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An Econometric Approach for Modeling Population Change in Doña Ana County, New Mexico

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Dedication

To my parents, Fernando and Bertha, and my sister, Denisse Villavicencio.

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by

DIANA VILLAVICENCIO

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Abstract

An econometric model using time series analysis techniques is used to model and forecast population changes in Doña Ana County, New Mexico. The model focuses on the interplay between economic and demographic variables. Individual, cointegrated equations are generated to account for the components of population change. Significant results were found in the components of population change - births, deaths, net domestic and net international migration. Birth and death equations prove easier to model because of stable changes from period to period in relation to the nation and income levels. Net migration equations were more difficult to model as economic conditions, specifically, labor market conditions, influence changes overtime. Further, out-of-sample simulations are calculated using predefined exogenous variables for the individual components of population change. Using those results, total population projections are estimated until the year 2018. Doña Ana County will witness a slowdown in population growth.

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Chapter 1: Introduction

Located within the international border region of the southwestern United States, the Las Cruces metropolitan economy exhibits interesting demographic tendencies. Within the border region, Las Cruces has long been recognized as one of the most dynamic urban economies in the area. It is also the second largest metropolitan economy in New Mexico.

The Las Cruces metropolitan statistical area is comprised by Doña Ana County. Population growth in this urban economy is highly variable. That variability occurs because net migration frequently represents a large component of population change in Las Cruces. As recently as 2010, net migration exceeded residential natural increase as a contributor of population change. Migratory flows are functionally dependent upon relative regional economic conditions, both cyclical and structural, and can fluctuate tremendously (Cebula & Alexander, 2006; Cebula & Clark, 2011; Cebula & Clark, 2013; Lim, 2011).

A substantial amount of research has been conducted for the border region between México and the United States, yet analyses of border population growth have been relatively infrequent (Fullerton & Barraza de Anda, 2008). Of the research that does exist, Estrella (1992) and Tuiran (1992) point out that information about migration across borders is minimal and often confusing. In the case of Doña Ana County, the interaction of structural demographic and cyclical economic factors on demographic expansion have yet to be studied econometrically. The study herein expands upon the Peach and Williams (1994) examination of the patterns and components of demographic change for the El Paso-Juarez-Las Cruces region by developing an econometric model of population change in Doña Ana County, New Mexico. The paper is organized as follows. Section two provides a review of relevant literature. Section three

discusses the data. The methodology utilized is discussed in Section four. Section five presents empirical findings. Summary and closing remarks are provided in the concluding section.

Chapter 2: Literature Review

2.1 Population Modeling

Population modeling at a county level is challenging because counties are subject to greater volatility in their growth patterns than nations (Smith, 1984). Migration, the most volatile of demographic components (Davis, 1995), is frequently the largest contributor to population growth at the regional level (Cushing & Poot, 2004). Time-series data on migration at the county level are limited and data disaggregated into cohorts are not always available. Measuring births and deaths is a more straight forward process because yearly changes are less severe (Plaut, 1981). In the absence of complete data, net migration can be calculated as a residual by subtracting natural increase from population change (Shryock & Siegel, 1975).

Modeling natural increase and net migration separately improves forecast accuracy (Plaut, 1981). In general, the ability to forecast population fluctuations is greater for large places than for small places (Tayman & Swanson, 1996). For an urban economy such as Las Cruces, this task is further complicated by the fluctuations associated with international migration (Davis, 1995).

2.1.1 Natural Increase

Population change due to births and deaths within a region are related to regional, national, and international factors. Some studies indicate that children are “inferior goods” and, therefore, as real incomes increase individuals will have fewer children (Isen & Stevenson, 2011). Women will have fewer children because the opportunity cost of having children increases as their value of time is increased by their wage rate or their education (Shultz, 2005). In addition, future fertility rates may be affected positively by migrants seeking employment. That is, as more migrants enter a labor market the greater the number of families having children.

Although natural increase is closely tied to the age-sex distribution, the aggregation of data can more clearly explain long-term historical trends and foreseeable structural changes (Smith, 1997). Plaut (1981) suggests using simple natural increase models because changes occur in relatively gradual manners. Fullerton and Barraza de Anda's (2008) simple birth and death specifications that capture local and national trends display good statistical diagnostics.

2.1.2 Net Migration

Economic factors tend to be the most dominant determinants of migration. Accordingly, studies of migration patterns can be analyzed using relative wage, income, and labor market data for different countries and regions (Bolton, 1985; Fullerton, 2001; Hernández-Murillo et al., 2011). Empirical evidence indicates that no single functional form or modeling strategy is superior to all others (Cushing & Poot, 2004).

Regional economic and geographic research have helped clarify why migration does or does not occur by analyzing push factors from the sending area and pull factors from the receiving area. It is business cycles that affect migration at the origin and destination (Lee, 1966). A lack of economic opportunity in the form of lower real wages and inflexible labor markets pushes individuals out of their place of origin. On the other hand, job availability and higher real wage rates act as pull factors that motivate immigration (Kazlauskienė & Rinkevičius, 2006; Djafar & Hassan, 2012).

The Harris and Todaro (1970) model of rural-to-urban migration models the decision to relocate based upon expected real wages and the probability of obtaining employment in the destination market. Although migrants are risk averse, wage premiums induce mobility even if faced with the probability of being unemployed. Results are similar in a modified Harris-Todaro model (Plaut, 1981). In addition, highly–skilled or productive labor migrates for higher returns

to one's human capital and higher employment growth rates (DaVanzo, 1978). Individuals do not only seek to improve their absolute income, but also their relative position in reference to the sending area (Baudassé, 2008). In all, wage differentials drive migration between dissimilar regions, whereas trade occurs between economically similar areas (Lim, 2011).

Cebula and Alexander (2006; 2001) demonstrate that economic factors are significant determinants of net interstate migration, while positive (amenities) and negative (disamenities) quality-of-life factors display mixed results. However, warm-climate retirement destinations have increased in popularity (DaVanzo, 1978; Cebula & Alexander, 2006; Anderson & Gerber, 2008). Las Cruces has a growing economy and is located in a warm weather region of the United States. In addition, migrants are averse to living in areas with low economic and personal freedoms (Cebula and Clark, 2011).

2.2 Doña Ana County

Peach and Williams (1994) use decennial data from the U.S. Census Bureau to extrapolate future population trends in Doña Ana. Future population is based upon disaggregated age, sex, and ethnic historical values. However, border region demographics are unique in that economic factors are particularly indicative of migration patterns.

For instance, regions in close proximity to Mexico exhibit lower per capita income. Even so, wages act as a pull factor because depending on the peso-dollar exchange rate, U.S. per capita income is eight or nine times greater than Mexico's per capita income (Peach & Williams, 2003). Although unemployment rates in border regions are usually higher and more variable, total employment in border counties is growing at a faster rate than the rest of the country (Peach & Williams, 2003). By considering local and national labor market conditions from both sides of the border, the study herein focuses on the interplay between economic and demographic variables across domestic and international boundaries.

Chapter 3: Data

Basic components of population change include births, deaths, and net migration. Annual frequency estimates of those data are used to model population change in the county of Doña Ana, New Mexico. Several different national and regional socio-economic variables are used as regressors.

Although Peach and Williams (1996) use decennial population counts, annual data from the Bureau of Economic Analysis (BEA, 2014) and other sources are used in this study. Records for births and deaths are collected from 1971 to 2012 from the New Mexico Indicator–Based Information System maintained by the New Mexico Department of Health (NMDH, 2014). The data are restricted to residents of New Mexico. United States birth and mortality statistics are obtained from the Center for Disease Control and Prevention National Vital Statistics System (CDC, 2014). Data for births range from 1969 to 2012. Mortality records begin in 1969 and end in the year 2012.

Data for net international migration estimates to Las Cruces comes from Moody's Analytics for the 1991 through 2013 period (White, 2013). In contrast, net domestic migration data are unavailable because records of internal migration in North America are not required of residents. Consequently, net domestic migration is determined residually from the other series in the sample.

Data on economic variables used as regressors come from several sources. Personal income data for Doña Ana County are acquired from the Bureau of Economic Analysis from 1969 to 2012. Personal income for Doña Ana County is adjusted for inflation using the personal consumption expenditures deflator. The personal consumption expenditures deflator is retrieved from the BEA's National Income and Product Accounts Tables. Real United States income is generated using the BEA's database for the 1969-2012 period. Employment data are retrieved

from 1974 to 2012 at the regional level and from the 1969 to 2012 period at national level from the Bureau of Labor Statistics (BLS, 2014) and the BEA, respectively. A ratio of local employment to national employment is used to measure labor market conditions. In addition, Mexico variables are obtained from the World Bank (WB) World Development Indicators dataset for the 1969 to 2012 time period (WB, 2014). These data are population and the GDP implicit deflator for Mexico. Appendix A lists series of data as well as generated data from 1969 to 2012.

