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TAX AMNESTIES AND COMPLIANCE IN THE LONG RUN: A TIME SERIES ANALYSIS

JAMES ALM* & WILLIAM BECK**

***Abstract** - This paper discusses time series methods that can be used to examine the long run effects of a tax amnesty, and applies these methods to the 1985 Colorado amnesty. Several time series models are estimated: simple ordinary least squares time trend models, univariate time series models, and multivariate intervention models. The empirical results from all models strongly indicate that the Colorado amnesty had no long run impact on either the level or the trend of tax collections. This result suggests that a typical amnesty seems unlikely to generate significant new revenues, but also seems unlikely to compromise voluntary compliance.*

INTRODUCTION

Governments of all kinds have increasingly turned to tax amnesties as part of their fiscal programs. An amnesty typically allows individuals or firms to pay previously delinquent taxes with reduced civil and criminal penalties (Mikesell, 1986; Federation of Tax Administrators, 1990). Since 1981, 34 states in the United States have enacted some form of tax amnesty, and numerous local governments have conducted amnesties as well. The American experience is not an isolated one. Many other countries have also had recent amnesties.

Governments have enacted an amnesty primarily to generate an immediate, short run increase in compliance. However, the long run effect of an amnesty on tax compliance is of perhaps more importance, and this impact is far from clear. Proponents of amnesties argue that compliance may actually increase after an amnesty if the amnesty is followed by greater enforcement efforts and better taxpayer services and if the amnesty is able to get individuals who previously did not file tax returns on the tax rolls. Critics suggest that postamnesty compliance is far more likely to decline, since honest taxpayers may view the amnesty as an unfair tax break for tax cheats, individuals may expect another amnesty to be given in the future, and the mere announcement of the amnesty may make taxpayers aware of the widespread presence—and ease—of noncompliance. However, although there is growing work on the theory and practice of tax amnesties and although there is accumulating evidence on the pre- and postamnesty revenues of governments, there has been no

*University of Colorado at Boulder, Boulder, CO 80309-0256.
**United States Air Force Academy, Colorado Springs, CO 80840.

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empirical investigation of the actual long run impact of any tax amnesty.[1]

This paper discusses various types of time series methods that can be used to examine the long run effects of an amnesty and applies these methods to the tax amnesty that was held in Colorado in the fall of 1985. Monthly data on Colorado individual income tax revenues are collected for the period January 1980 through December 1989, and these data are examined to determine whether the amnesty affected the level or the trend of tax collections. Several time series models are estimated, in successively more general formulations: simple ordinary least squares time trend models, univariate time series (autoregressive integrated moving average, or ARIMA) models, and multivariate ARIMA intervention (or MARIMA) models. The empirical results from all models strongly indicate that the Colorado amnesty had virtually no long run impact on either the level or the trend of tax collections, a result likely due either to the small size of the amnesty or to the offsetting effects of the revenue-increasing and revenue-decreasing effects of the amnesty. Given the similarity of the Colorado amnesty to those held elsewhere, a typical amnesty seems unlikely to generate significant amounts of new revenues, but it also seems unlikely to compromise the voluntary compliance program of the government.

THE COLORADO AMNESTY PROGRAM

The Colorado tax amnesty was similar to those in most other states.[2] The amnesty was designed as a legislated, one-time opportunity for individuals and businesses to pay any unpaid back taxes without penalties or criminal prosecution. The program was mandated by House Bill 1188, signed into law on June 6, 1985, and was scheduled for 2 months in 1985, September 15 through November 15. The amnesty program was part of a larger Colorado tax program entitled "Colorado Fair Share," an on-going program aimed at detecting tax evasion and promoting voluntary compliance with the tax code.

