Joint Prediction and Simulation of Labor Force and Fiscal Conditions of Nevada Counties

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Abstract
This study provides a system to jointly model labor and fiscal conditions of Nevada counties. Each is specified as a system of equations that are linked by allowing variables from the labor module to enter the fiscal module. Following the identification of parameters in the two modules, a simulation is analyzed to account for the effects of changes in exogenous employment to the labor and fiscal status of each Nevada county in addition to dynamic relationships of county budgets. In particular, uncertainties and noise in the estimation process are explicitly considered that allows the simulation process to produce confidence intervals rather than single point most likely solutions. This model may serve as a basis for understanding the ramifications of COVID-19 on the state of Nevada as county budget data becomes available in the future.

1 Introduction

County planning decisions involve onerous complexity in regards to matching tax base revenues with an appropriate allocation of resources to the amenities and services most valued by its residents. Rural counties in particular face uniquely challenging obstacles in making the fiscal decisions that best enhance the economic welfare and growth in a constrained resource environment. Often rural counties that are not diverse and relying on one or a few economic sectors find themselves vulnerable to being fiscally impacted by an idiosyncratic shock to a singular economic sector.

Building upon previous studies, the on-going applications of the Community Policy Analysis Network (CPAN) framework is applied in understanding the fiscal and labor sectors of the Nevada counties' economy. The empirical approach outlined by (Harris et al., 2000) and (Yeo and Holland, 2004) was followed with significant modifications. Compared with these previous studies, this current analysis addresses explicitly the issue of uncertainties in impact analysis and consequently policy decision making. Given the complexity of this process, a great deal of uncertainties is expected (Harris, 1995).

As (Chalmers and Anderson, 1977) state, “Uncertainty is the essence of the planning problem and the public is not well served by a strategy that simply plans for the most likely future.” Without an appropriate mechanism to incorporate these uncertainties into the decision-making process, results may be significantly biased, and this makes it difficult to provide a balanced and effective policy guidance to the county authorities. Some previous studies in county-level decision making notice some of the factors involved ((e.g. Swenson and Eathington, 1998)) but have not presented a clear approach to operationalize the analysis.

The primary objective of this paper is to develop a system that can link the labor and the fiscal sides of the county-level decision making while considering the uncertainties involved. First, a system of labor force models is established to generate the interrelationship between total labor supply, in- and out-commuting labor, unemployment, and county population growth. This procedure is critical given the uniqueness of Nevada counties. Nevada has a very low overall population density and yet the majority of Nevada’s population are concentrated in three metropolitan statistical areas (MSA’s): Las Vegas-Henderson-Paradise, Reno-Sparks, and Carson City. Even a slight labor or population change may introduce significant impacts to some counties (Swenson and Otto, 1998). Second, following (Harris et al., 2000) the fiscal conditions of Nevada counties are analyzed through the analysis of each county’s revenues and expenditures. A new approach is applied to model the potential correlations between these two fiscal aspects. Third, following Yeo and Holland (2004), the link between labor force and fiscal stages of the county-level decision making is introduced by allowing variables describing each county’s labor force characteristics to enter the models representing revenue and expenditure functions of a county government. Finally, the uncertainties involved with the decision-making process is addressed. This is achieved through taking appropriate consideration of the errors involved in various models.

2 Literature Review

Efficient local economic growth initiatives should consider all fiscal and labor factors which will lead to the need for creating a comprehensive approach by incorporating these factors in rural decision making (Harris et al., 2000). Following this need and with the assistance of relevant input-output analysis, a group of studies have focused on the impacts from regional policy changes and economic development on regional or industry sector fiscal conditions (e.g., Beemiller, 1989; Song et al., 1992). However, not until the launch of the CPAN (Community Policy Analysis Network) framework in 1995, has impact analysis has been formalized and presented in a systematic manner. The CPAN effort has brought impact analysis to a position with higher priority and drawn increasing attentions from both researchers and government policy makers.

The CPAN framework recommends studying regional economies in a comprehensive manner with focus on empirical module construction, appropriate estimation technique selection, sound interpretation, and feasible extension of results. Deller (1995) provides an overview of several characteristics of this framework and the early history involved in developing CPAN. Johnson and Scott (1996) and Swenson (1996) both offer applications of the CPAN framework addressing local economic issues and impact on regional decision making from changes in economic conditions. Swenson and Otto (1998) and Swenson and Eathington (1998) further summarizes the development of methods based on CPAN framework and impact analysis in general. Since then, empirical impact analyses within the framework of CPAN using more advanced techniques or with extended application areas have grown rapidly. Harris et al. (2000) and Yeo and Holland (2004) studied regional fiscal conditions and labor or population growth by building systems of models that reflect county-level decision making. Shields and Deller (2003) extract techniques from the broad impact analysis to improve the communication between regional authorities responsible for economic development and the general public. They also placed special focus on the pros and cons of the method. Bangsund et al. (2004) studied the impact from conservation policies on local agricultural and recreational activities. Evans and Stallmann (2006) extended the basic CPAN framework to create a customized system referred to as the TEX$AFE to address local situations in Texas.

