An Econometric Analysis of Population Change in Arkansas

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Abstract
Purpose - This study aims to model the components of population growth in Arkansas and to forecast the state's population through 2017.
Approach - A structural econometric model is developed and used to generate *ex-ante* forecasts. The model includes equations for births, deaths, and net migration. These three variables, in combination with population in the previous year, are used to estimate current-year population.
Findings - Births and deaths are found to contain strong inertial components and to follow national demographic trends. Net migration also contains an inertial component and is affected by labor market conditions in Arkansas relative to those of the United States as a whole.
Research Implications - One contribution of the paper is the selection of model functional form based upon deviance information criterion. Furthermore, results of out of sample simulations indicate that the modeling approach employed can potentially handle both the cyclical and the structural factors that typically affect regional population change.
Practical Implications - This analysis sheds light on demographic dynamics in a relatively understudied region of the United States. Regional population forecasts are potentially useful in planning for the provision of infrastructure and public services.

Keywords Population Economics, Regional Economics, Applied Econometrics

JEL Categories: J11 Demographic Trends and Forecasts; R11 Regional Economic Growth; C53 Econometric Forecasting

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Introduction

Demographic models and forecasts provide platforms for both private and public sector planning efforts. Examples of demographic forecasting applications include infrastructure planning, personnel management, and government case load projections. Population modeling is, therefore, an endeavor which receives substantial research attention. Fertility and mortality have historically played important roles for analyzing population change. Many studies in more recent years also devote substantial attention to migratory flows (Booth, 2006).

While the empirical specifications for births and deaths can be relatively simple, modeling migration flows can be more complicated. Numerous studies examine the causes and effects of migration. Harris and Todaro (1970) develop a model in which the economy is divided into two sectors – manufacturing and agriculture. In this model, migration continues until the actual rural wage and the expected urban wage converge. This wage, or income, differential framework can be modified to analyze migration between different geographic regions, for example between countries or states.

The objective for this study is to econometrically model population change in Arkansas. Labor market conditions are expected to play important roles in migration. The analysis draws on the regional approach employed by Fullerton and Barraza de Anda (2008). It has been suggested that forecasting population changes in areas with different characteristics and using different techniques can improve forecasts' accuracy (Tayman and Swanson, 1996). Subsequent sections include a review of recent literature on the subject; data and methodology; empirical analysis; and concluding remarks. A data appendix is included at the end of the study.

Literature Review

Booth (2006) identifies three approaches to forecasting population change: extrapolative methods, expectation-based methods, and structural modeling. Extrapolative methods assume that future observations will depend on past observations. Methods based on expectations rely on expert judgments regarding future behavior and trends. Structural modeling addresses demographic changes based on some theoretical assumptions and can sometimes be combined with extrapolative methods in order to help capture all variations (Smith et al., 2001). Another methodological issue concerns whether to disaggregate population change into its three basic components: births, deaths, and net migration (Smith, 1997). Booth (2006) highlights the need to forecast these three components of population change separately and to combine the separate forecasts in order to model population change.

Historically, fertility has proven difficult to model. One possible economic predictor of fertility that has been studied extensively is income. Becker (1960) hypothesizes that income and fertility are positively related but instead finds the relationship to be negative. It is suggested that this may result from missing sample information such as the use of contraceptives. A positive relationship between income and births in families that actively engaged in family planning is documented. However, Jones et al. (2008) indicate that most data confirm a robust inverse relationship between income and fertility. In a utility maximization framework, low incomes will cause high birth levels whenever the elasticity of substitution of children, with respect to consumption, is high.

Some studies make distinctions between increases in income for men and women. Schultz (2005) suggests that if the increase in family income is due to an increase in female wages, this will raise the price of children. When the price effect dominates the income effect, increases in female incomes result in lower fertility. Jones and Tertilt (2006) use microdata from nine different census surveys in order to analyze the relationship between income and lifetime fertility for five-year birth cohorts of women, beginning in the years 1826-1830 and ending in 1956-1960. The occupations and educational attainment of husbands are used as proxies for income. Lower fertility is found to result from any rise in income, not just increases in female wages.