Taxes eligible under the amnesty included individual income, corporate income, sales, use, gross ton mile, special fuel, cigarette, and liquor taxes; individual income taxes were by far the largest source of amnesty revenues, accounting for over 90 percent of the amnesty revenues. The program was designed to be as user-friendly as possible. All Department of Revenue district offices, located in 10 cities throughout the state, had specially trained staff who could answer questions about the amnesty program as well as interpret the tax code. To encourage participation, the state allowed installment payments as a method to pay taxes and penalties in some cases. Taxpayers who had received notices or billings for back taxes from the federal Internal Revenue Service were eligible for the Colorado amnesty, but taxpayers who had been notified or had been billed by the Colorado tax authorities were not allowed to participate.

The amnesty program was advertised as a last chance for delinquent taxpayers to comply with the tax laws before civil and criminal penalties for noncompliance were increased. In all, the bill authorizing the amnesty contained 51 new or increased penalties.[3] In addition, personnel and other resources devoted to tax law enforcement increased after the amnesty.[4]

The advertising budget for the amnesty program was $145,000, and the program was publicized widely through virtually all forms of the media, from radio and television spots to placards on the sides of buses. All carried the same message—"Don't Say We Didn't Warn You"—and cautioned that the amnesty was a one-time opportunity to clear up any previous nonpayment problems. The program directors expected to collect amnesty revenues

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of $5 million; actual collections exceeded $6.3 million.

TIME SERIES METHODS AND RESULTS

Time series methods are designed to use the *past* movements of a variable to forecast its *future* movements. Unlike models that predict the future movements of a variable by relating it to a set of variables in a causal or structural framework, time series methods extract predictable movements of a variable from its own past observed data and then use this information to forecast future movements of the variable. There are several reasons for the use of the time series approach. The precise form of a complete structural model may be difficult to specify.[5] Further, even if it is possible to write down a structural model, past data may not be available for all structural variables that are believed to affect the variable of interest; even if such data are available, estimation of a structural model might result in such large coefficient standard errors that forecasts also have unacceptably large errors. Future values of the structural variables may likewise be difficult to obtain, so that forecasting may not be feasible. All these reasons account for the use of time series methods in the analysis of tax amnesties.

Monthly data are collected for the period January 1980 through December 1989, showing the gross individual income tax collections by the Colorado Department of Revenue; these data include the amnesty revenues of $6.3 million over the relevant period. (Recall that the grace program was from September 15 through November 15, 1985.) Like most every amnesty held in the United States, income tax revenue was the largest source of revenue in the Colorado amnesty, so gross individual income tax collections are used as a proxy for all types of state tax revenue. Monthly individual income tax collections ranged from $43 million in January 1980 to $180 million in April 1989 and averaged under $100 million over this period.

The approach here starts with the simplest time series method and proceeds to more general and sophisticated procedures. All methods give the same result: the Colorado amnesty had no impact on the level or the trend of tax collections.

Simple Time Trend Analysis

The first and simplest analysis examines the long run time trend of the time series. A linear trend model is estimated with the form $Y_t = b_0 + b_1 T_t + e_t$, where Y_t represents individual income tax collections by month, T_t is the numeric representation of the month (*i.e.*, January 1980 is valued at one and December 1989 is valued at 120), e_t represents the error term, and b_0 and b_1 are parameters. This equation is estimated with ordinary least squares methods over the entire period and over the two subperiods before and after the amnesty (or January 1980 through August 1985 and September 1985 through December 1989) to evaluate any structural change that may have occurred in tax collections following the amnesty. The results are in Table 1.

If there was a change in tax collections over the subperiods before and after the amnesty, then some statistically significant change in either the intercept or the slope parameter should occur over the two subperiods of the equation. The Chow (1960) test for the two subperiods shows that there is no difference in the two regressions (F-statistic = 0.08). The trend of revenues collected, therefore, did not change over time.

Additional specifications allow for a separate intercept or slope change from the amnesty. The results for these equations are also in Table 1. Because the coefficients on A and $A * T_t$ are insignificant, these results confirm that the amnesty had no impact on the level or the trend of tax collections.

