (.06)	18.7
1703-1792	MC/L	.55 (.09)	-	19.0	.8	-2.20 (.04)	35.3
1703-1757		.52 (.13)	-	10.6		-2.16 (.10)	36.9
1758-1792		.59 (.14)	-	4.6		-2.30 (.13)	32.1

Note: (1) By DCD we cannot reject the null hypothesis of noninvertibility, CI(1,1) is thus confirmed.

Table 5: Summary of common univariate residual extreme values and their historical explanation

Year	Yearly Price Data											Relative Price Data							Comments:		
	L	A	H	M	S	G	V	PW	PC	MC	$\frac{A}{L}$	$\frac{H}{L}$	$\frac{M}{L}$	$\frac{S}{L}$	$\frac{G}{L}$	$\frac{V}{L}$	$\frac{PW}{L}$	$\frac{PC}{L}$		$\frac{MC}{L}$	
1708	++		+								-	-	-		-	-					War of the Spanish Succession
1709	++	+	++	+	++	I+64	+			+		-			I+24	-					“
1710			+	-	-	I+29	-								I+31						“
1714	-		+			++				+	+	++	+	++	++	+				+	“
1715	+	-	-		-	-	-			I-119				-							I-147
1716					-					I-143											I-158
1717					-					I-140											I-159
1718	-	-			-		+									++					
1720		-			I+53	-					-			I+51							
1724				-	+			+	+	-			-								
1727	+				+		-				-						-				
1731	-				+			-	-								-				
1733		+		++						-			+								War of the Polish Succession,
1734		+		++	+	+	-						+								
1737		++		-				+			++										
1739	+		+		-				-								I-67	I-85			War of Jenkins' Ear, War of the Austrian Succession
1740	+		++		+	I+48	+	+									I-88	I-115			
1741	-		++		+	I+43		+	++		+	++	++	++	I+47	+	+	+	++		“
1742	-		-					-				+									“
1746				++				-				+									“
1748		+		+				++									+				“
1749				-	I-56	+	-			+				I-49							++
1750				+		-	-			++											++
1752			+							-											-
1754	-								-	-											-
1755			-										-								
1756	++	-	+		-	+					I-87	-	-	-		-	-	-	-	-	Seven Years' War
1757						+	++			-	-										“

I+ There is a positive influential impulse intervention term at this date in this series (I- for negative) with the estimated increment (decrement) in percentage rate (%), ++ stand for positive residuals with absolute value greater than two standard deviations and + between one and two standard deviations respectively (-, - for negative values). This table provides a benchmark for coincidences in extreme values that might reveal how prices are related. Some extreme values that are not common are not reported.

Table 5: Summary of common univariate residual extreme values and their historical explanation (Cont.)

Year	Yearly Price Data										Relative Price Data									Comments:		
	L	A	H	M	S	G	V	PW	PC	MC	$\frac{A}{L}$	$\frac{H}{L}$	$\frac{M}{L}$	$\frac{S}{L}$	$\frac{G}{L}$	$\frac{V}{L}$	$\frac{PW}{L}$	$\frac{PC}{L}$	$\frac{MC}{L}$			
1762								+	++										+		Seven Years' War,	
1763																				-		
1764			++	+				-				+										
1770		+	-		++	-	+	+	+													
1771		-	+			+	+				-											
1775	-		+				-	-		-		++										
1776			-	-	-	-	-	-	+	+		-	-					-				American Revolutionary War
1777				++		-		-		-												"
1778	-								+			++							++			"
1779				-		-		I+50	I+66								I+80	I+88				"
1780	+					-	+	I+54	I+55			-		-			I+52	I+44				"
1782									I+138										I+128			"
1786					-					++										++		
1787		+			+		+		-										-			
1789					+	++				+												
1790																		++				
1791		-		++			-	-	-													
1793		+			I+64		-		+					I+77								French Revolutionary War
1794	+				I+37		+							I+28								"
1795	++	+	I+44	+	I+42	++		++	+	-			-	I-17					-	-		"
1796	-						-		++				+				++	++				
1797	+	+	-			-		-							-							
1799	I+55	-	+								I-100	I-52	I-63	I-66	I-57	I-66	I-41	I-65	I-66			Napoleonic Wars
1800	I+65		+	++		++	+				I-102	I-54	I-59	I-84	I-45	I-62	I-52	I-73	I-61			"
1802	-			-	+	+	+	-	-													"
1803						-																
1804	++	+		-		+	+		+	-		-	-	-	-		-		-			
1805			+	-		+	+	+									++					
1806								-									-					
1807						++																
1808	+	-					++	-	-								-	-				
1809	+	-		-	-	-		+			-	-			-	+						
1810				++		-	-	I+65		+				-			I+80					
1811	+	+		+	+	-									-							
1812		+	+		+		-									-						
1813	-		-		-	-	++			+						++						

I+ There is a positive influential impulse intervention term at this date in this series (I- for negative) with the estimated increment (decrement) in percentage rate (%), ++ stand for positive residuals with absolute value greater than two standard deviations and + between one and two standard deviations respectively (-, - for negative values). This table provides a benchmark for coincidences in extreme values that might reveal how prices are related. Some extreme values that are not common are not reported.

Appendix 3: Graphics and Models

In Appendix 3 we present extensive graphical and statistical information about the ten original price series and the pairwise relative prices/London (price ratios) calculated from them. Appendix 3 also shows the main characteristics of the ARIMA models that have been specified and estimated for all those series.

First, the identification instruments and the univariate models of available grain prices time series (1703-1815) for the ten markets considered in this study (London and Southern England (L), Arévalo (A), Amsterdam and Holland (H), Strasbourg (S), Vienna (V), Gdansk (G), Milan (M), Pennsylvania (PW and PC), Mexico (MC and MW)) are reported. All series are wheat prices time series, except Pennsylvania and Mexico, when the notation W and C indicate wheat or corn. As already mentioned above, series are expressed in grams of silver per liter (see Appendix 1).

Identification instruments for every series (P_t) are: 1) standardized graphs of first differences of $\ln P_t$ and 2) graphs of their simple autocorrelation function (acf) and of the partial autocorrelation function (pacf). Horizontal dotted lines in data (and acf/pacf) graphs are drawn at heights of $\pm 2\sigma_w$ ($\pm 2/\sqrt{N}$ for acf/pacf), where w represents the series for the market indicated at the top of the graphs by the corresponding initials (A for Arévalo, L for London and Southern England, etc.) listed in the first above and σ_w is the sample standard deviation of w . The value of the sample average, \bar{w} , with its standard deviation in parenthesis ($\sigma_{\bar{w}}$), and the sample standard deviation, σ_w , appear at the bottom of the graphs on the left and the right sides, respectively. The Q-statistic (Ljung and Box, 1978) is reported below the acf graphs, including degrees of freedom in parenthesis.

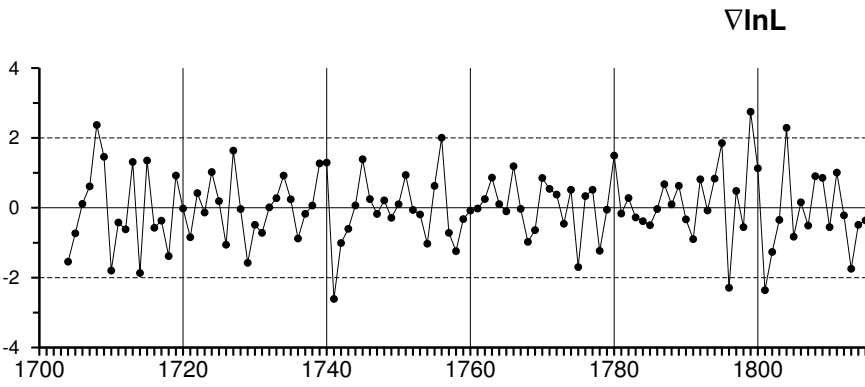
The specifications and the parameters of the estimated model may be found at the bottom of every graph. Relevant information regarding diagnosis, specification and estimated parameters is shown in the respective information module. Diagnostics tools are: 1) graphs of the typified residuals and of the residuals' acf/pacf, along with their elementary statistics, residuals are denoted by A (AA for Arévalo, AL for London, etc.); 2) a list, including year and typified value, of the residuals with an absolute value equal or higher than two residuals standard deviations. Estimated values of the terms of intervention coefficients and of the ARMA parameters, with their respective estimated standard deviation in brackets below them, are presented as well. We show the estimated standard deviation of the residuals, $\hat{\sigma}_A$, at the right of the model.

Second, we also present in this appendix our statistical analysis of the price ratios/London for hypothetical pairwise markets resulting from the ten original price series of grains that made up in different subsamples (i.e. A/L, H/L, ..., MC/L). For all price ratios, graphs in logarithms and univariate models are shown. We also present the graphs of the residuals of the univariate models.

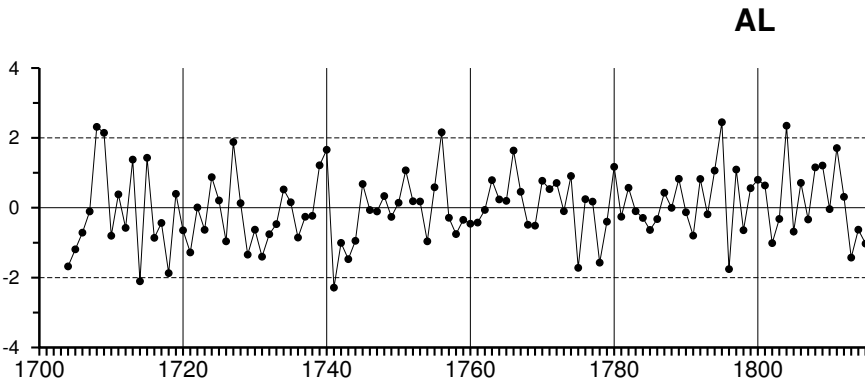
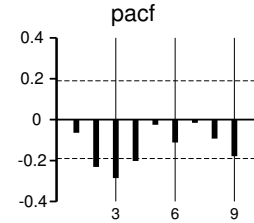
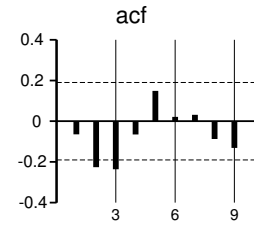
Some additional information is presented: 1) period in years (\hat{p}) and dampening factor (\hat{d}) of the AR(2) with imaginary roots operator, 2) the value of the SF statistic (Shin and Fuller, 1998) for contrasts whether the AR(1) operator is non-stationary, 3) the value of the DCD statistic for

an MA(1) operator, which is added as a test for regular over-differentiation. Notice that, in the case of an AR(2) with imaginary roots operator, the non-stationarity test of Shin and Fuller is not justified. An AR(2) with imaginary roots operator is a simple and irreducible factor. Therefore to control for an non-stationary AR(1) a regular difference is added. For testing over-differentiation we add an MA(1) operator. Invertibility of the MA(1) is tested through the DCD statistic. If $H_0 : \theta = 1$ is not rejected, then we accept that the pairwise relative price (price ratios) is stationary, $I(0)$. The hypothesis of normality of innovations is checked both by reference to skewness and excess kurtosis measures and by the Jarque-Bera test (JB).

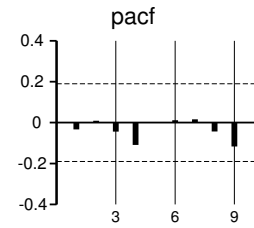
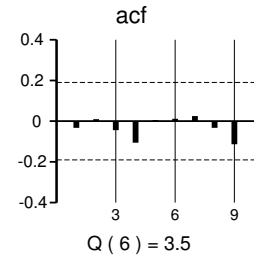
All efficient estimation of models in the present paper were performed with a computer program Free Univariate Estimation (FUE) originally designed, coded and debugged by J. Alberto Mauricio and modified later by David E. Guerrero. All time series graphics were performed with Free Univariate Graphics (FUG), a computer program designed, coded and debugged by Arthur B. Treadway and David E. Guerrero. The C source code together with user's manual for these computer programs are available from David E. Guerrero. These are free programs in the FSF sense. The estimation criterion is Exact Unconditional Maximum Likelihood and the implementation combines procedures for evaluation of the exact unconditional maximum likelihood function for the univariate ARMA model by Melard (1984) with other procedures developed by Mauricio (1992, 1995, 1997). In only some cases the conditional maximum likelihood criterion is used (Bartlett's Test). In these cases we used GNU/GRETL.



