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Does Lawrence Smoking Ban Impact Kansas Liquor Sales?

Lijia Mo, Rouch Financial Group, Lincoln, NE

Abstract

Four cities in Kansas (Johnson County, Manhattan, Topeka and Wichita) have been investigated to reveal the economic impact of a newly enacted Lawrence smoking ban on liquor sales in bars and restaurants in Kansas. Real world time series data on taxable liquor revenue of these cities covers 4.5 years pre ban and 3 years post ban around the enact date in Lawrence as of July 4th 2004, totally including 90 observations. Revealed economic impact assists in legislative consideration on state-wide ban, although current proposal includes county referendum to opt-out and opposition arises from bar owners taken as violation of state's constitution. Based on pre ban, researcher uses the major steps of Box Jenkins time series methodology to forecast one period ahead on post ban, including model identification, model estimation, and diagnostic checking the basic assumptions on the random shock. The lack of fit testing on residual sample Autocorrelation Functions (ACFs) as a unit to check the joint null hypothesis, and testing the parameters to be all significant and uncorrelated ensure the rest of model assumptions. Number of observations falling out of the forecast interval is within the tolerance level. As a conclusion, the smoking ban has no negative impact on the liquor sales.

JEL Code: C22 - Time-Series Models; Dynamic Treatment Models

1. Introduction

Political entity Lawrence was the first city in Kansas to institute comprehensive smoking ban in enclosed public places and places of employment since July 4th 2004. Smoking ban includes bars and restaurants. The controversy over the city's smoking ban will be played out on the state's highest legal stage. The Kansas Supreme Court has agreed to hear arguments by Lawrence bar owner Dennis Steffes that the city's two-year old smoking ban violates the state's constitution. Meanwhile, city leaders said the ban will continue to be enforced at various jurisdictional levels.

Large literature on economic impact of municipal smoking bans have been done by researchers, Consensus (of sorts) found no significant negative impact on overall business at the community level. However, some studies find overall positive impacts but some studies find negative impacts on bars or particular types of bars (most also find positive impacts on restaurants or other types of bars). In the significant findings, most negative impacts found are short-term. Fox's economic impact study of Lawrence smoking ban has been evaluated in the literature. Macy et al (2011) used regression analysis to compare the trend in per capita amount wagered at an off-track betting (OTB) location that went smoke-free to the trend in per capita amount wagered at two comparison OTB locations that continued to permit smoking with unemployment rate being included as a covariate. They measured the impact of a local smoke-free air law on wagering at an OTB facility in Indiana. They found a decreasing trend in the per capita amount wagered at each of the three OTB locations. No significant change in the trend for the location that went smoke free or for the locations where smoking has continued was found. They found no economic reason to exclude OTB facilities from smoke-free legislation.

Klein et al. (2010) used an interrupted time series analysis to evaluate the short-, intermediate, and longer-term economic effects of the local Clean Indoor Air (CIA) policies, accounting for the rest of the hospitality industry. They found the CIA policies were associated with a three percent to four percent increase in employment for restaurants in Minneapolis and St Paul. Moreover, an increase of five percent to six percent in bar employment in Minneapolis and a one percent nonsignificant decrease in bar employment in St Paul were found. Although the studies have found no significant economic effects on employment change from CIA policies, the concerns persist that CIA policies will negatively affect hospitality businesses.

Robert et al. (2008) examined the relationship between restaurant smoking bans and restaurant revenues in 267 California communities, therefore, reached two conclusions: firstly, they found the endogenous in a critical way- restaurant sales growth appears to cause restaurant bans caused by California's municipal restaurant smoking bans. Secondly, the ban heterogeneity (e.g., state versus local) can be exploited to sort out or rule out causal effects and the pooling data and treating smoking bans implemented at different levels as homogenous ignores an important source of information and lead to erroneous conclusion.

The debate on smoking ban arise the attention of the governor to consider the importance of smoking ban at higher level of jurisdiction e.g. municipality, county or state. Empirical evidence of the economic impact of smoking ban is lack in the previous literature assessing the city consumer reaction to convince the governor as to offer the economic theory to support performance assessment. This study uses four representative city data in Kansas wide as individual policy entities to evaluate the comprehensive impact on negative on the bar owners revenue. This study use monthly data and intervention analysis along with interval forecast to assess the economic impact of a municipal ban. Therefore the economic theory is used as to provide the basis for the empirical results.

