Monitoring CPS Seasonally Adjusted Series with an Eye to Recession Effects October 2014

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Abstract

Seasonal adjustment of national Current Popul ation Survey (CPS) series is im portant to help understand the health of the U.S. economy. Concern is occasionally expressed in the news media that unusual events su ch as recessions can aff ect seasonal factors. The majority of outliers that occur in CPS seri es have known causes as to t ype and duration. For example, these effects are often due to known shifts in population controls, sever e storms, or changes to the survey instrument. While it is unusual to try and handle other potentially distorting effects until there are many observations after the fact, it is useful to monitor for these potential outliers in real ti me. The monthly monitoring for CPS seasonally adjusted series is described below and includes numer ous tables, diagnostics, and graphics, and real-time outlier analy sis. Results are also presented for monitoring changes in the seasonal ARIM A coefficients over tim e. This battery of d iagnostics should also give clues for any evidence of recession effects in the seasonal ad justment process.

Introduction

Why monitor seasonally adjusted series? Why make a customized monitoring system? These are tw o natural questions that can ari se. Monitoring s easonally adjusted CPS series at the Bureau of Labor Statistics (BLS) is definitely useful. Questions often arise from the press or the public about unusual movements, but some of these events can be unexpected or unknown t o BLS staff. Wh ile the seasonal ad justment program s X-13ARIMA-SEATS (U.S. Census Bureau, 2013) an d TRAMO-SEATS (Capo rello an d Maravall, 2 004) pro vide many dia gnostics and so me graphics, so me important information is not available and is not in a convenient format for monitoring.

There are many recent instances where monitoring CPS series was useful. A regular example is in January when populatio n controls are revised. Occasionally, large breaks can occur in series when a demographic group gr ows more quickly if the populati on controls cannot keep up. Snow storm s and hurricanes can cause spikes in so me series and outlier monitoring can often find such abe rrations. Monitoring can save staff time to handle requests to BLS from the press and the general public for i nformation on unusual events. Other events might be spotted th rough m onitoring that might be un known or unexpected. About 150 national CPS series are directly adjust ed either m onthly or quarterly, and another 40 0+ series are indirectly adjusted. Without m onitoring, special runs m ust be m ade to explore unusual movements. Details on how BLS seasonally adjusts national CPS series are found in Tiller and Evans (2014).

Claims of re cession effects can often b e quickly examined thorough m onitoring. An example noted in Evans a nd Tiller (2013) shows where claims in Novem ber 2010 of seasonal bias due to reces sion effects t urned out to be only an irregular movement. A

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combined plot of the trend and seasonally ad justed series clea rly reveals this. Level shifts can occur during a recession if the eff ect is abrupt. Again, outlier monitoring can alert BLS staff to such changes, although the initial effect may appear to be an additive outlier until enough data are available to properly identify it.

The next sec tion describes the monitoring sy stem with exa mples of the tables an d graphs following in the appendix. A b asic familiarity with seasonal adjustment procedures is assumed for a reader.

Description of the Program and Output

The monitoring system is created with SAS and saved into pdfs. Most of the pdfs are for two directly adjusted series (employment and unem ployment) with their related indirectly adjusted series. The below exa mple tables and graphs are for m ales, ages 16-19. The f ollowing table gives the definitions for each series in t he example. Note that population levels are not seasonally adjusted directly or indirectly.

Definitions for Abbreviations used in Monitoring System Example
EM: Employment level
UN: Unemployment level
Labor force or **CLF**: Civilian noninstitutional labor force (EM + UN)
Pop: Population level
LFPR: Labor force participation rate (100*(CLF/Pop))
NILF: Not in labor force
NILFPR: Not in labor force participation rate (100*(NILF/Pop))
EP: EM to population ratio (100*(EM/Pop))
UR: Unemployment rate (100*(UN/(CLF))

Seasonal adjustm ent for national CPS seri es is cur rently performed with the X-12-ARIMA soft ware utilizing the X-11 procedure so the tables and plots are designed to follow that sty le. The concurrent sea sonal adjustment procedure is used for C PS so the monitoring system is run every month. Only the current y ear is shown in the tables and the example is for April. An additional month of data in the current year adds another line is added to Tables 1-3.

A list of the monitoring system tables is below:

List of Tables in the Appendix	
Number l	**sc ription**
1a	Year-to-Date Estimates Not Seasonally Adjusted
1b	Year-to-Date Estimates Concurrent Seasonally Adjusted
2a	Month-to-Month Changes Not Seasonally Adjusted (EM, EP, UN, UR)
2b	Month-to-Month Changes Concurrent Seasonally Adjusted (EM, EP, UN, UR)
2c	Month-to-Month Changes Not Seasonally Adjusted (CLF, LFPR, NILF)
2d	Month-to-Month Changes Concurrent Seasonally Adjusted (CLF, LFPR, NILF)
3a	Employment Concurrent Components of Change
3b	Unemployment Concurrent Components of Change
4a	EM Outlier Estimates
4b	UN Outlier Estimates
5a	EM Diagnostics
5b	UN Diagnostics

Table 1a has the not seasonally adjusted estimates for the current y ear. An error range for the unemployment rate is shown (90% confidence interval) to give analysts an idea as to the overall variability. Table 1b is t he same for the concurrent adjusted dat a, except that we cannot make error ranges at this time since we do not have standard errors for X-11 adjusted data. Table 2a shows the m onth-to-month changes f or the levels, rate, and EP, while 2b has those for the adjusted. Tables 2c and 2d follow with the same information for the rem aining i ndirect series. Tables 3a and 3 b have com ponents of change for E M and UN. X-11 decomposes the series into trend, irregular, and seasonal components. Analysts find these tables especially useful to help explain unusual changes in a series.

Tables 4a and 4b contain outlier information. Any hardcoded outliers that are included in the model are marked in the tables as "Outlier in Model." Each month, the monitoring system reruns the directly adjusted series with the automatic outlier detection routi ne switched on. The results are in these tables. A "marginal" or "al most" outlier is when a t-value is between the critical value and the critical value minus 0.5. A "potential outlier" is a detected outlier for the current year that is >= the critical value. Normally, at the end of the calend ar year during an annual review, each seasonally adjusted series i s revised back for five years. The almost or potential outliers are reevaluated at this time and may be added to the model. If an almost or potential outlier appears to have little impact, or is close to the end of the series, it may not be added during the annual review. A severe and abrupt outlier—such as those from terrorist attacks or major weather events—are the only types of outliers that may be considered for addition during the year.