A comprehensive approach is needed that considers all factors affecting the balance between economic growth and a county government's resource constraints (Harris et al., 2000). Additionally, as shown in Brückner and Pappa (2012), a comprehensive approach can capture the responses of labor force participation, employment, and unemployment from government expenditure shocks generated by fiscal policy changes. Using the relevant input-output has been in previous work for regional policy applications for economic development (Beemiller, 1989) and fiscal conditions of industries (Song et al., 1992).

Impact analysis took additional steps forward with CPAN (Community Policy Analysis Network) framework in 1995, by systematically formalizing and presenting data driven analysis for regional and community development with a position with higher priority and has drawn increasing attention from both researchers and government policy makers.

Further advancement of impact analysis with structural vector autoregressions (SVARs) by Brückner and Pappa (2012) incorporating the search and matching model of Diamond-Mortensen-Pissarides with insider and outsider labor market participant searching dynamics. Petrović et al. (2021) found that for Central and East European EU economies, effects of public investment on output are strong and persistent, but with shorter and weaker persistence for public consumption. Similar dynamics which they studied at an international scope are important for a regional scope in regards to local public investment and joint investment between localities. Cardi et al. (2020) analyzes sectoral fiscal impacts of government spending, finding that after the negative wealth effect is created from a spending shock causes households to provision more labor, increasing real GDP for 16 O.E.C.D. countries. Their application of sectoral fiscal multiplier estimates and sectoral share response to a government spending shock and partitioning the effects between traded and non-traded sectors.

3 Conceptual Framework

The labor sector and the fiscal sector of a county are considered jointly and can be conceptualized by Figure 1 . This diagram can be viewed as two sectors that are linked by some factors. The two sectors can be referred to as the labor module (the large box with solid border at the very left of the diagram and the two boxes in the middle of the diagram) and the fiscal module (the two smaller boxes at the very right edge of the diagram). In particular, population also functions as link between these two modules. This conceptual framework is discussed from left to right, i.e., from the labor module to the fiscal module. The labor module considers four factors in determining the supply of labor that are included in the large solid box at the left of the diagram. These factors are: employment, incommuting labor to the county known as incommuters, outcommuting labor to the county known as outcommuters, and the unemployed. There certainly are other factors that may be considered as important in this relationship. Some of these factors are considered in the specific models introduced in the next section. Nevertheless, the four factors in the box of Figure 1 represent those most commonly seen in the literature (e.g. Yeo and Holland, 2004) .

After defining these four factors in the labor module, the total labor force can be defined as a function that is affected by the four factors, which is captured by the arrow from the large box to labor force. Following (Yeo and Holland, 2004), labor force in turn determines the population growth in a county. This relationship is explained by the arrow from labor force to population in Figure 1. The labor module then includes the labor force and the population as a system of simultaneous equations. It is noteworthy however that within the four factors used to explain labor force, incommuters and outcommuters are likely to be endogenous. Any potential individual may decide to travel out of their resident county for work and this endogeneity has to be properly addressed in the modeling process. These two endogenous variables are reflected in Figure 1 by the dashed arrows directing to themselves. An appropriate modeling approach is to include equations explaining incommuters and outcommuters together with the two equations for labor force and population growth. Thus, these four equations complete the labor module.

For the fiscal module, the conceptual framework assumes that it is distinctively different from the labor sector but yet closely related (Swenson and Eathington, 1998). The distinctiveness is reflected by the fact that although the two individual models associated with the fiscal sector (expenditure and revenue) are estimated jointly to form the fiscal module, they are not directly included into the labor module. The close relationship between these two modules is created by the fact that many factors in the labor module are assumed to have direct impacts on the two aspect of the fiscal module. First of all, population is an important factor for counties to determine their expenditure. The increase of population may increase the overall expenditure but due to the potential higher concentration of population, the per capita expenditure by the county governments may decrease (Yeo and Holland, 2004). These effects can be captured by incorporating the population variable into the expenditure model.

The second source of impacts to the fiscal module may come from the factors that affect the supply of labor; i.e., the four factors identified in the labor module and included in the large box with solid border at the left of the diagram. These factors may also affect revenue in addition to expenditure. These relationships are represented by the dashed arrows linking these factors to the two equations of the fiscal module. Finally, the two fiscal models are incorporated into one complete system where they are modeled jointly. This is represented by the double dashed lined connecting these two measures in Figure 1. In this structure, factors affecting one aspect of the fiscal module (either expenditure or revenue) will also indirectly affect the other.

The conceptual framework presented in Figure 1 demonstrates a comprehensive system that accounts for both the labor and the fiscal sides of potential impacts to a county introduced by change of economic conditions. It provides a more complete picture of the county level impacts than considering only one side or the other (Harris et al., 2000). Given its completeness, the system is also relatively simple to implement. One can evaluate the labor and fiscal modules separately and the links between these two sectors are naturally created by the factors that appear in both modules, such as the population. Besides simplicity, the framework described in Figure 1 also differs from other existing systems that address the labor and fiscal conditions simultaneously (Yeo and Holland, 2004).