2. Methodology

Box Jenkins Times Series Model (TSM) identification is the first step, which include time plot to identify permanent or temporary effect, embracing time plotting the data to fit the permanent and temporary effects. For the seasonal data, if the autocorrelation function decays rapidly, it indicates stationary. Otherwise, it needs to be differenced. For seasonal data, ACFs of the series decays rapidly means stationary; otherwise difference is needed, as of 1 for non-seasonal, 12 for seasonal or both. The second step is to estimate the post test data to fit in one of the TSM: autoregression (AR), moving average (MA), autoregression moving average (ARMA) or seasonal (S). The third step is diagnostic checking the basic assumptions on the random shock to be white noise process, uncorrelated, zero mean, constant variance series, on which the model adequacy depends. The lack of fit testing on residual sample ACFs as a unit to check the joint null hypothesis, and testing the parameters to be all significant and uncorrelated ensure the rest of the assumptions. The model forecast is done based on pre ban to post ban. Number of observations fell out of the forecast interval need to be within the tolerance level. Insignificant results from the interaction of post dummy variable with time trend were found.

3. Smoking ban debate and data

The reviewed studies analyze a variety of performance measures: taxable sales, employment levels, number of establishment, number of permit applications, number of bankruptcies, unemployment insurance claim, self-reported patron intentions and proprietor predictions. The findings are mixed, which combined with either no effect or a positive effect on restaurant performance. However, some notable studies found positive effect.

Few of these studies offer any economic theory to support their empirical analyses but rather simply assert that more nonsmoking customers will patronize a nonsmoking restaurant or that a nonsmoking restaurant's expenses will be lower. The impact of restaurant smoking bans on restaurant performance remains an open empirical question Robert et al (2008).

Tax revenue data from Kansas Department of Revenue (KDOR) is used in the study. Time series covers 90 observations for Manhattan, Topeka, Wichita and Johnson County from January 2000 to June 2007, covering 4.5 years pre-ban, 3 years post-ban on a monthly basis. Taxable liquor sales data used in this study is converted from the liquor tax data. After log transformation, taxable liquor sales is corrected for the outliers and adjusted for inflation mid-west urban CPI. The cities are selected based on the distance to the ban enacted city – Lawrence. In the sequence of their distance to Lawrence, four cities are ranked as follows, Topeka 23.7 miles, Johnson county 23.9 miles, Manhattan 59.6 miles and Wichita 138 miles.

Sales tax from Food Services and Drinking Places (FS&DP) is city-level, monthly, covering from January 2000 to June 2007, including 4.5 years pre-ban and 3 years post-ban, by tax month (not process date). 5.5% tax on non-liquor sales (4.9% until July 2002), including full service restaurants, limited service restaurants, cafeterias, snack bars, food service contractors, caterers, mobile food services and drinking places. Liquor excise tax data is recovered based on 10% tax on alcoholic beverages sold on-premises at private clubs, drinking establishments, and by caterers. The data is illustrated in Figure 1. Table 1 shows the summary statistics of the time series.

