Modeling Recession Effects and the Consequences on Seasonal Adjustment

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Abstract
The 2008 U.S. recession generated many questions as to whether the large declines observed in many time series affected their seasonal adjustments. We investigated this by comparing seasonal adjustments obtained with versus without adjustments for recession effects for 23 monthly U.S. Census Bureau economic time series. We produced the recession adjustments using intervention models that fit short series of level shifts to series with relatively short (less than five month) declines, and ramps to series with longer declines. In all cases, adding the intervention terms substantially improved model fit; however, the effect of the recession preadjustments on the seasonal adjustments was generally small. The Census Bureau has started including these recession adjustments to series showing pronounced recession effects.

Key Words: ARIMA model, intervention, outlier, regression, time series

1. Introduction

The 2008 U.S. recession had a large impact on economic time series, with many series showing a large decline in this period. The effect varied by sector: some series were impacted for only a few months, while others showed a decline over several years; see Figures 1 and 3 for examples. The recession raised many questions as to whether the large declines affected the seasonal adjustment of the series; see, for examples, Alexander and Greenberg (2012), Alexander, Zentner, and Greenberg (2012), Feroli (2012), and Zentner, Amemiya, and Greenberg (2011). To investigate this question, we fit intervention effects in the form of a sequence of level shifts for short declines or a linear or quadratic ramp for longer declines to a set of 23 monthly U.S. Census Bureau economic time series. We then compared seasonal adjustments with and without preadjustments for these intervention effects. We found that, for the most part, the effect of these preadjustments on the seasonal adjustment was small. For series where the effects on seasonal adjustments of the preadjustments were larger, including the intervention preadjustments led to more stable seasonal factors.

2. Data Used

This study used 23 monthly Census Bureau economic time series from various sectors. The data are available from the Census Bureau's Economic Statistics website, www.census.gov/econ. Most of the series are subject to sampling error; more information on the data collection methods and sampling standard errors is available on the Census Bureau website. The study included six series from the Monthly Wholesale Trade Survey; four from the Monthly Retail Trade Survey; four import and three export series;

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one manufacturers' shipments series from the Manufacturers' Shipments, Inventories, and Orders Survey; and five construction series. The construction series included two construction spending series from the Value of Construction Put in Place Survey, one housing starts series from the Survey of Construction, one series from the Building Permits Survey, and one new residential sales series from the Survey of Construction.

These time series were chosen by Census Bureau staff from the individual program areas that are responsible for the seasonal adjustment of the series. The series chosen all showed a marked decline during the recession. Some were chosen because they were high-value series or considered highly important. Two of the series were already being modeled with a ramp regressor, as described in the next section. All series started in the early 1990s and, as of the time the analyses reported here were done, continued at least through December 2011. Some series included a few months in 2012 as well.

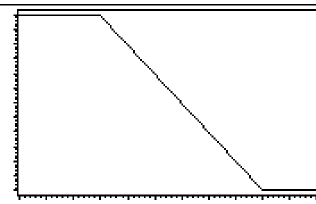
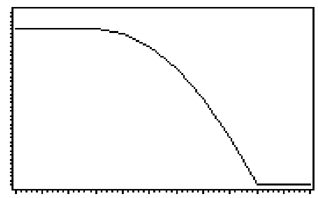
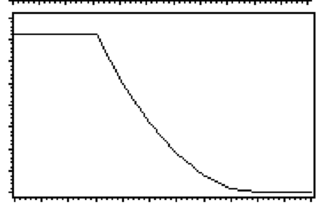
The effect of the recession varied amongst the 23 series. The manufacturers' shipments series included had a decline of only three months, and the seven import and export series had an average decline lasting four months. The 10 retail and wholesale series had more variation, but averaged about six months for their declines. The five construction series had long declines of, on average, about 28 months.

3. X-13ARIMA-SEATS Outliers

The Census Bureau uses the program X-13ARIMA-SEATS (U.S. Census Bureau 2013), hereafter X-13A-S, for seasonal adjustment. X-13A-S first fits a regression model with ARIMA residuals (a regARIMA model) to a time series to adjust it for outliers and for trading-day and holiday effects, and to forecast the series. The preadjusted, forecast extended series is then seasonally adjusted using either the Census Bureau's X-11 method or the canonical ARIMA model-based approach (Hillmer and Tiao 1982) as implemented in the TRAMO-SEATS software developed at the Bank of Spain (Gómez and Maravall 1996). In this study, we use the X-11 method for seasonal adjustment, as currently all series at the Census Bureau are adjusted with this method.

The focus of this study is on the preadjustment done before seasonal adjustment. Six types of X-13A-S outliers are used in this study. An additive outlier (AO) is a point outlier, used to adjust for an unusual value found at one time point. A level shift (LS) outlier occurs when the series suddenly jumps or drops to a new level at some time point, and then evolves from that new level. Temporary changes (TC) occur when the series jumps or drops at some time point, but then exponentially decays back to the original level. Like level shifts, ramps (RP) mark a shift from one level to another, but rather than shifting to the new level all at one time point, a ramp has a linear change from some time t_0 to some later time t_1. A ramp therefore requires specification of both a starting and an ending date. The next version of X-13A-S will have two additional types of ramp effects: a QI ramp and a QD ramp. These fit a quadratic ramp to the series between the starting and ending dates. For the QI ramp the rate of change increases over time, and for the QD ramp the rate of change decreases over time. Note that either type of ramp can reflect an increase or decrease in the level of the series, depending on the sign of the corresponding regression coefficient. The names distinguish different shapes of the curves reflecting the effects. The equations for these three ramp regression variables are given in Table 1, along with graphs showing the patterns of their effects for a six-month decline.