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TABLE 1
TIME TREND RESULTS[a]

Period	Independent Variables				R^2
	Constant	T	A	$A*T$	
1/80–12/89	56.48*	0.63*	—	—	0.48
	(13.60)	(10.48)			
1/80–8/85	55.23*	0.67*	—	—	0.48
	(12.91)	(6.22)			
9/85–12/89	54.25	0.64	—	—	0.11
	(2.17)	(2.46)			
1/80–12/89	55.53*	0.66*	−3.08	—	0.48
	(11.40)	(5.68)	(−0.38)		
1/80–12/89	55.16*	0.67*	—	−0.04	0.48
	(10.28)	(4.93)		(−0.38)	

[a]*t*-statistics are in parentheses.
*The coefficient is significant at the 0.01 level.

TABLE 2
ARIMA RESULTS[a]

Period	Independent Variables				R^2
	Constant	AR(1)	AR(2)	SAR(12)	
1/80–12/89	−0.83	−0.89*	−0.57*	1.05*	0.92
	(−0.11)	(−10.80)	(−6.91)	(27.94)	
1/80–8/85	−0.64	−0.81*	−0.47*	1.08*	0.91
	(−0.10)	(−6.32)	(−3.71)	(16.76)	
9/85–12/89	−0.37	−0.93*	−0.61*	1.03*	0.93
	(−0.21)	(−8.18)	(−5.42)	(21.07)	

[a]The ARIMA process for all three periods is ARIMA(2,1,0)(2,1,0)^{12} (see Endnote 6). AR(1), AR(2), and SAR(12) denote first-order autoregressive, second-order autoregressive, and 12-month seasonal autoregressive coefficients, respectively. *t*-statistics are in parentheses.
*The coefficient is significant at the 0.01 level.

These equations are also estimated using the natural logarithmic transformation of revenues and for the alternative segments January 1980 to November 1985 and December 1985 to December 1989. Models are also tested to examine a simultaneous change in slope and intercept and to allow for nonlinearities in the time trend. The conclusions are unaffected.

ARIMA Analysis

Another, more sophisticated, method is the ARIMA model, typically attributed to Box and Jenkins (1976). The essence of this method is similar to simple smoothing and decomposition. ARIMA modeling involves an iterative three-stage procedure of identification, estimation, and diagnostic checking.

Using the techniques of Box and Jenkins (1976), the monthly Colorado tax data are tested to see if the ARIMA process that generated the income tax revenues *before* the 1985 amnesty was the same as the process that generated the income tax revenues *after* the amnesty. Additionally, the identified ARIMA processes from before and after the amnesty may be used to "fit" not only the series itself (*i.e.*, the pre- or postamnesty data), but also to "forecast" the data of the opposite series (*i.e.*, the post- or preamnesty data).

The ARIMA results are given in Table 2.[6] These results indicate that the ARIMA pro-

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cess generating the tax revenue is the same before and after the amnesty; that is, there was no change in income tax compliance after the 1985 amnesty.[7] Other ARIMA specifications give the same results.

As a further check of this conclusion, the identified ARIMA models can be used to forecast the data from one series to another to examine if the same underlying process exists on each side of the amnesty; the identified model from each series can also be used to fit the same series. Figure 1 shows the results when the preamnesty ARIMA parameters are used to forecast the postamnesty data (where *Y* is the actual series and FORC1 is the forecasted results). Figure 1 indicates that the preamnesty ARIMA parameters are able to forecast quite accurately the postamnesty revenues, so that there is essentially no change in tax compliance following the amnesty.[8] Similar conclusions are found when postamnesty ARIMA parameters forecast preamnesty data, when preamnesty parameters fit preamnesty data, or when postamnesty parameters fit postamnesty data.

MARIMA Intervention Analysis

A discrete "intervention" like an amnesty can be represented as an additive effect of the amnesty on revenues (Box and Tiao, 1975). Intervention analysis requires the specification both of a starting point for the intervention and of the shape of the intervention impact. This method is commonly referred to as multivariate ARIMA or MARIMA time series analysis.

FIGURE 1. Preamnesty parameters forecast postamnesty revenues.