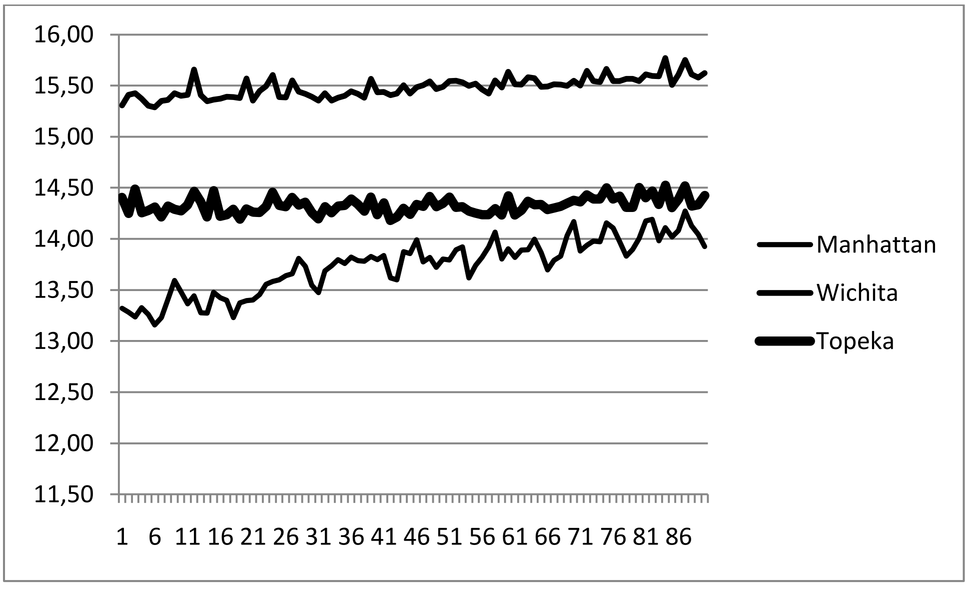

Figure 1 Monthly taxable liquor sales data from 2000 to 2007

Table 1 Summary statistics of the monthly taxable liquor sales data series

	Mean	SD	Minimum	Maximum
Manhattan	13.7382	0.2706	13.1581	14.2734
Wichita	15.4839	0.0991	15.2885	15.7712
Topeka	14.3305	0.0799	14.1796	14.5254
Johnson County	15.8629	0.0971	15.6539	16.1536

Moreover, original liquor sales data covers from January 2000 to December 2006, uncorrected for outliers, adjusted for inflation in log transformation format and including 84 observations is used in the analysis.

4 Results

4.1 Result of interval forecast

Table 1 Estimation Results

	Manhattan	Wichita	Topeka
Model	$(1-B^{12})(1-\emptyset B)lnY_t = (1-\theta B^{12})\alpha_t$	$(1-\emptyset B)lnY_t = (1-\theta B^{12})\alpha_t$	$(1-\emptyset B^{12})lnY_t = \alpha_t$
Explain	AR(1)*SMA(1)12 for (12) differenced	AR(1)*SMA(1)12 to the original data	SAR(1)12 to the data
Number of observation not in 95% Confidence Interval	3 (5)	11 (5)	6 (5)
Number of observation not in 90% Confidence Interval	9 (9)	17 (9)	10 (9)

Note: numbers in parentheses are the tolerate levels of the violation number.

Table 2 Report of the forecast violations – 95% Confidence interval

City Name	Observation number	Observed value	Forecasted value	Difference (Forecasted - Observed)
Manhattan	21	13.4	13.65	0.25
	68	13.83	14.08	0.25
	88	14.13	14.34	0.21
Wichita	12	15.67	15.42	-0.25
	20	15.58	15.40	-0.18
	60	15.64	15.47	-0.17
	72	15.64	15.43	-0.21
	75	15.66	15.43	-0.23
	81	15.61	15.43	-0.18
	84	15.77	15.43	-0.34
	86	15.61	15.43	-0.18
	87	15.75	15.43	-0.32
	89	15.58	15.43	-0.15
	90	15.62	15.43	-0.19
Topeka	3	14.49	14.32	-0.17

	12	14.47	14.32	-0.15
	75	14.5	14.36	-0.14
	80	14.5	14.31	-0.19
	84	14.53	14.35	-0.18
	87	14.52	14.35	-0.17

Notes: Observation number of the time of enacted ban is 58.

Table 3 Report of the forecast violations – 90% Confidence interval

City Name	Observation number	Observed value	Forecasted value	Difference (Forecasted - Observed)
Manhattan	13	13.28	13.46	0.18
	15	13.48	13.3	-0.18
	31	13.47	13.58	0.11
	68	13.83	14.08	0.25
	71	13.88	14.09	0.21
	77	13.97	14.19	0.22
	80	14	14.22	0.22
	83	13.98	14.22	0.24
	89	14.04	14.33	0.29
Wichita	1	15.31	15.43	0.12
	12	15.67	15.42	-0.25
	20	15.58	15.4	-0.18
	21	15.35	15.49	0.14
	27	15.55	15.4	-0.15
	60	15.64	15.47	-0.17
	72	15.64	15.43	-0.21
	75	15.64	15.43	-0.21
	81	15.61	15.43	-0.18
	82	15.6	15.43	-0.17
	83	15.59	15.43	-0.16
	84	15.77	15.43	-0.34
	86	15.61	15.43	-0.18
	87	15.75	15.43	-0.32
	88	15.61	15.43	-0.18
	89	15.58	15.43	-0.15
	90	15.63	15.43	-0.2
Topeka	3	14.49	14.32	-0.17
	7	14.22	14.32	0.1
	12	14.47	14.32	-0.15
	29	14.36	14.26	-0.1
	42	14.18	14.27	0.09
	75	14.5	14.36	-0.14
	80	14.5	14.31	-0.19
	82	14.47	14.33	-0.14
	84	14.53	14.35	-0.18
	87	14.52	14.35	-0.17

Notes: Observation number at the time of enacted ban is 58.