Table 1: Regression variables for the three types of ramp effects, and a graph of the effect for a six-month decline

Ramp Effect	***Regression Variable***	***Graph of 6 Month Decline***
Linear Ramp	$RP_t^{(t0,t1)} = \begin{cases} t_0 - t_1 & for\ t \le t_0 \\ t - t_1 & for\ t_0 < t < t_1 \\ 0 & for\ t \ge t_1 \end{cases}$	
Increasing Quadratic Ramp	$QI_t^{(t0,t1)} = \begin{cases} -(t_1 - t_0)^2 & for\ t \le t_0 \\ (t - t_0)^2 - (t_1 - t_0)^2 & for\ t_0 < t < t_1 \\ 0 & for\ t \ge t_1 \end{cases}$	
Decreasing Quadratic Ramp	$QD_t^{(t0,t1)} = \begin{cases} -(t_1 - t_0)^2 & for\ t \le t_0 \\ -(t_1 - t)^2 & for\ t_0 < t < t_1 \\ 0 & for\ t \ge t_1 \end{cases}$	

X-13A-S has automatic outlier identification procedures available to find additive outliers and level shifts, and, if requested, temporary changes. Very briefly, this procedure involves fitting all points in the requested span with all the requested outlier types and adding to the model those outliers that have a *t*-value exceeding the specified critical value (U.S. Census Bureau 2013). This critical value can be specified or can be chosen by the program based on the length of the outlier detection span using a suggestion of Ljung (1993). For series of the length included in this study, if the full series is considered as the outlier span, this critical value tends to be around 4.

At the Census Bureau, time series being seasonally adjusted are investigated for outliers at least annually in a review of seasonal adjustment options. All program areas search for additive outliers and level shifts, and most also search for temporary changes. The outliers that were included in each series during the period of the decline due to the recession as of the 2011 annual review are included in Tables 2 and 5 below.

The X-11 seasonal adjustment procedure of X-13A-S involves alternating the application of trend filters and seasonal filters to the series. Because sudden changes in the series can negatively impact the adjustment, X-13A-S adjusts the original series for the identified outliers before applying the seasonal adjustment filters. After the X-11 procedure is completed, the estimated outlier effects are returned to the seasonally adjusted series. Level shifts and ramps are assigned to the trend, and additive outliers and temporary changes are assigned to the irregular component.

4. Using Interventions to Model Recession Effects

The idea of refining a series' seasonal adjustment using intervention models for recession effects is not a new one. Buszuwski and Scott (1988) used a spline regression model to fit ramps to model recession effects in a price index series. Ciammola, Cicconi, and Marini (2010) fit a series of level shifts over a recession decline, and added a ramp where two or more consecutive level shifts were statistically significant. Maravall and Pérez (2012) fit models with ramps and chose the best model based on the Bayesian Information Criterion (BIC). To fit ramps to Current Employment Statistics series, Kropf and Hudson (2012) identified the peaks and troughs of the recession in each industry using methods developed at the National Bureau of Economic Research, and used these as the starting and ending dates of the ramps. The approach we pursue here is closest to that of Maravall and Pérez.

We looked for a systematic approach to identifying an appropriate intervention model for each series. For series for which the decline was of a short duration, four months or less, we looked at adding to the model a sequence of level shift outliers covering the decline. For those series showing a longer decline, we included one or more ramp variables in the model. We used Akaike's Information Criterion Corrected for Sample Size (*AICC*) to compare models (U.S. Census Bureau 2013). Its formula is

$$AICC = -2L_N + 2n_p\left(1 - \frac{n_p + 1}{N}\right)^{-1}$$

where L_N is the maximized log likelihood, N is the number of data points after differencing, and n_p is the number of parameters estimated. Smaller values of *AICC* indicate a better model fit. This statistic is usually used only when two models have the same outlier sets, but as the level shifts and ramps being added are modeling effects due to known events they can be regarded as interventions rather than outliers, so it is valid to use the *AICC* to compare the models.

Our procedure for identifying the best linear ramp model is as follows:

1. Estimate the model with the outlier set as specified for production seasonal adjustment by the program areas, and graph the original series, seasonally adjusted series, and trend. Use the graphs to identify an initial guess for the starting and ending points of the ramp. If the rate of the decline seems to change over the interval, use two or more ramps.
2. Remove from the model any outliers that occur in the period of the decline, and add to the model the new ramp(s). Estimate this model and do conventional outlier detection (looking for additive outliers and level shifts, and, if the program area uses them, temporary changes) over the entire series using the default critical values. Add newly identified outliers to the model.
3. Turn off outlier identification, but maintain the outliers found at step 2. Fit models with the starting and ending dates of the ramp(s) shifted a few months forwards or backwards. Compare the models using the *AICC* criterion to find the ramp yielding the best fit. (Since n_p and N remain fixed across these model fits, this approach picks the ramp that maximizes L_N.)
4. With this best ramp included, perform additional outlier identification only over the span of data covered by the ramp, but using a lower critical value. We used 2.5 as a critical value as we wanted this procedure to be fairly sensitive to

potential outliers in the decline, but a smaller or larger critical value could be used.
5. If changes were made to the model in steps 3 and 4, perform conventional outlier detection again over the whole series.