Economic variables can also be highly useful for the analysis of migration. Several studies note that differences in expected income between origin and destination regions tend to stimulate migration. Harris and Todaro (1970) develop a two-sector model in which manufacturing activity takes place in an urban setting while agricultural production occurs in a rural setting. In addition, the model acknowledges that a politically determined urban minimum wage exists, and this minimum wage is assumed to be higher than the agricultural wage. Results indicate that migration from the rural to the urban sector will continue until the actual agricultural real wage equals the expected manufacturing wage. The expected manufacturing wage is defined as the real manufacturing wage multiplied by the probability of being employed. Corden and Findlay (1975) further extend the low-wage to high-wage sectoral migration model to permit capital mobility between the two sectors.

Other factors can influence the decision to migrate. Hernández-Murillo et al. (2011) document a negative correlation between migration and age and a positive correlation between education and migration. Life changing events, such as marriage and divorce, also exhibit correlations with migration. Surprisingly, the study finds that economic conditions between the origin state and the destination state are very similar. Finally, the post-move outcomes show that wages in destination states increase relative to wages in origin states, but the employment rate falls for all movers. This is most likely due to an adjustment period immediately following the move. Lim (2011) indicates that wage differentials play a role in the decision to migrate but that the impact is conditioned by the degree to which the sectoral employment structure of the origin location resembles that of the destination.

An important practical question for decision-makers is how an understanding of population dynamics can be used to promote regional growth. In a study of county-level growth patterns, Clark and Murphy (1996) find evidence that, even though the feedback effects are weak, changes in population and employment are determined simultaneously. It is noted that, while public policy tools seem to have little direct effect on patterns of regional demographic change, such policies can be more effective at stimulating employment, which may have the indirect effect of spurring population growth. Another relevant policy concern is whether in-migration into a particular region entails human capital stock growth. Krieg (1991) finds that, for some states, the flow of interstate human capital is statistically different from the flow of interstate migrants. An analysis of the costs and benefits that arise due the migration of individuals requires examining the human capital associated with those migrants.

As mentioned above, models of natural increase and net migration can be combined to forecast population growth. Plaut (1981) takes this approach in developing an econometric model for population growth in Texas. Net migration is expected to respond to relative labor market conditions in Texas with respect to the rest of the country. A simple model is also constructed for natural increase. The results indicate that the explanatory power of the model is high, and out of sample simulations perform well when compared to other, more simple, models. Fullerton and Barraza de Anda (2008) develop a similar population model for the El Paso-Ciudad Juárez border region. Border demographic studies differ from analyses in other areas due to the presence of international boundaries as well as, in the case of Mexico, incomplete demographic time series data. In spite of these obstacles, the latter study provides an example of how to model and forecast a region's population using a system of equations for births, deaths, and migration when international labor market conditions vary (Corden and Findlay, 1975).

Arkansas appears to be an understudied region, particularly when it comes to demographics. Bennett (1970) uses a case study of a mostly agricultural twelve county region in northeastern Arkansas to illustrate population changes and mobility. The case study notes that, after World War II, industrial areas outside of Arkansas created a "pull" factor which served as the primary motive for migration outside of the area of study. In subsequent years, the application of labor-saving technology in agriculture created a "push" factor, further spurring out-migration from the region. The migration patterns uncovered are broadly consistent with the frameworks presented by Harris and Todaro (1970) and Corden and Findlay (1975). For the period from 1990 to 2000, Shbikat and Striffler (2000) notes that Arkansas experienced a high degree of migration from Latin America. However, the study finds that domestic in-migration was still greater than international in-migration. Not surprisingly, the counties with lower unemployment are also the counties that experienced higher influxes of migrants.

This study seeks to model population changes in Arkansas by employing a methodology similar to Plaut (1981) and Fullerton and Barraza de Anda (2008). A small econometric system of equations is developed for births, deaths, and migration as the main components of population change. Model specification is selected on the basis of an information criterion not previously utilized in the context of population economics (Spiegelhalter et al., 2002). In addition to in-sample fit diagnostics, out of sample simulations are also employed to assess model reliability.