4.2 Result of intervention analysis

Political entity – Johnson County ban smoking in enclosed public places and places of employment since July 1st 2004 as intervention issue.

The period before July 1st 2004 the smoking ban, is assumed to be free of intervention effects and is used to estimate the noise model for $\ln y_t$.

The plot of the data means stationary. Moreover ACF of the series decays rapidly, which indicates that the series is stationary too. It is unnecessary for differencing.

The ACF of the original data is found that the "lnliqtot_a" has a damping ACF within 12 months, which means it is a AR model of degree n (n can be identified by the following step). Studying the ACF every 12 months gives one the seasonal property. The spikes at 0 and 12 mean it is a moving average of degree one, indicating the ACF pattern repeats every 12 months. It is a property of the seasonal series.

The partial autocorrelation function (PACF) of the series shows PACF cuts off after three lags, which indicates it is a AR(3). AR(3) does repeat every 12 months, which indicates that it is not a seasonal AR(3); PACF is damping every 12 months, indicating the series is MA(1) every 12 months. Therefore, the time series pattern is identified as AR(3)*$SMA(1)_{12}$.

The model can be specified as follows: $\ln y_t - \phi_1 \ln y_{t-1} - \phi_2 \ln y_{t-2} - \phi_3 \ln y_{t-3} = a_t - \theta a_{t-12}$, where the process $\{a_t\}$ is called a white noise process uncorrelated with mean zero and variance (a_t)=σ_a^2 constant, covariance (a_t, a_{t+k})=0. The different lags t-1, t-2, t-3, t-12 denote the different time lags for the same variable.

This model can be represented as: $(1-\phi_1 B - \phi_2 B^2 - \phi_3 B^3)\ln y_t = (1-\theta B^{12})a_t$, where the backshift operator is defined as $B^j x_t = x_{t-j}$.

The estimated parameters are listed in Table 4 as follows:

Table 4 Estimation results of the AR(3)*$SMA(1)_{12}$

parameter	Estimate	Standard Error	t-value	P>|t|	Lag
	15.68987	0.04508	348.08	<.0001	0
θ	-0.54652	0.14764	-3.7	0.0005	12
$\emptyset_1$	0.40657	0.13541	3	0.0042	1
$\emptyset_2$	0.16318	0.14869	1.1	0.2778	2
$\emptyset_3$	0.35822	0.13698	2.62	0.0118	3

$\emptyset_2$ is insignificant but other parameters are significant at 5% level. σ_a^2 is estimated as 0.004153. Akaike's Information Criterion (AIC) is -138.138.

The model diagnostic checking is used to assess the model adequacy by checking whether the model assumptions are satisfied after the parameters have been estimated. The basic assumption is that

$\{a_t\}$ are white noise: $\{a_t\}$ are uncorrelated random shocks with zero mean and constant variance.

For any estimated model, the residuals $\hat{a}_t$'s are estimates of these unobserved white noise a_t's.

The model diagnostic checking is accomplished through a careful analysis of the residual series $\hat{a}_t$.

To check whether the residuals are approximately white noise, one can compute the sample ACF and sample PACF of the residuals to see whether they do not form any pattern and are all statistically insignificant, i.e., within two standard deviations if α = 0.05.

The portmanteau lack of fit test uses all residual sample ACFs as a unit to check the joint null hypothesis:

H0: $\rho_1 = \rho_2 .... = \rho_k = 0$. Under the null hypothesis of model adequacy,

$Q = n(n+2)\sum_{k=1}^{K}(n-k)^{-1}\hat{\rho}_k^2$ approximately follows the $\chi^2(K-m)$ distribution, where m=p+q.

Indicators for model diagnostic test, Lack-of-fit test, formal χ^2 test shows insignificance, the p-values are bigger than critical values, which indicates the model is correct and Q(k) has a χ^2 distribution. The autocorrelations of the residual are low.

The intervention factor has been imported as a pulse indicator dummy variable with temporary change $I_t^T = \begin{cases} 0 & t \neq July2004 \\ 1 & t = July2004 \end{cases}$.

The correlation between the dummy variable and series "lnliqtot_a" shows that the correlation spikes every 12 months at lag 5 in December and lag 17 in next December.

The transfer model without noise with the input dummy variable shifted after 5 lags, and therefore the transfer model is specified as $\ln y_t = B^5(\omega_0 B^0)I_t = \omega_0 B^5 I_t$

The estimated parameters are in Table 5.