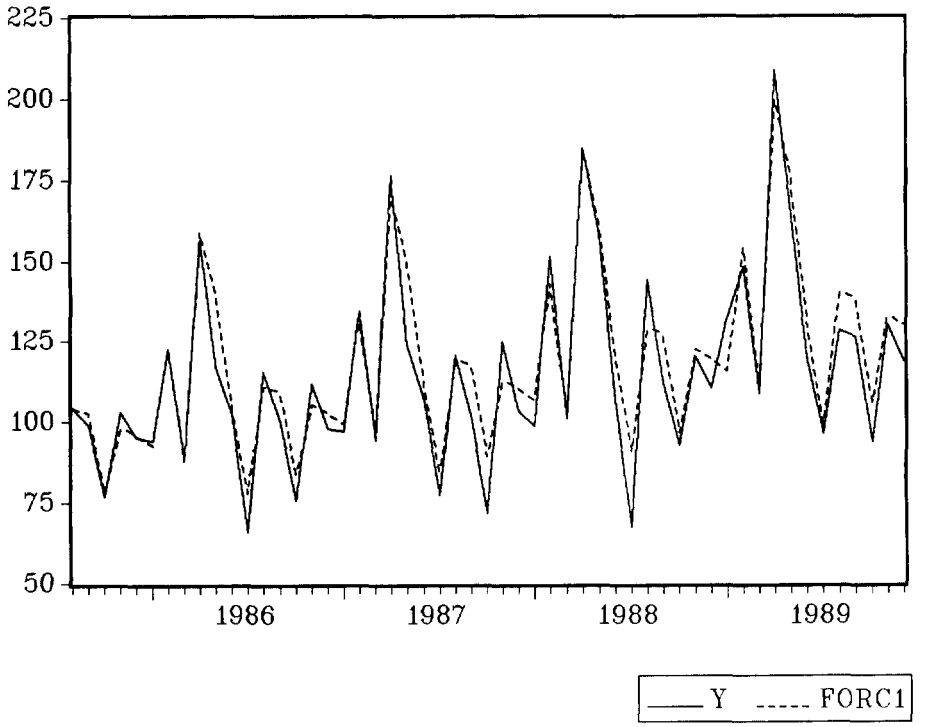

TABLE 3
INTERVENTION ANALYSIS RESULTS[a]

Intervention	Coefficient	R^2
Step	0.717	0.88
	(1.02)	
Pulse	0.124	0.89
	(1.04)	
Ramp	0.544	0.88
	(1.11)	

[a]The ARIMA process in all three estimations is ARIMA(2,1,0)(2,1,0)[12] (see Endnote 6). *t*-statistics are in parentheses.

The starting point for the intervention (or the amnesty) is simply the time at which the amnesty occurs. The shape of the intervention is more complicated. The shape may be modeled by a "step" function with zero values up to the point of the intervention and one for all periods following the intervention, by a "pulse" function where the intervention occurs at one period and the intervention variable has just one nonzero value, or by a "ramp" function in which the step is spread over some period as a ramp response. Put differently, a step function assumes that the amnesty has a discrete impact on revenues at the time of the amnesty and an equal impact for all subsequent periods, a pulse function assumes that the amnesty has an impact only in the period in which the amnesty is initially introduced, and a ramp function allows the amnesty to have an impact both at the time of the amnesty and after the amnesty, although the postamnesty impact may decline in subsequent periods.[9] These three interventions are estimated separately. Like the ARIMA approach, MARIMA analysis requires that the underlying time series be identified, estimated, and checked.

The MARIMA estimation results are shown in Table 3. The *t*-statistic on the various intervention variables (step, pulse, or ramp) never exceeds 1.11. These results therefore indicate that there is no time when the intervention is statistically significant; note, in particular, that the pulse coefficient is insignificant, so that there is no impact on revenues even in the month in which the amnesty is enacted. As with the previous results, the amnesty had no impact on postamnesty tax compliance.