Data and Methodology

This study analyzes annual frequency population data for Arkansas. As observed by Booth (2006), one viable approach for modeling population is to specify the three components of population change separately and then combine these separate equations into one model. Plaut (1981) and Fullerton and Barraza de Anda (2008) both employ this disaggregation method where births minus deaths constitutes natural increase, and population is the sum of the previous year's population, natural increase, and net migration. Fertility and mortality are notoriously difficult to predict, as many of the determinants of these variables are complex and still not fully understood. Therefore, it is common for simpler specifications to be used instead of more complex ones (Plaut, 1981; Booth, 2006).

Migration is modeled using a variation of the wage-differential framework set up by Harris and Todaro (1970) and Corden and Findlay (1975). Plaut (1981) and Fullerton and Barraza (2008) both specify the migration equation using a variant of this theory. Plaut (1981) employs a ratio of expected incomes but allows for the effects of the real wage and probability of employment to have separate and unequal effects, as opposed to combining them into one term. The reasoning behind this is that migrants, being risk averse, will respond more favorably to a higher probability of being employed than to a higher wage rate. In that study, a ratio of employment to vacancies serves as a proxy for the probability of finding employment. When modeling El Paso domestic net migration, Fullerton and Barraza de Anda (2008) use a ratio of local to national employment.

Table 1: Model Variables

Series	Description	Units

akbir	Arkansas Births	Persons, thousands
akdea	Arkansas Deaths	Persons, thousands
akni	Arkansas Natural Increase	Persons, thousands
aknmig	Arkansas Net Migration	Persons, thousands
akpop	Arkansas Population	Persons, thousands
akemp	Arkansas Total Full and Part Time Employment	Persons, thousands
akpy	Arkansas Personal Income	Dollars, thousands
nb	United States Births	Persons, thousands
nd	United States Deaths	Persons, thousands
npop	United States Population	Persons, thousands
usemp	United States Total Full and Part Time Employment	Persons, thousands
gdpd	GDP Implicit Price Deflator	Index, 2005 = 100
akrpy	Arkansas Real Personal Income	(akpy/gdpd*100)
emp	Employment Ratio	(akemp/usemp)

To model population for Arkansas, a mixture of state and national demographic and economic variables is included (see Table 1). The demographic variables for both the state and national level are comprised of total population, births, deaths, and net migration. Data for births and deaths are obtained from the Arkansas Department of Health and from the Center for Disease Control and Prevention's National Vital Statistics System. The United States Census Bureau provides estimates of population as well as domestic and international migration.

Data for the migration variables begin in 1990 and conclude in the year 2011. Given the relatively small number of annual observations of the component migration series, it proves more useful to estimate total net migration by subtracting natural increase from the change in population. The latter variables are available from 1969 to 2011, which comprises the sample period. A drawback of this approach is that domestic and international migration cannot be distinguished from one another; however, internal migration typically outweighs international migration. The economic variables included in the model, and obtained from the Bureau of Economic Analysis (BEA), are employment at the state and national levels, and personal income in Arkansas.

Generalized least squares methods are used to analyze the data. There are five equations in the theoretical model. Equation 1, which is an identity, represents natural population increase in Arkansas, which is calculated as resident births in Arkansas minus resident deaths in Arkansas. The specification for births, represented by Equation 2, includes a one period autoregressive lag, and lags of real personal income as well as a scaled national births-to-population ratio. The latter consists of the ratio of births to population at the national level multiplied by Arkansas population. This variable is included because, as noted by Booth (2006) and Fullerton and Barraza de Anda (2008), it is important to attempt to capture not only local trends, but national trends as well. The relationship between births and real personal income is expected to be negative (Becker, 1960; Jones and Tertilt, 2006). The specification for deaths includes a one period autoregressive lag as well as scaled lags of a national deaths-to-population ratio, which is the nationwide ratio of deaths to population multiplied by the population of Arkansas (Equation 3).