Various diagnostics are in tables 5a an d 5b. These include Ljung-Box and normality statistics for the ARIMA model, important X-11 m easures, ARIMA specifications, and the lengths for the seasonal and trend filters.

Numerous graphs follow the tables. A list is below.

List of Figures in the Appendix	
Number Desc	**ription**
1a	CPS Official National EM
1b	CPS Official National UN
1c	CPS Official National UN Rate
1d	CPS Official National Civilian Labor Force
1e	CPS Official National Not in Labor Force
1f	CPS Official National Population
1g	CPS EM ARIMA Outlier Effects
1h	CPS UN ARIMA Outlier Effects
1i	CPS EM ARIMA Forecasts
1j	CPS UN ARIMA Forecasts
1k	CPS EM Outlier Absolute T-Values
1l	CPS UN Outlier Absolute T-Values
2a	CPS EM Historical Seasonal Factors (subplots by month)
2b	CPS UN Historical Seasonal Factors (subplots by month)
2c	CPS EM Historical Seasonal Factors
2d	CPS UN Historical Seasonal Factors
2e	CPS EM Historical Trend
2f	CPS UN Historical Trend
2g	CPS EM Historical Irregular Factors
2h	CPS UN Historical Irregular Factors
3a	AR Spectrum EM
3b	AR Spectrum UN
4a	EM Standardized ARIMA Residuals (not shown)
4b	EM Cusum (not shown)
4c	EM Cusum of Squares (not shown)
4d	EM Cumulative Periodogram (not shown)
4e	UN Standardized ARIMA Residuals
4f UN	Cusum
4g	UN Cusum of Squares
4h	UN Cumulative Periodogram
5a	EM Sample Autocorrelation Functions
5b	UN Sample Autocorrelation Functions (not shown)

The purpose for most of the graphs is obvious and will be skipped. Figure 1f has the population level and is h elpful to detect possible level shifts. Figures 1g and 1h demonstrate the effects of any outliers in recent years. Figures 1k and 1l show the largest outlier t-values by m onth for the last four years. Either AO (additive out lier), TC (temporary change), or LS (level shift) is plotted for each month to indicate which type of outlier has the largest t-valu e for a given month. The monthly subplots for seasonal factors gives some indication as to whether the sea sonal factors are reasonab ly stable. They also show the sea sonal patterns for each se ries that are especially helpful for analysts. Figures 2c an d 2d again show the s easonal fa ctors, but in a t ime series perspective. These plots a re another wa y to examine how the fact ors are moving across time. The trends are in fi gures 2e/2f with any outliers from the ARIMA model noted. The irregular factors in figures 2g/2h are similar to 2e/2f except they plot the irregula r factors.

The autoregressive spe ctra plots for the unadj usted and adjusted series are in 3a/3b. Any visual significant peaks are marke d. These plots are in the frequency domain and are often helpful to check for seasonality and tr ading day effects in the unadjusted series. No peaks for the seasonally adjusted series gives an indication of no residual seasonality.

Figures 4e-4h are helpful in detecting model issues. While t hey may be m ore helpful as we move adjustments to SEATS, they can be useful for X-11. Each plot presents th e standardized ARIMA resi duals in a different way for the EM and UN series. Figure 4c simply give the ARIMA residuals ac ross ti me. The gray bars indicate the NBER recession periods. Note that the model tends to over- or under-esti mate during recessions. Figure 4e are a different way to che ck the residuals as they plot the cumulative sums for detecting structura l change. The cusum of squares plot i n figure 4g may assist i n detecting structural cha nge and heteroscedasticity . Figure 4h has the cumulative periodogram s for the two s eries. The test is not strictly valid, but is still worthwhile as a frequency domain alternative to the Ljung-Box tests. In many of the recessions, t he residuals tend to diverge aw ay from the white-noise lines. For more details on these plots, see Harvey (1989).

The final set of plots is in Figure 5a. The first row h as sample autocorrelation plots by different degrees of differencing. Par tial autocorrelation (SPACF) and inverse autocorrelation (SIACF) are in the next two rows. While the automatic modeling procedures in TRAMO and RegARIMA are quite advanced and typically accurate, there can be a co mfort level for some to exa mine the autocorrelations as a ver ification. Occasionally, the autocorrelations are d ifficult to interpret, yet they can still be effective as a model-selection tool.

Summary

This paper gives a description of a m onitoring sy stem for seasonal adjust ment of national CPS series. The tables and graphs ar e designed to speed analysis and to provide useful information on a monthly basis. Much data are available t o assist BLS staff with information requests on a timely data. The graphs and outlier tables can alert staff to data issues from recessions, weather events, etc., on a timely basis.

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Appendix

Males 16-19, 2014

Table 1a: Not Seasonally Adjusted

+ 90% confidence interval

	Labor Force		NILF		Employment		Unemployment			Pop
Month	Level	LFPR	Level	NILFPR	Level	EP	Level	Rate	Error Range +	Level
Jan	2,494,350	29.4	5,977,356	70.6	1,903,250	22.5	591,100	23.7	21.3-26.1	8,471,706
Feb	2,426,741	28.7	6,041,197	71.3	1,805,056	21.3	621,685	25.6	23.1-28.1	8,467,938
Mar	2,636,737	31.2	5,827,370	68.8	2,006,755	23.7	629,982	23.9	21.5-26.2	8,464,107
Apr	2,532,902	29.9	5,927,832	70.1	2,027,438	24.0	505,464	20.0	17.7-22.2	8,460,734

Table 1b: Concurrent Seasonally Adjusted

	Labor Force		NILF		Employment		Unemployment	
Month	Level	LFPR	Level	NILFPR	Level	EP	Level	Rate
Jan	2,770,847	32.7	5,700,859	67.3	2,144,083	25.3	626,764	22.6
Feb	2,679,908	31.6	5,788,030	68.4	2,028,034	23.9	651,875	24.3
Mar	2,881,082	34.0	5,583,025	66.0	2,186,081	25.8	695,000	24.1
Apr	2,734,943	32.3	5,725,791	67.7	2,158,924	25.5	576,019	21.1