Chapter 4: Methodology

This study represents an extension of the work by Peach and Williams (1994) for the Las Cruces region. It utilizes different aspects of the econometric models of population growth by Plaut (1981) and Fullerton and Barraza de Anda (2008). Multiple regression analysis is used to analyze the various components of population growth. Separate models for the components of population change often exhibit greater forecast accuracy (Plaut, 1981). Out-of-sample simulations are used to examine if that is also the case for Doña Ana County.

Current year population for Doña Ana County is the sum of its prior year value, natural increase, and net migration. Equation 1 is an identity.

(1) $dapop_{t} = dapop_{t-1} + dani_{t} + danm_{t}$

Equation 2, also an identity, represents natural increase at time t. Natural increase is calculated as the difference between births and deaths. Fertility and mortality records are accurate at the county level, allowing for reliable natural increase measurement. Typically, in the short-to-medium run, fertility changes are small and will not hamper forecast capabilities (Plaut, 1981).

(2) $dani_{t} = dabir_{t} – dadea_{t}$

At the regional level, net migration can have a greater effect on population change than natural increase. In Equation 3, net migration in Doña Ana is the sum of net domestic and net international migration.

(3) $danm_{t} = dandm_{t} + danim_{t}$

In the absence of time series data for net migration flows, historical net migration is calculated indirectly using the residual method (Davis, 1995). That is, net migration is the difference between the change in population from one time period to the next and natural increase. A

disadvantage of this method is that migration rates are extremely volatile over time (Davis, 1995) and errors can occur as a consequence of errors in population counts. In addition, international migrants can either settle or "float" in areas immediately along the border. Nonetheless, this technique is preferred in regional economics to modeling total population because it is a more accurate forecasting method (Plaut, 1981). For this study, net international migration estimates are available, while net domestic migration estimates are generated using Equation 4.

(4) $dandm_t = [(dapop_t - dapop_{t-1}) - dani_t] - danim_t$

The framework for analyzing the combined effect of economic variables on the variability of births, deaths, and net migration is completed using generalized least squares estimation procedures. Although demographic-economic interaction approaches do not always yield forecasts that outperform the outcomes of more simple specifications, such approaches provide clear theoretical foundations to population projections, provide consistent economic and demographic projections, and are useful analytical tools (Smith, 1984).

Moreover, the structural analysis of demographic-economic interactions using time-series methods allows for the extrapolation of the dynamics of the data by exploiting the relationship that exists over time for any single variable (Asteriou & Hall, 2011). However, demographic variables tend to diverge over time and variables like births or deaths will not have the same properties in 1969 as in 2012. That is, the mean, at the very least, is not constant overtime, making it more difficult to model the time-series from previous data. In addition, as a previous error term affects the following period's error term, neighboring errors can suffer from serial correlation.

For those reasons, two sets of models are specified using level and differenced data. In the differenced equations, each variable is integrated (I) (differenced) one or more times to obtain

stationarity. Differencing produces more accurate coefficient estimates and smaller forecast errors (Smith et al., 2001).

The specifications for the stochastic equations are described below. Several tests and evaluation criteria are used to choose the final specification for each equation. This includes the Autocorrelation Function (ACF), the Q-statistic (Hoff, 1983), and the Breusch-Godfrey Lagrange Multiplier test (Breusch & Godfrey, 1981). Finally, the Deviance Information Criterion (DIC) selection tool is utilized to choose the functional form. The DIC compares models that have high explanatory powers (Spiegelhalter, 2002; Xiao et al., 2007).

As noted in Booth (2006), regional fluctuations in births are conditioned by national trends and are generally a non-stationary series. Accordingly, a national birth to national population ratio, scaled by the population of Doña Ana County, is included in the births equations. Additionally, some studies indicate that the curve relating fertility and income flattens out or even rises at higher income levels, while other data indicate a strong negative relationship between income and fertility (Becker, 1960). In this study, births are predicted to be inversely correlated with real personal income.

(5) $dabir_t = \alpha_o + \alpha_1\, dabir_{t-1} + \beta_0 dapop_t{*}\,(usbir_t/uspop_t) + \beta_1 dapop_{t-1}{*}(usbir_{t-1}/uspop_{t-1}) + \ldots + \beta_n dapop_{t-n}{*}(usbir_{t-1}/uspop_{t-1}) + \theta_0 darpyce_t + \theta_1 darpypce_{t-1} + \ldots + \theta_n darpypce_{t-n} + \varepsilon_t$

Further, as an area's economic conditions improve and levels of living rise, death rates tend to fall (Todaro & Smith, 2011). Deaths in Doña Ana County are modeled as a function of previous deaths and the ratio of United States deaths to United States population, scaled by Doña Ana population. In addition, a real personal income variable is used to account for Doña Ana County economic development.

(6) $dadea_t = \alpha_o + \alpha_1 dadea_{t-1} + \beta_0 dapop_t * (usdea_t/uspop_t) + \beta_1(dapop_{t-1}*(usdea_{t-1}/uspop_{t-1}) + \ldots + \beta_n(dapop_{t-n}*(usdea_{t-n}/uspop_{t-n}) + \theta_0 darpypce_t + \theta_1 darpypce_{t-1} + \ldots + \theta_n darpypce_{t-n} + \mu_t$

To model net migrations for Doña Ana County, two separate equations are utilized. First, the specification for net domestic migration is taken directly from Fullerton and Barraza de Anda (2008), where the main economic variable is a local to national employment ratio. Net domestic migration in Doña Ana is expected to increase if employment in Doña Ana increases relative to employment in the United States.

(7) $dandm_t = \alpha_o + \alpha_1 dandm_{t-1} + \beta_0(daemp/usemp)_t + \beta_1(daemp/usemp)_{t-1} + \ldots + \beta_n(daemp/usemp)_{t-n} + w_t$

Second, migration flows are affected by push and pull factors. The Neoclassical approach defines income differentials and employment opportunities as primary determinants of international migration (Massey et al., 1994). Places located immediately along an international border are affected not only by changes outside the region, but outside the country as well (Fullerton, 2001). Population growth due to migration is attributed to wage differentials and employment opportunities as immigrants search for improved economic conditions. Equation 8 approximates the wage differential between countries by the gap between United States real per capita income, multiplied by the probability of employment, and real per capita gross domestic product in Mexico (Fullerton & Barraza de Anda, 2008).

(8) $danim_t = \alpha_o + \alpha_1 danim_{t-1} + \beta_0 diff_t + \beta_1 diff_{t-1} + \ldots + \beta_n diff_{t-n} + v_t$

Statistical estimation diagnostics and the DIC outcomes help determine the model forms selected below. Out-of-sample model simulations also help assess the validity of the system of equations that is developed. All empirical results are discussed in the next section.

Chapter 5: Results

The estimates for the four individual components of population change – births, deaths, net international migration, and net domestic migration- are compared using the Deviance Information Criterion (DIC) selection tool for Doña Ana County. The DIC is used to compare different methods when using an identical dependent variable. Therefore, the components of demographic change were compared using four equations with level data and four equations with differenced data.

The DIC tool is based on a goodness of fit measure and model size (Berg et al., 2004). Less complex models with a smaller DIC are preferred. The DIC is not a strict criterion for model choice (Berg et al., 2004). Therefore,

(9) $n \ln 2\pi + 2n \ln \sigma + (\frac{1}{\sigma^2})\sum_{t=1}^{n} \varepsilon^2$

is similar to the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) (Spiegelhalter, 2002; Xiao et al., 2007). In Equation 9, n is the number of observations, ε is the residual term, and σ, the standard deviation of the residuals.

Deviance Information Criterion results are compared in Table 5.1 below. Selected results are in bold. Model comparison is conducted for statistically significant equations with the exception of the differenced birth and the level net domestic migration equations. The level form of the birth equation is preferred over the differenced equation. In addition, DIC results indicate that the differenced death equation is preferred to the level form equation. Further, a differenced net domestic migration equation is favored over the level form. Lastly, a level net international migration specification for Doña Ana County is also favored on the basis of the DIC calculations.

Table 5.1: Deviance Information Criterion Results

Dependent Variables	Level Models	Differenced models
Births	**-96.0793236**	-87.1729
Deaths	-151.1367319	**-153.9718458**
Net Domestic Migration	101.3507217	**87.33713**
Net International Migration	**-33.98430825**	-23.52486508

Cointegration tests for the level linear equation results above are performed because modeling differenced series may omit long-run relationships (Engle & Granger, 1987; Wooldridge, 2013). That is, the combination of the individual level, non-stationary series form part of a stationary (cointegrated) equation when a long-run equilibrium exists. First, and in addition to the evaluation criteria used in Chapter four, Augmented Dickey-Fuller (ADF) unit root tests of the individual series reject the unit root null hypothesis at the 5% level; all variables are of the same level of integration, I(1), and are cointegration candidates. A two-step Engle-Granger test checks for cointegration. Dickey-Fuller results for the equation error terms can be found in Appendix C. The Durbin-Watson statistic further checks for the existence of autocorrelation. In the absence of autocorrelation, the Durbin-Watson statistic will fall between the limits 1.85 and 2.15. If autocorrelation is present, the Dickey-Fuller measurement is not valid.