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.52\% (2.31\%) \quad \hat{\sigma}_w = 24.50\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 2.52\% (1.97\%) \quad \hat{\sigma}_w = 20.88\%$$



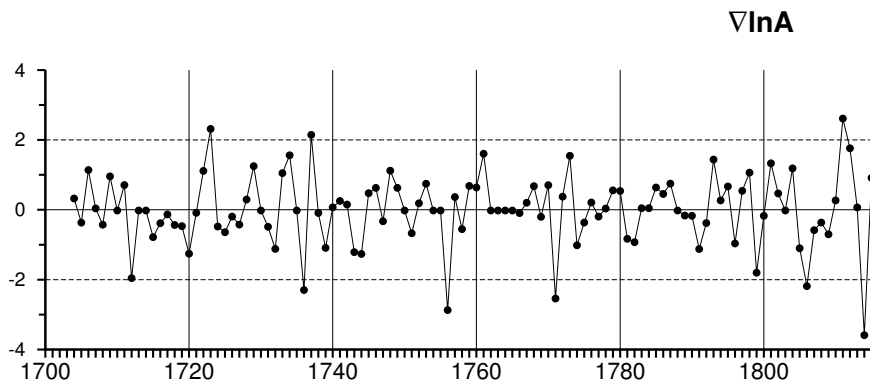
$$\ln L_t = + \begin{matrix} (0.55 + 0.65B) \\ (0.19) \quad (0.20) \end{matrix} \xi_t^{I,1799} + N_t$$

$$(1 - 0.56B + 0.20B^2) \nabla N_t = (1 - 0.80B) AL_t; \quad \hat{\sigma}_{AL} = 21.06\% \\ (0.12) \quad (0.10) \quad (0.08)$$

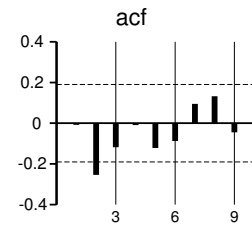
Obs.	Date	Std. Val.
5	1708	2.31
6	1709	2.14
11	1714	-2.10
38	1741	-2.29
53	1756	2.16
92	1795	2.45
101	1804	2.35

Comments:

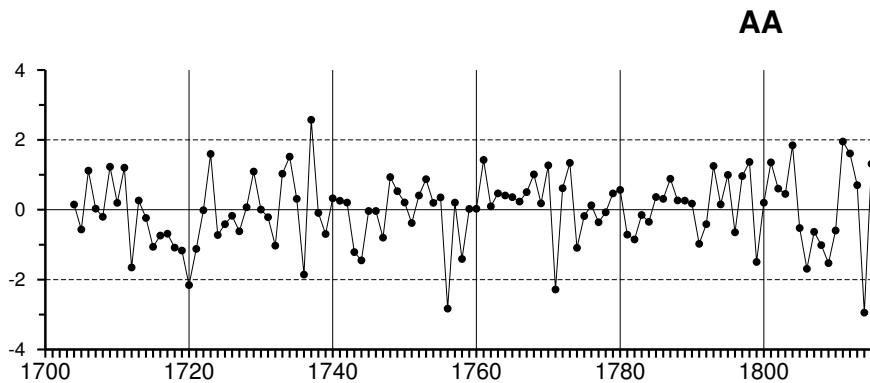
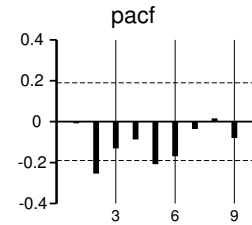
- 1) JB= 1.28
- 2) In AR(2) with i.r.: $\hat{p} = 7.0(1.9)$ and $\hat{d} = .45(.11)$
- 3) DCD = 13.3 reject $\theta = 1$



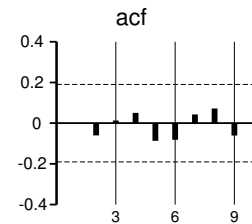
$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.76\% (3.25\%) \quad \hat{\sigma}_w = 34.42\%$$



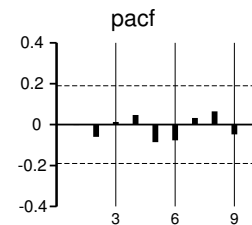
$$Q(9) = 15.3$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 3.58\% (2.95\%) \quad \hat{\sigma}_w = 31.26\%$$



$$Q(6) = 3.8$$



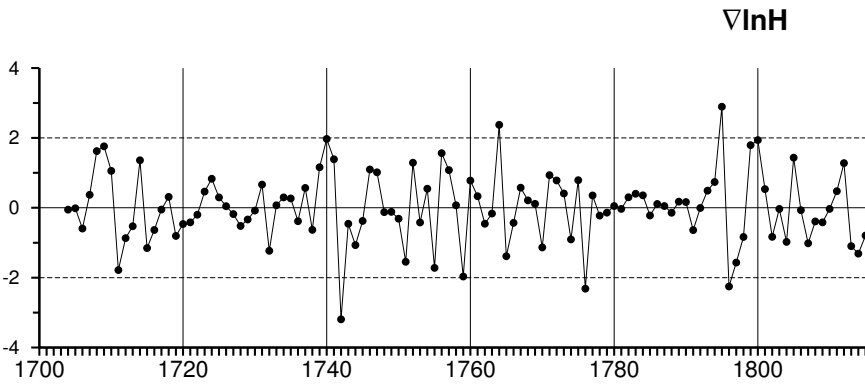
$$(1 - 0.75B + 0.22B^2)\nabla \ln A_t = (1 - 0.90B)AA_t; \quad \hat{\sigma}_{AA} = 31.48\%$$

$$(0.10) \quad (0.09) \quad (0.05)$$

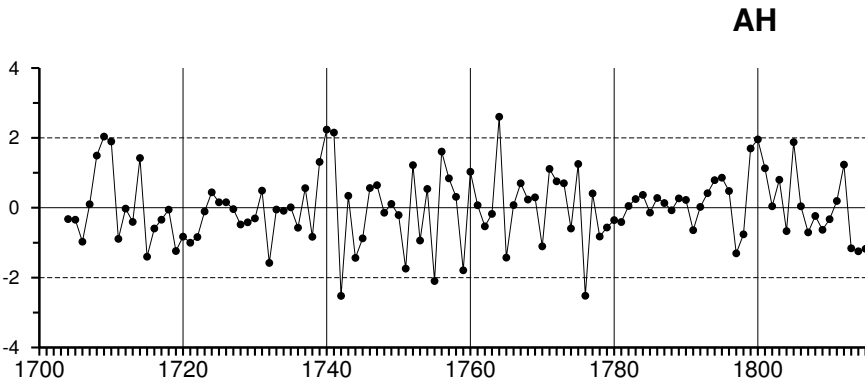
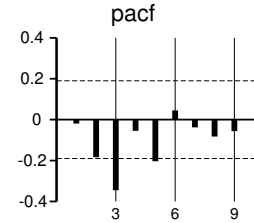
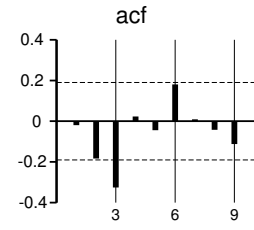
Obs.	Date	Std. Val.
17	1720	-2.16
34	1737	2.58
53	1756	-2.83
68	1771	-2.28
111	1814	-2.95

Comments:

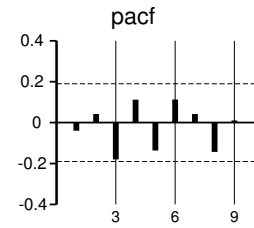
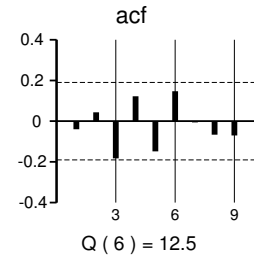
- 1) JB= 2.96
- 2) In AR(2) with i.r: $\hat{\rho} = 9.8(4.2)$ and $\hat{d} = .47(.10)$
- 3) DCD = 8.3 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.63\% (1.80\%) \quad \hat{\sigma}_w = 19.01\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 2.25\% (1.56\%) \quad \hat{\sigma}_w = 16.49\%$$



$$\ln H_t = +0.44 \xi_t^{I,1795} + N_t$$

(0.13)

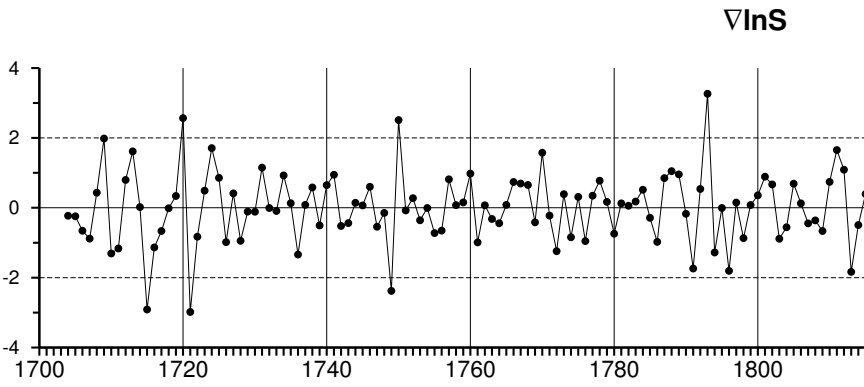
$$(1 - 0.70B + 0.23B^2) \nabla N_t = (1 - 0.82B) AH_t; \quad \hat{\sigma}_{AH} = 16.67\%$$

(0.13) (0.10) (0.10)

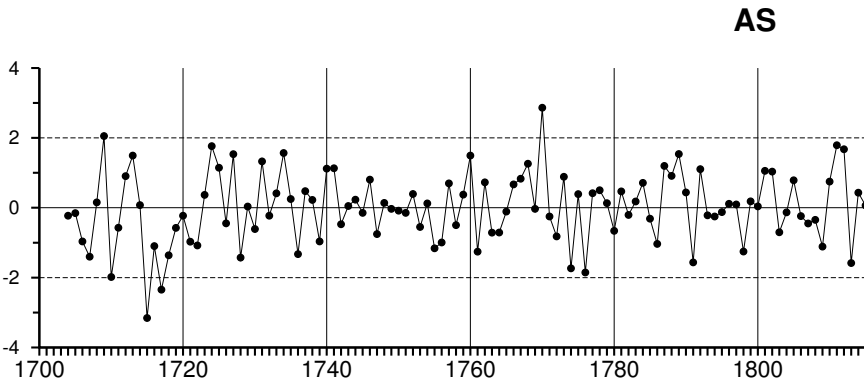
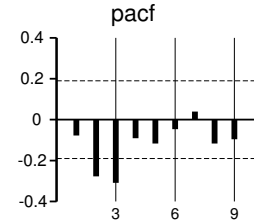
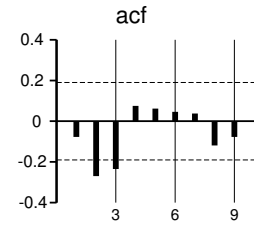
Obs.	Date	Std. Val.
6	1709	2.04
37	1740	2.24
38	1741	2.15
39	1742	-2.52
52	1755	-2.10
61	1764	2.60
73	1776	-2.52

Comments:

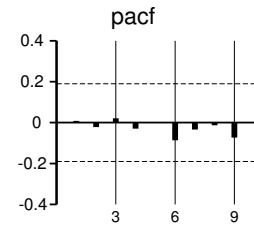
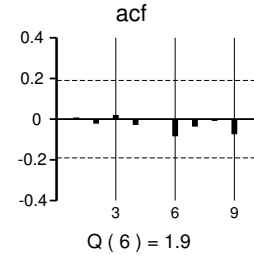
- 1) JB= .40
- 2) In AR(2) with i.r.: $\hat{p} = 8.3(3.2)$ and $\hat{d} = .48(.11)$
- 3) DCD = 10.7 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.11\% (2.14\%) \quad \hat{\sigma}_w = 22.69\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.36\% (1.52\%) \quad \hat{\sigma}_w = 16.14\%$$



$$\ln S_t = +0.53\xi_t^{I,1720} - 0.56\xi_t^{I,1749} + (0.64 + 0.37B + 0.42B^2)\xi_t^{I,1793} + N_t$$

(0.11)
(0.11)
(0.16) (0.19) (0.15)

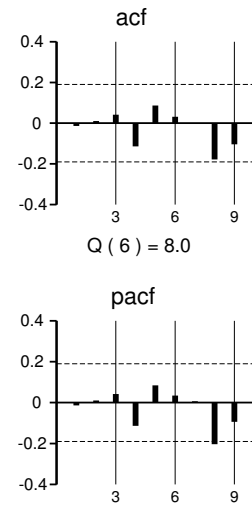
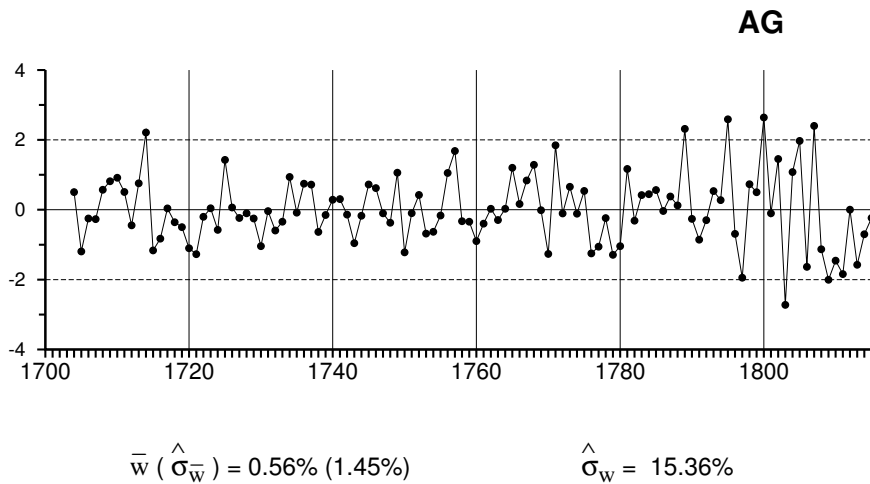
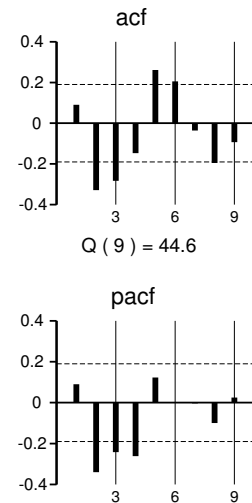
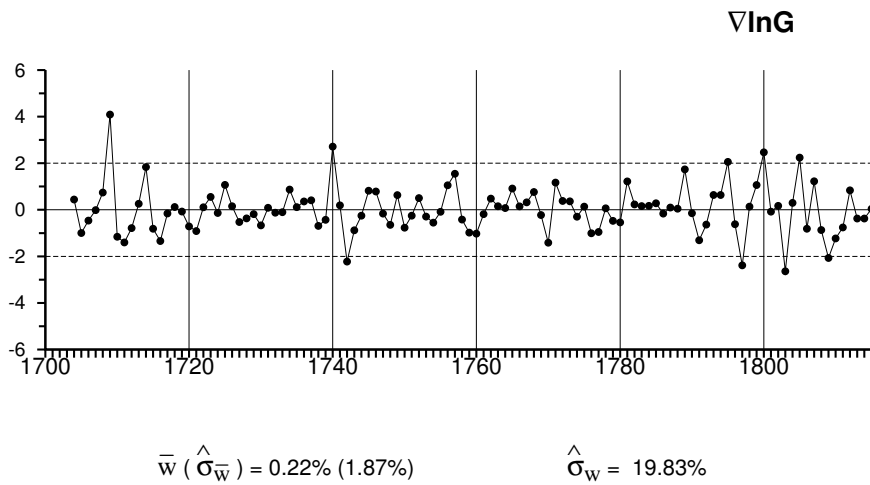
$$(1 - 0.50B + 0.41B^2)\nabla N_t = (1 - 0.50B)AS_t; \quad \hat{\sigma}_{AS} = 16.15\%$$