Table 2a: Not Seasonally Adjusted
Month-to-Month Changes

** Significant change at 90% level, ** Significant change at 95% level*

	Employment				Unemployment			
	Level		EP		Level		Rate	
Month	Change	%	Change	%	Change	%	Change	%
Jan	** -224,900	-10.6	**-2.6	-10.4	69,060	13.2	** 4.0	20.3
Feb	-98,194	-5.2	-1.1	-5.1	30,585	5.2	1.9	8.1
Mar	** 201,699	11.2	** 2.4	11.2	8,297	1.3	-1.7	-6.7
Apr	20,683	1.0	0.3	1.1	** -124,518	-19.8	**-3.9	-16.5

Table 2b: Concurrent Seasonally Adjusted

	Employment				Unemployment			
	Level		EP		Level		Rate	
Month	Change	%	Change	%	Change	%	Change	%
Jan	-112,462	-10.0	-1.3	-4.8	24,744	11.5	1.6	7.4
Feb	-116,050	-4.6	-1.4	-5.4	25,111	4.9	1.7	7.5
Mar	158,048	9.9	1.9	7.8	43,126	1.3	-0.2	-0.8
Apr	-27,157	0.9	-0.3	-1.2	-118,981	-17.9	-3.1	-12.7

Table 2c: Not Seasonally Adjusted
Month-to-Month Changes
**** Significant change at 90% level***
***** Significant change at 95% level***

	Labor Force				NILF	
	Level		LFPR		Level	
Month	Change	%	Change	%	Change	%
Jan	** -155,840	-5.9	**-1.8	-5.7	** 137,466	2.3
Feb	-67,609	-2.7	-0.8	-2.7	63,841	1.1
Mar	** 209,996	8.7	** 2.5	8.7	** -213,827	-3.7
Apr	-103,835	-3.9	-1.2	-3.9	100,462	1.7

Table 2d: Concurrent Seasonally Adjusted

	Labor Force				NILF	
	Level		LFPR		Level	
Month	Change	%	Change	%	Change	%
Jan	-87,718	-3.1	-1.0	-3.1	69,344	1.2
Feb	-90,939	-3.3	-1.1	-3.3	87,171	1.5
Mar	201,173	7.5	2.4	7.5	-205,004	-3.5
Apr	-146,139	-5.1	-1.7	-5.1	142,766	2.6

Table 3a: Employment Concurrent Components of Change

	CPS Employment		Trend		Irregular		Seasonal	
Month	Level	% Relative Change	Level	% Relative Change	Factor	% Relative Change	Factor	% Relative Change
Jan	1,903,250	-10.6	2,173,407	-2.2	0.99	-2.8	0.89	-5.9
Feb	1,805,056	-5.2	2,106,597	-3.1	0.96	-2.4	0.89	0.3
Mar	2,006,755	11.2	2,154,539	2.3	1.01	5.4	0.92	3.1
Apr	2,027,438	1.0	2,149,998	-0.2	1.00	-1.0	0.94	2.3

Table 3b: Unemployment Concurrent Components of Change

	CPS Unemp		Trend		Irregular		Seasonal	
Month	Level	% Relative Change	Level	% Relative Change	Factor	% Relative Change	Factor	% Relative Change
Jan	591,100	13.2	645,713	-3.8	0.97	8.2	0.94	8.8
Feb	621,685	5.2	640,275	-0.8	1.02	4.9	0.95	1.1
Mar	629,982	1.3	646,574	1.0	1.07	5.6	0.91	-5.0
Apr	505,464	-19.8	621,103	-3.9	0.93	-13.7	0.88	-3.2

Table 4a: EM Outlier Estimates
Critical Value = 3.58
**** See paper for description***

Year	Month	Type	Coef	T-Value	Outlier in Model	Almost Outlier*	Potential Outlier*
1983	6	LS	1.08	(3.6)	X		
1990	1	LS	1.06	(2.9)	X		
1994	1	LS	1.04	(2.0)	X		
2012	8	TC	.	(-3.3)		X	
2014	2	AO	0.93	(-3.6)			X

Table 4b: UN Outlier Estimates
Critical Value = 3.58

Year	Month	Type	Coef	T-Value	Outlier in Model	Almost Outlier*	Potential Outlier*
1980	5	LS	1.21	(3.8)	X		
1997	12	AO	0.79	(-4.2)	X		
2008	5	LS	1.24	(4.3)	X		
2013	11	LS	0.83	(-3.6)			X

Table 5a: EM Diagnostics for SMS Use, 1976 - 2014

Log	Model	Seas Filter	Trend Filter	LB 12	LB 12 PV	LB 24	LB 24 PV	M7	Q2	Stable F
log	(3 1 0)(0 1 1)	s3x5	13	20.8	*0.01	30.8	0.06	0.098	0.19	1132.1

JB Lambda	Norm P-Value	Skewness	Excess Kurtosis	Hetero	Hetero P-Value
1.4	0.50	-0.11	0.15	0.48	*1.00

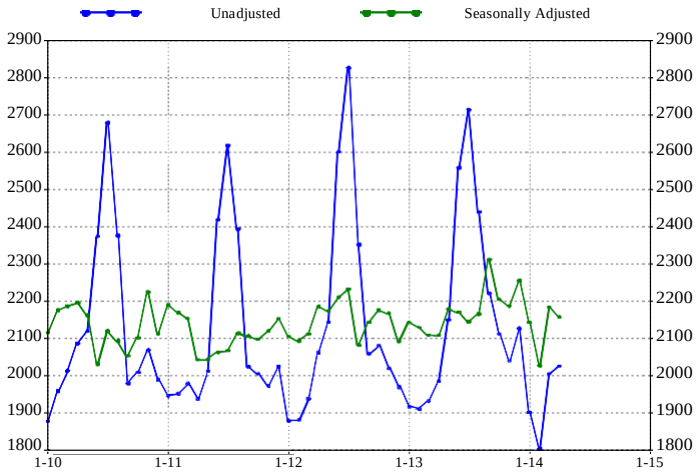
Table 5b: UN Diagnostics, 1976 - 2014

Log	Model	Seas Filter	Trend Filter	LB 12	LB 12 PV	LB 24	LB 24 PV	M7	Q2	Stable F
log	(0 1 1)(0 1 1)	s3x5	13	7.6	0.67	18.9	0.66	0.155	0.46	227.3

JB Lambda	Norm P-Value	Skewness	Excess Kurtosis	Hetero	Hetero P-Value
2.4	0.31	-0.14	0.22	0.71	*0.98