(1) $akni_t = akbir_t - akdea_t$

(2) $akbir_t = \alpha_o + \alpha_1 akbir_{t-1} + \beta_0 akpop_t{*}nb_t/npop_t + \beta_1 akpop_{t-1}{*}nb_{t-1}/npop_{t-1} + \ldots + \beta_n akpop_{t-n}{*}nb_{t-n}/npop_{t-n} + \theta_0 akrpy_t + \theta_1 akrpy_{t-1} + \ldots + \theta_n akrpy_{t-n} + \varepsilon_t$

(3) $akdea_t = \alpha_o + \alpha_1 akdea_{t-1} + \beta_0\, akpop_t{*}nd_t/npop_t + \beta_2\, akpop_{t-1}{*}nd_{t-1}/npop_{t-1} + \ldots + \beta_n\, akpop_{t-n}{*}nd_{t-n}/npop_{t-n} + u_t$

Equation 4 represents migration, and is specified similar to Plaut (1981) and Fullerton and Barraza de Anda (2008). It is modeled as a function of an autoregressive lag along with relative labor market conditions, as measured by a ratio of total state to total national employment levels (Plaut, 1981). All else equal, net migration is expected to increase if total full- and part-time employment in Arkansas increases relative to total employment in the United States. Some recent literature suggests that other factors, such as the education, age, and marital status may all affect an individual's propensity to migrate (Hernandez-Murillo et al., 2011). Similar to Harris and Todaro (1970) and Corden and Findlay (1975), this study utilizes labor market conditions as the stimulants for migration. That is because many recent efforts utilize individual survey responses, but this study employs aggregate data. In addition, model complexity does not necessarily guarantee forecast accuracy (Smith, 1997; Booth, 2006). Finally, Equation 5 represents total population in Arkansas, which equals the sum of population in period t-1, natural increase in period t, and total net migration in period t.

(4) $aknmig_t = \alpha_o + \alpha_1 netmig_{t-1} + \beta_0 emp_t + \beta_1 emp_{t-1} + \ldots + \beta_n emp_{t-n} + w_t$

(5) $akpop_t = akpop_{t-1} + akni_t + aknmig_t$

When working with time series data, it is often helpful to employ the stationary components of the variables comprising the sample. A series that is stationary has a constant mean and variance over time. Stationarity can be induced by differencing the data in question (Pindyck and Rubinfeld, 1998). For this study, parameter estimation is conducted using the level form of the data as well as the first difference of the data, and both approaches produce desirable results with respect to the signs and statistical significance of the coefficients. Given that, some sort of model selection tool should be utilized (Pindyck and Rubinfeld, 1998).

Spiegelhalter et al. (2002) develop the Deviance Information Criterion (DIC) as an alternative to the Akaike Information Criterion and the Schwarz Information Criterion. This study compares models using level data and models using first differences of the data. Xiao et al. (2007) provide a formula with which to calculate deviance for linear models, shown in equation 6.

(6) $$n \ln 2\pi + 2n \ln \sigma + \left(\frac{1}{\sigma^2}\right) \sum_{i=1}^{n} \varepsilon^2$$

In equation 6, n is the number of observations, ε represents the residual term of a particular regression, and σ is the standard deviation of said residuals (Xiao et al., 2007). Similar to the selection rules of the AIC and SIC, the model with the smaller DIC value is the one that is selected. With respect to the models for births and deaths, the lower DIC values correspond to the models using level data. On the other hand, the net migration model using first differenced data has a lower DIC value when compared to the model which uses level data. Given that two of the three comparisons obtain lower DICs for models using level data, parameter estimation is carried out using level data (Xiao et al., 2007). Out of sample simulations are also conducted to further assess model reliability.

Empirical Results

This study employs a methodology in which births, deaths, and net migration constitute the three components of population change. The components are estimated separately and then aggregated in order to model total population. Equations 7 through 11 present the final model specifications. Equations 7 and 11 are identities and correspond to natural increase and population at time t, respectively, while Equations 8, 9, and 10 represent births, deaths, and net migration.