Conclusions

The time series results in this paper indicate clearly that the Colorado amnesty has had no impact on either the level or the trend of tax collections. It is important to recognize that this conclusion may have several alternative explanations. One possibility is that the amnesty itself was of such small size that it had no effect on the compliance decisions of individuals. However, remember that the amnesty was accompanied by greater postamnesty enforcement efforts by the Colorado Department of Revenue. It is also possible that any compliance-reducing effects of the amnesty itself were just offset by the compliance-enhancing effects of the greater enforcement efforts; that is, if the amnesty had not been followed by stiffer penalties, then postamnesty revenues may well have fallen. Unfortunately, it is not possible to isolate the separate effects of the amnesty and the enforcement.

Still, these results suggest that the short- and long-term effects of a typical amnesty—at least of an amnesty that is followed by greater tax enforcement—may be somewhat benign. These results therefore give little solace either to advocates or to critics of amnesties: a typical amnesty seems unlikely to generate large one-time revenues, but it also seems unlikely to have significant negative effects on long run compliance.

ENDNOTES

We would like to thank William Kaempfer and Robert McNown of the University of Colorado at Boulder, Charles Dieter of the Colorado Department of Revenue, and several anonymous referees for helpful comments.

[1] For example, Alm and Beck (1990) and Andreoni (1991) analyze the effects of a tax amnesty but use theoretical methods. Empirical work has so far been unable to examine the long run compliance effects (see Fisher *et al.*, 1989; Alm and Beck, 1991; Dubin *et al.*, 1990 for var-

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ious types of empirical work). Only Alm *et al.* (1990) examine the long run effects of a tax amnesty, and they find that compliance falls unless postamnesty enforcement efforts are increased. However, they use data generated from laboratory experimental methods, not actual field data.

[2] See Mikesell (1986) and Federation of Tax Administrators (1990) for a detailed discussion of the state programs. The specific formats of the various amnesty programs have generally differed. However, there have been many common aspects. A "typical" amnesty has generally applied to both domiciled and nondomiciled residents and businesses and has lasted 2–3 months. Most programs have applied to unpaid individual income taxes, but some states with no individual income tax have held an amnesty. In a majority of the states known delinquents (or "accounts receivable") have not been allowed to participate. Some states have waived some or all of the interest penalties that had accrued on back taxes. Importantly, most states have increased the penalty for tax evasion following the grace period, and many have provided for greater funding for postamnesty tax code enforcement.

[3] For example, penalties for most types of willful and fraudulent noncompliance were increased from a misdemeanor or no penalty to a Class 4 felony, which imposes a maximum fine of $100,000 for individuals and $500,000 for corporations plus up to 4 years in jail upon conviction. On a lesser scale, penalties for willful failure to pay any tax or estimated tax, make a required return, keep required records, or supply required information were increased to a misdemeanor with a maximum fine of $50,000 for individuals and $100,000 for corporations plus up to 1 year in jail upon conviction; prior to the amnesty, the maximum penalty for this type of violation was just $5,000 plus 1 year in jail.

[4] For example, the number of personnel in the "Colorado Fair Share" department increased from 6 to 36. Further, operations were computerized following the amnesty, which led to an increase from roughly 1500 per year to 90,000 per year in the number of tax notices mailed to taxpayers. Nevertheless, the number of individuals actually convicted of tax evasion has not increased significantly since the amnesty.

[5] Note, however, that Zellner and Palm (1974) demonstrate that a time series equation may be seen as a reduced form equation from a more complete structural system.