The steps for identifying a sequence of level shifts for series with a decline of four or less months are similar. We used graphs from the original seasonal adjustment to tentatively identify the starting and ending point of the level shift sequence. We then added the level shift sequence to the model, dropping any additive outliers and temporary changes already specified in this interval. We then performed conventional outlier identification over the entire series, adding any newly identified outliers to the model. Next we turned off outlier detection and compared fits from models where we shifted the starting and ending dates of the level shift sequence. We looked at the *AICC*s of the various models for the best fit, and also at the *t*-statistics of the level shifts to see whether these were greater than 2.0. Although we wanted the *t*-statistics at the start and end of the sequence to be greater than 2, we kept level shifts in the middle of the sequence with a smaller *t*-statistic. After identifying the sequence of level shifts to model the recession decline, we performed outlier identification over the entire series once more.

We also looked at fitting quadratic ramps to series with longer declines. To do this, we looked at a graph of the decline to determine whether an increasing or a decreasing ramp would be a better fit, and then used the chosen effect in the procedure given above for linear ramps.

Once we had a model including intervention effects for the series, we generally compared the seasonal adjustment obtained using preadjustments from the intervention model to that obtained with the original model specification used by the program areas during production seasonal adjustment in 2011. There were two exceptions stemming from two Retail/Wholesale series for which production seasonal adjustment had used a ramp regressor to adjust for recession effects. For these two series, we compared the model with the interventions identified by the above method with seasonal adjustments obtained using a model with no ramps, but rather with the outliers identified by conventional automatic outlier identification.

5. Results

Section 5.1 discusses the results for series where we used a sequence of level shifts to model short declines, Section 5.2 discusses the results for series where we used linear ramps to model longer declines, and Section 5.3 discusses the results for series with longer declines that we modeled by quadratic ramps.

5.1 Series with Declines of Four Months of Less: Sequence of Level Shifts

Eleven series showed a decline of four months or less during the recession. These series are listed in Table 2, along with the set of outliers included in the original model for each series. For the series Gasoline Station Retail Sales, a short ramp of three months had been in the original model. Since this series has a short decline, to compare the level shift sequence results to those with regular outlier effects, we replaced this ramp with the outliers that X-13A-S identified automatically. After the process described in Section 4 was applied, five of the series in Table 2 had one new level shift and two series had two new level shifts included in their models. For four series, no new significant level shifts were found so their seasonal adjustments were not changed from the production results. The Gasoline Station Retail Sales falls in this last category, as the outlier sequence of two additive outliers and a level shift results in the same outlier adjusted series, and hence the same seasonal adjustment, as an outlier sequence of three level shifts.

For the five series for which one new outlier was found, the *t*-statistics of the new level shifts were relatively small; they each fell between -2.08 and -2.68. However, each series showed a decline in the *AICC* when the new level shift was included. The smallest of these differences was 2.0, and the largest 4.8. In one series, Machinery, Equipment, and Supplies Wholesale, an additive outlier specified in the original model was changed to a level shift. As this additive outlier is immediately followed by another level shift, changing it to a level shift produces an equivalent model, and so does not affect the *AICC* or the seasonally adjusted series. The estimated trend will be different, however.

Table 2: Series with short declines: outliers from the original model and from the model with a level shift sequence used to model recession effects.

Series	***Original Outlier Set [t-values]***	***New Outlier Set [t-values]***	***# New Outliers***	***AICC Difference***
Computer Imports	LS2008.Nov [-3.65]	LS2008.Nov [-3.65]	0	n/a
Telecommunications Equipment Imports	LS2008.Dec [-3.34]	LS2008.Nov [-2.76] LS2008.Dec [-1.76] LS2009.Jan [-2.04]	2	7.0
TV & Video Receivers Imports	LS2008.Nov [-4.13]	LS2008.Nov [-4.13]	0	n/a
Industrial Organic Chemicals Exports	LS2008.Nov [-4.19] TC2008.Dec [-5.55]	LS2008.Sep [-4.14] LS2008.Oct [0.14] LS2008.Nov [-3.47] LS2008.Dec [-5.96]	2	12.0
Engines and Parts for Cars Exports	LS2008.Nov [-3.65] LS2009.Jan [-5.38]	LS2008.Nov [-2.52] LS2008.Dec [-2.54] LS2009.Jan [-4.18]	1	4.1
Automobile Manufacturing	LS2009.Jan [-4.83]	LS2008.Dec [-2.68] LS2009.Jan [-3.89]	1	4.6
Petroleum and Petroleum Products, Wholesale Inventories	LS2008.Oct [-5.05]	LS2008.Oct [-5.10] LS2008.Nov [-2.08]	1	2.0
Furniture, Home Furnishings, Electronics, and Appliance Stores, Retail Inventories	LS2008.Nov [-6.19]	LS2008.Nov [-6.31] LS2008.Dec [-2.66]	1	4.8
Machinery, Equipment, and Supplies, Wholesale	AO2008.Dec [-4.37] LS2009.Jan [-7.48]	LS2008.Nov [-2.67] LS2008.Dec [-3.43] LS2009.Jan [-4.54]	1	4.7
Grocery Stores, Retail	LS2008.Dec [-4.04]	LS2008.Dec [-4.04]	0	n/a
Gasoline Stations, Retail	AO2008.Oct [-4.75] AO2008.Nov [-8.23] LS2008.Nov [-9.36]	LS2008.Oct [-4.75] LS2008.Nov [-8.21] LS2008.Dec [-5.10]	0	n/a