(7) $akni_t = akbir_t - akdea_t$

(8) $akbir_t = \alpha_o + \alpha_1 akbir_{t-1} + \theta_0\, akpop_t * nb_t/npop_t + \theta_1\, akpop_{t-1} * nb_{t-1}/npop_{t-1}$

(9) $akdea_t = \alpha_o + \alpha_1\, akdea_{t-1} + \beta_1\, akpop_t * nd_t/npop_t + \beta_2\, akpop_{t-1} * nd_{t-1}/npop_{t-1}$

(10) $aknmig_t = \alpha_o + \alpha_1\, netmig_{t-1} + \beta_0\, emp_t + \beta_1\, emp_{t-1}$

(11) $akpop_t = akpop_{t-1} + akni_t + aknmig_t$

First, births for this sample period in Arkansas are difficult to model. The final specification, represented by Equation 8, includes a one period lag of the dependent variable and a contemporaneous and a one period lag of a scaled national births-to-population ratio. The coefficients for the real personal income variables are not statistically significant at the 5-percent level, and are therefore dropped from the final model. Table 2 depicts the equation for births, and shows good statistical fit. The residuals show no sign of serial correlation. Births from the previous period are positively correlated with the number of births in the current period. As noted in Booth (2006), national trends provide useful information when modeling regional births. The coefficients pertaining to the scaled national birth ratios are statistically significant.

Table 2: Arkansas Births Equation

Dependent Variable: AKBIR

Method: Least Squares
Sample (adjusted): 1970 2011
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.402028	2.678373	0.523463	0.6037
AKBIR(-1)	0.929380	0.078592	11.82543	0.0000
AKPOP*NB/NPOP	0.419294	0.125517	3.340533	0.0019
AKPOP(-1)*NB(-1)/NPOP(-1)	-0.387438	0.121583	-3.186626	0.0029

R-squared	0.839515	Mean dependent var	36.38707
Adjusted R-squared	0.826846	S.D. dependent var	1.950078
S.E. of regression	0.811463	Akaike info criterion	2.510438
Sum squared resid	25.02197	Schwarz criterion	2.675930
Log likelihood	-48.71919	Hannan-Quinn criter.	2.571097
F-statistic	66.26092	Durbin-Watson stat	1.671197
Prob(F-statistic)	0.000000		

Table 3 summarizes output results for deaths. Deaths in Arkansas are modeled as a function of a one period autoregressive lag, a scaled national deaths-to-population ratio, and a one period lag of the same scaled ratio. The equation has a coefficient of determination over 98 percent, indicating good statistical fit. There is no evidence of serial correlation, and all of the coefficients are statistically significant individually as well as jointly. Deaths in the previous period are directly correlated with deaths in the current period. Additionally, an increase in the scaled national deaths to population ratio at time *t* produces a disproportionate increase in deaths at the state level, which is offset at period *t-1*.

Table 3: Arkansas Deaths Equation

Dependent Variable: AKDEA
Method: Least Squares
Sample (adjusted): 1970 2011
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.437790	1.340762	-2.564056	0.0144
AKDEA(-1)	0.612681	0.129173	4.743104	0.0000
AKPOP*ND/NPOP	1.393259	0.183034	7.612031	0.0000
AKPOP(-1)*ND(-1)/NPOP(-1)	-0.767218	0.258489	-2.968087	0.0052

R-squared	0.985914	Mean dependent var	25.11988
Adjusted R-squared	0.984802	S.D. dependent var	2.769947
S.E. of regression	0.341485	Akaike info criterion	0.779366
Sum squared resid	4.431252	Schwarz criterion	0.944858
Log likelihood	-12.36668	Hannan-Quinn criter.	0.840025
F-statistic	886.5463	Durbin-Watson stat	2.289088
Prob(F-statistic)	0.000000		

In Equation 10, net migration is modeled as a function of a one period lag of itself, and a contemporaneous and a one period lag of the ratio of total employment in Arkansas to that in the United States. In Table 4, all of the slope coefficients satisfy the 5-percent criterion and are also jointly significant at the 5-percent level. Also, the regression shows no indication of serial correlation. Net migration has a fairly strong inertial component associated with it. It also responds to contemporaneous labor market conditions. Specifically, if the employment ratio improves by 0.1 percentage points, implying higher job gains in Arkansas relative to the rest of the country, net migration in Arkansas will increase by close to 6,000 people, all else equal. This result is in line with evidence reported in Davies et al. (2001), as well as in Fullerton and Barraza de Anda (2008).