Testing the stationarity of the residuals with the Dickey-Fuller test for births, deaths, net domestic, and net international migration confirms that the equations are cointegrated. The critical values presented in the Dickey Fuller table are represented by the Davidson-MacKinnon critical values. Table C.1 in the appendix shows that the computed ADF test statistic of the residuals for the birth equation is less (-3.52) than the Davidson-Mackinnon critical value (-2.94)

at the five percent level without a time trend and with one lag rejects the unit root null hypothesis. The residuals are stationary and the Durbin-Watson statistic (1.96) confirms the absence of autocorrelation. Therefore, the birth equation is cointegrated.

The birth equation for Doña Ana confirms a long-run relationship between the dependent and independent variables (Equation 10). The equation output can be found in the Appendix in Table B.1. A high F-statistic confirms the explanatory power of the combined independent variables, with a coefficient of determination over 98 percent. Births in the previous period affect births in the following year. $DABIR_{t-1}$ is statistically significant at the five percent level. In addition, the top-down relationship between national and regional changes is confirmed for Doña Ana County. Births in the United States are representative of births in Doña Ana County. Real per capita income has the predicted negative effect on births within Doña Ana County and is significant at the 5% level. The finding supports the result found in other studies conducted (Isen & Stevenson, 2011). For every one thousand dollar increase in real personal income, births will decrease by .000736 people.

(10) $dabir= -.103032 + .568455 * dabir_{t-1} + .706141 * dpubirup_{t-1} - .0000000736 * darpypce_{t-1}$

Next, the computed Dickey Fuller test-statistic (-8.81) for the death equation (Table C.2) is smaller than the critical values at the five percent significance level (-3.53) with and without a time trend. Therefore, the H_0 is rejected. This means the residuals do not have a unit root problem and are stationary at the five percent significance level; the dependent and independent variables are cointegrated. Further, the Durbin-Watson test statistic confirms that autocorrelation is not present. These findings confirm the cointegration suspicions given the DIC results. .

Equation 11, the representation of deaths in Doña Ana County is below. Output results for deaths can be found in Table B.2. Jointly, the coefficients are significant at the five percent

level with a goodness of fit of nearly 99 percent. Individually, the explanatory variables are significant at the 5% level. Deaths in Doña Ana County for a given period are positively related to deaths in the previous period. The inertial pattern of deaths is underscored by the approximate 810 people who pass away for every 1,000 persons that die in the previous year. In addition, the scaled national death-to-population ratio is positively correlated with deaths in the county, confirming the prevalence of national demographic trends throughout most regions of the country. The variable describing real personal income is omitted from Equation 11 because it did not display statistically significant results.

(11) $dadea = -0.068824 + 0.808883*dadea_{t-1} + 0.210755*dpudeaup_{t-1}$

In addition, Doña Ana County's net domestic migration equation is cointegrated because the ADF test-statistic (-8.41) is smaller than the critical value (-3.67) at the five percent level with a time trend and one lag. The Durbin-Watson statistic is reliable because it lies within the 1.85 and 2.15 interval: autocorrelation is not present. Results are located in Table C.3.

Equation 12 represents net domestic migration as a function of net domestic migration in the last period, and a contemporaneous and one period lag of the ratio of total employment in Doña Ana County to the United States. A strong inertial component in net domestic migration is confirmed by the 688 increase that results for every 1,000 prior period migrants to the county. Also, Table B.3 shows that the effects regional labor market conditions on net migration wear off fairly quickly. Although this equation does not exhibit optimal statistical fit characteristics, it does have good out-of-sample simulation results associated with it. Alternative equations can be found in Appendix F.

(12) $dandm = 1.438889 + 0.687723*dandm_{t-1} +194223.3*emp_t - 198052*emp_{t-1}$

Finally, net international migration residuals for the county of Doña Ana are stationary because the Dickey Fuller t-statistic is below the Davidson-Mackinnon critical value at the 5% significance level for tests with and without a time trend (as seen in Tables C.4 and C.5). The Durbin-Watson test statistic falls within the acceptable range, rejecting the presence of autocorrelation.

Equation (13) represents net international migration to Doña Ana as a function of net international migration in the previous period and a wage differential lagged two and three periods. Output results in Appendix Table B.4 show that individually and together all variables are statistically significant. The overall goodness of fit is 90.1 percent. International migration flows to Doña Ana are positively correlated with the previous year's migration flows. In addition, the wage differential approximated by the gap between the United States real per capita income, multiplied by the probability of employment, and real per capita gross domestic product in Mexico lagged two periods has a positive correlation with net international migration. This supports the finding that improved economic conditions are driving forces behind migration. Even with the probability of being unemployed, migrants are responsive to a higher wage rate (Lim, 2011). This may in fact, be due to network effects of communication two periods in the past.

The aggregate effect of the differential lagged three periods has a total negative effect on the overall equation. The negative effect does not support prior approaches. The positive effect of the differential lagged two periods attempts to correct for the negative effect. However, the change cannot counter act the effect the differential lagged three times on net international migration.

(13) $danim = 1.55043 + 0.53105*danim_{t-1} + 80.66736*diff_{t-2} - 118.85201*diff_{t-3}$

Further, to test the validity of the equations, out of sample simulations are conducted to forecast total population change five years into the future. Time series extrapolations are widely used because they are easily automated and reliable (Armstrong, 2001). Because the simulation period is beyond the sample, some assumptions are required for the independent variables (Pindyck and Rubinfeld, 1976) in order to ultimately calculate total population changes. The percentage changes for the forecasted independent variables are attained from the United States Census Bureau, Précis U.S. Metro West, Précis U.S. Macro, and the Political Risk Yearbook for Mexico and are listed in Table 5.2 below.

The variables were subsequently used in the formation of the four components of population change for the 2013 to 2018 period and incorporated into Equation 1, total population change.

(1) $dapop_{t\,=}\ dapop_{t-1} + dani_t + danm_t$

Table 5.2: Endogenous Variable Forecasts (in thousands), 2013-2018

Endogenous Variables (in thousands), 2013 - 2018						
	2013	**2014**	**2015**	**2016**	**2017**	**2018**
DABIR	3.174	3.224	3.282	3.343	3.412	3.490
% Change	3.35%	1.57%	1.80%	1.87%	2.08%	2.27%
DADEA	1.437	1.468	1.502	1.538	1.576	1.616
% Change	-3.44%	2.16%	2.30%	2.41%	2.49%	2.56%
DANDM	-1.857	-2.969	-2.105	-1.047	-0.707	-0.765
% Change	973.22%	59.89%	-29.10%	-50.25%	-32.52%	8.28%
DANIM	0.453	0.485	0.489	0.454	0.399	0.239
% Change	398.06%	7.06%	0.86%	-7.29%	-12.13%	-39.95%
DAPOP	214.478	213.46264	213.349	214.293	215.561	216.652
% Change	0.02%	-0.47%	-0.05%	0.44%	0.59%	0.51%

As can be seen from Table 5.2 above and figures in Appendix E, birth rates in the area drop through 2014, but pick up in 2015. Deaths in the area will increase to 1,616 deaths by 2018. Net domestic migration is the largest determinant of population change within Doña Ana County in the near future. Given its volatility, net domestic migration will witness a large

negative fluctuation of 2,969 people in 2014, but will see an increasing number of domestic migrants by 2015. Net international migration to the region will experience an influx of 418.1 people on average, from 2013 to 2018. In all, with the irregular movement and large outflow of U.S. citizens and the small number of international migrants, Doña Ana County will witness a small decrease in total population from 2014 to 2015, with a steady upward shift from 2016 to 2018 (Figure E.5).

Prediction of total population movements within Doña Ana County are affected by international, national, and state economic and demographic conditions. Although some of the estimates prove reasonable, net domestic migration may require additional experimentation. The final equation used presented a smaller change in net domestic migration than alternative models; however, it predicts a population decrease from 2014 to 2015. In addition, the small predicted net international migration to Doña Ana County given the wage differential is subject to revision, given the fact that minimum wage and employment opportunities in the area will improve.

Chapter 6: Conclusion

Measuring and predicting population changes via economic variables are important in the planning of regional economies. Of the substantial research that exists for the United States-Mexico border, econometric analyses of border population growth have been infrequent. The purpose of this paper is to develop such a model for Doña Ana County, New Mexico. Estimation and simulation results for the system of equations developed exhibit good properties.

Four sets of level and four sets of differenced equations are generated to analyze the components of population growth. Comparisons between the two types of equations using the Deviance Information Criterion (DIC) do not reveal a preferred modeling method. However, Augmented Dickey-Fuller cointegration tests support the application of level form equations. This is a key finding because modeling differenced series may omit long-run relationships (Engle & Granger, 1987; Wooldridge, 2013).

An out-of-sample simulation is developed using economic forecasts of the exogenous variables. Results from that exercise indicate that natural increase is a growth component because births outnumber deaths. Relative to national economic factors, net domestic migration is predicted to increase, yet the measurement remains negative. Net international migration is expected to decrease in response to international economic factors. Using these results, population projections are estimated until the year 2018. Doña Ana County will witness two periods of negative growth; subsequent to that, total population is expected to trend upward at a slower rate.