Figure 1a: CPS Official National EM

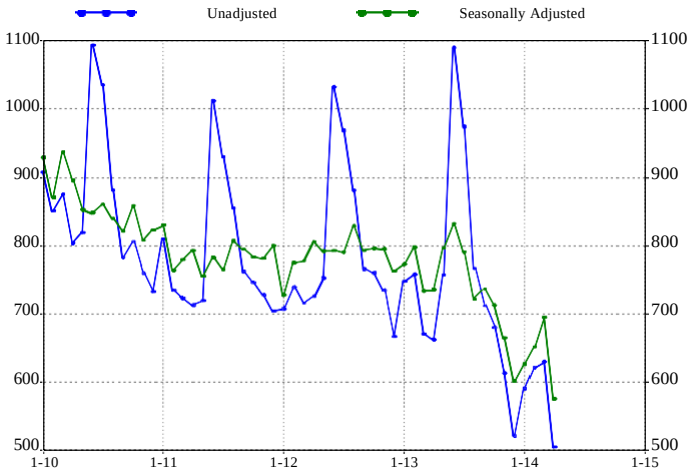
Males 16-19, Direct Adj (000s)



AO = Additive Outlier, LS = Level Shift, TC = Temporary Change

Figure 1b: CPS Official National UN

Males 16-19, Direct Adj (000s)



AO = Additive Outlier, LS = Level Shift, TC = Temporary Change

Figure 1c: CPS Official National UN Rate

Males 16-19, Indirect Adj

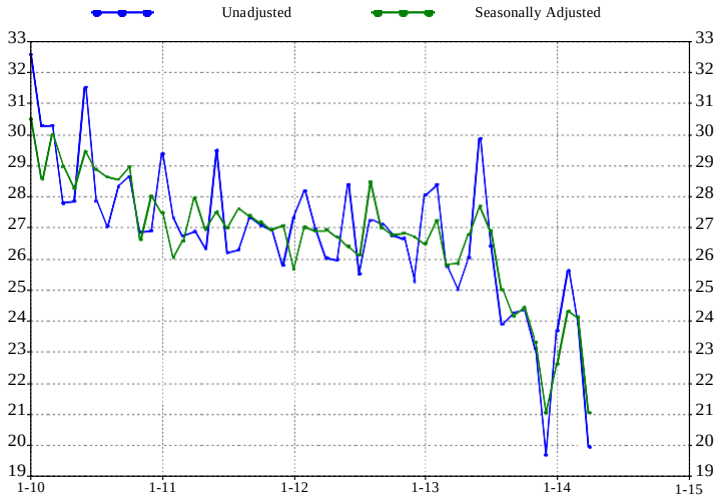


Figure 1d: CPS Official National Civilian Labor Force

Males 16-19, Indirect Adj (000s)

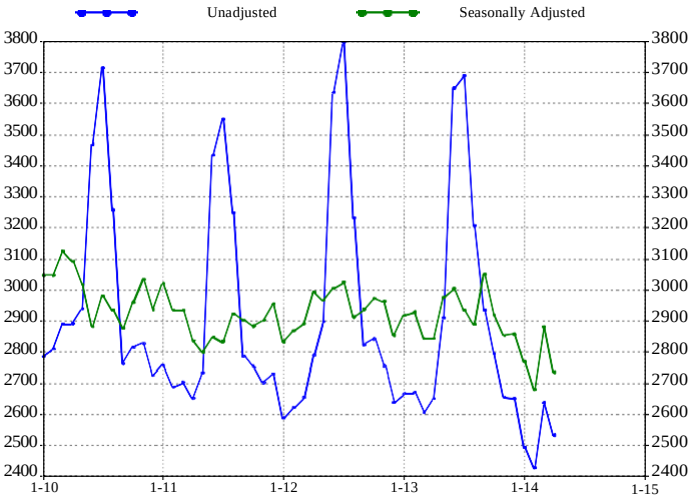


Figure 1e: CPS Official National Not in Labor Force

Males 16-19, Indirect Adj (000s)

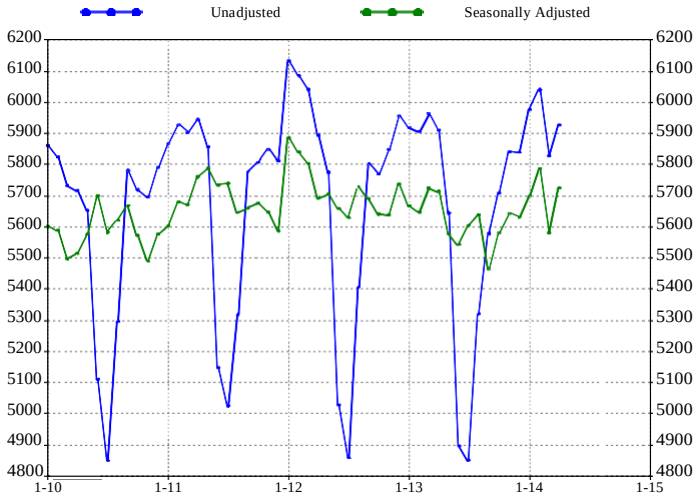


Figure 1f: CPS Official National Population

Males 16-19 (000s)