This is reflected by its capacity to allow uncertainty. No analysis can capture all impacts that may affect the system (Swenson and Eathington, 1998). The dotted arrows in the figure reflect this fact. Uncertainties or noise to the system may be introduced from two aspects. First are the omitted factors. Due to the complexity of the issues involved, models with a limited number of variables may in fact only be viewed as incomplete. Second, errors may be introduced in the estimation process. These uncertainties and errors make it necessary to allow the system to support results with upper and lower bounds with a certain level of confidence. These uncertainties or errors can be introduced in all stages of the framework outlined in Figure 1 and therefore can easily accommodate this requirement.

4 Data

Data used in this study are obtained and merged from two major sources for the period 2004 to 2016. The labor module uses data procured from the St. Louis Federal Reserve FRED economic data. For the labor module, FRED sources labor force from U.S. Bureau of Labor Statistics (B.L.S.), persons in the civilian labor force for each county and year. Unemployment figures are also from B.L.S. and the place of work employment $POWEMP_{i,t}$ is sourced from BLS Quarterly Census of Employment and Wages. For in- and out-commuting activities in each county the U.S. CENSUS "OntheMap" application is used. Additionally U.S. Census Bureau resident population figures for each county and year are used.

External labor force and external employment are denoted $XLF_{i,t}$ and $XMP_{i,t}$. Data for $XLF_{i,t}$ and $XMP_{i,t}$ are from B.L.S. employed persons and civilian labor data but were aggregated from the contiguous counties adjacent to each of the seventeen Nevada counties. Distance figures were determined by the shortest time driving distance between the county seats for each pair of adjacent counties using Google maps.

It is noticeable however, that since Nevada only has seventeen counties, it determines that labor module has a limited degree of freedom. To reduce this problem, (Harris et al., 2000) integrated bordering counties from nearby states based on the BEA classification. In this analysis, we choose to focus on Nevada counties only because this may offer a more direct description of conditions that would be of interest to the state. In addition, although not applied in this study, more advanced statistical methods, such as the Bayesian approach, may assist the analysis with limited data. This remains an interesting future research avenue for regional impact studies since in many cases, these studies are troubled by the lack of observations.

In the fiscal module, annual county general fund revenue and expenditure data for all 17 Nevada counties from Nevada Department of Taxation was complied into a panel dataset (Nevada Department of Taxation, various issues). The use of cross-sectional data for the labor module and panel data for the fiscal module does not impose a problem in this study. This is because the two modules are estimated separately but jointed by the common factors in both modules. The parameter estimates are those that are useful in interpretation and follow-up analysis.

5 Model and Empirical Methodology

5.1 Labor Model

Following the discussion on the aforementioned conceptual framework and (Swenson and Eathington, 1998), the labor module is comprised of four equations simultaneously explaining four quantities: labor force, incommuters, outcommuters, and the population. Based on the cross-sectional nature of the data used under the labor module and using subscript i to denote counties , subscript t to denote the year, and superscript to denote the equation number, the four equations can be expressed as:

$$LF_{i,t} = \beta_0^1 + \beta_1^1 POWEMP_{i,t} + \beta_2^1 INCOMM_{i,t} + \beta_3^1 OUTCOMM_{i,t} + \beta_4^1 UNEMP_{i,t} + \epsilon_{i,t}^1 \tag{1}$$

$$INCOMM_{i,t} = \beta_0^2 + \beta_1^2 POWEMP_{i,t} + \beta_2^2 XLF_{i,t} + \beta_3^2 UNEMP_{i,t} + \epsilon_{i,t}^2 \tag{2}$$

$$OUTCOMM_{i,t} = \beta_0^3 + \beta_1^3 POWEMP_{i,t} + \beta_2^3 XEMP_{i,t} + \beta_3^3 UNEMP_{i,t} + \epsilon_{i,t}^3 \tag{3}$$

$$POP_{i,t} = \beta_0^4 + \beta_1^4 LF_{i,t} + \epsilon_{i,t}^4 \tag{4}$$

where $LF_{i,t}$ is the total civilian labor force, $POWEMP_{i,t}$ is the place of work employment for the number of employees in the covered area for all industries, $INCOMM_{i,t}$ is the total number of incommuters who are employed in the study area but living outside the study area, $OUTCOMM_{i,t}$ is the total number of outcommuters who are living in the study area but employed outside the study area, $XLF_{i,t}$ external labor force, $XEMP_{i,t}$ is external employment, $POP_{i,t}$ is total population, $XLF_{i,t}$ and $XEMP_{i,t}$ are created following (Yeo and Holland, 2004) and (Swenson and Otto, 1998) where:

$$XLF_{i,t} = \sum_j \frac{Contiguous\ Labor\ Force_{j,t}}{distance_{ji}^2}$$

$$XEMP_{i,t} = \sum_j \frac{Contiguous\ Employment_{j,t}}{distance_{ji}^2}$$

Subscript j represents the adjacent counties to county i and $distance_{ji}$ represents the distance between county seats of county j to i.