In both series where two new level shifts were added, one of the outliers in the new outlier set had a *t*-statistic below 2. The original model for the series Telecommunications Equipment Imports had a level shift in December 2008. Additional level shifts were found in November 2008 and January 2009, both with *t*-values greater than two; however, including these in the model reduced the *t*-value of the December outlier to -1.76. Because it fell in the middle of the sequence, we retained this outlier in the new outlier set. With the two new outliers, the *AICC* fell by 7.0. The model for the series Industrial Organic Chemicals Exports originally had a level shift in November 2008 and a temporary change in December 2008. To apply the recession level shift identification procedure, the temporary change was removed from the model, and level shifts were included throughout the decline. A new significant level shift was found in September 2008, and both November and December had significant level shifts. The level shift in October 2008 was not significant (nor even negative), but was retained because it fell in the middle of the sequence. When X-13A-S is allowed to automatically identify outliers, it chooses a level shift at this time point.

Table 3 shows the largest differences in the seasonally adjusted series for the seven series for which at least one new level shift was specified, and Table 4 shows the largest differences in the month-to-month percent changes. Even these largest differences are relatively small. Automobile Manufacturing showed the largest difference. The addition of one level shift in December 2008 increased the seasonally adjusted series by 1.7% in November 2008, which decreased the month-to-month change from November to December 2008 by 2.7%. Figure 1 shows the series and its two seasonal adjustments; Figure 2 shows the seasonal factors by month from these adjustments. For four of the seven series the seasonal adjustments were changed by one percent or less at all points by the explicit modeling of the recession effects. Although the decline in all series occurred in late 2008/early 2009, the timing of the largest differences varied from late 2006 to late 2009. To put these differences in some context, Table 3 also shows the average absolute month-to-month percent change in the seasonally adjusted series as an indication of the series' volatility.

Table 3: Largest differences in the seasonally adjusted series for series with a level shift sequence used to adjust for recession effects; the average absolute month-to-month percent change in the seasonally adjusted series is also included.

Series	***Average Abs Month-to-Month % Change in Seas Adj***	***Date***	***Original Seasonally Adjusted Value (millions)***	***Seasonally Adjusted Value Using Intervent'n Model (millions)***	***Percent Diff***
Telecom Equipment Imports	4.12%	2008.10	3,765	3,806	1.1%
Industrial Chemical Exports	5.38%	2007.10	2,762	2,723	-1.4%
Engine & Car Parts Exports	4.56%	2007.04	2,138	2,116	-1.0%
Automobile Manufacturing	4.49%	2008.11	6,095	6,198	1.7%
Petroleum Inventories, Wh.	3.08%	2009.10	18,564	18,725	0.9%
Furniture et al Inventories, Ret.	0.90%	2006.10	31,103	31,367	0.8%
Machinery et al Wholesale	1.84%	2008.10	29,588	29,825	0.8%

Table 4: Largest differences in the month-to-month percent changes for the series with a level shift sequence used to adjust for recession effects

Series	*Date*	*Original Month-to-Month % Change*	*Month-to-Month % Change, Intervention Model*	*Difference*
Telecom Equipment Imports	2011.01	3.9%	2.7%	-1.2%
Industrial Chemical Exports	2007.10	-1.1%	-2.9%	-1.8%
Engine & Car Parts Exports	2009.12	5.2%	3.8%	-1.4%
Automobile Manufacturing	2008.12	-10.1%	-12.8%	-2.7%
Petroleum Inventories, Wh.	2009.11	8.3%	6.5%	-1.8%
Furniture et al Inventories, Ret.	2006.11	0.4%	-0.6%	-0.9%
Machinery et al Wholesale	2010.11	2.6%	1.3%	-1.3%

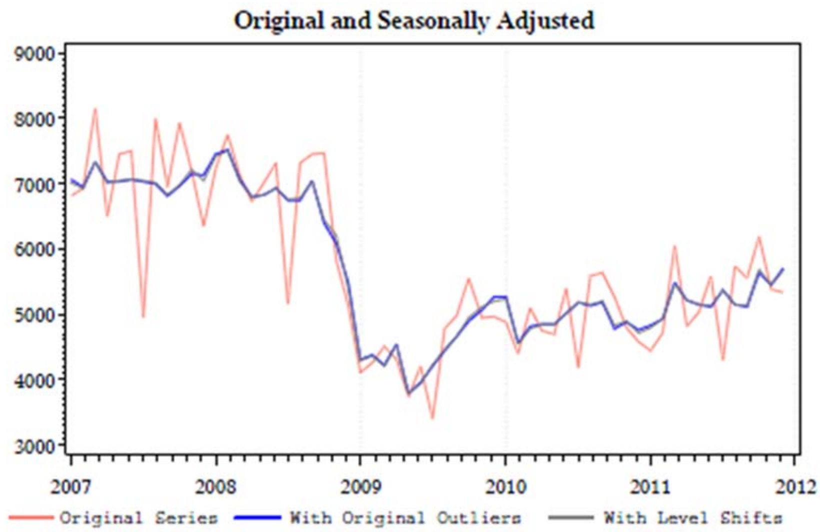


Figure 1: The Automobile Manufacturing series, with the seasonal adjustments found both with and without the level shift in December 2008