Although the level set of econometric models used here appear to be useful for projecting population growth in Doña Ana County, the validity of the approach should be tested for other

border regions. Border counties have generally been overlooked in terms of econometric analysis. Relatively rapid rates of growth for many of these counties means that accurate modeling efforts are likely to encounter numerous challenges.

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Appendix A: Data

Table A.1: Data

	Description	Units
Series		
dapop	Doña Ana Population	Persons, Thousands
dabir	Doña Ana Residential Births	Persons, Thousands
dadea	Doña Ana Residential Deaths	Persons, Thousands
dani	Doña Ana Natural Increase	Persons, Thousands
danm	Doña Ana Net Migration	Persons, Thousands
dandm	Doña Ana Net Domestic Migration	Persons, Thousands
danim	Doña Ana Net International Migration	Persons, Thousands
dapy	Doña Ana Personal Income	Dollars, Thousands
pced	Personal Consuption Expenditure	Indexed Numbers, 2009=100
daemp	Doña Ana Total Full and Part-Time Employment	Persons, Thousands
usbir	United States Births	Persons, Thousands
usdea	United States Deaths	Persons, Thousands
uspop	United States Population	Persons, Thousands
uspy	United States Personal Income	Dollars, Thousands
usemp	United States Total Full and Part-Time Employment	Persons, Thousands
usumr	United States Unemployment Rate	Rate
mxpop	Mexico Population	Persons, Thousands
mxrgdp	Mexico Real GDP	2009 Dollars, Thousands
Generated Variables		
dpubirup	National Birth to National Population Ratio Scaled by Doña Ana Population	dapop*(usbir/uspop)
dpudeaup	National Death to National Population Ratio Scaled by Doña Ana Population	dapop*(usdea/uspop)
darpypce	Doña Ana Real Personal Income	(dapy/pced)*100
emp	Employment Ratio	(daemp/usemp)
usrpy	United States Real Personal income	(uspy/pced)*100
usrpcy	United States Real Per Capita Personal Income	(usrpy/uspop)
mxrpcgdp	Mexican Real Per Capita GDP	(mxrgdp/mxpop)
diff	Wage Differential	(1-usumr/100)*(usrpcy)-mxrpcgdp

Table A.2: Doña Ana County Demographic Variables (in thousands), 1969-2012

Year	dapop	dabir	dadea	dani	dandm	danim
1969	69.000					
1970	70.254					
1971	72.726	1.638	0.425	1.213		
1972	76.553	1.480	0.394	1.086		
1973	76.909	1.564	0.397	1.167		
1974	78.888	1.563	0.476	1.087		
1975	81.979	1.564	0.384	1.180		
1976	85.259	1.581	0.412	1.169		
1977	88.302	1.600	0.455	1.145		
1978	92.193	1.630	0.446	1.184		
1979	93.741	1.704	0.508	1.196		
1980	97.012	1.886	0.507	1.379		
1981	99.623	1.955	0.533	1.422		
1982	103.448	2.007	0.523	1.484		
1983	107.627	2.123	0.560	1.563		
1984	112.474	2.289	0.604	1.685		
1985	116.321	2.187	0.598	1.589		
1986	120.474	2.320	0.652	1.668		
1987	125.032	2.404	0.659	1.745		
1988	130.016	2.554	0.721	1.833		
1989	132.957	2.753	0.726	2.027		
1990	136.593	2.852	0.713	2.139		
1991	141.228	3.059	0.804	2.255	1.461	0.794
1992	146.995	3.167	0.851	2.316	1.398	0.918
1993	153.049	3.284	0.802	2.482	1.542	0.940
1994	157.530	3.121	0.914	2.207	1.210	0.997
1995	161.014	3.032	0.925	2.107	1.042	1.065
1996	165.618	3.058	0.904	2.154	0.835	1.319
1997	169.081	2.973	0.965	2.008	0.696	1.312
1998	172.057	2.996	1.019	1.977	0.879	1.098
1999	173.889	2.917	0.986	1.931	0.880	1.051
2000	175.098	3.025	1.054	1.971	0.749	1.222
2001	176.496	3.005	1.091	1.914	1.160	0.754
2002	178.464	3.081	1.130	1.951	1.234	0.717
2003	182.045	3.201	1.185	2.016	1.404	0.612
2004	184.939	3.315	1.206	2.109	1.451	0.658
2005	189.199	3.331	1.224	2.107	1.417	0.690
2006	193.701	3.385	1.210	2.175	1.462	0.713
2007	197.853	3.460	1.287	2.173	1.538	0.635
2008	200.855	3.310	1.282	2.028	1.407	0.621
2009	205.401	3.323	1.356	1.967	1.049	0.918
2010	210.325	3.323	1.433	1.890	0.606	1.284
2011	212.944	3.240	1.428	1.812	1.771	0.041
2012	214.445	3.071	1.488	1.583	1.492	0.091

Table A.3: United States and Mexico Demographic Variables (in thousands), 1969-2012

Year	uspop	usbir	usdea	mxpop	dpubirup	dpudeaup
1969	202,736.00	3,600.21	1,921.99	51,360.85	1.23	0.65
1970	205,089.00	3,731.39	1,921.03	52,988.14	1.28	0.66
1971	207,692.00	3,555.97	1,927.54	54,669.03	1.25	0.67
1972	209,924.00	3,258.41	1,963.94	56,395.80	1.19	0.72
1973	211,939.00	3,136.97	1,973.00	58,155.59	1.14	0.72
1974	213,898.00	3,159.96	1,934.39	59,931.34	1.17	0.71
1975	215,981.00	3,144.20	1,892.88	61,708.37	1.19	0.72
1976	218,086.00	3,167.79	1,909.44	63,486.20	1.24	0.75
1977	220,289.00	3,326.63	1,899.60	65,261.30	1.33	0.76
1978	222,629.00	3,333.28	1,927.79	67,012.87	1.38	0.80
1979	225,106.00	3,494.40	1,913.84	68,715.44	1.46	0.80
1980	227,726.00	3,612.26	1,989.84	70,353.01	1.54	0.85
1981	230,008.00	3,629.24	1,977.98	71,916.28	1.57	0.86
1982	232,218.00	3,680.54	1,974.80	73,415.74	1.64	0.88
1983	234,333.00	3,638.93	2,019.20	74,880.33	1.67	0.93
1984	236,394.00	3,669.14	2,039.37	76,351.11	1.75	0.97
1985	238,506.00	3,760.56	2,086.44	77,859.34	1.83	1.02
1986	240,683.00	3,756.55	2,105.36	79,410.22	1.88	1.05
1987	242,843.00	3,809.39	2,123.32	80,999.18	1.96	1.09
1988	245,061.00	3,909.51	2,168.00	82,635.33	2.07	1.15
1989	247,387.00	4,040.96	2,150.47	84,326.92	2.17	1.16
1990	250,181.00	4,158.21	2,148.46	86,077.00	2.27	1.17
1991	253,530.00	4,110.91	2,169.52	87,890.09	2.29	1.21
1992	256,922.00	4,065.01	2,175.61	89,757.92	2.33	1.24
1993	260,282.00	4,000.24	2,268.55	91,653.83	2.35	1.33
1994	263,455.00	3,952.77	2,278.99	93,541.58	2.36	1.36
1995	266,588.00	3,899.59	2,312.13	95,392.65	2.36	1.40
1996	269,714.00	3,891.49	2,314.69	97,201.53	2.39	1.42
1997	272,958.00	3,880.89	2,314.25	98,968.56	2.40	1.43
1998	276,154.00	3,941.55	2,337.26	100,678.87	2.46	1.46
1999	279,328.00	3,959.42	2,391.40	102,316.78	2.46	1.49
2000	282,398.00	4,058.81	2,403.35	103,873.61	2.52	1.49
2001	285,225.00	4,025.93	2,416.43	105,339.88	2.49	1.50
2002	287,955.00	4,021.73	2,443.39	106,723.66	2.49	1.51
2003	290,626.00	4,089.95	2,448.29	108,056.31	2.56	1.53
2004	293,262.00	4,112.05	2,397.62	109,381.55	2.59	1.51
2005	295,993.00	4,138.35	2,448.02	110,731.83	2.65	1.56
2006	298,818.00	4,265.56	2,426.26	112,116.69	2.77	1.57
2007	301,696.00	4,316.23	2,423.71	113,529.82	2.83	1.59
2008	304,543.00	4,247.69	2,471.98	114,968.04	2.80	1.63
2009	307,240.00	4,130.67	2,437.16	116,422.75	2.76	1.63
2010	309,776.00	3,999.39	2,468.44	117,886.40	2.72	1.68
2011	312,036.00	3,953.59	2,513.17	119,361.23	2.70	1.72
2012	314,278.00	3,952.84	2,544.91	120,847.48	2.70	1.74