Given the construct of the four equations for the labor force models, the system is simultaneous which requires using the three stage least squares (3SLS) estimation approach. The first group of candidates for instrument variables is the exogenous variables present in the equations. These variables are: $POWEMP_{i,t}$, $XLF_{i,t}$, and $XEMP_{i,t}$. Given the system, to ensure that it is identifiable, at least four instruments are required. Although more instrument variables can be used, an exact instrument may often reduce the complexity of estimating and validating the system (Kennedy, 2003). After several trials, the variable describing contiguous employment is selected as the additional instrument variable as the incorporating of this variable generates the highest overall model fit in comparison to several other competing options. As to the functional form, there is no explicit theoretical guidance. The selection is rather case by case. Given the most commonly used linear or logarithm forms, we have tested different models with these specifications and the linear models appear to have the best model fit.

5.2 Fiscal Model

The fiscal impact module considers the expenditure and revenue of each of seventeen counties in Nevada. Denote $PCEXP_{i,t}$ and $PCREV_{i,t}$ as the per capita expenditure and revenue for each county and subscript t for time, the following expressions can be specified:

$$PCEXP_{i,t} = f(POWEMP_{i,t}, UNEMP_{i,t}, POPDEN_{i,t}, PCB_{i,t-1}) \tag{5}$$

$$PCREV_{i,t} = f(POWEMP_{i,t}, UNEMP_{i,t}, , PCB_{i,t-1}) \tag{6}$$

where $POPDEN_{i,t}$ is population density of county i in year t and $PCB_{i,t-1}$ is fiscal balance per capita in county i in year t. $PCB_{i,t-1}$ is used instead of other income variables (such as household incomes) and this is because the county-level fiscal conditions are of interest in this study. Per capita fiscal balance enters the models in a one-period lagged form since it is only expected that the previous term's balance, which is observed at the end of the previous term, will affect the current period's financial decisions of the government, but not the current term's balance.

Also the lagged per capita balance variable is supported by Holtz-Eakin et al. (1987) whose research suggested that standard regressions that examine only the contemporaneous relationships of county budget fiscal variables are inappropriate. There exist inter-temporal relationships that need to be incorporated in county government fiscal models. In this application, the two models take a linear functional form, which is the most commonly seen in the literature. The panel nature of the data is addressed by incorporating one-way fixed effects into the two models to capture the differences between counties.

Similarly, variables in the fiscal models may take either their original or the log form in the literature (Harris et al., 2000). After some investigation, models with linear dependent variable and log independent variables seem to have the best fit. This structure is taken as the final model specification. Variable $PCB_{i,t-1}$ however was not transformed into log format due to the fact that some observations of the balance terms are negative Specifically, the expenditure and revenue models can be written as:

$$\begin{aligned} PCEXP_{i,t} = \alpha_{0,i} + \alpha_1 LNPOWEMP_{i,t} + \alpha_2 LNUNEMP_{i,t} \\ + \alpha_3 LGPCB_{i,t} + \alpha_4 LNPOPDEN_{i,t} + \epsilon_{i,t} \end{aligned} \tag{7}$$

$$PCREV_{i,t} = b_{0,i} + b_1 LNPOWEMP_{i,t} + b_2 LNUNEMP_{i,t} + b_3 LGPCB_{i,t} + \nu_{i,t} \tag{8}$$

where LNPOWEMP, LNUNEMP, and LNPOPDEN are the log transformation of variables POWEMP, UNEMP, and POPDEN. Variable LGPCB is the lagged term of variable PCB while $\epsilon_{i,t}$ and $\nu_{i,t}$ are error terms. It is obvious that the above models could be consistently estimated individually as separate models, but since government expenditure and revenue are often resulted from one system of decisions, these two quantities are expected to be correlated. In other words, error terms $\epsilon_{i,t}$ and $\nu_{i,t}$ are expected to be correlated as well. This gives a system of equations that can be estimated by the seemingly unrelated regression (SUR) approach. The definition and descriptive statistics of variables used in this study are summarized in Table 1.

6 Estimation Results

The three stage least squared (3SLS) estimation results of the labor force models are presented in Table 2. The overall adjusted R squared values are high indicating good model fit. Signs of model coefficients are consistent with previous literature. Place of work employment has positive impacts in all three models: labor force, incommuters, and outcommuters. For the labor force model, while incommuters decrease labor force, outcommuters have a positive impact. Although this result is difficult to interpret, it is consistent with (Yeo and Holland, 2004). Further investigation of this issue may be warranted.

Variable XLF (external labor force) has a positive coefficient in the incommuters model, indicating that the increase of external labor force will lead to increase in the number of incommuters. Similarly, an increase in external employment (variable XEMP) will increase the number of outcommuters. Finally, total labor force has direct positive impact on the growth of population as reflected by the positive coefficient associated with variable LF in the population model. Since the labor module is closely related to the fiscal module and the fiscal module also extends the labor module, we interpret the fiscal module in more detail.