(0.20) (0.10)
(0.22)

Obs.	Date	Std. Val.
6	1709	2.05
12	1715	-3.15
14	1717	-2.34
67	1770	2.86

Comments:

- 1) JB= 0.73
- 2) In AR(2) with i.r: $\hat{\rho} = 5.4(0.8)$ and $\hat{d} = 0.64(0.08)$
- 3) DCD = 14.1 reject $\theta = 1$



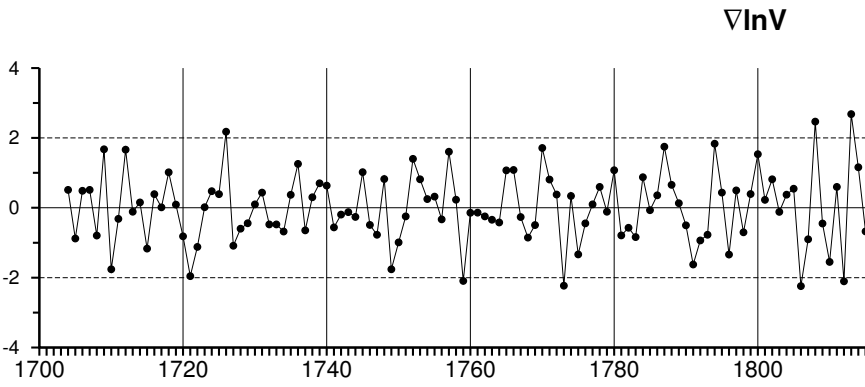
$$\ln G_t = + \begin{pmatrix} 0.64 \\ 0.14 \end{pmatrix} + \begin{pmatrix} 0.29B \\ 0.14 \end{pmatrix} \xi_t^{I,1709} + \begin{pmatrix} 0.48 \\ 0.13 \end{pmatrix} + \begin{pmatrix} 0.43B \\ 0.13 \end{pmatrix} \xi_t^{I,1740} + N_t$$

$$(1 - \begin{pmatrix} 0.66B \\ 0.17 \end{pmatrix} + \begin{pmatrix} 0.39B^2 \\ 0.09 \end{pmatrix}) \nabla N_t = (1 - \begin{pmatrix} 0.60B \\ 0.18 \end{pmatrix}) AG_t; \quad \hat{\sigma}_{AG} = 15.38\%$$

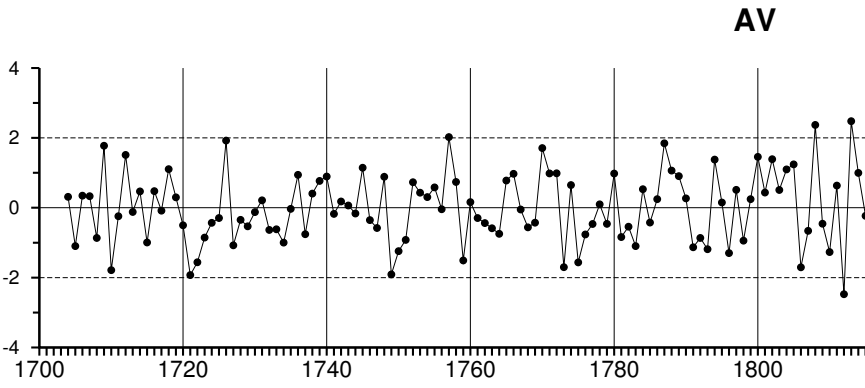
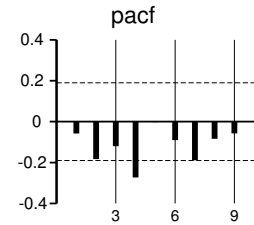
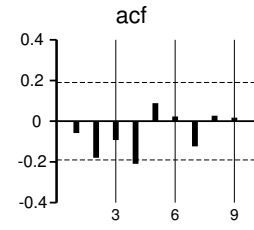
Obs.	Date	Std. Val.
11	1714	2.21
86	1789	2.32
92	1795	2.59
97	1800	2.64
100	1803	-2.72
104	1807	2.40
106	1809	-2.00

Comments:

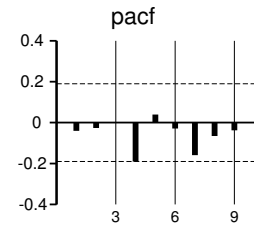
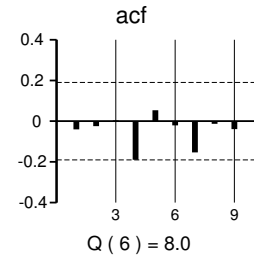
- 1) JB= 2.49
- 2) In AR(2) with i.r.: $\hat{p} = 6.2(1.1)$ and $\hat{d} = 0.62(0.07)$
- 3) DCD = 10.8 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 1.34\% (2.18\%) \quad \hat{\sigma}_w = 23.10\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 3.76\% (2.01\%) \quad \hat{\sigma}_w = 21.23\%$$



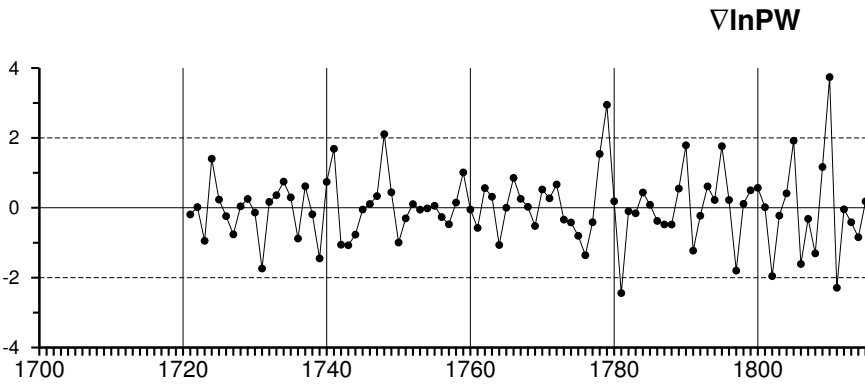
$$(1 - 0.69B + 0.17B^2)\nabla \ln V_t = (1 - 0.86B)AV_t; \quad \hat{\sigma}_{AV} = 21.57\%$$

$$(0.11) \quad (0.10) \quad (0.06)$$

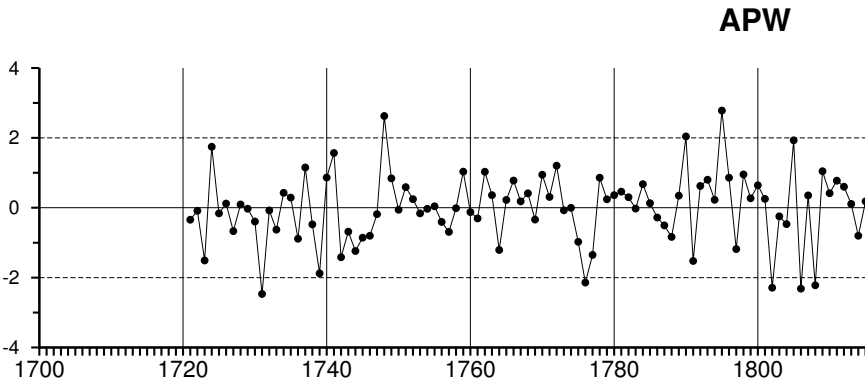
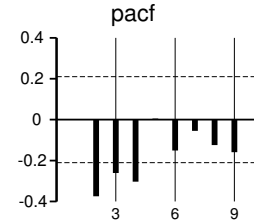
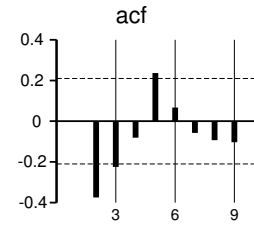
Obs.	Date	Std. Val.
54	1757	2.02
105	1808	2.37
109	1812	-2.48
110	1813	2.48

Comments:

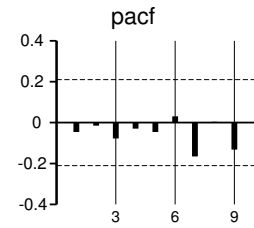
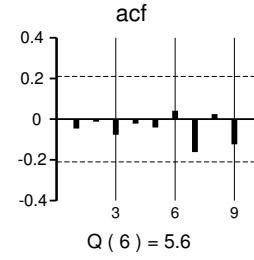
- 1) JB= 0.76
- 2) In AR(2) with i.r.: $\hat{p} = 10.4(6.7)$ and $\hat{d} = .42(.12)$
- 3) DCD = 12.0 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 1.17\% (2.40\%) \quad \hat{\sigma}_w = 23.41\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 3.02\% (1.71\%) \quad \hat{\sigma}_w = 16.62\%$$



$$\ln PW_t = + \begin{matrix} (0.50 + 0.54B) \\ (0.16) \end{matrix} \xi_t^{I,1779} + \begin{matrix} 0.65 \\ (0.13) \end{matrix} \xi_t^{I,1810} + N_t$$

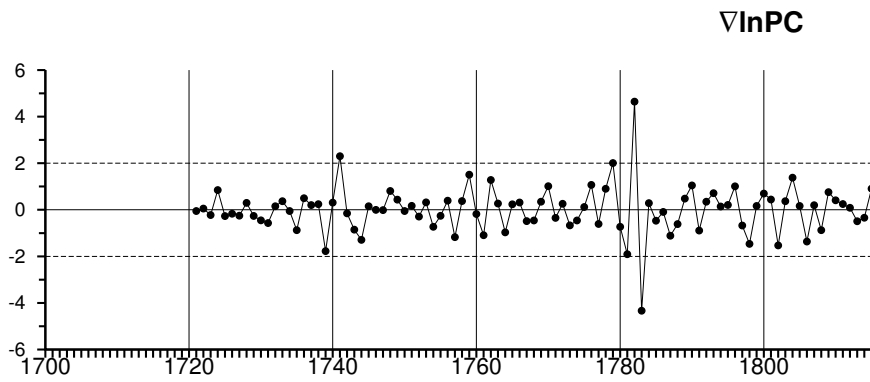
$$(1 - 0.58B + 0.38B^2) \nabla N_t = (1 - 0.67B) APW_t; \quad \hat{\sigma}_{APW} = 16.90\%$$

(0.14) (0.10) (0.13)

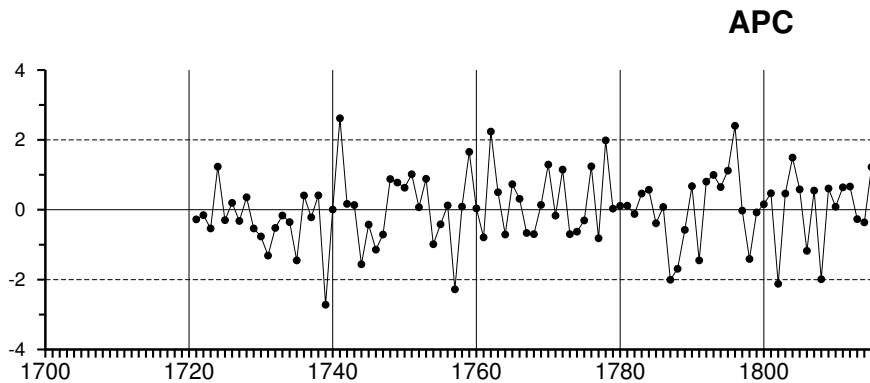
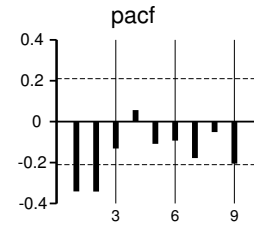
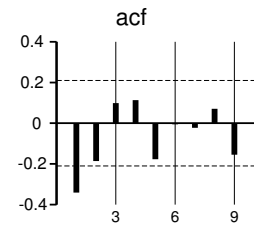
Obs.	Date	Std. Val.
11	1731	-2.47
28	1748	2.63
56	1776	-2.14
70	1790	2.04
75	1795	2.78
82	1802	-2.29
86	1806	-2.32
88	1808	-2.22