Table A.4: Economic Variables (in thousands), 1969-2012

Year	pced	dapy	darpy(pce)	daemp	usemp	emp
1969	21.326	198,149	929,142.83		79,850.00	
1970	22.325	210,886	944,618.14		79,750.00	
1971	23.274	235,809	1,013,186.39		79,554.00	
1972	24.070	256,830	1,067,012.88		81,583.00	
1973	25.367	284,614	1,121,985.26		85,202.00	
1974	28.008	331,389	1,183,194.09	23.3	86,573.00	0.000269137
1975	30.347	362,059	1,193,063.56	23.5	85,044.00	0.000276328
1976	32.012	412,459	1,288,451.21	24.8	87,402.00	0.000283746
1977	34.091	462,590	1,356,927.05	26.9	90,421.00	0.000297497
1978	36.479	530,721	1,454,867.18	28.8	94,777.00	0.000303871
1979	39.713	583,977	1,470,493.29	29.6	98,017.00	0.000301988
1980	43.977	665,495	1,513,279.67	29.5	98,370.00	0.000299888
1981	47.907	776,517	1,620,884.21	30.1	99,225.00	0.000303351
1982	50.552	864,264	1,709,653.43	31.5	97,305.00	0.000323724
1983	52.728	985,315	1,868,675.09	33.3	98,041.00	0.000339654
1984	54.723	1,077,273	1,968,592.73	35.1	102,458.00	0.000342579
1985	56.660	1,179,631	2,081,946.70	36.4	104,987.00	0.00034671
1986	57.886	1,275,629	2,203,691.74	38	106,873.00	0.000355562
1987	59.649	1,371,038	2,298,509.61	39.4	109,754.00	0.000358985
1988	61.973	1,441,566	2,326,119.44	41.1	112,864.00	0.000364155
1989	64.640	1,592,579	2,463,767.02	43	115,501.00	0.000372291
1990	67.439	1,705,836	2,529,450.32	43.8	116,964.00	0.000374474
1991	69.651	1,832,863	2,631,495.60	43.5	115,525.00	0.000376542
1992	71.493	2,014,761	2,818,123.45	44.6	115,968.00	0.000384589
1993	73.277	2,146,877	2,929,810.17	45.9	117,604.00	0.000390293
1994	74.802	2,247,773	3,004,963.77	46.9	120,379.00	0.000389603
1995	76.345	2,446,525	3,204,564.80	48.5	123,236.00	0.000393554
1996	77.980	2,567,112	3,292,013.34	49.9	125,461.00	0.000397733
1997	79.326	2,693,065	3,394,933.57	51.1	128,316.00	0.000398236
1998	79.934	2,931,403	3,667,279.26	52.6	131,563.00	0.000399808
1999	81.109	3,026,161	3,730,980.53	55.1	134,350.00	0.000410123
2000	83.128	3,167,436	3,810,311.81	57	137,228.00	0.000415367
2001	84.731	3,628,589	4,282,481.03	57.7	136,890.00	0.000421506
2002	85.872	3,839,670	4,471,387.65	59.8	135,937.00	0.00043991
2003	87.573	3,999,205	4,566,710.06	61.7	135,602.00	0.000455008
2004	89.703	4,267,377	4,757,228.86	62.6	137,067.00	0.000456711
2005	92.260	4,657,800	5,048,558.42	65.1	139,006.00	0.000468325
2006	94.728	4,947,291	5,222,627.95	67	141,440.00	0.000473699
2007	97.099	5,371,846	5,532,339.16	68.3	142,928.00	0.000477863
2008	100.063	5,665,167	5,661,600.19	69.5	142,000.00	0.000489437
2009	100.000	5,891,595	5,891,595.00	68.6	136,170.00	0.000503782
2010	101.654	6,231,504	6,130,111.95	69.4	134,846.00	0.000514661
2011	104.086	6,492,340	6,237,476.70	69.5	136,542.00	0.000509001
2012	106.009	6,618,103	6,242,963.33	69.4	138,756.00	0.000500159

Table A.5: Economic Variables (in thousands), 1969-2012 (cont.)

Year	uspy	usrpy	usumr	rmxgdp	diff
1969	800.30	3,752.70	3.5	0.01319	0.01786
1970	864.60	3,872.79	5	0.01354	0.01794
1971	932.10	4,004.90	6	0.01439	0.01813
1972	1,023.60	4,252.60	5.6	0.01532	0.01912
1973	1,138.50	4,488.11	4.9	0.01738	0.02014
1974	1,249.30	4,460.51	5.6	0.02140	0.01969
1975	1,366.90	4,504.23	8.5	0.02474	0.01908
1976	1,498.10	4,679.81	7.7	0.02953	0.01981
1977	1,654.20	4,852.31	7.1	0.03853	0.02046
1978	1,859.50	5,097.45	6.1	0.04469	0.02150
1979	2,077.90	5,232.29	5.9	0.05347	0.02187
1980	2,316.80	5,268.21	7.2	0.07133	0.02147
1981	2,595.90	5,418.62	7.6	0.08989	0.02177
1982	2,778.80	5,496.91	9.7	0.14465	0.02137
1983	2,969.70	5,632.11	9.6	0.27551	0.02172
1984	3,281.30	5,996.20	7.5	0.43833	0.02346
1985	3,515.90	6,205.26	7.2	0.68703	0.02414
1986	3,725.10	6,435.23	7	1.19283	0.02485
1987	3,955.30	6,630.96	6.2	2.85871	0.02558
1988	4,275.30	6,898.65	5.5	6.08064	0.02653
1989	4,618.20	7,144.49	5.3	7.69372	0.02726
1990	4,904.50	7,272.50	5.6	9.85801	0.02733
1991	5,071.10	7,280.73	6.9	12.15005	0.02660
1992	5,410.80	7,568.29	7.5	13.90100	0.02709
1993	5,646.80	7,706.10	6.9	15.22063	0.02740
1994	5,934.70	7,933.88	6.1	16.51005	0.02810
1995	6,276.50	8,221.23	5.6	22.76315	0.02887
1996	6,661.90	8,543.09	5.4	29.76119	0.02966
1997	7,075.00	8,918.89	4.9	35.02520	0.03072
1998	7,587.70	9,492.46	4.5	40.41391	0.03243
1999	7,983.80	9,843.30	4.2	46.51268	0.03330
2000	8,632.80	10,384.95	4	52.14180	0.03480
2001	8,987.10	10,606.63	4.7	55.20690	0.03492
2002	9,149.50	10,654.81	5.8	59.04750	0.03430
2003	9,487.60	10,833.93	6	70.23592	0.03439
2004	10,049.20	11,202.75	5.5	76.60329	0.03540
2005	10,610.30	11,500.43	5.1	80.08349	0.03615
2006	11,389.80	12,023.69	4.6	85.44155	0.03762
2007	11,995.70	12,354.09	4.6	90.25165	0.03827
2008	12,430.60	12,422.77	5.8	95.96845	0.03759
2009	12,082.10	12,082.10	9.3	100.00002	0.03481
2010	12,435.20	12,232.87	9.6	104.00971	0.03482
2011	13,191.30	12,673.46	8.9	110.25998	0.03608
2012	13,743.80	12,964.75	8.1	114.25916	0.03697

Appendix B: Doña Ana County Population Level Estimations

Table B.1: Doña Ana Births Level Equation

Dependent Variable: DABIR
Method: Least Squares
Date: 04/05/14 Time: 11:58
Sample (adjusted): 1972 2012
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.103032	0.070227	-1.467135	0.1508
DABIR(-1)	0.568455	0.102102	5.567521	0.0000
DPUBIRUP	0.706141	0.145876	4.840702	0.0000
DARPYPCE	-7.36E-08	1.90E-08	-3.864724	0.0004

R-squared	0.987130	Mean dependent var	2.626659
Adjusted R-squared	0.986086	S.D. dependent var	0.666921
S.E. of regression	0.078668	Akaike info criterion	-2.154687
Sum squared resid	0.228981	Schwarz criterion	-1.987510
Log likelihood	48.17109	Hannan-Quinn criter.	-2.093810
F-statistic	945.9390	Durbin-Watson stat	1.653211
Prob(F-statistic)	0.000000		

Table B.2: Doña Ana County Deaths Level Equation

Dependent Variable: DADEA
Method: Least Squares
Date: 04/13/14 Time: 16:16
Sample (adjusted): 1972 2012
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.068824	0.035235	-1.953301	0.0582
DADEA(-1)	0.808883	0.087280	9.267684	0.0000
DPUDEAUP(-1)	0.210755	0.084395	2.497254	0.0170

R-squared	0.986740	Mean dependent var	0.849073
Adjusted R-squared	0.986042	S.D. dependent var	0.336763
S.E. of regression	0.039786	Akaike info criterion	-3.540223
Sum squared resid	0.060153	Schwarz criterion	-3.414839
Log likelihood	75.57456	Hannan-Quinn criter.	-3.494565
F-statistic	1413.870	Durbin-Watson stat	2.673115
Prob(F-statistic)	0.000000		