The single equation and SUR estimation results of the fiscal models are presented in Table 3. Most of the fixed effects constant terms are significant in both models under either the single equation or the SUR estimation procedures. These constants however are omitted from this table for simplicity. The adjusted R^2 value indicates that the SUR model has a better fit than the single equation estimation with regards to the expenditure model but worse than the fit with regards to the single equation revenue model. Signs of coefficients are consistent across the two estimation procedures. Place of work employment has positive impact on both government expenditure and revenue. This can be interpreted as the employment contributing to the increase of the volume of local economy. Based on the formulation of the models, the marginal effect of employment to government expenditure evaluated at the average employment level across Nevada is given as the ratio of the coefficient associated with variable LNPOWEMP and the average employment: $\frac{b_{LNPOWEMP}}{average(POWEMP)}$.

The implied marginal effect is 0.00121 and 0.012285 under the single equation and SUR estimation respectively. These indicate that the one additional employee will generate approximately \$0.001 to \$0.012 in expenditure per capita for Nevada counties on average. Similarly, one additional employee will contribute \$0.0023 and \$0.01624 in per capital revenues of the counties under the single equation and SUR methods. Therefore, if only the public fiscal conditions are considered, new employment leads to more revenue than expenditure to the county governments.

LNUNEMP is also significant under the revenue model and unemployment will lead to less expenditure for the counties. Based on a similar calculation as above, a one person decrease in the number of unemployed will yield an additional \$-0.004122 in per capita expenditure to the county in the single equation approach and \$0.004465 in per capita expenditure in the SUR approach. It is clear from these results that an additional employee can stimulate the economy and generate economic activity for Nevada counties due to the coefficient's sign in the single equation and SUR methods. However, unemployment only produces net government expenditure and accordingly impacts fiscal balances for Nevada country governments. Furthermore, the marginal effect of unemployment (evaluated at the average unemployment level) on county expenditures is close to four times greater than that from employment. Therefore, any further degradation of federal unemployment assistance programs to county governments without accompanying financial assistance will negatively impact country government fiscal balances.

County population density is only used to explain county expenditures. Previous studies show that the higher the population density yields lower per capita government expenditure (Harris et al., 2000). This is consistent with the result in the paper. The marginal effect indicates that one additional person per square mile in Nevada can reduce the government expenditure by $98.22 per capita in the single equations case or $441.17 per capita in the SUR model, as seen in Table 6 and Table 3 respectively. These values are considerably large partially because many rural counties in Nevada are the most sparsely populated in the nation. Ensuring the offering and quality of many federally and state mandated public facilities and services to all Nevadans can be a costly proposition especially for the sparsely populated rural areas.

The lagged per capita county balance variable (LGPCB) is significant and positive in both fiscal models, except for the SUR revenue model. These positive coefficients also confirm (Holtz-Eakin et al., 1987) research that inter-temporal relationships need to be incorporated in county government models. Since variable LGPCB was included in the models in its linear form, the marginal effect is the coefficient associated with the variable in the models. Each additional per capita dollar from the last fiscal year can generate an additional $0.86 in per capita expenditure (based on the single equation model) and approximately $0.89 (consistent in two estimation procedures) in increased per capita revenue. An alternative way to explain this effect is to first calculate net revenue or loss, the difference between the expenditure and revenue implied in the period, then this calculated amount may be interpreted as the result of the balance increase or dissipation from the beginning of the period to the end of the period. In this case, holding other factors constant, a one-dollar per capita balance entering the fiscal year can generate $0.06 in per capita balance at the end of the fiscal year.

7 Simulation

Given the estimation results of the labor force and the fiscal impact models, it is feasible to investigate the impact of an external shock to the local Nevada labor and fiscal conditions. Following (Swenson and Eathington, 1998), simulations of model predictions are conducted by assuming the place of work employment as an exogenous shock. In community models, employment opportunities can often be assumed to come from external investment such as the location or relocation of a manufacturing or service business. Jobs are created by these external investments and therefore stimulate both the labor force and fiscal balances in a community. A simulation model usually begins with the labor force models. Since the labor force models are simultaneous, the assumed exogenous shock (such as a change in place of work employment in variable POWEMP) will not give a unique solution to the system. A solution however can be achieved by converting the labor force models into the reduced form through substituting. After substituting, the labor force model can be rewritten as:

$$LF_i = (\beta_0^1 + \beta_2^1\beta_0^2 + \beta_3^1\beta_0^3) + (\beta_1^1 + \beta_2^1\beta_1^2 + \beta_3^1\beta_1^3)POWEMP + \beta_2^1\beta_2^2 XLF + \beta_3^1\beta_2^3 XEMP \tag{9}$$

The reduced form labor force equation, the population growth equation, and the fiscal models can be further written by substituting the corresponding estimated coefficients:

$$POP_i = \beta_0^4 + \beta_1^4 LF \tag{10}$$

$$\begin{aligned} PCEXP_{i,t} = \alpha_{0,i} + \alpha_1 LNPOWEMP_{i,t}\alpha_2 LNUNEMP_{i,t} \\ + \alpha_3 LNPOPDEN_{i,t} + \alpha_4 LGPCB_{i,t} \end{aligned} \tag{11}$$

$$PCREV_{i,t} b_{o,i} + b_1 LNPOWEMP_{i,t} b_2 LNUNEMP_{i,t} + b_3 LGPCB_{i,t} \tag{12}$$

To incorporate the errors involved in estimating the labor force and fiscal impact equation systems, estimated coefficients are drawn using the approach specified by (Krinsky and Robb, 1986). The coefficients are assumed to be drawn from a multivariate normal distribution with mean and covariance matrix given by the estimation results in the two systems, respectively.