Table 4: Arkansas Net Migration Equation

Dependent Variable: AKNMIG
Method: Least Squares
Sample (adjusted): 1970 2011
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-58.71673	60.24860	-0.974574	0.3359
AKNMIG(-1)	0.579873	0.132821	4.365819	0.0001
EMP	37273.75	12557.58	2.968226	0.0052
EMP(-1)	-31389.87	12382.36	-2.535047	0.0155

R-squared	0.524663	Mean dependent var	13.13707
Adjusted R-squared	0.487136	S.D. dependent var	13.95457
S.E. of regression	9.993495	Akaike info criterion	7.532139
Sum squared resid	3795.058	Schwarz criterion	7.697631
Log likelihood	-154.1749	Hannan-Quinn criter.	7.592798
F-statistic	13.98110	Durbin-Watson stat	2.503309
Prob(F-statistic)	0.000003		

To further examine the empirical properties of the model, out of sample simulations are conducted for the years 2012 to 2017. Because the simulation period is beyond the historical edge of the sample, some assumptions or forecasts are required for the exogenous variables (Pindyck and Rubinfeld, 1998). Table 5 reports exogenous variable values, in thousands, for the years 2012 to 2017. Forecasts are obtained from IHS Global Insight for economic variables and from the U.S. Census Bureau population projections for national demographic variables (Garg, 2013; Montgomery, 2013; U.S. Census Bureau Population Division, 2012). For the period in question, the national economy is expected to grow more rapidly than that of Arkansas. Personal income in Arkansas is expected to rise somewhat faster than employment, in part due to rapid job growth in professional and business services (Garg, 2013).

Table 5: Exogenous Variable Forecasts (in thousands)

	2012	2013	2014	2015	2016	2017
AKPY	102,400,000	105,200,000	110,000,000	114,900,000	120,415,200	126,556,375
% Change	3.3%	2.7%	4.6%	4.5%	4.8%	5.1%
AKRPY	88,735,249	89,902,962	92,433,627	95,124,261	97,882,864	100,819,350
% Change	1.5%	1.3%	2.8%	2.9%	2.9%	3.0%
AKEMP	1,559.295	1,552.473	1,570.581	1,586.953	1,602.347	1,615.165
% Change	0.4%	-0.4%	1.2%	1.0%	1.0%	0.8%
USEMP	133,700	135,800	138,000	140,800	143,600	145,700
% Change	-2.4%	1.6%	1.6%	2.0%	2.0%	1.5%
EMP	0.01166	0.01143	0.01138	0.01127	0.01116	0.01109
% Change	3.0%	-2.0%	-0.4%	-1.0%	-1.0%	-0.7%
NB	4,209.571	4,238.995	4,265.811	4,290.077	4,312.261	4,332.538
% Change	6.5%	0.7%	0.6%	0.6%	0.5%	0.5%
ND	2,521.852	2,552.865	2,583.281	2,613.406	2,643.433	2,673.485
% Change	0.3%	1.2%	1.2%	1.2%	1.1%	1.1%
NPOP	314,004.465	316,438.601	318,892.103	321,362.789	323,848.670	326,347.810
% Change	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
PGDP	115.4	117.0	119.0	120.8	122.7	124.6
% Change	1.8%	1.4%	1.7%	1.5%	1.6%	1.5%