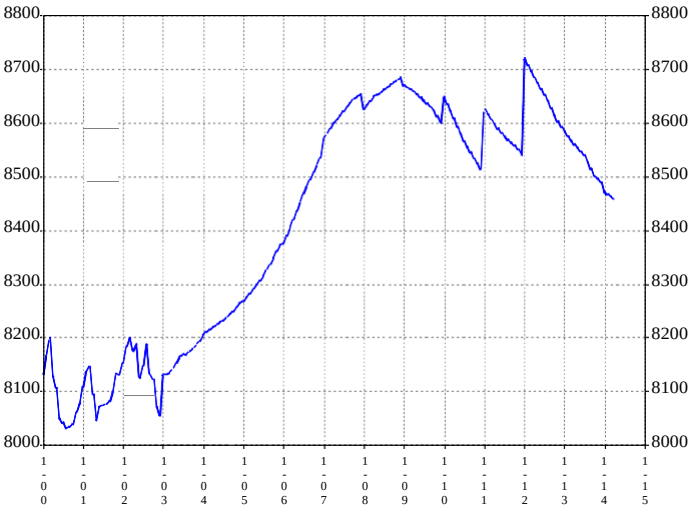


Figure 1g: CPS EM ARIMA Outlier Effects

Males 16-19

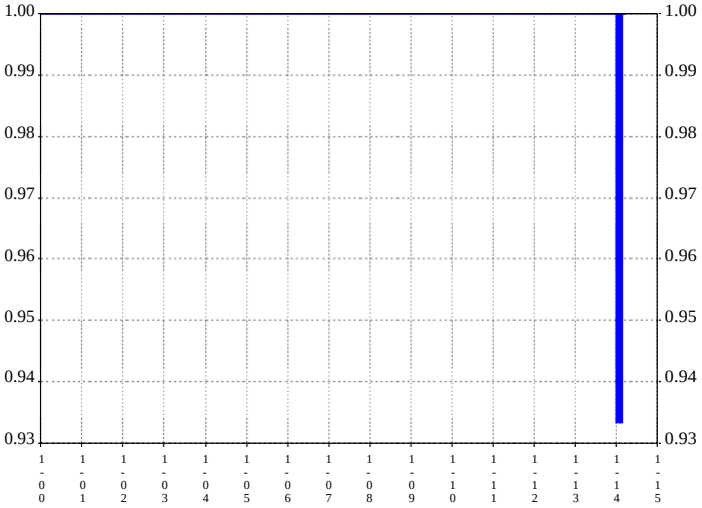


Figure 1h: CPS UN ARIMA Outlier Effects

Males 16-19

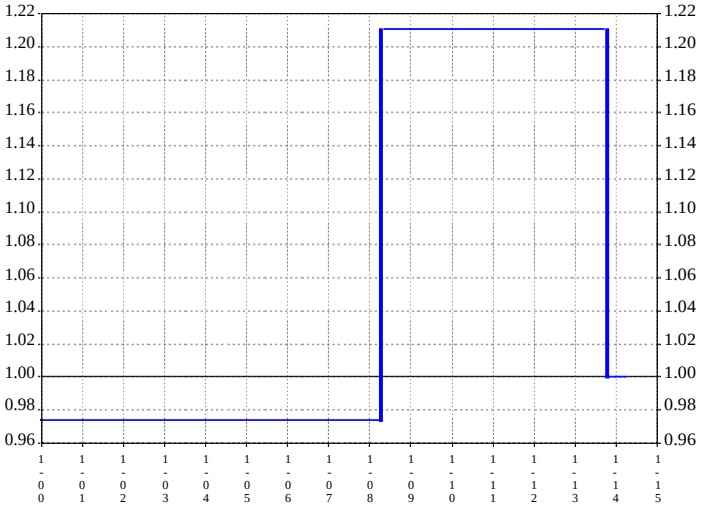


Figure 1i: CPS EM ARIMA Forecasts

Males 16-19 (000s)
AAPE Last 3 Years = 4.56

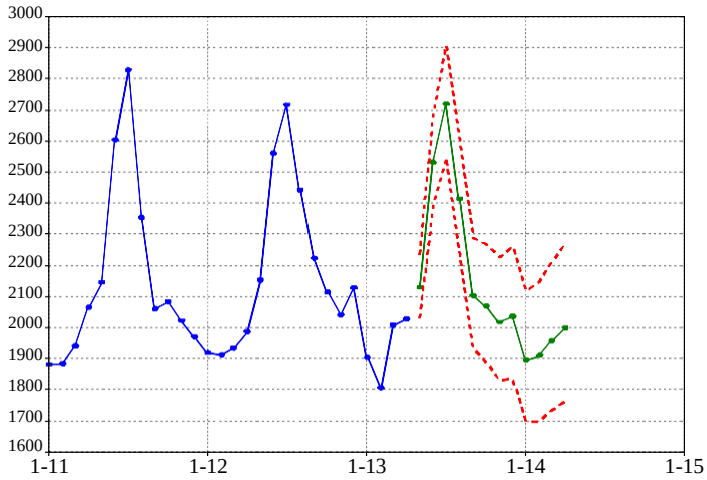


Figure 1j: CPS UN ARIMA Forecasts

Males 16-19 (000s)
AAPE Last 3 Years = 4.62

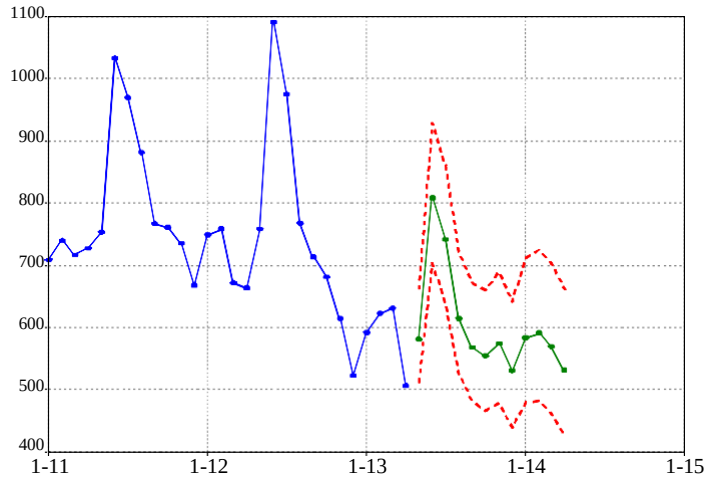


Figure 1k: CPS EM Outlier Absolute T-Values

Critical Value = 3.58

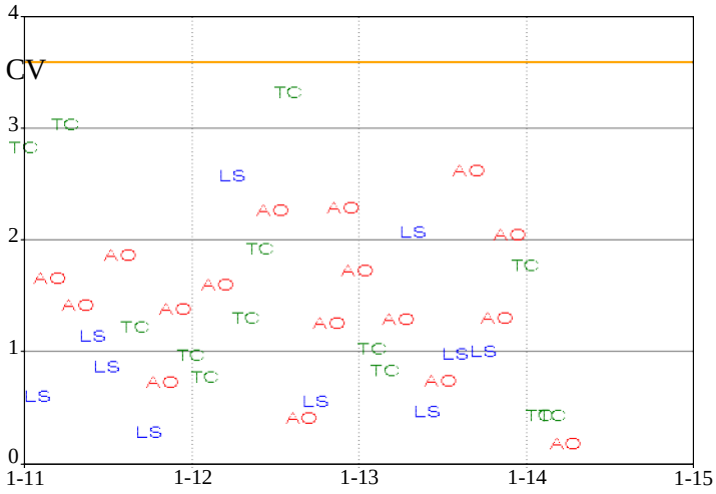