Table 5 Estimation results of the transfer model for Johnson County taxable Liquor sales

parameter	Estimate	Standard Error	t-value	P>|t|	Lag
	15.86526	0.0099	1594.57	<.0001	0
ω_0	0.16672	0.09334	1.79	0.0776	5

The fitted transfer function with the preliminary noise model is specified as:

$$ln y_t = \omega_0 B^5 I_t + \frac{(1-\theta B^{12})}{(1-\emptyset_1 B - \emptyset_2 B^2 - \emptyset_3 B^3)}\alpha_t$$

The estimated parameters are in Table 6.

Table 6 Estimation results of the fitted transfer function for Johnson County taxable liquor sales

parameter	Estimate	Standard Error	t-value	P>|t|	Lag
	15.73181	0.03938	399.45	<.0001	0
θ	-0.51508	0.1026	-5.02	<.0001	12
$\emptyset_1$	0.29364	0.09875	2.97	0.0039	1
$\emptyset_2$	0.19414	0.10186	1.91	0.0602	2
$\emptyset_3$	0.46602	0.09902	4.71	<.0001	3
ω_0	0.08441	0.04547	1.86	0.067	0, 5(shift)

All parameters are significant, i.e. before intervention $\emptyset_2$ is insignificant and other parameters are significant at 5% level. σ_a^2 is estimated as 0.003637 and before intervention σ_a^2 is estimated to be 0.004153. AIC is -238.735 and before intervention AIC is -138.138.

Indicators for model diagnostic test, Lack-of-fit test, formal χ^2 test show significance and the p-values are bigger than critical values, which indicates the model is correct and Q(k) follows a χ^2 distribution. The autocorrelations are low except for at lag 24, which is 0.289 and before intervention is 0.25. The result from the diagnostic test is same as the result before intervention.

Because the model is built with logarithm of the corrected sales of liquor, the estimate of the intervention effect in terms of the original sales of liquor is $e^{0.08441}$=1.08807, which means the post-intervention level of sales of liquor is 108.807% of the pre-intervention level, or equivalently, the effect of the smoking ban increased the sales of liquor by 8.807%.

As a consistency test, the original series for Johnson County taxable liquor sales is used to analyze the intervention impact. The test shows a damping ACF within 12 months and PACF cuts off at lag 1 and lag 3. AR(1,3) does not rotate every 12 months, which indicates a AR(1,3) without seasonal behavior. The ACF at every 12 months is identified as a MA(1) in every 12 months, therefore the time series is identified as AR(1,3)* $SMA(1)_{12}$.

The model is specified as follows: $(1-\emptyset_1 B-\emptyset_3 B^3)lnN_t=(1-\theta B^{12})\alpha_t$

The estimated parameters are in Table 7.

Table 7 Estimation results of the original series for Johnson County taxable liquor sales

parameter	Estimate	Standard Error	t-value	P>|t|	Lag
	15.80977	0.03688	428.66	<.0001	0
θ	-0.49136	0.13669	-3.59	0.0007	12
$\emptyset_1$	0.44585	0.12467	3.58	0.0008	1
$\emptyset_3$	0.22375	0.12489	1.79	0.0793	3

All parameters are significant at 10% level. σ_a^2 is estimated 0.006132. AIC is -117.996.

Indicators for model diagnostic test, Lack-of-fit test, formal χ^2 test show significance, and the p-values are bigger than critical values, which indicates the model is correct and Q(k) follows a χ^2 distribution. The autocorrelations are low except for at lag 24 with the value of 0.287.

Correlation between the dummy variable and original liquor sales shows the correlation spicks at lag 5 in December and lag 17 in next December.

Transfer model without noise with the input dummy variable shifts after five lags and the transfer model is specified as $y_t = B^5(\omega_0 B^0)I_t$=$\omega_0 B^5$.

The estimated parameters are in Table 8.

Table 8 Estimation results for transfer model of original liquor taxable sales series in Johnson County

parameter	Estimate	Standard Error	t-value	P>|t|	Lag
	15.86447	0.01076	1474.88	<.0001	0
ω_0	0.16751	0.0974	1.72	0.0894	5

The fit transfer function with the preliminary noise model is specified as:

$$lny_t = \omega_0 B^5 + \frac{(1-\theta B^{12})}{(1-\emptyset_1 B-\emptyset_3 B^3)}\alpha_t$$

The estimated parameters are in Table 9.