Table 6: Endogenous Variables (in thousands), 2010 – 2017

Variable	2010	2011	2012	2013	2014	2015	2016	2017

AKBIR	38.223	38.396	39.351	39.371	39.386	39.380	39.359	39.330
% Change	-3.7%	0.5%	2.49%	0.05%	0.04%	-0.01%	-0.06%	-0.07%
AKDEA	28.632	29.229	29.550	30.041	30.522	30.965	31.374	31.768
% Change	-0.1%	2.1%	1.1%	1.7%	1.6%	1.5%	1.3%	1.3%
AKNI	9.591	9.167	9.802	9.330	8.864	8.415	7.985	7.562
% Change	-13.0%	-4.4%	6.9%	-4.8%	-5.0%	-5.1%	-5.1%	-5.3%
AKNMIG	15.154	7.224	24.592	15.570	15.675	13.235	11.079	10.647
% Change	11.0%	-52.3%	240.4%	-36.7%	0.7%	-15.6%	-16.3%	-3.9%
AKPOP	2,921.588	2,937.979	2,972.373	2,997.273	3,021.811	3,043.462	3,062.526	3,080.735
% Change	0.9%	0.6%	1.2%	0.8%	0.8%	0.7%	0.6%	0.6%

The Gauss-Seidel solution method is used to simulate the model (Fisher and Hallett, 1988). Table 6 details outcomes of the simulation. Because employment is expected to grow faster at the national level than in Arkansas after 2012, it is not surprising that net migration trends downward in most years. Deaths rise more rapidly than births, causing natural increase to also decline. Given these developments, population growth slows to only 0.6 percent by 2017. The results reported in Table 4 indicate that one possible means of attracting more migrants, and thereby potentially boosting the rate of population growth, is to improve employment conditions in Arkansas relative to those in the rest of the country. Among the determinants of population growth, labor market conditions are distinguished by being relatively responsive to regional public policy interventions (Clark and Murphy, 1996).

Conclusion

This study models population in Arkansas using annual frequency data. A small econometric model is developed using fertility, mortality, and migration as the components of population change. Births and deaths contain strong inertial components but are noticeably influenced by national trends in fertility and mortality. Empirical results further indicate that real personal income has no statistically reliable effect on births. Net migration is modeled as a function of relative labor market conditions. Similar to natural increase, net migration also has a pronounced inertial component associated with it. The results indicate that when labor market conditions improve in Arkansas relative to the rest of the country, in-migration will increase.

Out of sample simulations are conducted in order to further test model reliability. Several assumptions regarding the independent variables are made to permit simulating the model beyond the end of the sample. National deaths are expected to increase at a faster rate than births. Additionally, labor market conditions in the U.S. are expected to improve relative to labor market conditions in Arkansas. Given these independent variable assumptions, as well as the model’s parameters, natural increase in Arkansas is expected to decline during the simulation period. Arkansas net migration is also expected to trend downward. This leads population growth in Arkansas to slow to 0.6 percent by the year 2017.

Parameter estimation of this model confirms several of the original hypotheses and simulation results seem reasonable and are in line with recent demographic trends in Arkansas. It has been suggested that modeling population growth in different regions, as well as with different techniques, can lead to improvements in forecast accuracy (Tayman and Swanson, 1996.) Experimentation with alternate specifications, plus simulations using different growth rates for the exogenous variables, is also likely to prove useful. Additional modeling efforts for other nearby states may also help confirm, or overturn, the results obtained for Arkansas.

References

Becker, G.S. (1960), “An economic analysis of fertility”, in Universities National Bureau Committee for Economic Research (Ed.), Demographic and Economic Change in Developed Countries, Princeton University Press, Princeton, NJ, pp. 209-231.

Bennett, D.G. (1970), “Population change and mobility: a case study of an Arkansas state economic area”, *Land Economics*, Vol. 46 No. 2, pp. 206-208.

Booth, H. (2006), “Demographic forecasting: 1980 to 2005 in review”, *International Journal of Forecasting*, Vol. 22 No. 3, pp. 547-581.

Clark, D. and Murphy, C. (1996), “Countywide employment and population growth”, *Journal of Regional Science*, Vol. 36 No. 2, pp. 235-256.

Corden, W.M. and Findlay, R. (1975), “Urban unemployment, intersectoral capital mobility and development policy”, *Economica*, Vol. 42 No. 165, pp. 59-72.