Figure 1l: CPS UN Outlier Absolute T-Values

Critical Value = 3.58

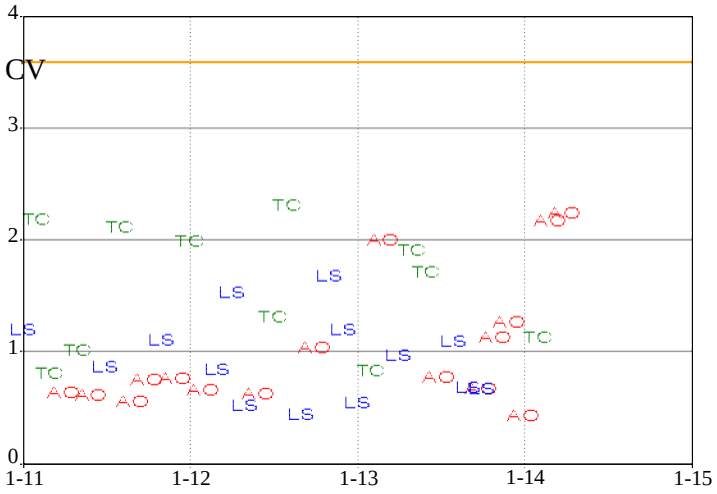


Figure 2a: CPS EM Historical Seasonal Factors

Males 16-19, 2000 - 2014

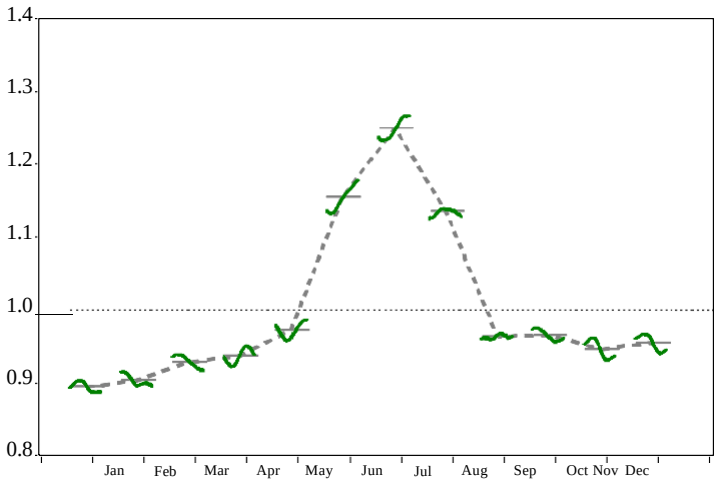


Figure 2b: CPS UN Historical Seasonal Factors

Males 16-19, 2000 - 2014

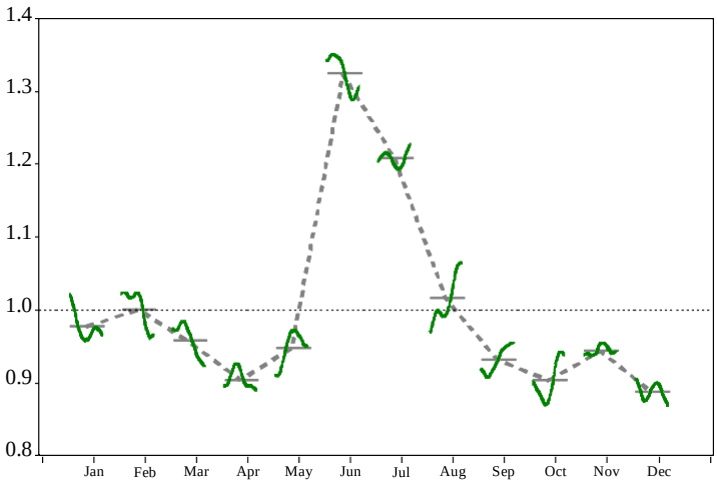


Figure 2c: CPS EM Historical Seasonal Factors

Males 16-19

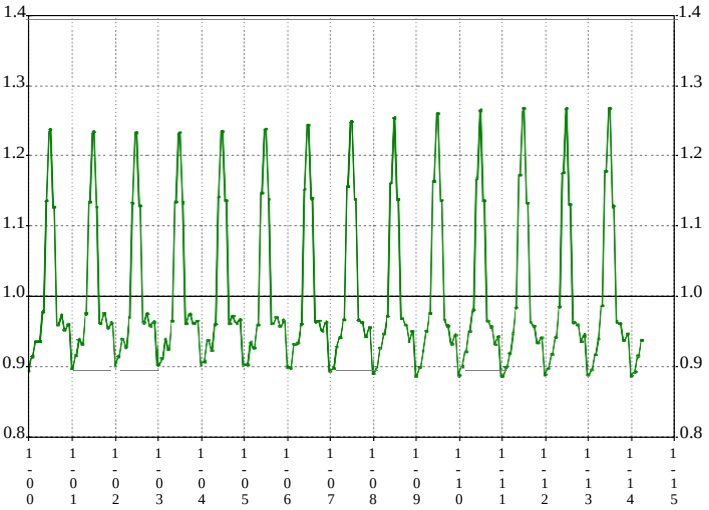


Figure 2d: CPS UN Historical Seasonal Factors

Males 16-19

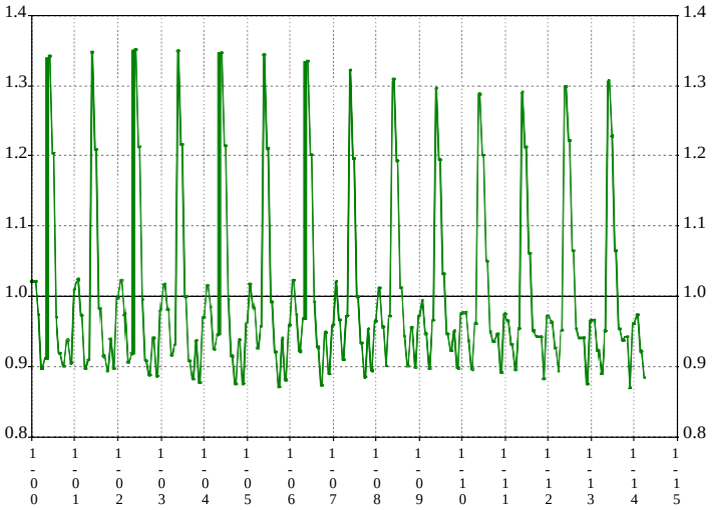
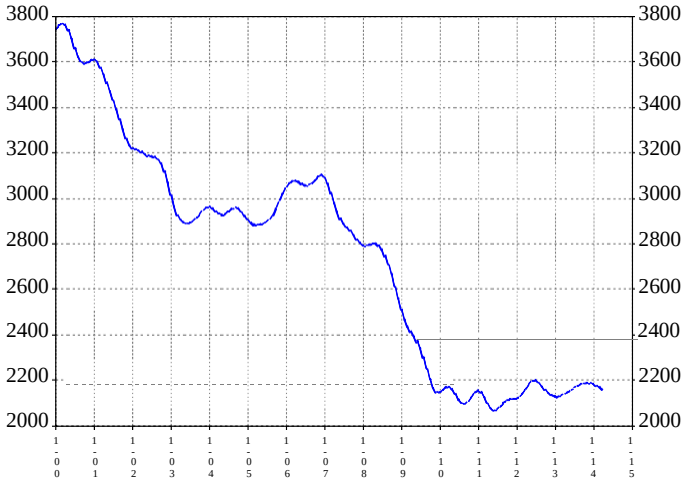