Table B.3: Doña Ana County Net Domestic Migration Level Equation

Dependent Variable: DANDM
Method: Least Squares
Date: 08/25/14 Time: 17:08
Sample (adjusted): 1992 2012
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.438889	6.853689	0.209944	0.8362
DANDM(-1)	0.687723	0.193583	3.552605	0.0024
EMP	194223.3	106689.7	1.820450	0.0863
EMP(-1)	-198052.0	105588.4	-1.875699	0.0780

R-squared	0.450939	Mean dependent var	3.341637
Adjusted R-squared	0.354046	S.D. dependent var	3.735032
S.E. of regression	3.001892	Akaike info criterion	5.206006
Sum squared resid	153.1931	Schwarz criterion	5.404963
Log likelihood	-50.66306	Hannan-Quinn criter.	5.249185
F-statistic	4.653986	Durbin-Watson stat	1.366264
Prob(F-statistic)	0.014966		

Table B.4: Doña Ana County Net International Migration Level Equation

Dependent Variable: DANIM
Method: Least Squares
Date: 04/16/14 Time: 16:02
Sample (adjusted): 1992 2012
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.550433	0.380095	4.079063	0.0008
DANIM(-1)	0.531050	0.130415	4.071987	0.0008
DIFF(-2)	80.66736	30.81822	2.617522	0.0180
DIFF(-3)	-118.8520	33.19875	-3.580015	0.0023

R-squared	0.901499	Mean dependent var	0.780952
Adjusted R-squared	0.884117	S.D. dependent var	0.351540
S.E. of regression	0.119670	Akaike info criterion	-1.238519
Sum squared resid	0.243454	Schwarz criterion	-1.039562
Log likelihood	17.00445	Hannan-Quinn criter.	-1.195340
F-statistic	51.86257	Durbin-Watson stat	1.869579
Prob(F-statistic)	0.000000		

Appendix C: Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) Results

Table C.1: Doña Ana County Birth Equation ADF Test

Null Hypothesis: BIR_EQ1_RES has a unit root
Exogenous: Constant
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.517602	0.0127
Test critical values:	1% level	-3.610453	
	5% level	-2.938987	
	10% level	-2.607932	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BIR_EQ1_RES)
Method: Least Squares
Date: 08/26/14 Time: 16:05
Sample (adjusted): 1974 2012
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BIR_EQ1_RES(-1)	-0.757959	0.215476	-3.517602	0.0012
D(BIR_EQ1_RES(-1))	-0.059380	0.161076	-0.368644	0.7146
C	-0.001090	0.011920	-0.091471	0.9276

R-squared	0.403120	Mean dependent var	-0.005572
Adjusted R-squared	0.369960	S.D. dependent var	0.093462
S.E. of regression	0.074185	Akaike info criterion	-2.290695
Sum squared resid	0.198125	Schwarz criterion	-2.162729
Log likelihood	47.66855	Hannan-Quinn criter.	-2.244782
F-statistic	12.15680	Durbin-Watson stat	1.956120
Prob(F-statistic)	0.000092		

Table C.2: Doña Ana County Death Equation DF Test

Null Hypothesis: DEA_EQ7_RES has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.813989	0.0000
Test critical values:	1% level	-4.205004	
	5% level	-3.526609	
	10% level	-3.194611	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DEA_EQ7_RES)
Method: Least Squares
Date: 08/26/14 Time: 16:09
Sample (adjusted): 1973 2012
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEA_EQ7_RES(-1)	-1.364126	0.154768	-8.813989	0.0000
C	-0.000656	0.013423	-0.048864	0.9613
@TREND("1969")	3.70E-05	0.000513	0.072150	0.9429

R-squared	0.677427	Mean dependent var	0.001587
Adjusted R-squared	0.659991	S.D. dependent var	0.064190
S.E. of regression	0.037429	Akaike info criterion	-3.660680
Sum squared resid	0.051836	Schwarz criterion	-3.534015
Log likelihood	76.21361	Hannan-Quinn criter.	-3.614882
F-statistic	38.85141	Durbin-Watson stat	2.141345
Prob(F-statistic)	0.000000		

Table C.3: Doña Ana County Net Domestic Migration Equation ADF Test

Null Hypothesis: NDM_EQ6_RES has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.410193	0.0000
Test critical values:	1% level	-4.532598	
	5% level	-3.673616	
	10% level	-3.277364	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 19

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NDM_EQ6_RES)
Method: Least Squares
Date: 08/26/14 Time: 16:12
Sample (adjusted): 1994 2012
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NDM_EQ6_RES(-1)	-1.534151	0.182416	-8.410193	0.0000
D(NDM_EQ6_RES(-1))	0.303758	0.121391	2.502302	0.0244
C	-6.337961	2.159811	-2.934498	0.0103
@TREND("1969")	0.164115	0.062368	2.631380	0.0189

R-squared	0.839718	Mean dependent var	-0.135799
Adjusted R-squared	0.807661	S.D. dependent var	3.305573
S.E. of regression	1.449706	Akaike info criterion	3.765263
Sum squared resid	31.52472	Schwarz criterion	3.964092
Log likelihood	-31.77000	Hannan-Quinn criter.	3.798913
F-statistic	26.19498	Durbin-Watson stat	1.855541
Prob(F-statistic)	0.000003		

Table C.4: Doña Ana County Net International Migration Equation DF Test

Null Hypothesis: NIM_EQ2_RES has a unit root
Exogenous: Constant
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.955664	0.0073
Test critical values:	1% level	-3.808546	
	5% level	-3.020686	
	10% level	-2.650413	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NIM_EQ2_RES)
Method: Least Squares
Date: 08/26/14 Time: 16:53
Sample (adjusted): 1993 2012
Included observations: 20 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NIM_EQ2_RES(-1)	-0.982138	0.248287	-3.955664	0.0009
C	0.000804	0.026050	0.030881	0.9757

R-squared	0.465038	Mean dependent var	-0.006689
Adjusted R-squared	0.435318	S.D. dependent var	0.154624
S.E. of regression	0.116193	Akaike info criterion	-1.372497
Sum squared resid	0.243013	Schwarz criterion	-1.272924
Log likelihood	15.72497	Hannan-Quinn criter.	-1.353059
F-statistic	15.64728	Durbin-Watson stat	1.893496
Prob(F-statistic)	0.000927		

Table C.5: Doña Ana County Net International Migration Equation DF Test

Null Hypothesis: NIM_EQ2_RES has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.819813	0.0370
Test critical values:	1% level	-4.498307	
	5% level	-3.658446	
	10% level	-3.268973	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NIM_EQ2_RES)
Method: Least Squares
Date: 08/26/14 Time: 16:55
Sample (adjusted): 1993 2012
Included observations: 20 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NIM_EQ2_RES(-1)	-0.976444	0.255626	-3.819813	0.0014
C	0.045574	0.157540	0.289285	0.7759
@TREND("1969")	-0.001338	0.004639	-0.288362	0.7766

R-squared	0.467642	Mean dependent var	-0.006689
Adjusted R-squared	0.405012	S.D. dependent var	0.154624
S.E. of regression	0.119270	Akaike info criterion	-1.277376
Sum squared resid	0.241830	Schwarz criterion	-1.128016
Log likelihood	15.77376	Hannan-Quinn criter.	-1.248220
F-statistic	7.466710	Durbin-Watson stat	1.908688
Prob(F-statistic)	0.004707		

Appendix D: Exogenous Variable Forecasts

Table D.1: Exogenous Variable Forecasts (in thousands), 2013-2018

	2013	2014	2015	2016	2017	2018
dapy	6,694,211.18	6,754,459.09	6,997,619.61	7,277,524.40	7,481,295.08	7,653,364.87
% Change	1.15%	0.90%	3.60%	4.00%	2.80%	2.30%
pced	107.55	109.34	111.39	113.49	115.69	118.00
% Change	1.45%	1.66%	1.88%	1.88%	1.94%	2.00%
darpy	6,224,200.05	6,177,406.26	6,281,855.53	6,412,447.84	6,466,567.49	6,485,640.33
% Change	-0.30%	-0.75%	1.69%	2.08%	0.84%	0.29%
daemp	70.02	70.37	71.99	73.94	75.49	76.77
% Change	0.90%	0.50%	2.30%	2.70%	2.10%	1.70%
usbir	4,239.00	4,266.00	4,290.00	4,312.00	4,333.00	4,351.00
%Change	7.24%	0.64%	0.56%	0.51%	0.49%	0.42%
usdea	2,553.00	2,583.00	2,613.00	2,643.00	2,673.00	2,704.00
% Change	0.32%	1.18%	1.16%	1.15%	1.14%	1.16%
uspop	316,439.00	318,892.00	321,363.00	323,849.00	326,348.00	328,857.00
% Change	0.69%	0.78%	0.77%	0.77%	0.77%	0.77%
uspy	14,376.01	15,037.31	15,729.03	16,452.56	17,209.38	18,001.01
% Change	4.60%	4.60%	4.60%	4.60%	4.60%	4.60%
usrpcy	0.042	0.043	0.044	0.045	0.046	0.046
% Change	2.40%	2.10%	1.88%	1.88%	1.82%	1.77%
usemp	141,114.85	143,654.92	146,384.36	149,019.28	151,403.59	153,674.64
% Change	1.70%	1.80%	1.90%	1.80%	1.60%	1.50%
usumr	7.40%	6.40%	6.00%	5.80%	5.60%	5.40%
% Change	-8.64%	-13.51%	-6.25%	-3.33%	-3.45%	-3.57%
mxpop	122,418.49	124,009.93	125,622.06	127,255.15	128,909.47	130,585.29
% Change	1.30%	1.30%	1.30%	1.30%	1.30%	1.30%
mxrgdp	118.60	123.11	127.79	132.64	137.68	142.91
% Change	3.80%	3.80%	3.80%	3.80%	3.80%	3.80%
diff	0.038	0.039	0.041	0.041	0.042	0.043
% Change	0.03114527	0.03216187	0.03453239	0.00957271	0.0202481	0.01965243