5.2 Series with Declines of More than Four Months: Linear Ramps

Twelve series had a decline of more than four months. For all these series, including a linear ramp in the model improved model fit. For three series, the best model had only the ramp in the recession period, i.e., no other outliers were identified there. Seven series had a ramp with additional outliers identified over the interval containing the ramp. For two of these series, Wholesale and Retail Sales of Motor Vehicles and Wholesale Sales of Motor Vehicle Parts and Supplies, the best model found had two ramps. The length of the ramps varied from 4 months (for Miscellaneous Durable Goods, Wholesale) to 38 months (for South Region New Homes Sold). Table 5 shows the original outlier sets, the new outlier set after the intervention was added, and the difference in *AICC* of the two models. These *AICC* differences ranged from 4.9 (Computer Accessories Exports) to 28.6 (Retail Sales of Motor Vehicle and Parts Dealers).

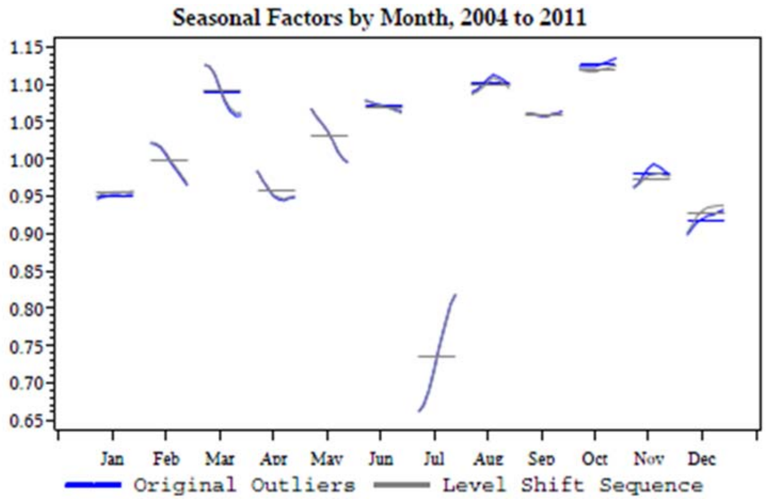


Figure 2: Seasonal factors of the Automobile Manufacturing series, with and without the additional level shift in December 2008. The largest difference is in November, while other months show practically no change.

Table 6 shows the maximum percent difference in the seasonally adjusted series when the series is modeled with the ramp and without it, along with the average absolute percent difference between 2007 and 2011. Table 7 shows the maximum difference in the month-to-month percent changes, along with the average absolute difference between 2007 and 2011. Also included in table 6 is the average absolute month-to-month percent change of the seasonally adjusted series, as an indication of how volatile the series is. The changes are small for many of the series—six of the twelve show a maximum percent difference in the seasonally adjusted series of 2% or less. Other series have a more substantial change. The largest difference is in Northeast Single Family Housing Starts, which is the series with the largest measure of volatility. This series added a 36 month ramp and two additive outliers and lost one level shift with the intervention model, resulting in a maximum percent difference in the seasonally adjusted series of -8.5% in November 2008. Figure 3 shows this series and the two seasonal adjustments; Figure 4 shows the seasonal factors by month of the two adjustments. The graphs show small to moderate changes in most months, but large changes in November. In January and November, the two months with the largest changes, the seasonal pattern is more stable when the ramp is included.

The series with the second and third largest maximum percent difference in the seasonally adjusted series are Midwest Single Family Building Permits (4.7%) and Petroleum and Petroleum Products Wholesale Sales (3.9%), respectively. Midwest Building Permits is ranked towards the middle when comparing volatility, but it is the most changed in its outlier set; in addition to a 36 month ramp, both an additive outlier and a temporary change were added. Petroleum and Petroleum Products is discussed in the next section.

Table 5: Series with declines over four months, with their original outlier set and intervention model outlier set.