Table 9 Estimation results for fitted transfer model of original liquor taxable sales series

parameter	Estimate	Standard Error	t-value	P>|t|	Lag
	15.8253	0.03728	424.5	<.0001	0
θ	-0.50384	0.10399	-4.85	<.0001	12
$\emptyset_1$	0.40748	0.10203	3.99	0.0001	1
$\emptyset_3$	0.36123	0.10135	3.56	0.0006	3
ω_0	0.11534	0.05663	2.04	0.0451	0, 5(shift)

All parameters are significant at 1% and before intervention it is significant at 10% level. σ_a^2 is estimated 0.005328 and before intervention it is 0.006132. AIC is -191.699 and before intervention the AIC value is -117.996.

Indicators for model diagnostic test, Lack-of-fit test, formal χ^2 test show significance, and the p-values are bigger than critical values, which indicates the model is correct and Q(k) follows a χ^2 distribution. The autocorrelations are low except for at lag 24 as of 0.259 and before intervention the value is 0.287. The result from the diagnostic test is same as that before intervention.

Since the model is built with logarithm of the original sales of liquor, the estimate of the intervention effect in terms of the original sales of liquor is $e^{0.08441}$=1.1222, which means the post-intervention level of sales of liquor is 112.22% of the pre-intervention level, or equivalently, the effect of the smoking ban increased the sales of liquor by 12.22%.

5. Conclusion

In this article, researcher investigated the economic impact of Lawrence smoking ban on four Kansas cities liquor sales in bars restaurants. Insignificant negative influence has been noticed in Lawrence

Manhattan and Topeka. In the interval forecast, Wichita has noticed more violation than expected. Topeka has more violations than other due to distance. Intervention analysis shows the result equivalently, as the effect of the smoking ban increased the sales of liquor by 8.807% in Johnson County. Based on a sound statistical theory the insignificant empirical results on the negative impact have been established.

Reference

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SAS Code

```
DATA mht;
      INFILE "d:\backupflash\statconsult\mht.txt";
      INPUT ;
Run;

Proc timeplot data=mht;
      plot tot_a;
      ID year month;
Run;

Proc Arima data=mht;
      identify var=tot_a NLAG=40;
      estimate p=(1,5) q=(12) plot ;
run;


DATA mht1;
      INFILE "d:\backupflash\statconsult\mht1.txt";
      INPUT;
Run;

proc arima data=mht1;
identify var=tot_a NLAG=40;
run;
```

```
proc arima data=mht1;
identify var=tot_a(1) NLAG=40;
run;

proc arima data=mht1;
identify var=tot_a(12) NLAG=40;
run;

proc arima data=mht1;
identify var=tot_a(1,12) NLAG=40;
run;

Proc Arima data=mht1;
      identify var=tot_a(1,12) NLAG=40;
      estimate q=(1)(12) plot outstat=stat1;
      forecast lead=40 alpha=.1 out=res1;
run;

data res1;
set res1;
obsno=_n_;
run;

data res1;
merge res1 mht;
run;

proc print data= res1;
var city obsno year month L90 tot_a forecast U90;
title1 'forecast from preban data/model +all observations';
run;

data notin;
set res1;
if tot_a=. or L90=. or U90=. then delete;
if L90 le tot_a le U90 then delete;
run;

proc print data=notin;
title5 'observations that are not in the 90% forecast interval';
run;

proc timeplot data=res1;
id obsno;
plot tot_a='o' forecast='F'/overlay;
title4 'timeplot of observations (o) and forecasts (F)';
run;

Proc Arima data=mht1;
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      estimate q=(1)(12) plot outstat=stat1;
      forecast lead=40 alpha=.05 out=res1;
run;

data res1;
set res1;
obsno=_n_;
run;

data res1;
merge res1 mht;
run;
```

```
proc print data= res1;
var city obsno year month L95 tot_a forecast U95;
title1 'forecast from preban data/model +all observations';
run;

data notin;
set res1;
if tot_a=. or L95=. or U95=. then delete;
if L95 le tot_a le U95 then delete;
run;

proc print data=notin;
title5 'observations that are not in the 95% forecast interval';
run;

proc timeplot data=res1;
id obsno;
plot tot_a='o' forecast='F'/overlay;
title4 'timeplot of observations (o) and forecasts (F)';
run;
```

Contact Information

Name Lijia Mo

Enterprise Rouch Financial Group

Address PO Box 504

City, State ZIP Manhattan KS 66505-0504

Phone: 785-317-5228

E-mail: lijiamo@agecon.ksu.edu