Appendix E: Endogenous Variable Graphs

Figure E.1: Doña Ana County Births (in thousands), 1971-2018

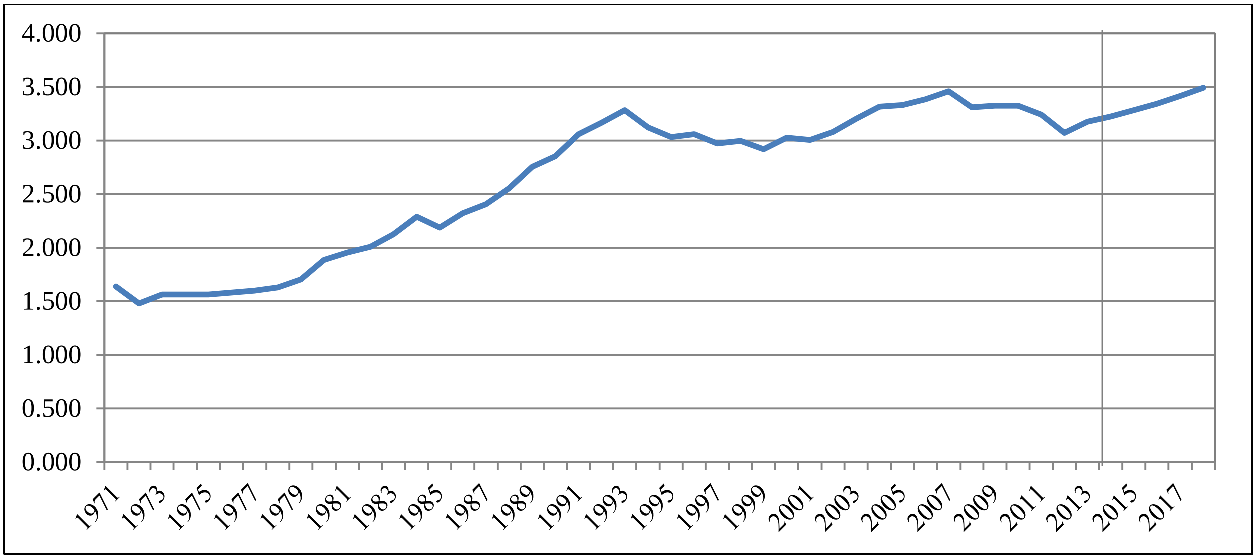

Figure E.2: Doña Ana County Deaths (in thousands), 1971-2018

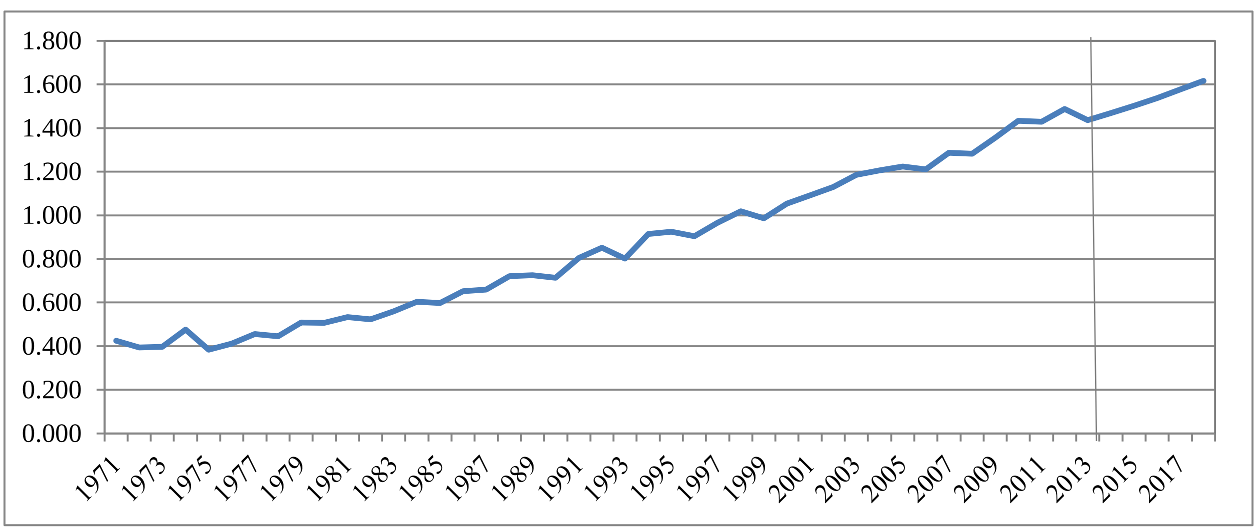

Figure E.3: Doña Ana County Net Domestic Migration (in thousands), 1991-2018

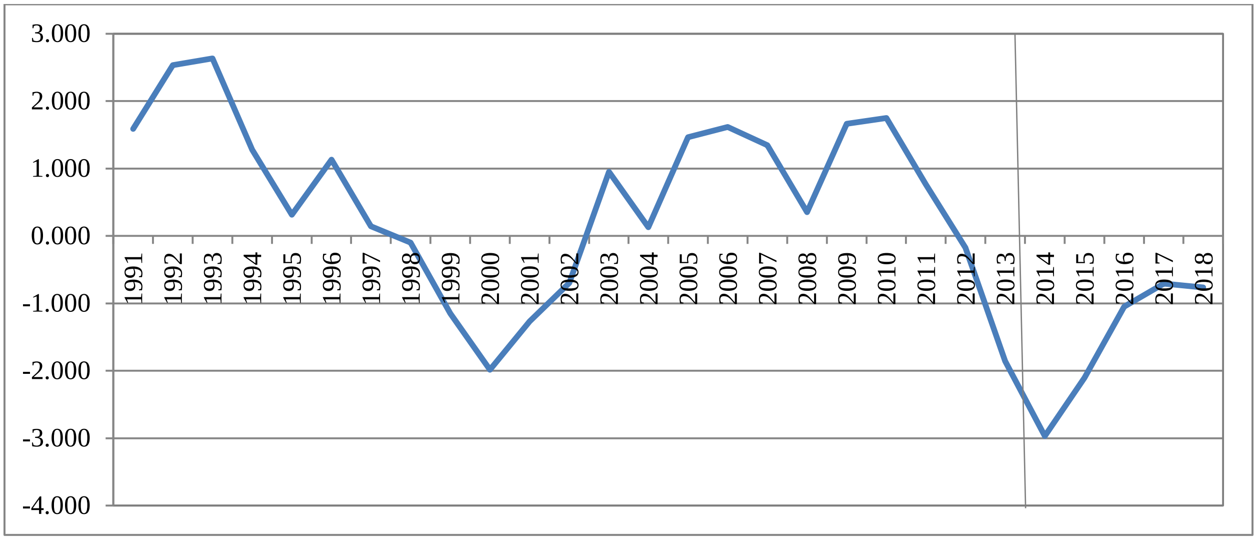

Figure E.4: Doña Ana Net International Migration (in thousands), 1991-2018

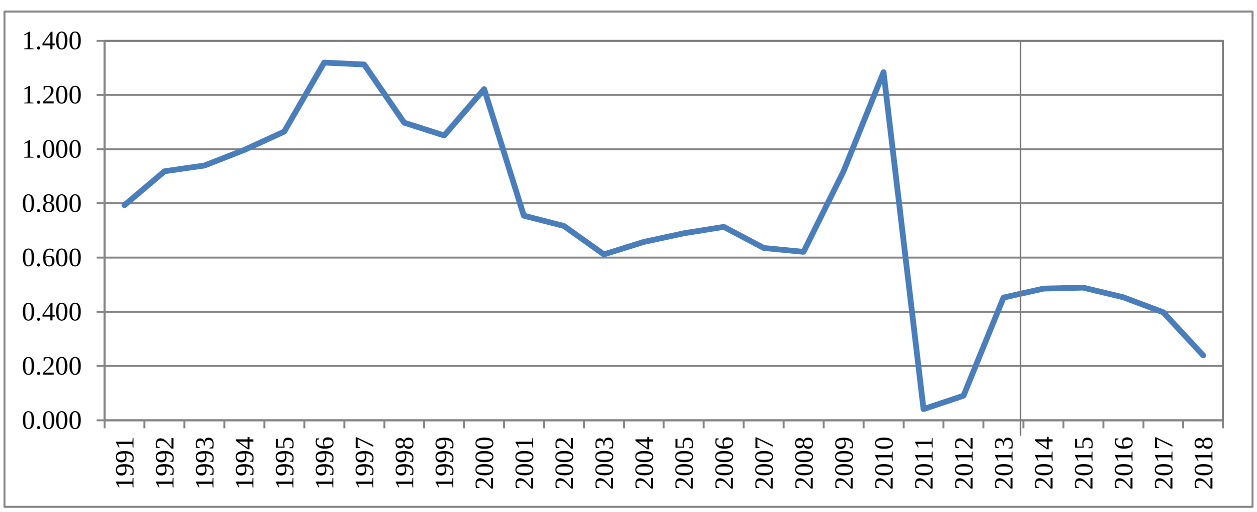

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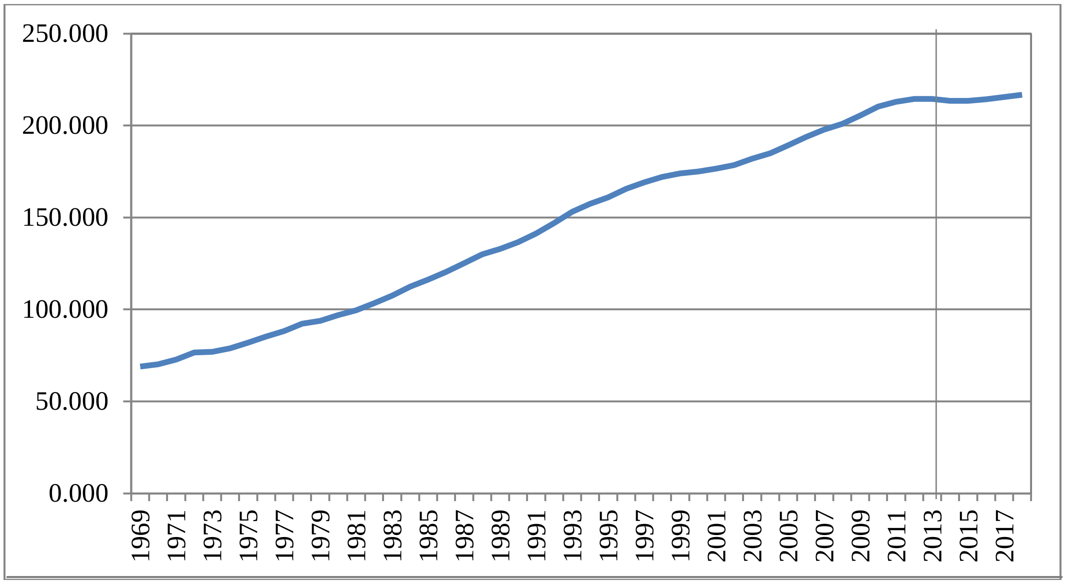
Figure E.5: Doña Ana Total Population Change (in thousands), 1969-2018.



Appendix F: Alternate Equations

Table F.1: Doña Ana County Net Domestic Migration Equation (with lags at 12 and 13)

Dependent Variable: DANDM
Method: Least Squares
Date: 08/24/14 Time: 15:08
Sample (adjusted): 1992 2012
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.90040	5.341964	2.976509	0.0085
DANDM(-1)	0.704948	0.132133	5.335127	0.0001
EMP(-12)	-503226.9	85443.36	-5.889596	0.0000
EMP(-13)	469254.7	84521.89	5.551872	0.0000

R-squared	0.791573	Mean dependent var	3.341637
Adjusted R-squared	0.754791	S.D. dependent var	3.735032
S.E. of regression	1.849534	Akaike info criterion	4.237388
Sum squared resid	58.15318	Schwarz criterion	4.436344
Log likelihood	-40.49257	Hannan-Quinn criter.	4.280566
F-statistic	21.52105	Durbin-Watson stat	2.136799
Prob(F-statistic)	0.000005		

Table F.2 Doña Ana County Net Domestic Migration Equation (without a lagged dependent Variable)

Dependent Variable: DANDM
Method: Least Squares
Date: 08/24/14 Time: 22:10
Sample (adjusted): 1991 2012
Included observations: 22 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	23.43776	4.819139	4.863475	0.0001
EMP(-1)	133125.0	24927.46	5.340497	0.0000
EMP(-12)	-212784.4	32935.56	-6.460628	0.0000

R-squared	0.697952	Mean dependent var	3.411752
Adjusted R-squared	0.666158	S.D. dependent var	3.659824
S.E. of regression	2.114612	Akaike info criterion	4.461744
Sum squared resid	84.96011	Schwarz criterion	4.610522
Log likelihood	-46.07918	Hannan-Quinn criter.	4.496791
F-statistic	21.95200	Durbin-Watson stat	1.755579
Prob(F-statistic)	0.000012		

Appendix G: Doña Ana County Differenced Equations

Table G.1: Doña Ana County Births Differenced Equation

Dependent Variable: DDABIR
Method: Least Squares
Date: 04/12/14 Time: 15:20
Sample (adjusted): 1972 2012
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.005986	0.017200	-0.348058	0.7297
DDPUBIRUP	1.162043	0.299160	3.884355	0.0004
DDDARPYPCE	1.41E-07	1.19E-07	1.184140	0.2437

R-squared	0.296829	Mean dependent var	0.034951
Adjusted R-squared	0.259820	S.D. dependent var	0.100887
S.E. of regression	0.086797	Akaike info criterion	-1.980132
Sum squared resid	0.286282	Schwarz criterion	-1.854748
Log likelihood	43.59270	Hannan-Quinn criter.	-1.934474
F-statistic	8.020451	Durbin-Watson stat	1.950518
Prob(F-statistic)	0.001242		

Table G.2: Doña Ana Deaths Differenced Equation