Series	***Original Outliers [t-value]***	***New Outlier Set [t-value]***	***AICC Difference***
South New Homes Sold		Rp2005.Oct-2008.Dec [-7.21] LS2006.Aug [3.18]	23.9
General Merchandise (Department store) Construction		Rp2007.Oct-2008.Jun [-3.08]	6.2
Northeast Single Family Housing Starts	LS2008.Feb [-3.95] TC2009.Jan [-6.06]	Rp2006.Jan-2009.Jan [-6.05] AO2008.Jan [3.38] AO2008.Nov [-3.23] TC2009.Jan [-5.04]	20.4
New Multifamily Construction		Rp2008.Jul-2010.Mar [-6.32]	28.2
Building Permits MW Single Family	AO2007.Feb [-4.17] TC2008.Feb [-4.49] TC2008.Dec [-5.57]	Rp2006.Jan-2009.Jan [-4.55] AO2007.Feb [-4.20] TC2008.Feb [-4.25] TC2008.Apr [3.16] TC2008.Dec [-4.99] AO2009.Jan [-2.71]	28.4
Petroleum Imports	LS2008.Nov [-6.08] LS2009.1 [-3.85]	Rp2008.Jul-2009.Jan [-6.63] AO2008.Oct [5.70]	10.9
Computer Accessories Exports	LS2008.Nov [-2.90]	Rp2008.Jul-2009.Jan [-3.75]	4.9
Metal and Mineral (except Petroleum), Wholesale Inventories	LS2008.Dec [-4.27] LS2009.Mar [-4.24]	Rp2008.Sep-2009.Sep [-4.41] LS2008.Dec [-4.12] LS2009.Mar [-4.30]	14.5
Motor Vehicle and Motor Vehicle Parts and Supplies, Wholesale	AO2008.Nov [-4.56] LS2008.Dec [-7.60]	Rp2008.Mar-2008.Aug [-4.32] Rp2008.Sep-2009.Jan [-9.75]	23.4
Miscellaneous Durable Goods, Wholesale	LS2008.Sep [-3.85] LS2008.Oct [-5.31] AO2009.Feb [4.28] AO2009.Apr [-3.28]	Rp2008.Jul-2008.Nov [-5.30] LS2008.Oct [-2.11] AO2009.Feb [4.43] AO2009.Apr [-3.27]	11.9
Petroleum and Petroleum Products, Wholesale	LS2008.Nov [-5.33]	LS2008.Jun [2.53] Rp2008.Jun-2008.Dec [-4.91] LS2008.Nov [-4.04]	23.3
Motor Vehicle and Parts Dealers, Retail Sales	LS2008.Oct [-4.63]	Rp2007.Sep-2008.Jul [-6.09] Rp2008.Aug-2008.Dec [-7.98]	28.6

Table 6: Maximum and average (from 2007 to 2011) percent difference in the seasonal adjustment with and without the ramp(s). The average absolute month-to-month percent changes of the series over its entire span is also included.

Series	*Ave Month-to-Month % Diff of Sadj*	*Date*	*Without Ramps*	*With Ramps*	*Max %Diff*	*Ave Abs %Diff, 2007-2011*
South Sold	6.28%	2002.01	33,128	33,679	1.7%	0.40%
Dep't Store Construction	7.24%	2009.06	358M	349M	-2.4%	0.78%
NE Housing Starts	10.47%	2008.11	3,701	3,387	-8.5%	2.12%
New Multifamily Construction	3.11%	2011.03	1,126M	1,113M	-1.1%	0.52%
MW Building Permits	4.78%	2009.01	4,431	4,224	-4.7%	1.24%
Petroleum Imports	6.80%	2009.12	21,157M	20,419M	-3.5%	0.96%
Computer Acc. Exports	2.55%	2007.06	2,648M	2,680M	1.2%	0.36%
Metal & Mineral Inventories	1.50%	2007.09	25,097M	25,176M	0.3%	0.10%
Motor Vehicles & Parts, Wh.	2.40%	2008.12	19,738M	20,139M	2.0%	0.48%
Misc Durable Goods, Wh.	3.23%	2008.08	22,856M	22,263M	-2.6%	0.84%
Petroleum & Products, Wh.	4.10%	2008.06	64,898M	67,441M	3.9%	1.76%
Motor Vehicle & Parts, Ret.	2.14%	2008.12	54,631M	54,195M	-0.8%	0.28%

Table 7: Largest differences in the month-to-month percent changes for the series modeled with and without the ramp, along with the average absolute difference from 2007 to 2011.

Series	*Date*	*Without Ramps*	*With Ramps*	*Diff*	*Ave Abs Diff, 2007-2011*
South Sold	2002.02	15.1%	12.8%	-2.3%	0.52%
Dep't Store Construction	2009.07	-4.8%	-2.7%	2.1%	0.62%
NE Housing Starts	2008.12	17.7%	27.0%	9.3%	2.14%
New Multifamily Construction	2011.06	-1.3%	0.0%	1.3%	0.34%
MW Building Permits	2008.04	13.2%	19.9%	6.7%	1.60%
Petroleum Imports	2009.12	11.8%	8.2%	-3.6%	1.12%
Computer Acc. Exports	2009.07	6.4%	5.1%	-1.3%	0.54%
Metal & Mineral Inventories	2006.11	1.0%	0.8%	-0.2%	0.10%
Motor Vehicles & Parts, Wh.	2008.01	4.1%	1.8%	-2.3%	0.78%
Misc Durable Goods, Wh.	2009.08	3.0%	-1.1%	-4.2%	1.02%
Petroleum & Products, Wh.	2007.04	7.7%	12.4%	4.7%	1.32%
Motor Vehicle & Parts, Ret.	2008.09	-4.3%	-5.6%	-1.4%	0.40%