Comments:

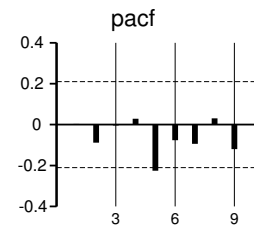
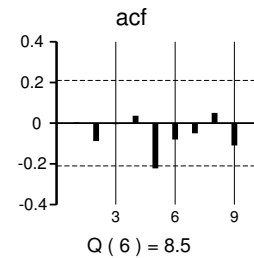
- 1) JB= 1.83
- 2) In AR(2) with i.r.: $\hat{p} = 5.8(0.5)$ and $\hat{d} = 0.62(0.08)$
- 3) DCD = 20.1 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 1.23\% (3.02\%) \quad \hat{\sigma}_w = 29.48\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 3.19\% (1.81\%) \quad \hat{\sigma}_w = 17.67\%$$



$$\ln PC_t = + \begin{matrix} (0.66 + 0.55B) \\ (0.17) \end{matrix} \zeta_t^{I,1779} + \begin{matrix} 1.38 \\ (0.14) \end{matrix} \zeta_t^{I,1782} + N_t$$

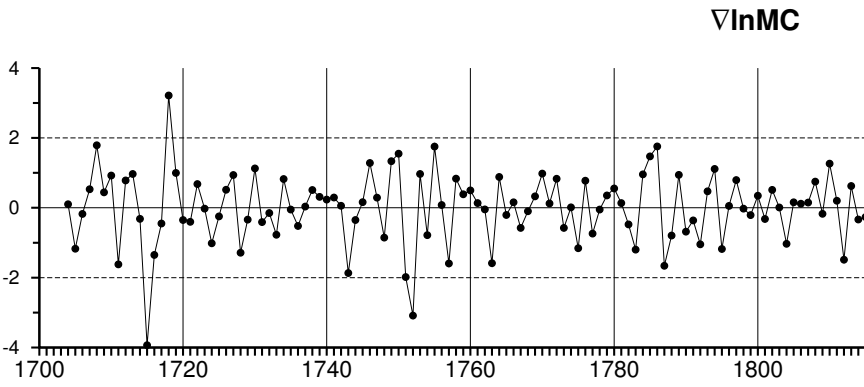
$$(1 - 0.41B + 0.35B^2) \nabla N_t = (1 - 0.69B) APC_t; \quad \hat{\sigma}_{APC} = 17.96\%$$

$$\begin{matrix} (0.14) & (0.11) \\ & (0.14) \end{matrix}$$

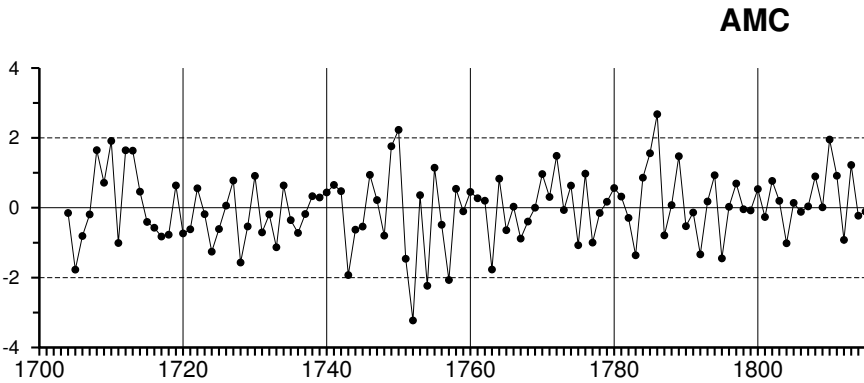
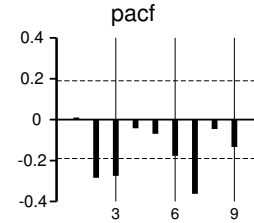
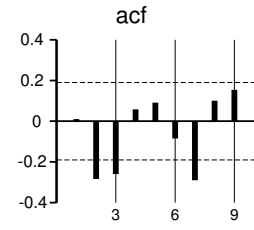
Obs.	Date	Std. Val.
19	1739	-2.72
21	1741	2.62
37	1757	-2.28
42	1762	2.24
67	1787	-2.01
76	1796	2.40
82	1802	-2.12

Comments:

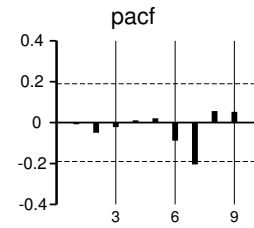
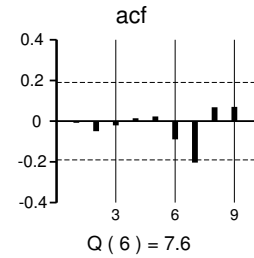
- 1) JB= 0.40
- 2) In AR(2) with i.r.: $\hat{\rho} = 5.2(0.6)$ and $\hat{d} = 0.59(0.09)$
- 3) DCD = 23.4 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.98\% (3.87\%) \quad \hat{\sigma}_w = 40.92\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 3.80\% (3.04\%) \quad \hat{\sigma}_w = 32.14\%$$



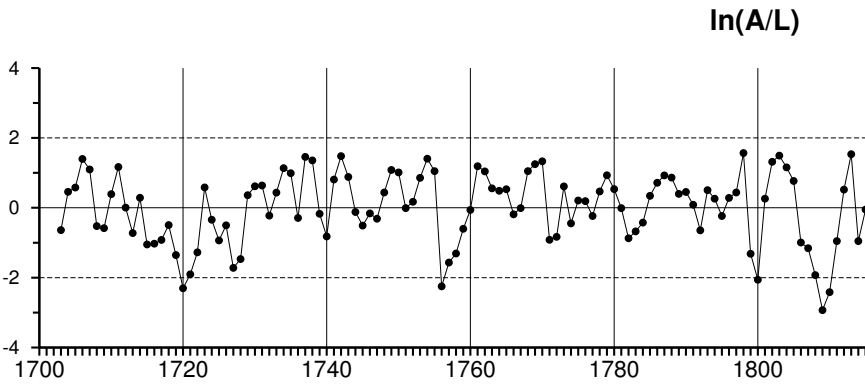
$$\ln MC_t = -\begin{pmatrix} 1.19 \\ (0.30) \end{pmatrix} + \begin{pmatrix} 1.43B \\ (0.35) \end{pmatrix} + \begin{pmatrix} 1.40B^2 \\ (0.31) \end{pmatrix} \xi_t^{I,1715} + N_t$$

$$(1 - \begin{pmatrix} 0.63B \\ (0.10) \end{pmatrix} + \begin{pmatrix} 0.20B^2 \\ (0.09) \end{pmatrix}) \nabla N_t = (1 - \begin{pmatrix} 0.88B \\ (0.08) \end{pmatrix}) AMC_t; \quad \hat{\sigma}_{AMC} = 32.40\%$$

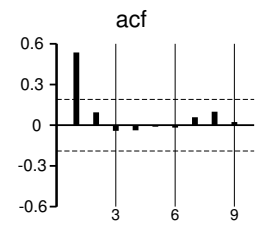
Obs.	Date	Std. Val.
47	1750	2.23
49	1752	-3.23
51	1754	-2.24
54	1757	-2.07
83	1786	2.68

Comments:

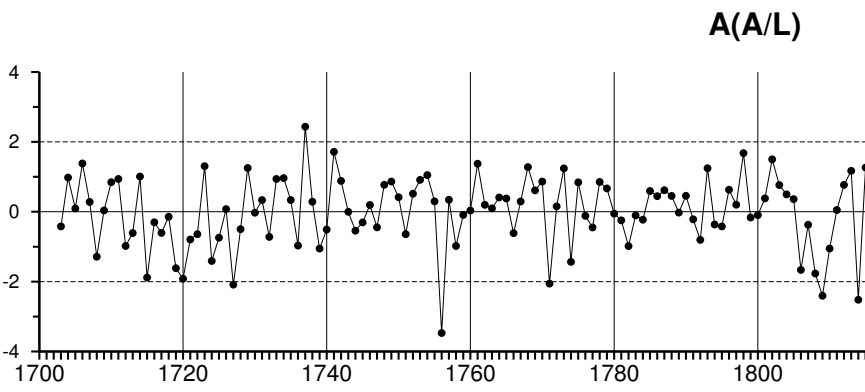
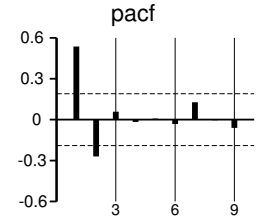
- 1) JB= 1.11
- 2) In AR(2) with i.r.: $\hat{p} = 7.9(2.3)$ and $\hat{d} = 0.45(0.10)$
- 3) DCD = 7.9 reject $\theta = 1$



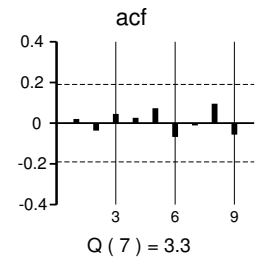
$$\bar{w} (\hat{\sigma}_{\bar{w}}) = -43.40\% (4.21\%) \quad \hat{\sigma}_{\bar{w}} = 44.77\%$$



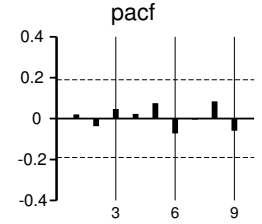
Q (9) = 36.6



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.25\% (3.25\%) \quad \hat{\sigma}_{\bar{w}} = 34.60\%$$



Q (7) = 3.3



$$\ln(A/L)_t = -(1.00 + 1.02B)\zeta_t^{I,1799} + N_t$$

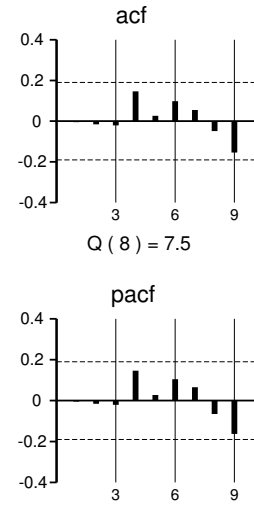
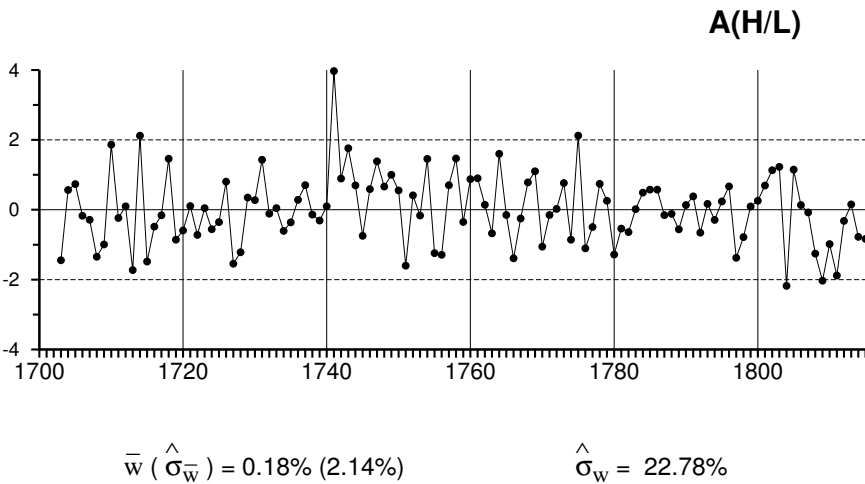
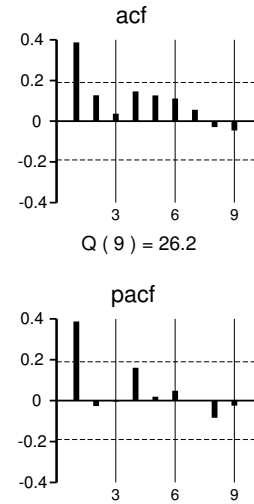
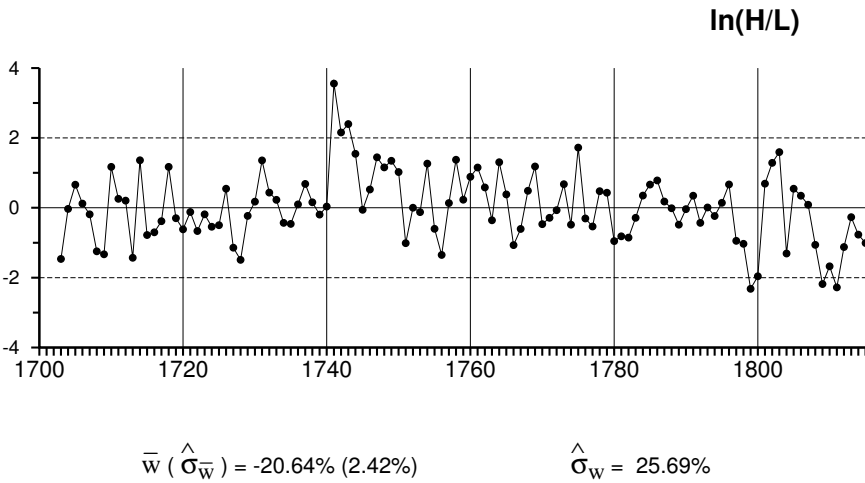
(0.34) (0.34)

$$(1 - 0.71B + 0.24B^2) \begin{bmatrix} N_t + 0.42 \\ (0.09) \quad (0.09) \quad (0.06) \end{bmatrix} = A(A/L)_t; \quad \hat{\sigma}_{A(A/L)} = 34.65\%$$

Obs.	Date	Std. Val.
25	1727	-2.09
35	1737	2.43
54	1756	-3.47
69	1771	-2.06
107	1809	-2.40
112	1814	-2.52

Comments:

- 1) JB= 10.19
- 2) In AR(2) with i.r: $\hat{p} = 8.3(2.7)$ and $\hat{d} = .49(.09)$
- 3) In a potentially over-differenced model, DCD = 0 don't reject $\theta = 1 \rightarrow I(0)$ is confirmed
- 4) Very extreme value in 1756. Adding I1756 is just influential over JB only. Could be explained by 7 years war, but is not clear.
- 5) JB= 2.90 after added I1756.