Davies, P.S., Greenwood, M.J. and Li, H. (2001), “A conditional logit approach to U.S. state-to-state migration”, *Journal of Regional Science*, Vol. 41 No. 2, pp. 337-360.

Fisher, P.G. and Hallett, A.J.H. (1988), “Iterative techniques for solving simultaneous equation systems: a view from the economics literature”, *Journal of Computational and Applied Mathematics*, Vol. 24 Nos. 1-2, pp. 241-255.

Fullerton, T.M. Jr. and Barraza de Anda, M. (2008), “Borderplex population modeling”, *Migraciones Internacionales*, Vol. 4 No. 3, pp. 91-104.

Garg, A. (2013), “Arkansas”, IHS Global Insight US Markets State Economies South, June, pp. 39-48.

Harris, J. R. and Todaro M.P. (1970), “Migration, unemployment, and development”, *American Economic Review*, Vol. 60 No. 1, pp. 126-142.

Hernandez-Murillo, R., Ott, L.S., Owyang, M.T., and Whalen, D. (2011), “Patterns of interstate migration in the United States from the survey of income and program participation”, *Federal Reserve Bank of St. Louis Review*, Vol. 93 No. 3, pp. 169-186.

Jones, L.E. and Tertilt, M. (2006), “An economic history of fertility in the U.S.: 1826-1960”, working paper no. 12796, *National Bureau of Economic Research*, Cambridge, MA, December.

Jones, L.E., Schoonbroodt, A. and Tertilt, M. (2008), "Fertility theories: can they explain the negative fertility-income relationship?" working paper no. 14266, *National Bureau of Economic Research, Cambridge*, MA, August.

Krieg, R.G. (1991), "Human-capital selectivity in interstate migration", *Growth and Change*, Vol. 22 No. 1, pp. 68-76.

Lim, J. (2011), "Does wage differential driven migration continue to exist? Tests on the role of regional economic structure in wage differential driven migration", *Annals of Regional Science*, Vol. 47 No. 1, pp. 213-233.

Montgomery, M. (2013), "Employment", IHS Global Insight US Economic Outlook, June, pp. 81-85.

Pindyck, R.S. and Rubinfeld, D.L. (1998), *Econometric Models and Economic Forecasts*, McGraw Hill Companies, Boston, MA.

Plaut, T.J. (1981), "An econometric model for forecasting regional population growth", *International Regional Science Review*, Vol. 6 No. 1, pp. 53-70.

Schultz, T.P. (2005), "Fertility and income", working paper no. 925, *Economic Growth Center*, Yale University, New Haven, CT, October.

Shbikat, G. and Striffler, S. (2000), "Arkansas migration and population", *Arkansas Business and Economic Review*, Vol. 33 No. 3, pp. 1-5.

Smith, S.K. (1997), "Further thoughts on simplicity and complexity in population projection models", *International Journal of Forecasting*, Vol. 13 No. 4, pp. 557-565.

Smith, S.K., Tayman, J. and Swanson, D.A. (2001), *State and Local Population Projections Methodology and Analysis*, Kluwer Academic/Plenum Publishers, New York, NY.

Spiegelhalter, D.J., Best, N.G., Carlin, B.R. and van der Linde, A. (2002), "Bayesian measures of model complexity and fit", *Journal of the Royal Statistical Society Series B*, Vol. 64 No. 4, pp. 583-616.

Tayman, J. and Swanson, D.A. (1996), "On the utility of population forecasts", *Demography*, Vol. 33 No. 4, pp. 523-528.

U.S. Census Bureau Population Division (2012), "Projected population by single year of age, sex, race, and Hispanic origin for the United States: 2012 to 2060", available at: http://www.census.gov/population/projections/files/downloadables/NP2012_D1.csv (accessed 10 September 2013).

Xiao, N., Zarnikau, J. and Damien, P. (2007), "Testing functional forms in energy modeling: an application of the Bayesian approach to U.S. electricity demand", *Energy Economics*, Vol. 29 No. 2, pp. 158-166.