Figure 2e: CPS EM Historical Trend

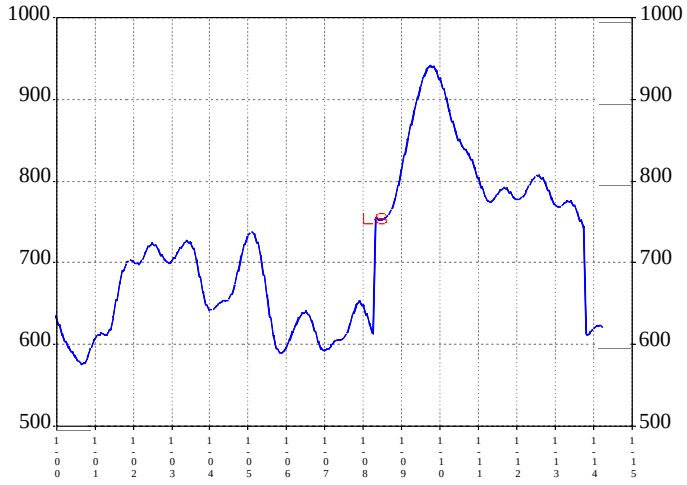
Males 16-19 (000s)



AO = Additive Outlier, LS = Level Shift, TC = Temporary Change

Figure 2f: CPS UN Historical Trend

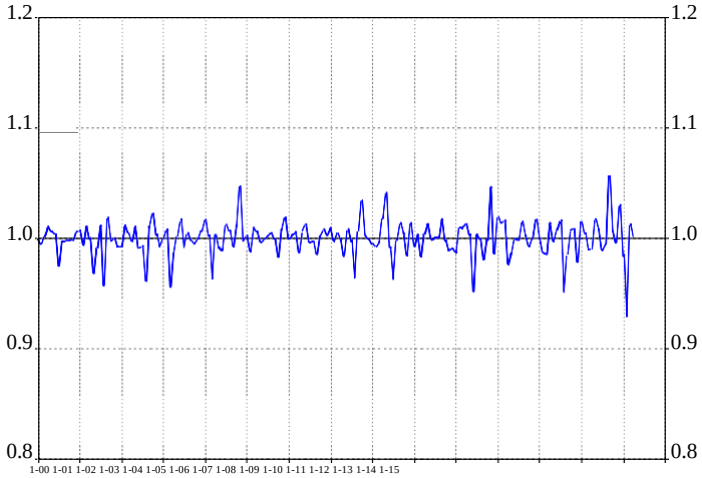
Males 16-19 (000s)



AO = Additive Outlier, LS = Level Shift, TC = Temporary Change

Figure 2g: CPS EM Historical Irregular Factors

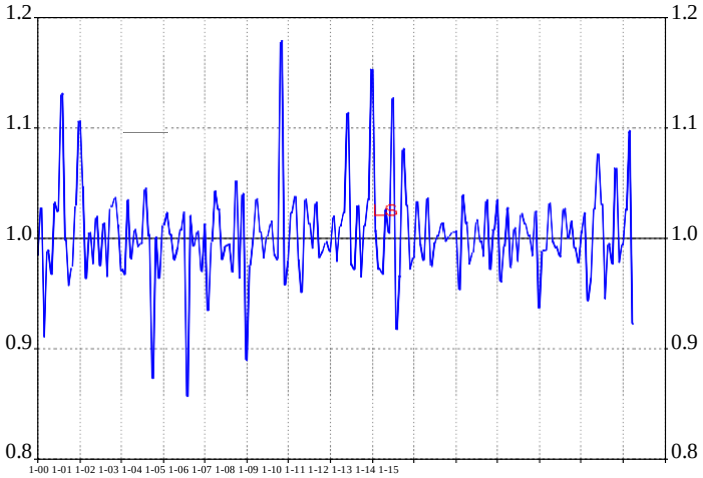
Males 16-19



AO = Additive Outlier, LS = Level Shift, TC = Temporary Change

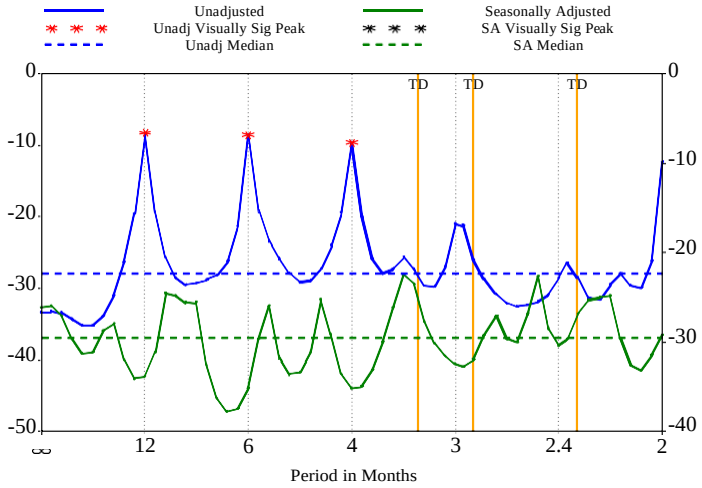
Figure 2h: CPS UN Historical Irregular Factors