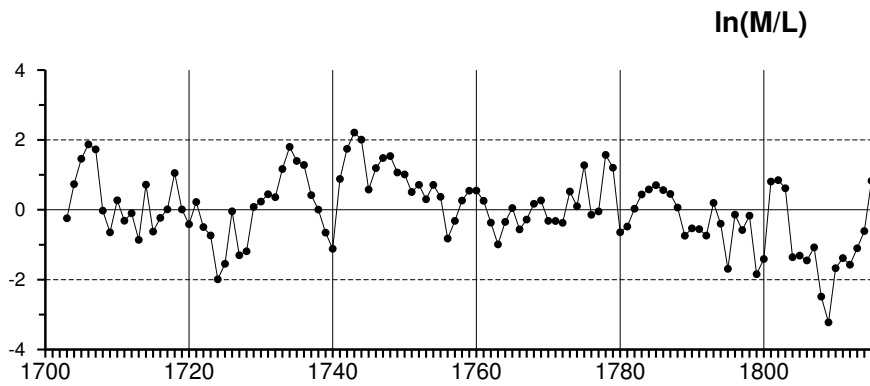
$$\ln(H/L)_t = -\begin{pmatrix} 0.52 \\ 0.23 \end{pmatrix} + \begin{pmatrix} 0.54B \\ 0.22 \end{pmatrix} \xi_t^{I,1799} + N_t$$

$$(1 - 0.38B) \begin{bmatrix} N_t + 0.20 \\ 0.03 \end{bmatrix} = A(H/L)_t; \quad \hat{\sigma}_{A(H/L)} = 22.82\%$$

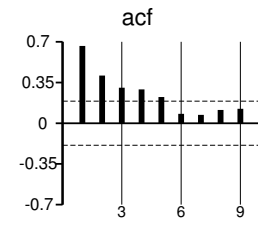
Obs.	Date	Std. Val.
12	1714	2.12
39	1741	3.97
73	1775	2.12
102	1804	-2.18
107	1809	-2.03

Comments:

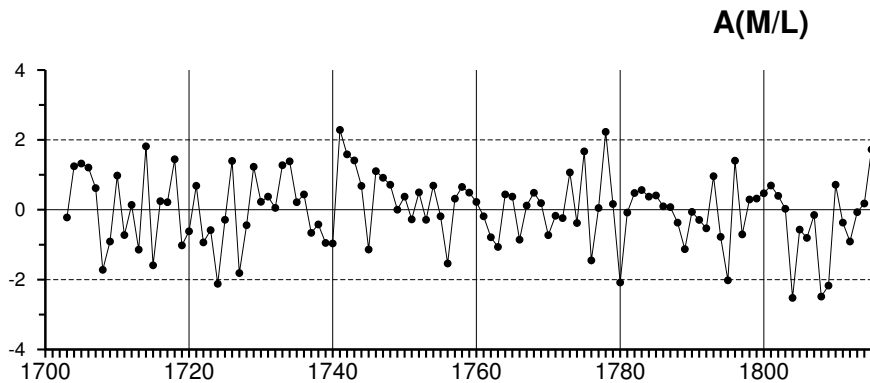
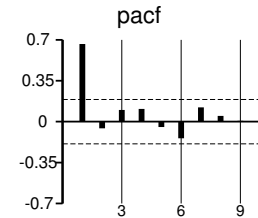
- 1) JB= 10.03
- 2) SF= 39.1
- 3) In a potentially over-differenced model, DCD= 1.9 is ambiguous respect $\theta = 1$
- 4) Very extreme value in 1741. Adding I1741, I1742 and I1743 are just influential over JB only.
- 5) JB= 0.72 after added 3 impulses in 1741-43.



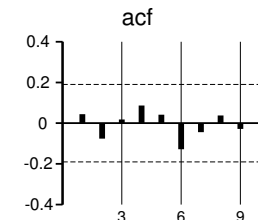
$$\bar{w} (\hat{\sigma}_{\bar{w}}) = -24.15\% (3.02\%) \quad \hat{\sigma}_{\bar{w}} = 32.07\%$$



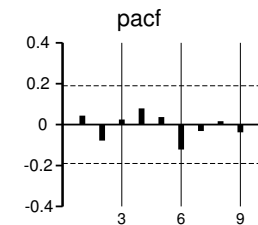
$$Q(9) = 102.9$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.09\% (2.14\%) \quad \hat{\sigma}_{\bar{w}} = 22.79\%$$



$$Q(8) = 4.6$$



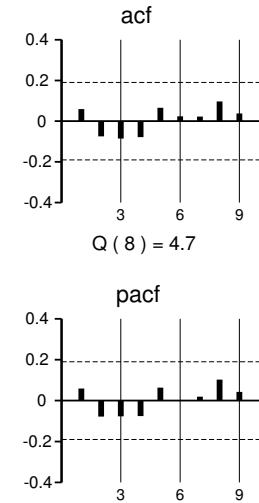
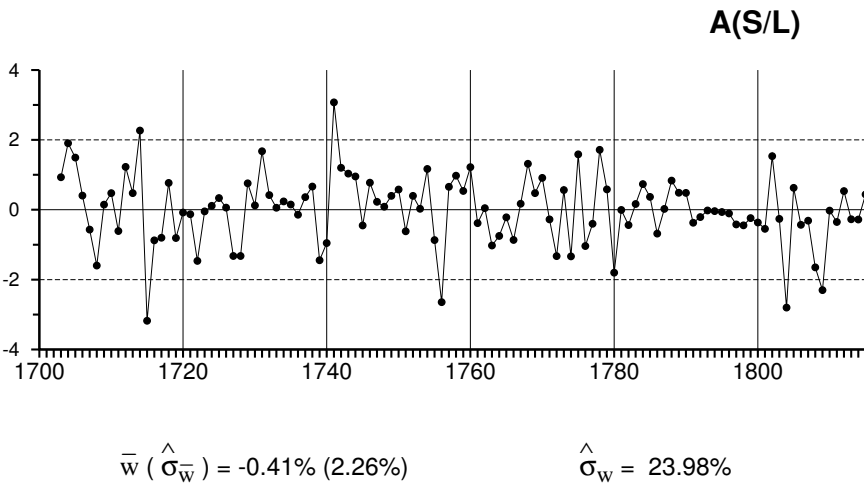
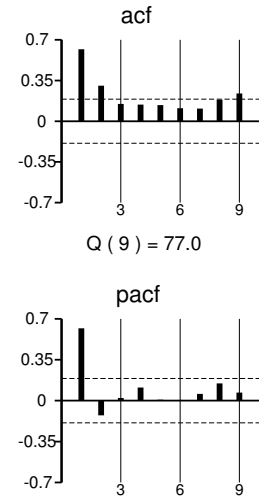
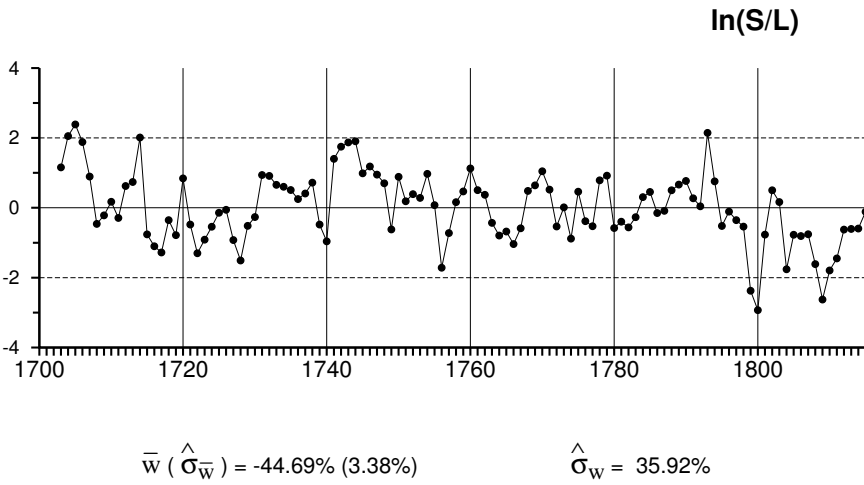
$$\ln(M/L)_t = -\frac{(0.63 + 0.59B)\xi_t^{I,1799}}{(0.21) (0.22)} + N_t$$

$$(1 - 0.68B) \begin{bmatrix} N_t + 0.23 \\ (0.07) \end{bmatrix} = A(M/L)_t; \quad \hat{\sigma}_{A(M/L)} = 22.79\%$$

Obs.	Date	Std. Val.
22	1724	-2.12
39	1741	2.29
76	1778	2.23
78	1780	-2.08
93	1795	-2.02
102	1804	-2.52
106	1808	-2.49
107	1809	-2.17

Comments:

- 1) JB= 1.25
- 2) SF= 17.2
- 3) In a potentially over-differenced model, DCD= 0
don't reject $\theta = 1 \rightarrow I(0)$ is confirmed



$$\ln(S/L)_t = +0.51 \xi_t^{I,1720} - 0.49 \xi_t^{I,1749} + (0.77 + 0.28B - 0.17B^2) \xi_t^{I,1793} - (0.66 + 0.84B) \xi_t^{I,1799} + N_t$$

(0.14) (0.16) (0.21) (0.25) (0.23) (0.21) (0.22)

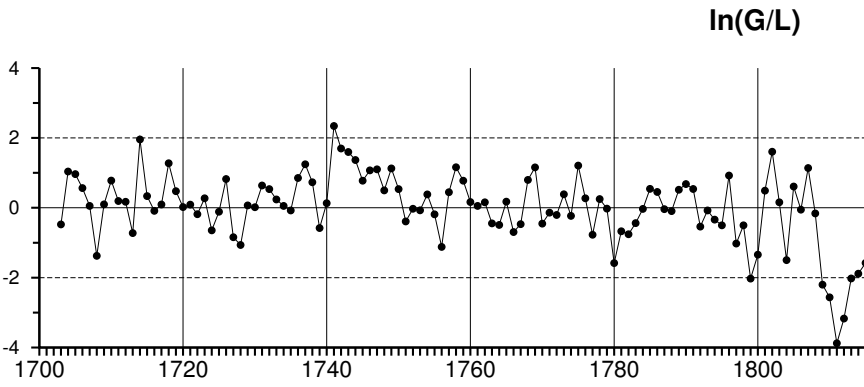
$$(1 - 0.68B) \left[N_t + 0.44 \right] = A(S/L)_t; \quad \hat{\sigma}_{A(S/L)} = 24.06\%$$

(0.07) (0.07)

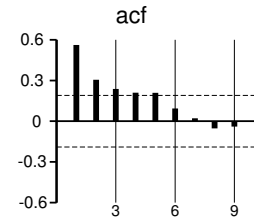
Obs.	Date	Std. Val.
12	1714	2.27
13	1715	-3.18
39	1741	3.08
54	1756	-2.64
102	1804	-2.80
107	1809	-2.30

Comments:

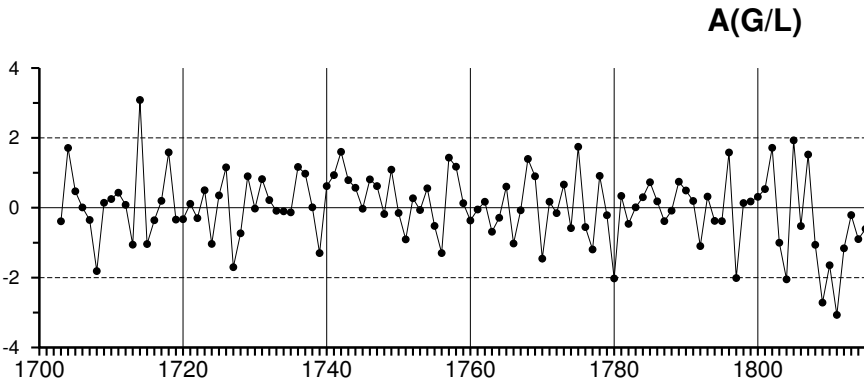
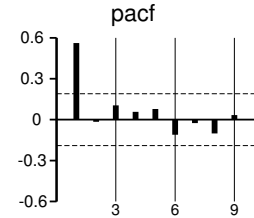
- 1) JB= 8.35
- 2) SF= 17.3
- 3) In a potentially over-differenced model, DCD= .5 don't reject $\theta = 1 \rightarrow I(0)$ is confirmed
- 4) Very extreme value in 1715. Adding I1714, is only influential over JB.
- 5) JB= 5.04 after added impulse in 1714.