Table 4 and Table 7 summarize the results after assuming the place of work employment changes by 1% for each county within state of Nevada. In both tables, various quantities measured before and after the change are reported. The purpose of presenting the values before change is to verify the robustness of the simulation process through comparing the simulated measures with the actual data. Simple comparisons show that the simulations indeed produce reliable results. The mean estimates and their associated standard deviations reported in Table 4 and Table 7 are obtained after 1,000 simulation replications. All results are significant based on the relative magnitude of the mean estimates to their corresponding standard deviations. Table 4 gives the labor module simulation results for the overall labor force and population. For each county, the increase of 1% place of work employment will yield approximately 1,083 person increase in the overall labor force. This is because the coefficient of variable POWEMP is translated to approximately one in its relationship to variable LF (labor force).

The standard deviation associated with each county's labor force gives an interval range for which the estimated labor force may fall after the change of place of work employment. For example, for the county of Carson City, the predicted increase in the labor force after an increase in place of work employment of 1% is approximately 38,364 with a t-test statistic of 1.7 which coincides with a p-value of 9%. Therefore, when analyzing the impact of the increased place of work employment on labor force, county authorities or county economic development professionals should use the interval for economic and fiscal impact analysis rather than a simple mean estimate. The same principle applies to other aspects in both the labor module and the fiscal module. However, calculated standard deviation estimates for sparsely populated rural Nevada counties such as Esmeralda County are quite large compared with the mean estimates. Prediction in these counties can be impacted greatly by outliers. For population, the change in each county is approximately 1%. This can also be explained by the coefficient of variable LF in the model of population, which is approximately 2. Overall, the labor module indicates a magnifying effect of place of work employment on population growth. In other words, one unit increase in place of work employment will create one unit increase in labor force and subsequently cause the population to increase by two units.

Similarly, the fiscal module is simulated in accordance to the increase in place of work employment. From the mean estimate, the increase of POWEMP increases per capita expenditure in most counties, except for Carson City, Eureka, Storey, and Washoe counties. This can be explained: although an increase of POWEMP will lead to increase in population, which by theory and by model coefficient in this study, will decrease the per capita expenditure, the direct impact of POWEMP and the induced impact of un- employment act positively on per capita expenditures. Depending on the relative strength of these variables and the magnitude of other variables in the expenditure model, the effects on per capita expenditures may either be positive or negative. Nevertheless, these comparisons are only based on the mean estimates of expenditures before and after the change. When the standard deviations are considered, the interval of per capita expenditure may overlap (such as in Storey county), which in turn indicates that for these counties based on a certain level of statistical confidence, the change in per capita expenditures may be either positive or negative. For the per capita revenue, results based on the mean estimates show that all changes are positive. When standard deviations associated with each mean estimate are considered, these differences are also not fixed. For example, a 1% POWEMP increase in Clark County may increase the county's per capita revenues by 0.23 cents based on mean estimates but the same result does not necessarily hold when standard deviations are incorporated. Model results which incorporated both mean and standard deviation estimates affirm concerns of Chambers and Anderson (1977) that uncertainty is the essence of the planning problem and that the public may not be well served by fiscal analysis that incorporates only the most likely future.

Table 7 presents the simulated results of a 1% change from the base level in POWEMP on the probability of a negative fiscal balance. Overall, the average nevada county reduces the probability of a negative fiscal balance by 7%. The change in probability from the base level values differs widely when examining individual counties. Washoe county for example has a 32% increase in the probability of a negative fiscal balance. This result aligns with results from Table 7 where the fiscal module simulation for Washoe indicates a 19.01% increase in per capita expenditures but only a 9.31% increase in per capita revenues.

8 Conclusions

In this article a system that jointly considers both the labor and fiscal aspects of county-level decision-making process are analyzed. In the labor module, it is found that place of work employment has positive impacts on overall labor force, incommuters and outcommuters. The endogenous variables incommuters and outcommuters also have important implications on the overall labor force. The growth of county population can be explained relatively well by the labor force. Model results indicate a one-person labor force increase yields a two person increase in county population. The fiscal module is closely related to the labor module since some key factors in the labor sector are significant in explaining the fiscal status of a county, and that increased population density tends to lower county per capita expenditure. Increasing place of work employment may boost the size of the counties' economy. The fiscal balance from the previous year also has important implications on the current year's, cut government expenditures and revenues. Incorporating previous year balances enhances the county fiscal model by incorporating dynamic relationships in county budgets, which is often ignored.