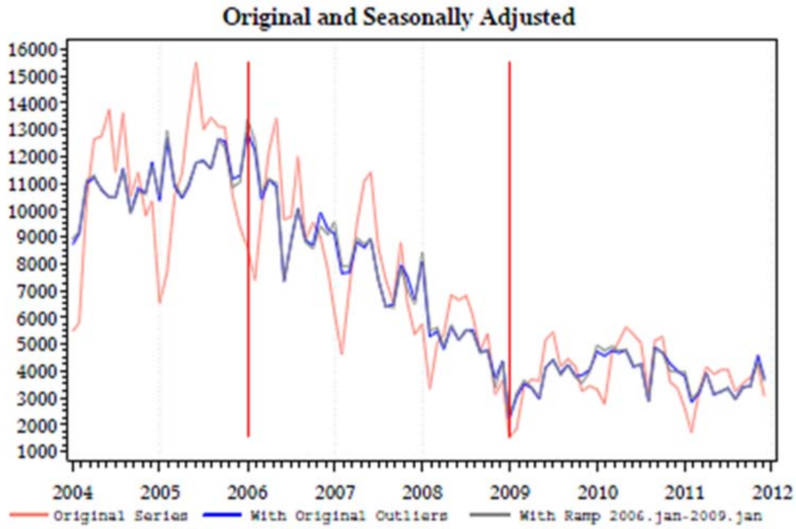


Figure 3: Original and seasonally adjusted series, with and without the ramp, of Northeast Single Family Housing Starts.

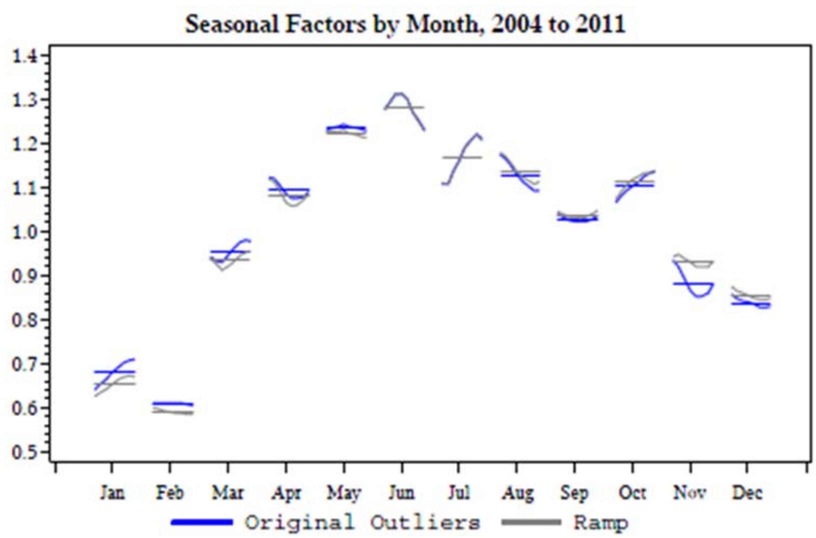


Figure 4: Seasonal factors obtained with and without the ramp for Northeast Single Family Housing Starts. The largest differences are in November; June and July show little changes.

5.3 Series with Declines of More than Four Months: Quadratic Ramps

Quadratic ramps provided a slightly better model fit for four of the eleven series with a decline lasting more than four months. Three increasing quadratic ramps and one decreasing quadratic ramp of lengths varying from five to ten months were found that produced a slightly smaller AICC than the linear ramp models given in Section 5.2. These AICC declines, shown in Table 8, ranged from 1.06 to 4.14.

For three of these series, the use of quadratic ramps did not alter the other outlier terms in the model. For the series Wholesale Sales of Petroleum and Petroleum Products, the only change was that the linear ramp became an increasing quadratic ramp over the same span of time. For Wholesale Sales of Miscellaneous Durable Goods, the decreasing quadratic ramp started at the same time as the linear ramp, but ended in April 2009, whereas the linear ramp ended in November 2008. For the series Computer Accessories Exports, the linear ramp from July 2008 to January 2009 changed to an increasing quadratic ramp from June 2008 to November 2008. Finally, for the series Wholesale Sales of Motor Vehicles and Motor Vehicle Parts and Supplies, the linear ramp model had two ramps. An increasing quadratic ramp over this entire time span augmented with a level shift at the starting point of the second linear ramp provided a slightly better fit.

Table 8: Series fit with a quadratic ramp, with the new intervention effects and their t-values and the drop in AICC from the linear ramp model

Series	***QI/QD Outlier Set [t-value]***	***AICC Difference Linear – Quadratic Ramp Models***
Computer Accessories Exports	QI2008.Jun-2008.Nov[-4.07]	2.24
Motor Vehicle and Motor Vehicle Parts and Supplies, Wholesale	QI2008.Mar-2009.Jan[-10.55] LS2008.Sep[2.78]	1.06
Miscellaneous Durable Goods, Wholesale	QD2008.Jul-2009.Apr [-5.74] LS2008.Oct[-2.74] AO2009.Feb[4.84] AO2009.Apr [-3.12]	4.14
Petroleum and Petroleum Products, Wholesale	LS2008.Jun[2.81] QI2008.Jun-2008.Dec[-7.75] AO2008.Nov[-3.41]	3.39

Table 9: Maximum percent difference in the series with a quadratic ramp compared to using no ramps