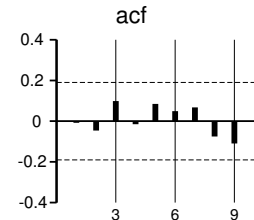
$$\bar{w} (\hat{\sigma}_{\bar{w}}) = -50.10\% (2.87\%) \quad \hat{\sigma}_{\bar{w}} = 30.54\%$$



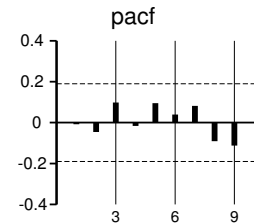
$$Q(9) = 66.5$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.11\% (2.22\%) \quad \hat{\sigma}_{\bar{w}} = 23.61\%$$



$$Q(8) = 5.4$$



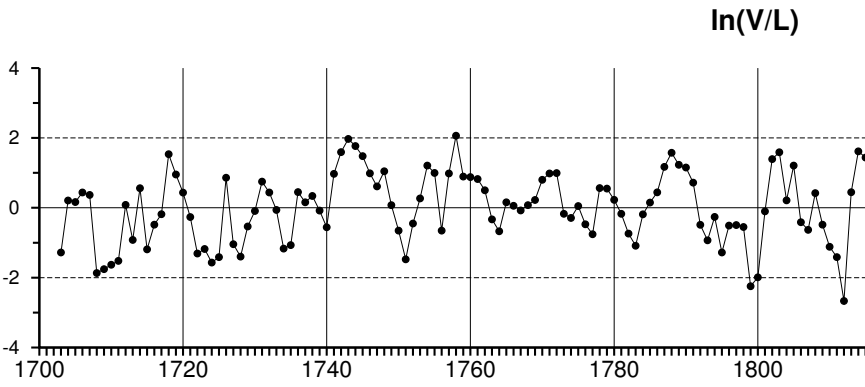
$$\ln(G/L)_t = + \begin{matrix} (0.24 + 0.31B) \\ (0.20) \end{matrix} \xi_t^{I,1709} + \begin{matrix} 0.47 \\ (0.20) \end{matrix} \xi_t^{I,1741} - \begin{matrix} (0.57 + 0.45B) \\ (0.14) \end{matrix} \xi_t^{I,1799} + N_t$$

$$(1 - 0.59B) \begin{bmatrix} N_t + 0.51 \\ (0.07) \quad (0.05) \end{bmatrix} = A(G/L)_t; \quad \hat{\sigma}_{A(G/L)} = 23.61\%$$

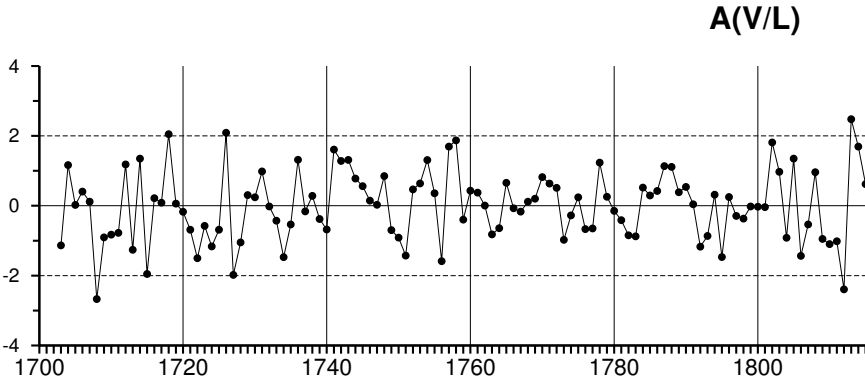
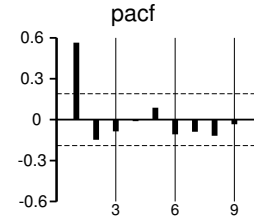
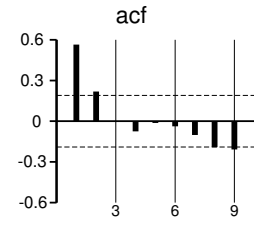
Obs.	Date	Std. Val.
12	1714	3.09
78	1780	-2.02
95	1797	-2.01
102	1804	-2.05
107	1809	-2.72
109	1811	-3.07

Comments:

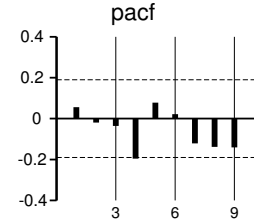
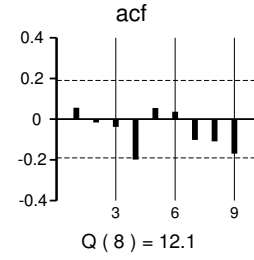
- 1) JB= 3.25
- 2) SF= 23.3
- 3) In a potentially over-differenced model, DCD= 2.7 reject $\theta = 1$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = -72.88\% (3.18\%) \quad \hat{\sigma}_{\bar{w}} = 33.86\%$$



$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.35\% (2.51\%) \quad \hat{\sigma}_{\bar{w}} = 26.66\%$$



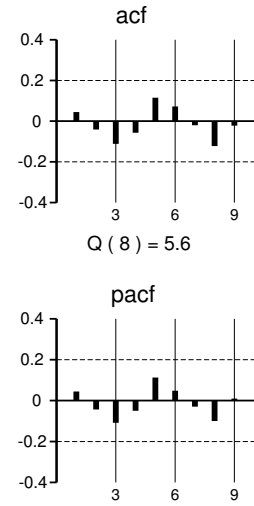
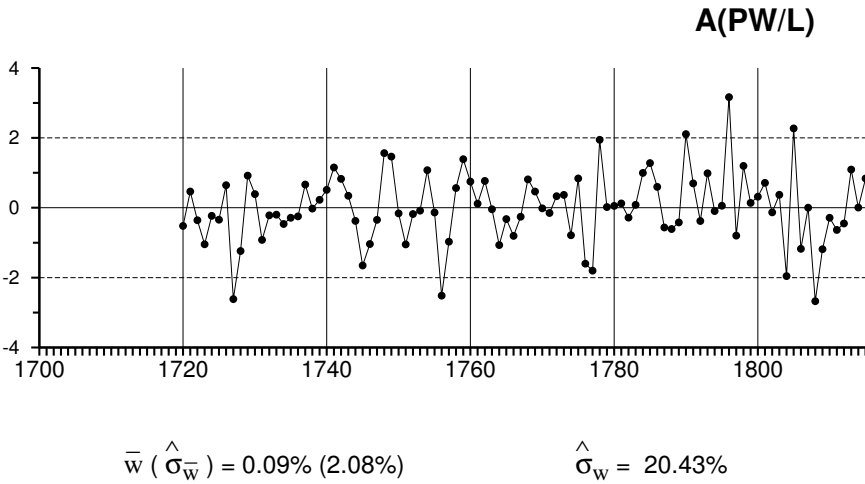
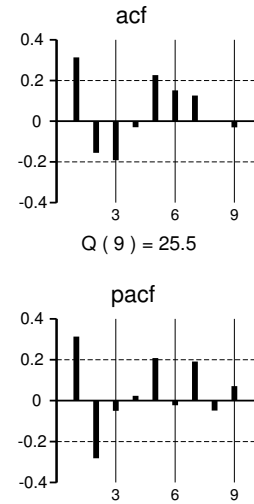
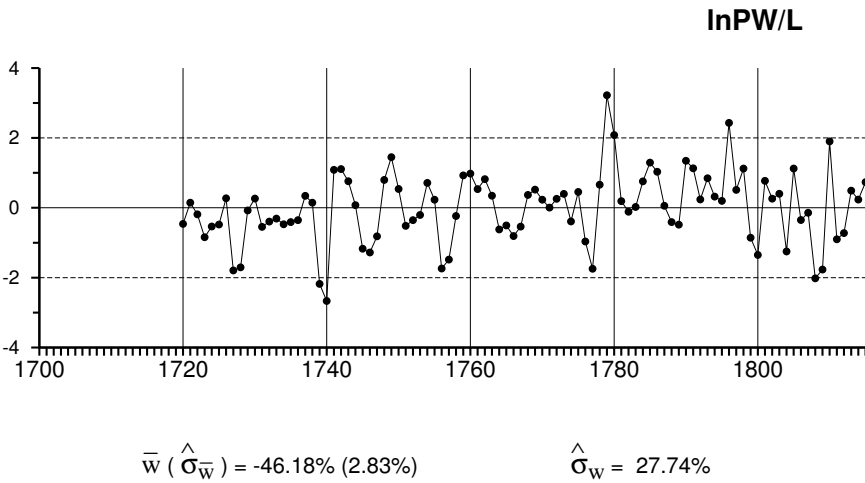
$$\ln(V/L)_t = -\begin{matrix} (0.66 + 0.62B) \\ (0.26) (0.26) \end{matrix} \xi_t^{I,1799} + N_t$$

$$(1 - 0.57B) \begin{bmatrix} N_t + 0.72 \\ (0.08) (0.06) \end{bmatrix} = A(V/L)_t; \quad \hat{\sigma}_{A(V/L)} = 26.74\%$$

Obs.	Date	Std. Val.
6	1708	-2.67
16	1718	2.05
24	1726	2.09
110	1812	-2.39
111	1813	2.48

Comments:

- 1) JB= 0.18
- 2) SF= 24.0
- 3) In a potentially over-differenced model, DCD= 0 don't reject $\theta = 1 \rightarrow I(0)$ is confirmed



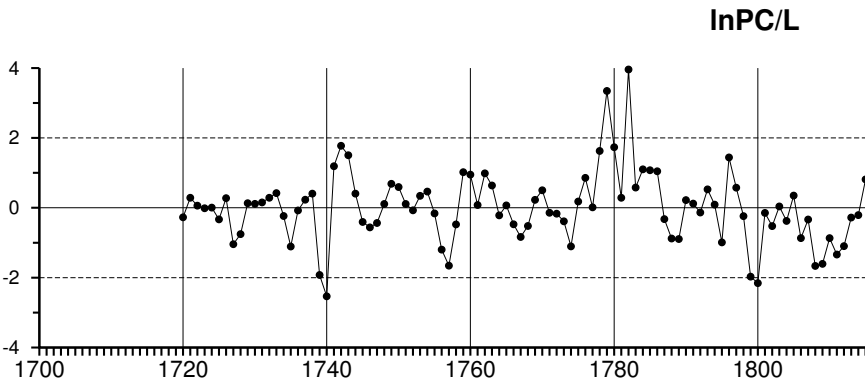
$$\ln(PW/L)_t = -\frac{(0.67 + 0.88B)}{(0.16) (0.16)} \xi_t^{I,1739} + \frac{(0.80 + 0.52B)}{(0.19) (0.19)} \xi_t^{I,1779} - \frac{(0.41 + 0.52B)}{(0.15) (0.15)} \xi_t^{I,1799} + \frac{0.80 \xi_t^{I,1810}}{(0.19)} + N_t$$

$$(1 - 0.45B) \left[N_t + \frac{0.46}{(0.04)} \right] = A(PW/L)_t; \quad \hat{\sigma}_{A(PW/L)} = 20.43\%$$

Obs.	Date	Std. Val.
8	1727	-2.62
37	1756	-2.52
71	1790	2.11
77	1796	3.17
86	1805	2.27
89	1808	-2.67

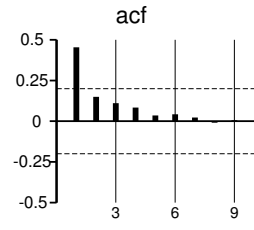
Comments:

- 1) JB= 3.98
- 2) SF= 28.5
- 3) In a potentially over-differenced model, DCD= 0 don't reject $\theta = 1 \rightarrow I(0)$ is confirmed