The effects of linking the labor and the fiscal modules are further demonstrated by a series of simulations. Changes are assumed to be introduced exogenously to the place of work employment. The simulation results provide not only replication of current situations but also predictions under the exogenous changes. Most importantly, the results show that if only mean estimates are considered, county governments' decision may be biased in terms of reflecting the magnitude and even the direction of the impacts of changes. The statistical confidence intervals provided in this study may help the decision makers to incorporate uncertainty in their planning process by deriving potential impacts other than the most likely future. One way of future modification may be using the approach outlined in (Harris et al., 2000) where they break down the labor force and employment into sectors according to their nature, such as tradable labor and non-tradable labor. Finally, such a fiscal and labor model might be adapted to other exogenous shocks such as the COVID-19 pandemic.

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Table 1: Variable Definition and Sample Statistics

VARIABLE	DEFINTION	MEAN	STD. DEV.
LABOR FORCE MODELS:			
LF	total labor force	62,414.73	183,525.20
POWEMP	place of work employment	55,636.73	162,960.39
INCOM	total number of incommuters	14,727.48	45,105.30
OUTCOM	total number of outcommuters	18,359.53	60,278.58
UNEMP	total number of unemployment	5,529.53	17,895.07
XLF	external labor force	22,074.65	137,508.91
XEMP	external employment	315.68	1,253.44
POP	total population	148,228.82	424,782.71
CONEMP	contiguous employment	626,374.95	1,355,917.83
FISCAL MODELS:			
PCEXP	per capita government expenditure (inflation adjusted)	1,616.23	2,011.59
PCREV	per capita government revenue (inflation adjusted)	1,705.09	2,107.96
POWEMP	place of work employment	55,636.73	162,960.39
UNEMP	total number of unemployment	5,529.53	17,895.07
POPDEN	population density (person/ sq. mile)	36.32	73.96
LNPOWEMP	log of place of work employment	9.13	1.72
LNUNEMP	log of total number of unemployment	6.71	1.72
LNPOPDEN	log of population density (person/ sq. mile)	1.84	1.91
LGPCB	lagged per capita balance	1,084.91	2,048.27

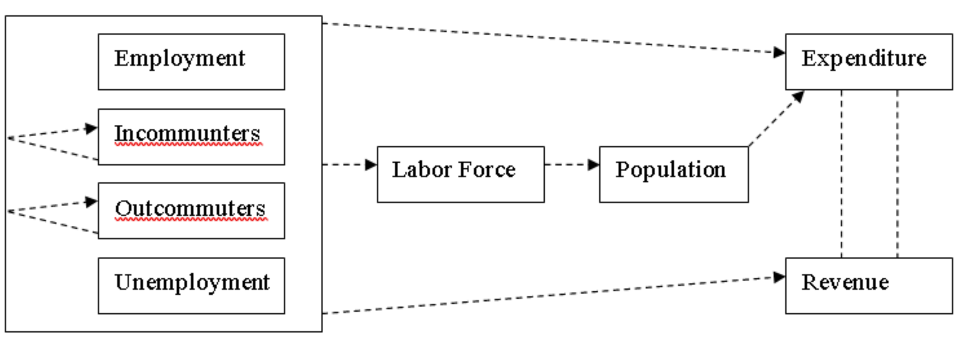

Figure 1: Conceptual Framework Diagram

Table 2: 3SLS Estimation Results of Labor Force Models (No Fixed Effects)

Variable	Labor Force		Incommuters		Outcommuters		Population Growth	
	Coeff.	Std Error	Coeff.	Std Error	Coeff.	Std Error	Coeff.	Std Error
Constant	607.575	781.911	3943.595	1509.271	2408.419	512.258	6516.913	3964.707
POWEMP	1.182	0.016	0.188	0.009	0.0512	0.003		
INCOMM	-1.905	0.4375						
OUTCOMM	1.311	0.296						
XLF			0.013	0.004				
XEMP					41.475	0.421		
LF							2.270	0.020
R^2	0.992		0.466		0.963			

Table 3: Single Equation and SUR Estimation Results of the Fiscal Models

	Expenditure			Revenue	
Variable	Single Equation	SUR Model	Variable	Single Equation	SUR Model
LNPOWEMP	0.0228532	0.0306297	LNPOWEMP	0.0621259	0.0621259
Std. Err.	0.0218321	0.0201045	Std. Err.	0.0202605	0.0200763
LNUNEMP	-0.0699935	-0.0674783	LNUNEMP	-0.0895202	-0.08952
Std. Err.	0.0201222	0.0197304	Std. Err.	0.0211843	0.0209917
LNPOPDEN	0.0360409	0.0249414	LGPCB	0.0000437	0.0000437
Std. Err.	0.0154736	0.0104106	Std. Err.	0.0000107	0.0000106
LGPCB	0.0000581	0.000056			
Std. Err.	0.0000105	0.0000101			
Constant	1.422874	1.3561	Constant	1.26939	1.26939
Std. Err.	0.1385623	0.1192406	Std. Err.	0.1097326	0.108735
R^2	0.1924	0.2052	R$\hat{2}$	0.1831	0.1942