[6] This process is somewhat involved and consists of three steps. The first step is *identification* of the model first with respect to its stationarity or nonstationarity and then with respect to the form of the autoregressive or moving average or combined components; this analysis must be performed both for the entire period and for the two subperiods before and after the amnesty (of January 1980–August 1985 and September 1985–December 1989). Once the processes are tentatively identified, *estimation* of the parameters of the model is performed using maximum likelihood techniques. In the third step, *diagnostic checking* is done to determine whether the model has been correctly specified. This analysis is repeated until the ARIMA process is correctly specified. In the case here, analysis of the autocorrelation functions of the raw data and a plot of the raw data for the entire period indicate that the series is nonstationary and that it has a 12-month seasonality component; also, the Augmented Dickey-Fuller (ADF) test also indicates that the raw series is nonstationary. Consequently, the series is first differenced and additively seasonally adjusted. Analysis of the adjusted data *via* the ADF test indicates that the adjusted series for the entire period is stationary. This process is then repeated for raw data broken down into the subperiods before and after the amnesty; for both subperiods, the series also need to be first differenced and additively seasonally adjusted to achieve stationarity. Given that the adjusted series for the entire period and the two subperiods are not stationary, the underlying ARIMA processes generating the tax revenue are identified, estimated, and checked until the ARIMA process is correctly specified. This analysis indicates that ARIMA processes are the same before and after the amnesty and are equal to ARIMA$(2,1,0)(2,1,0)^{12}$; that is, the ARIMA processes consist of two parts, a nonseasonal process that has an autoregressive polynomial of order two, a stationary process in difference one, and a moving average polynomial of order zero, and a 12-month seasonal process of the same orders.

[7] A Chow (1960) test confirms that there is no difference between the processes in the subperiods (F-statistic = 0.11).

[8] Conventional measures of forecast performance (*e.g.*, the root-mean-square error) indicate that forecast revenues are very close to actual revenues. Also, the root-mean-square error for the postamnestry forecasts is virtually identical to that of the preamnesty fits.

[9] More formally, denote T as the month in which the amnesty occurs. Then a step intervention is specified by a variable $S_t^{(T)}$, which equals zero in all months before the amnesty and one in all months during and after the amnesty. A pulse intervention is specified by $P_t^{(T)}$, equal to zero in all months before and after the amnesty and one in the first month of the amnesty (or $t = T$). A ramp intervention is designated $R_t^{(T)}$ and equals zero in all months before and after the amnesty and one in the 3 months of amnesty (or September, October, and November, 1985).

REFERENCES

Alm, James and William Beck. "Tax Amnesties and Tax Revenues." *Public Finance Quarterly 18* (October, 1990): 433–53.

Alm, James and William Beck. "Wiping the Slate Clean: Individual Response to State Tax Amnesties." *Southern Economic Journal 57* (April, 1991): 1043–53.

Alm, James, Michael McKee, and William Beck. "Amazing Grace: Tax Amnesties and Compliance." *National Tax Journal 43* (March, 1990): 23–37.

Andreoni, James. "The Desirability of a Permanent Tax Amnesty." *Journal of Public Economics 45* (July, 1991): 1435–59.

Box, G. E. and G. M. Jenkins. *Times Series Analysis, Forecasting, and Control.* San Francisco: Holden-Day, 1976.

Box, G. E. and G. C. Tiao. "Intervention Analysis with Application to Economic and Environmental Problems." *Journal of the American Statistical Association 70* (March, 1975): 70–79.

Chow, Gregory C. "Tests of Inequality between Sets of Coefficients in Two Linear Regressions." *Econometrica 28* (July, 1960): 591–605.

Dubin, Jeffrey A., Michael Graetz, and Louis L. Wilde. "State Income Tax Amnesties: Causes." Social Science Working Paper 712. Pasadena: California Institute of Technology, May, 1990.

Federation of Tax Administrators. "State Tax Amnesty Programs." Research Report No. 133. Washington, D.C.: July, 1990.

Fisher, Ronald C., John H. Goddeeris, and James C. Young. "Paritiipation in Tax Amnesties: The Individual Income Tax." *National Tax Journal 42* (March, 1989): 15–27.

Mikesell, John L. "Amnesties for State Tax Evaders: The Nature of and Response to Recent Programs." *National Tax Journal 39* (December, 1986): 507–25.

Zellner, Arnold and Frank Palm. "Time Series Analysis and Simultaneous Equation Econometric Models." *Journal of Econometrics 2* (May, 1974): 17–54.