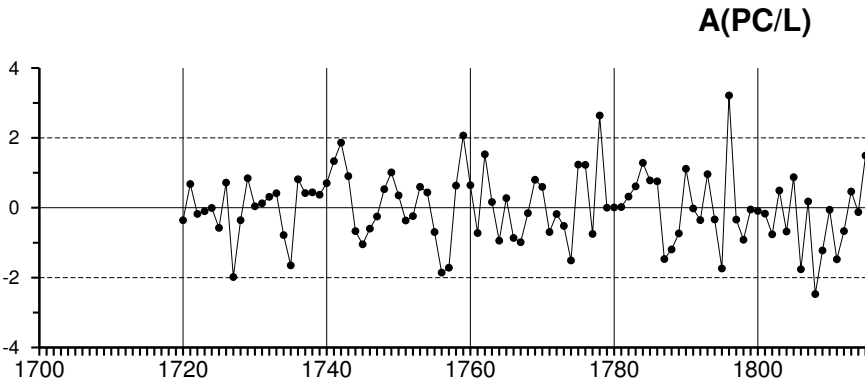
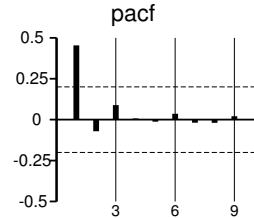


$$\bar{w} (\hat{\sigma}_{\bar{w}}) = -107.35\% (3.63\%)$$

$$\hat{\sigma}_w = 35.59\%$$

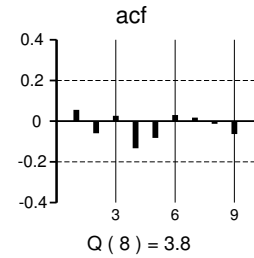


$$Q(9) = 25.0$$

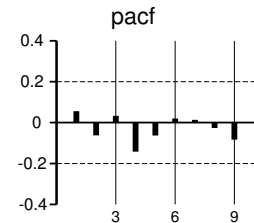


$$\bar{w} (\hat{\sigma}_{\bar{w}}) = 0.09\% (2.21\%)$$

$$\hat{\sigma}_w = 21.61\%$$



$$Q(8) = 3.8$$



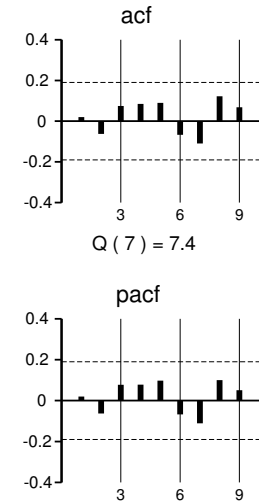
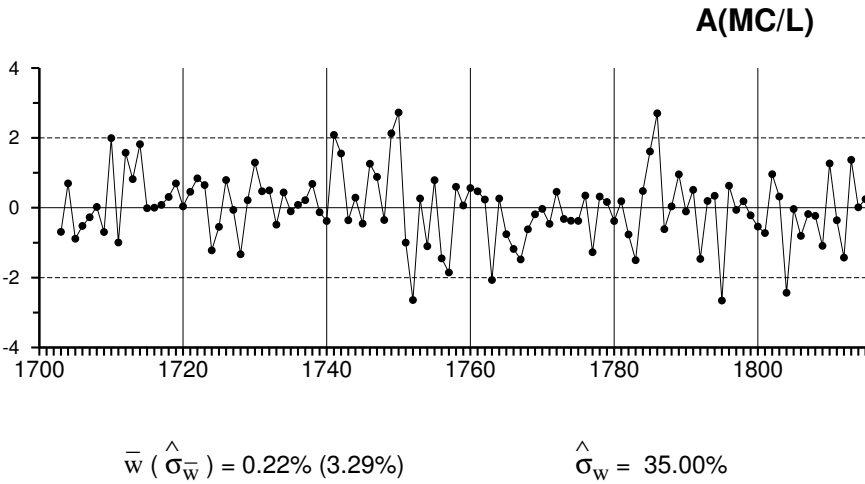
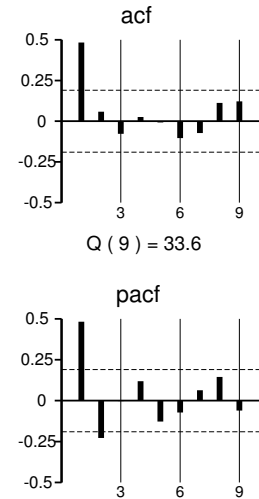
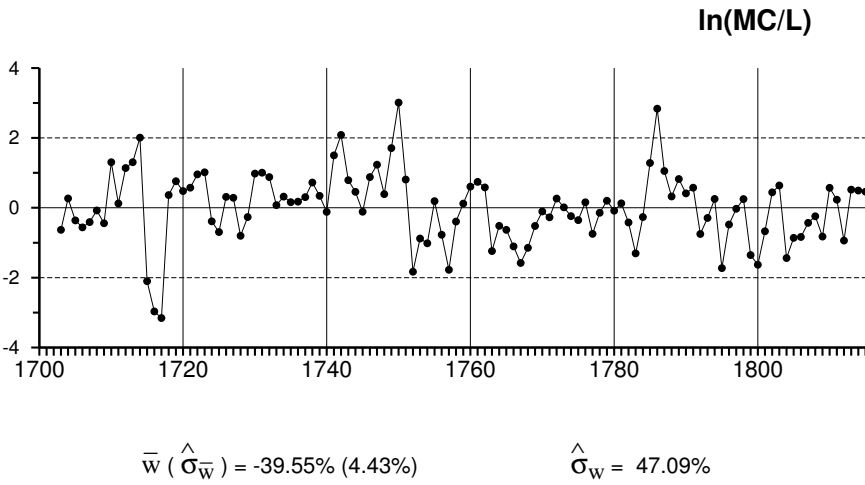
$$\ln(PC/L)_t = -\begin{matrix} (0.85 & + & 1.15B) \\ (0.17) & (0.18) \end{matrix} \xi_t^{I,1739} + \begin{matrix} (0.88 & + & 0.44B) \\ (0.19) & (0.18) \end{matrix} \xi_t^{I,1779} + \begin{matrix} 1.28 \\ (0.19) \end{matrix} \xi_t^{I,1782} - \begin{matrix} (0.65 & + & 0.73B) \\ (0.20) & (0.20) \end{matrix} \xi_t^{I,1799} + N_t$$

$$\begin{matrix} (1 - 0.53B) \\ (0.09) \end{matrix} \begin{bmatrix} N_t + 1.06 \\ (0.05) \end{bmatrix} = A(PC/L)_t; \quad \hat{\sigma}_{A(PC/L)} = 21.61\%$$

Obs.	Date	Std. Val.
40	1759	2.07
59	1778	2.64
77	1796	3.21
89	1808	-2.47

Comments:

- 1) JB= 1.96
- 2) SF= 23.5
- 3) In a potentially over-differenced model, DCD= 0 don't reject $\theta = 1 \rightarrow I(0)$ is confirmed



$$\ln(\text{MC/L})_t = -\begin{pmatrix} 1.47 \\ 0.34 \end{pmatrix} + \begin{pmatrix} 1.58B + 1.59B^2 \\ 0.39 \end{pmatrix} \xi_t^{I,1715} - \begin{pmatrix} 0.66 + 0.61B \\ 0.32 \end{pmatrix} \xi_t^{I,1799} + N_t$$

$$\begin{pmatrix} 1 - 0.57B + 0.13B^2 \\ 0.09 \end{pmatrix} \begin{pmatrix} N_t + 0.35 \\ 0.06 \end{pmatrix} = A(\text{MC/L})_t; \quad \hat{\sigma}_{A(\text{MC/L})} = 35.04\%$$

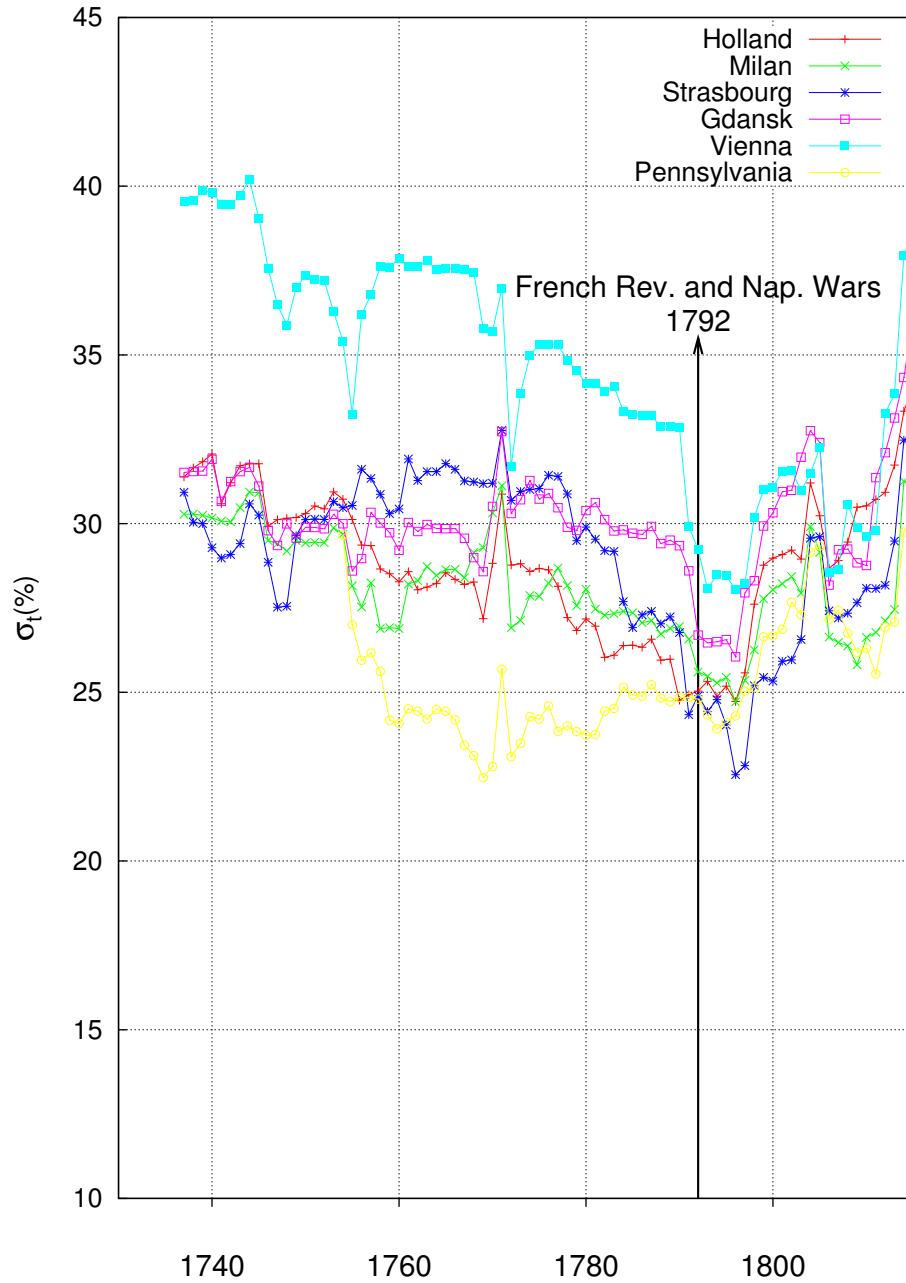
Obs.	Date	Std. Val.
39	1741	2.08
47	1749	2.13
48	1750	2.73
50	1752	-2.64
61	1763	-2.07
84	1786	2.71
93	1795	-2.65
102	1804	-2.43

Comments:

- 1) JB= 2.07
- 2) In AR(2) with i.r: $\hat{p} = 9.5(5.9)$ and $\hat{d} = .36(.13)$
- 3) In a potentially over-differenced model, DCD= 0 don't reject $\theta = 1 \rightarrow I(0)$ is confirmed

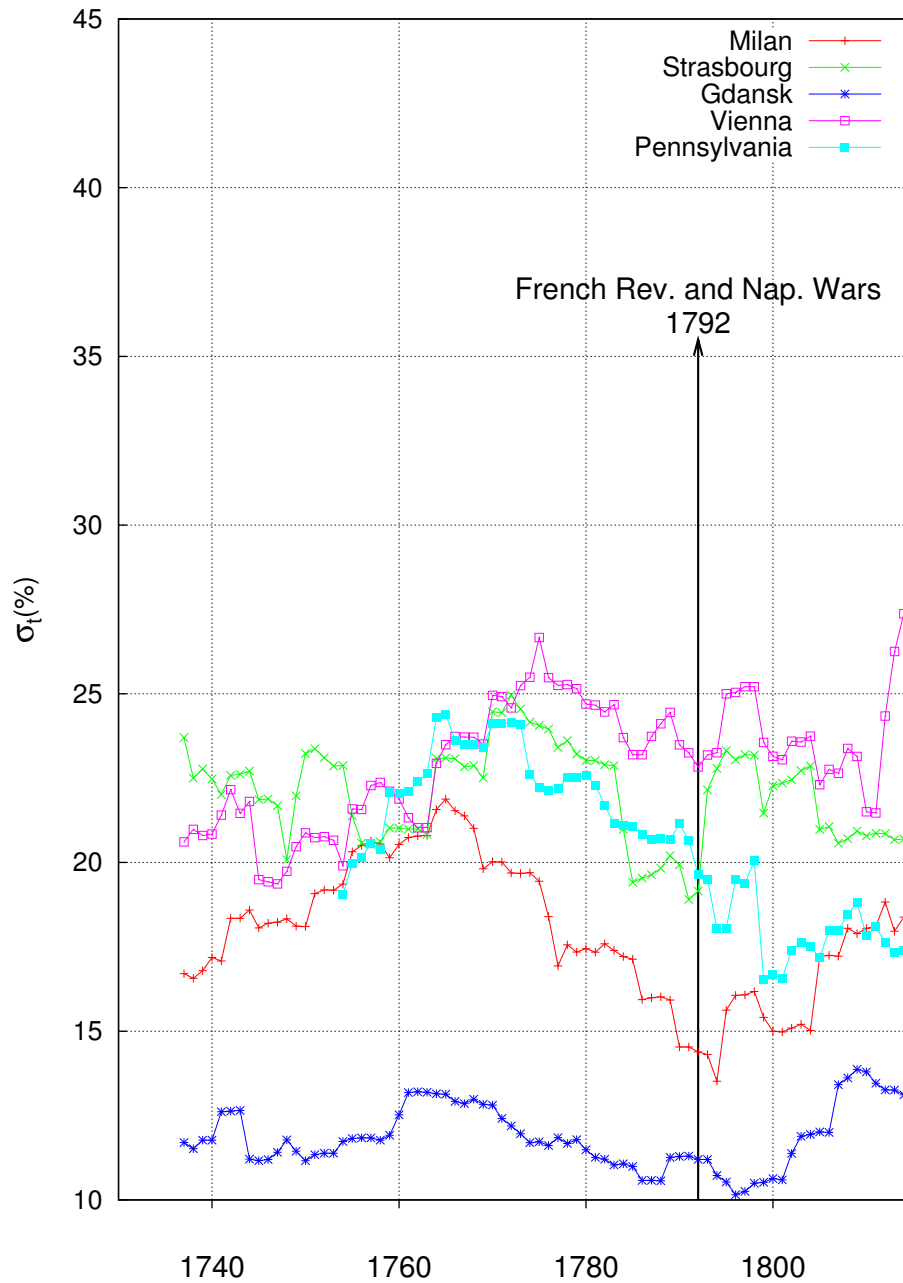
Appendix 4: SDSI Graphics

Figure A4.1: Evolution of Arévalo's Wheat Relative Prices Dispersion (SDSI) in the 18th-19th Century