Males 16-19



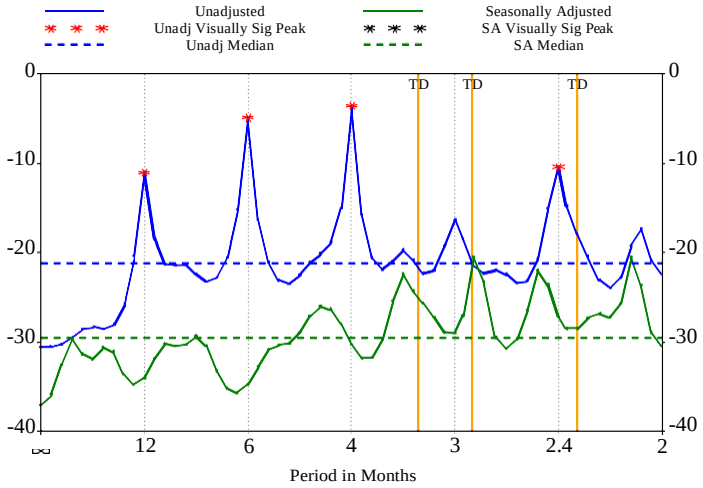
AO = Additive Outlier, LS = Level Shift, TC = Temporary Change

Figure 3a: AR Spectrum EM Males 16-19



TD = Trading Day

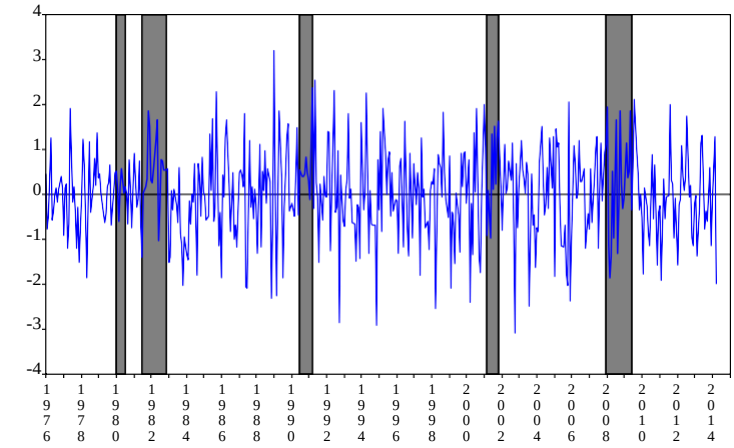
Figure 3b: AR Spectrum UN Males 16-19



TD = Trading Day

Figure 4e: UN Males 16-19

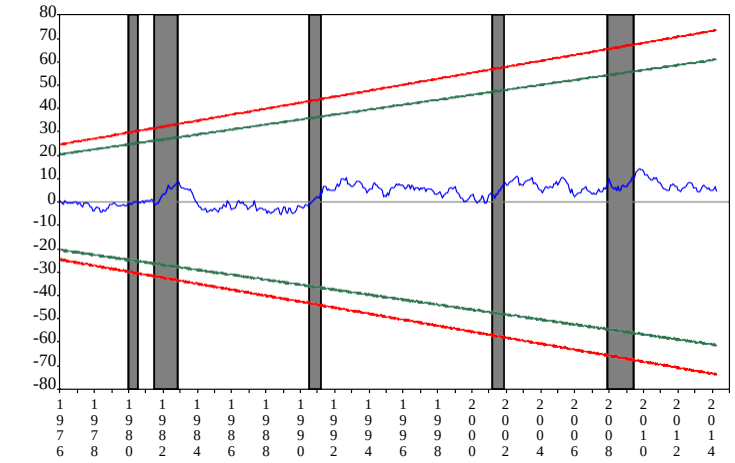
Standardized ARIMA Residuals
BJ Normality = 2.4, Skewness = -0.14,
Excess Kurtosis = 0.22, Hetero = 0.71 (PV=*0.98)



NBER Recessions in Gray

Figure 4f: UN Males 16-19 Cusum

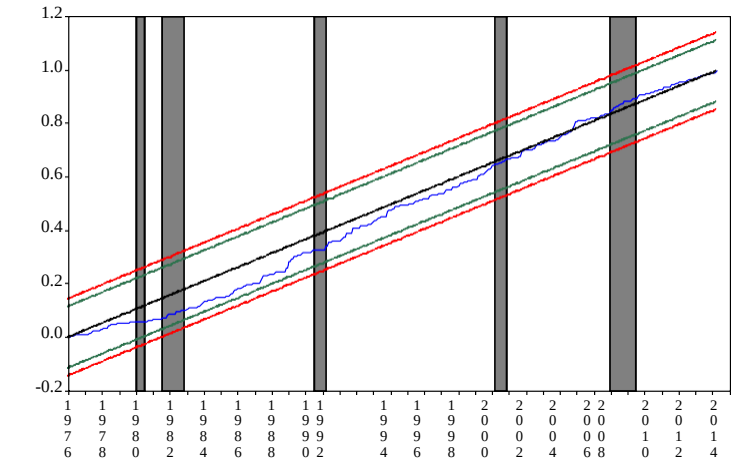
Standardized ARIMA Residuals
5% Bounds 1% Bounds



NBER Recessions in Gray

Figure 4g: UN Males 16-19 Cusum of Squares

Standardized ARIMA Residuals
5% Bounds 1% Bounds



NBER Recessions in Gray

Figure 4h: UN Males 16-19 Cumulative Periodogram

Standardized ARIMA Residuals
5% Bounds
Kolmorogov-Smirnov = 0.04, P-Value = 0.88
LB12 = 7.6, PV12 = 0.67, LB24 = 18.9, PV 24 = 0.66

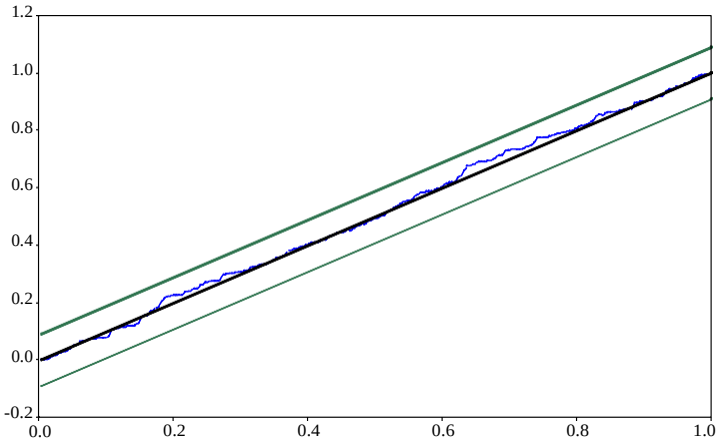


Figure 5a: EM Males 16-19 SACFs

Selected Model = (0 1 1)(0 1 1), Selected Transformation = log