Dependent Variable: DDADEA
Method: Least Squares
Date: 05/13/14   Time: 16:14
Sample (adjusted): 1973 2012
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.020634	0.010970	1.880973	0.0679
DDADEA(-1)	-0.405981	0.138570	-2.929792	0.0058
DDARPYPCE(-2)	1.30E-07	6.41E-08	2.032515	0.0493

R-squared	0.274070	Mean dependent var	0.027350
Adjusted R-squared	0.234830	S.D. dependent var	0.041964
S.E. of regression	0.036708	Akaike info criterion	-3.699614
Sum squared resid	0.049856	Schwarz criterion	-3.572948
Log likelihood	76.99228	Hannan-Quinn criter.	-3.653816
F-statistic	6.984539	Durbin-Watson stat	2.647962
Prob(F-statistic)	0.002670		

Table G.3: Doña Ana County Net Domestic Migration Differenced Equation

Dependent Variable: DANDM
Method: Least Squares
Date: 08/24/14 Time: 15:27
Sample (adjusted): 1992 2012
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.933111	0.720109	4.073150	0.0007
DANDM(-1)	0.837361	0.136172	6.149282	0.0000
DEMP(-12)	-472462.1	95484.42	-4.948054	0.0001

R-squared	0.718285	Mean dependent var	3.341637
Adjusted R-squared	0.686984	S.D. dependent var	3.735032
S.E. of regression	2.089671	Akaike info criterion	4.443454
Sum squared resid	78.60105	Schwarz criterion	4.592672
Log likelihood	-43.65627	Hannan-Quinn criter.	4.475838
F-statistic	22.94720	Durbin-Watson stat	1.884297
Prob(F-statistic)	0.000011		

. **Table G.4: Doña Ana County Net International Migration Differenced Equation**

Dependent Variable: DANIM
Method: Least Squares
Date: 05/14/14 Time: 14:35
Sample (adjusted): 1992 2012
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.159092	0.106364	-1.495732	0.1521
DANIM(-1)	1.043512	0.108437	9.623238	0.0000
DGAP(-8)	138.4821	53.58040	2.584566	0.0187

R-squared	0.837913	Mean dependent var	0.780952
Adjusted R-squared	0.819904	S.D. dependent var	0.351540
S.E. of regression	0.149186	Akaike info criterion	-0.835689
Sum squared resid	0.400614	Schwarz criterion	-0.686471
Log likelihood	11.77473	Hannan-Quinn criter.	-0.803304
F-statistic	46.52582	Durbin-Watson stat	2.235557
Prob(F-statistic)	0.000000		

Vita

Diana Villavicencio was born and raised in El Paso, Texas and is the eldest daughter of Fernando and Bertha Villavicencio. She graduated from Coronado High School in 2005 and subsequently attended the University of Texas at El Paso (UTEP). There, she received a B.B.A in Economics and General Business in 2010. After completing her undergraduate degree, she enrolled in the Master of Science in Economics program at UTEP. During this time, she worked as a Graduate Teaching Assistant for the Department of Economics and Finance and as a Graduate Research Assistant at the Institute for Policy and Economic Development (IPED). She recently accepted a position as a Field Economist at the Office of Policy Development and Research (PD&R) with the U.S. Department of Housing and Economic Development (HUD) in Chicago, Illinois.>

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