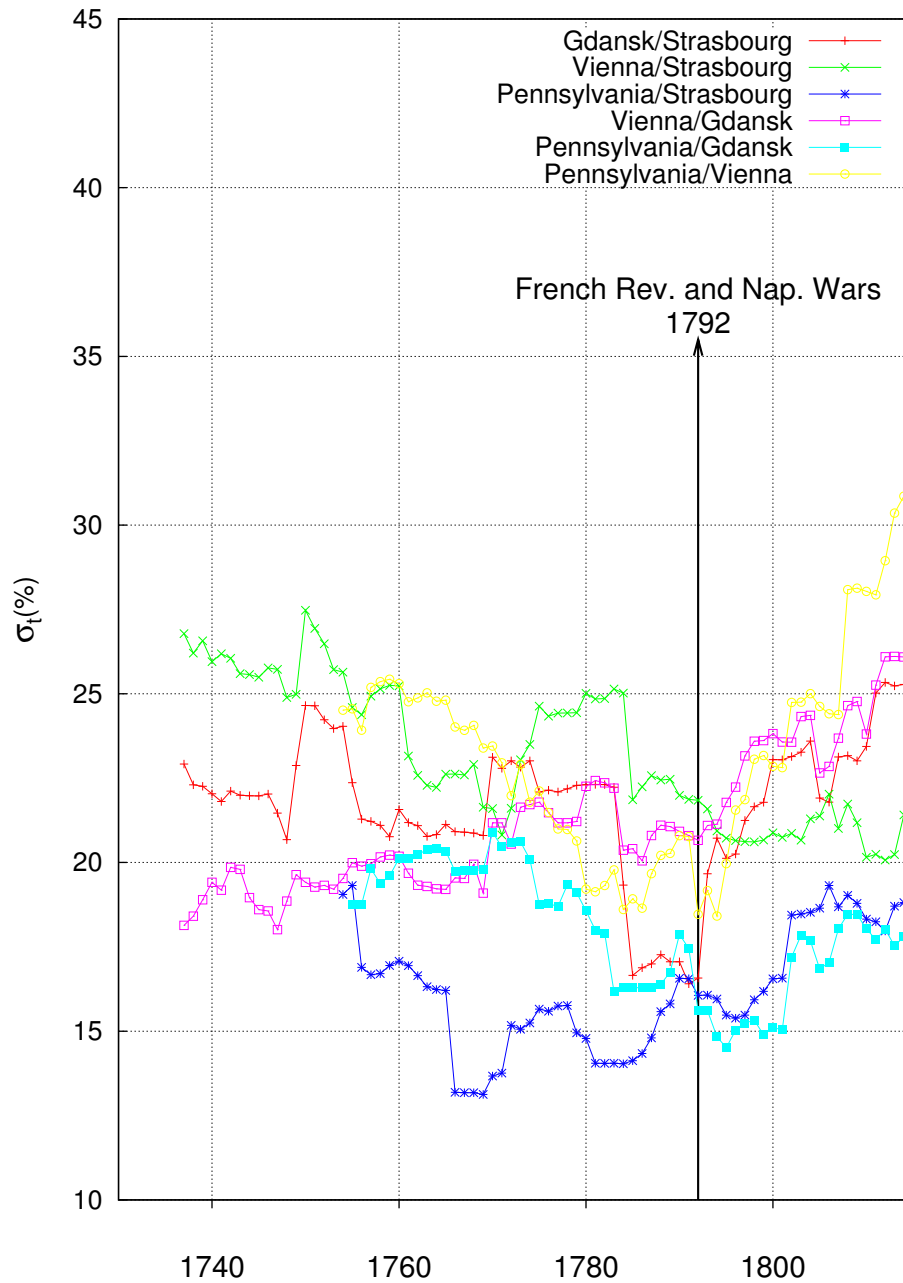
Note: Each point in the graph is the standard deviation of the innovation computed with the last 35 unconditional residuals at year t (from t to $t - 35$, each time). In Each case the unconditional residuals are of a univariate model for the pairwise relative prices in Europe and America with Arévalo.

Figure A4.2: Evolution of Holland's Wheat Relative Prices Dispersion (SDSI) in the 18th-19th Century



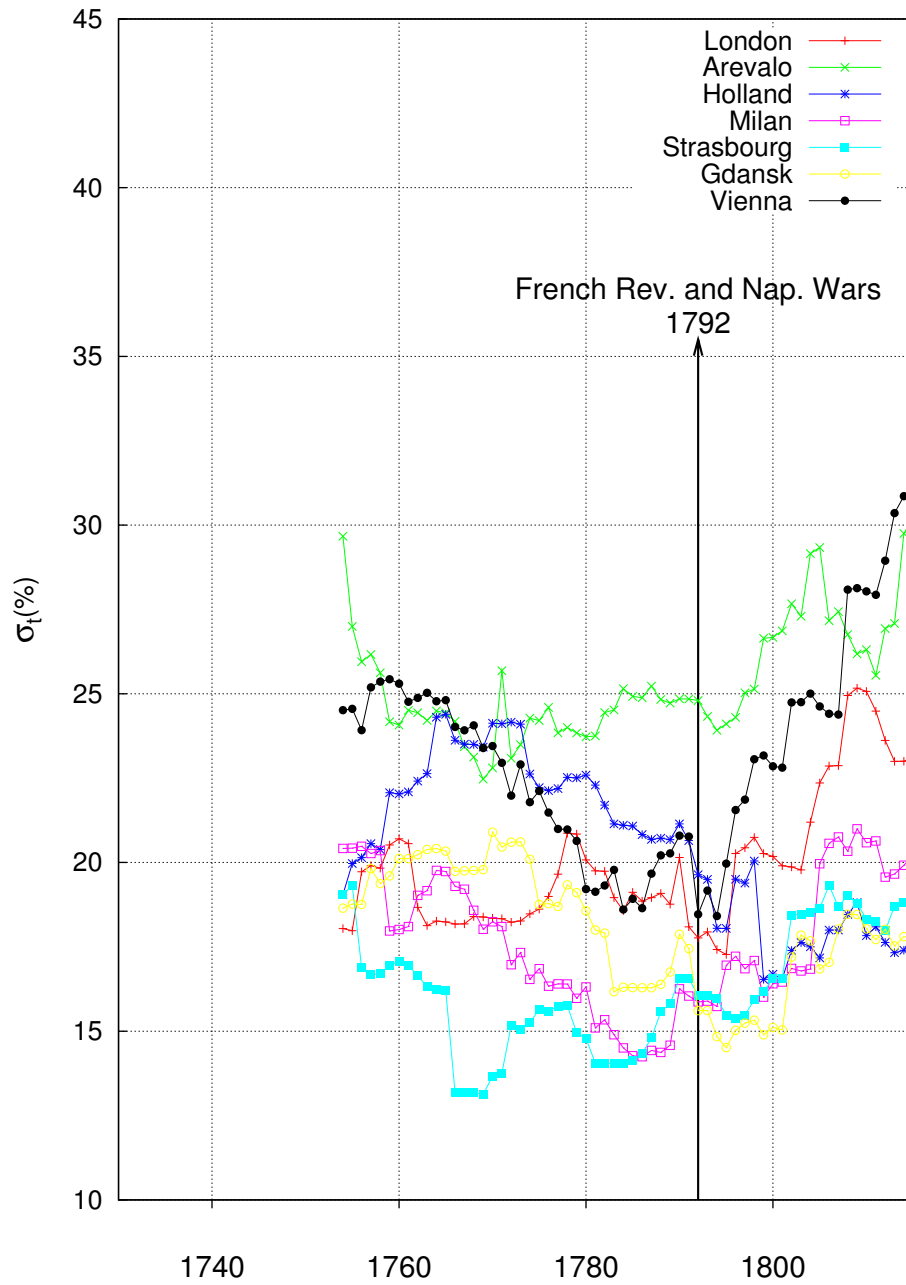
Note: Each point in the graph is the standard deviation of the innovation computed with the last 35 unconditional residuals at year t (from t to $t - 35$, each time). In Each case the unconditional residuals are of a univariate model for the pairwise relative prices in Europe and America with Utrecht.

Figure A4.3: Evolution of Several Wheat Relative Prices Dispersion (SDSI) in the 18th-19th Century



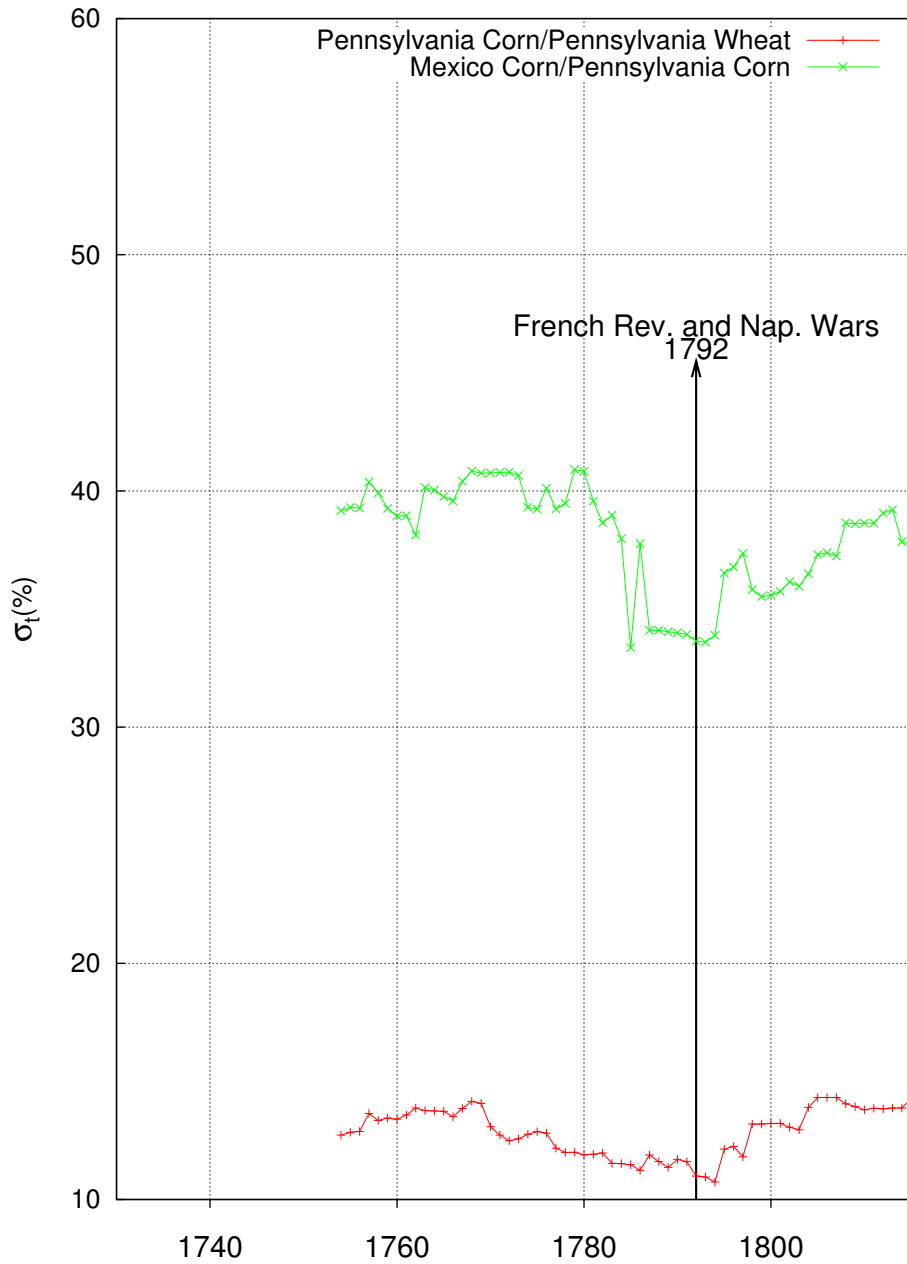
Note: Each point in the graph is the standard deviation of the innovation computed with the last 35 unconditional residuals at year t (from t to $t - 35$, each time). In Each case the unconditional residuals are of a univariate model for several pairwise relative prices in Europe and America.

Figure A4.4: Evolution of Pennsylvania's Wheat Relative Prices Dispersion (SDSI) in the 18th-19th Century



Note: Each point in the graph is the standard deviation of the innovation computed with the last 35 unconditional residuals at year t (from t to $t - 35$, each time). In Each case the unconditional residuals are of a univariate model for the pairwise relative prices in Europe with Pennsylvania's Wheat.

Figure A4.5: Evolution of Corn's Relative Prices Dispersion (SDSI) in the 18th-19th Century



Note: Each point in the graph is the standard deviation of the innovation computed with the last 35 unconditional residuals at year t (from t to $t - 35$, each time). In Each case the unconditional residuals are of a univariate model for several pairwise relative prices in America.