Series	***Date***	***Seasonally Adjusted Series (in millions), Without ramps***	***Seasonally Adjusted Series (in millions), With Quadratic Ramp***	***Max Perc Diff, Quadratic Ramp vs. No Ramp***
Computer Acc. Exports	2008.10	2,302	2,271	-1.4%
Motor Vehicle & Parts, Wh.	2008.12	19,738	20,152	2.1%
Misc Durable Goods, Wh.	1992.05	8,743	8,608	-1.5%
Petroleum & Products, Wh.	2008.07	60,546	63,340	4.6%

Table 10: Maximum difference in the month-to-month percent changes of the series with a quadratic ramp compared to no ramps

Series	***Date***	***Month-to-Month Percent Change, Without ramps***	***Month-to-Month Percent Change, With Quadratic Ramp***	***Difference***
Computer Acc. Exports	2009.07	6.4%	4.8%	-1.6%
Motor Vehicle & Parts, Wh.	2008.01	4.1%	1.3%	-2.8%
Misc Durable Goods, Wh.	2008.08	-3.4%	-5.8%	-2.4%
Petroleum & Products, Wh.	2007.04	7.7%	11.9%	4.2%

Tables 9 and 10 show the maximum percent difference in the seasonally adjusted series and the maximum difference in the month-to-month changes of the seasonally adjusted series found using the quadratic ramp versus using no ramps. Interestingly, the largest percent difference for Miscellaneous Durable Goods Wholesale Sales occurred in 1992, showing that although most of the largest differences happen around the time of the recession, we can still see some differences at the beginning of the series. The maximum percent difference for this series when we considered only 2002 through 2012 is 1.5%, occurring in July 2008.

The maximum percent difference in the seasonally adjusted series and the maximum difference in the month-to-month changes of the seasonally adjusted series found in the previous section for linear ramps, and in this section for quadratic ramps, are similar for Computer Accessories Exports and Motor Vehicle and Motor Vehicle Parts and Supplies Wholesale Sales. The changes in the seasonally adjusted series and the month-to-month changes are smaller in magnitude when using quadratic ramps for the series Miscellaneous Durable Goods Wholesale Sales. For Petroleum and Petroleum Products Wholesale Sales, the maximum percent difference in the seasonally adjusted series is higher for the quadratic model. This last series shows the largest changes in the seasonally adjusted series when using the quadratic ramp as opposed to no ramp (as it also does amongst these four when using the linear ramp). Graphs of the seasonal factors from all three adjustments are shown in Figure 5. For most months, the factors from the linear ramp and those from the quadratic ramp move similarly; these two also generally show more stability over time than the factors without a ramp. Graphs for the other three series are not shown, but they generally show these same features.

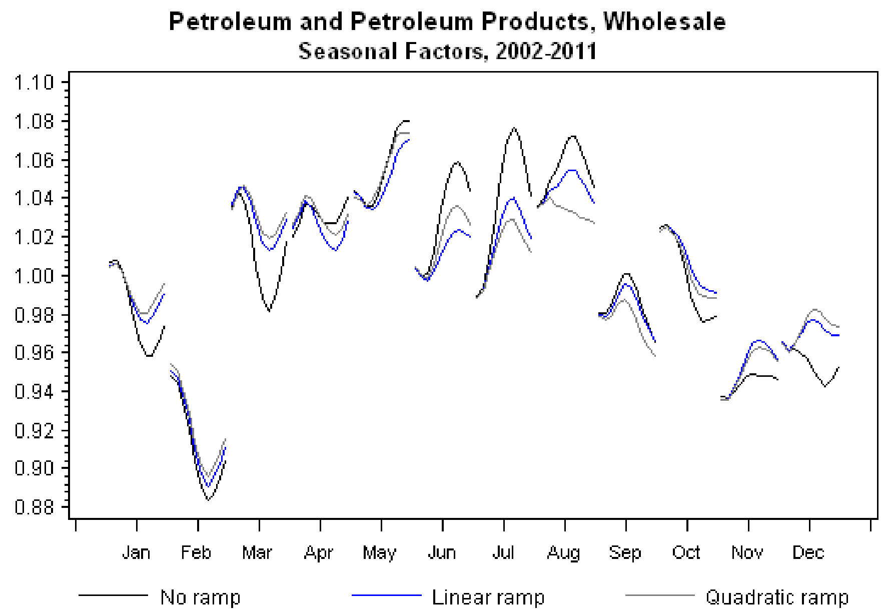


Figure 5: The seasonal factors from the three adjustments of Petroleum and Petroleum Products, Wholesale Sales.

6. Conclusions

For all series for which an intervention effect was added to the model, the intervention improved the model fit. For the series with short declines, the effect on the seasonal adjustment of adding level shifts to the model was generally small. For the series with declines of over four months, these effects were sometimes larger when ramps were added to the models. However, the series with the larger changes tended to be series that were more volatile, so a larger change is not unexpected.

The process for choosing the intervention effects to include was straightforward to implement in this study; however, it will be more complicated in practice as the ARIMA model and the other regressors may also be changed during the review of spec files due to poor diagnostic results. In 2012 the Census Bureau started including these intervention effects in some series showing a marked decline during the 2008 recession.

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