Table 4: Simulation Results of the Labor Force Module

			Labor Force			
Counties	Base	EMP 1%	Change (after-before)	% Change	T-Test stat	P-value
NEVADA	**1,072,687**	**1,083,183**	**10,497**	**0.98%**	**1.42**	**16%**
Carson City	38,125	38,364	240	0.63%	1.70	9%
Churchill	6,407	6,474	67	1.05%	1.70	9%
Clark	782,158	789,948	7,789	1.00%	1.16	25%
Douglas	19,111	19,264	153	0.80%	1.00	32%
Elko	16,778	16,979	202	1.20%	1.78	8%
Esmeralda						
Eureka	672	714	42	6.29%	0.98	33%
Humboldt	4,142	4,215	72	1.74%	1.69	9%
Lander	364	391	28	7.60%	0.64	52%
Lincoln						
Lyon	770	780	11	1.37%	0.18	86%
Mineral						
Nye	7,225	7,321	96	1.32%	1.05	30%
Pershing						
Storey	25,513	25,570	57	0.22%	0.40	69%
Washoe	171,135	172,841	1,705	1.00%	1.14	26%
White Pine	287	322	35	12.35%	1.32	19%

			Population			
Counties	Base	EMP 1%	Change (after-before)	% Change	T-Test stat	P-value
NEVADA	**2,531,422**	**2,555,252**	**28,830**	**0.94%**	**1.52**	**13%**
Carson City	92,798	93,342	544	0.59%	1.80	7%
Churchill	20,943	21,095	152	0.73%	1.97	5%
Clark	1,771,484	1,789,168	17,684	1.00%	1.21	23%
Douglas	49,664	50,012	348	0.70%	1.05	29%
Elko	44,345	44,803	458	1.30%	2.00	5%
Esmeralda	6,513	6,513	0	0.00%		
Eureka	8,032	8,128	96	1.19%	0.99	33%
Humboldt	15,837	16,001	164	1.04%	1.79	7%
Lander	7,314	7,377	63	0.86%	0.65	52%
Lincoln	6,491	6,491	0	0.00%		
Lyon	8,000	8,024	24	0.30%	0.27	79%
Mineral	6,495	6,495	0	0.00%		
Nye	22,703	22,919	217	0.96%	1.22	22%
Pershing	6,484	6,484	0	0.00%		
Storey	64,417	64,547	130	0.02%	0.39	69%
Washoe	392,781	396,652	3,871	0.99%	1.18	24%
White Pine	7,119	7,200	80	1.13%	1.43	15%

Table 5: Simulation Results of the Fiscal Model

Per Capita Expenditure						
Counties	Base Avg.	EMP 1%	Change (after-before)	% Change	T-Test stat	P-value
NEVADA	**1,828**	**1,848**	**20**	**1.09%**	**0.79**	**43%**
Carson City	1,199	639	-560	-46.69%	-27.09	0%
Churchill	773	822	49	6.35%	8.95	0%
Clark	596	721	126	21.08%	8.18	0%
Douglas	883	631	-252	-28.50%	-9.92	0%
Elko	628	608	-20	-3.25%	-3.85	0%
Esmeralda	5,088	4,731	-357	-7.02%	-2.44	2%
Eureka	8,833	9,274	441	4.99%	1.11	27%
Humboldt	1,064	1,147	83	7.83%	6.50	0%
Lander	2,065	1,999	-66	-3.20%	-2.40	2%
Lincoln	811	824	13	1.65%	0.66	51%
Lyon	595	634	39	6.61%	4.37	0%
Mineral	1,420	1,426	6	0.47%	0.46	65%
Nye	790	793	3	0.38%	0.70	49%
Pershing	1,043	964	-79	-7.64%	-5.60	0%
Storey	3,368	3,434	66	-1.98%	1.01	31%
Washoe	647	770	123	19.01%	8.67	0%
White Pine	1,305	1,443	138	10.56%	5.69	0%

Per Capita Expenditure						
Counties	Base Avg.	EMP 1%	Change (after-before)	% Change	T-Test stat	P-value
NEVADA	**1,916**	**1,966**	**80**	**4.17%**	**3.96**	**0%**
Carson City	1,185	928	-257	21.68%	-9.64	0%
Churchill	779	835	56	7.16%	6.87	0%
Clark	592	605	13	2.20%	2.17	3%
Douglas	886	742	-144	16.23%	-7.37	0%
Elko	581	685	104	17.91%	14.67	0%
Esmeralda	5,095	4,740	-355	-6.97%	-1.71	9%
Eureka	10,071	11,248	1,177	11.69%	5	0%
Humboldt	1,104	1,279	175	15.81%	12.98	0%
Lander	2,562	2,596	34	1.33%	0.65	51%
Lincoln	574	775	201	35.03%	24.82	0%
Lyon	574	591	17	2.94%	3.71	0%
Mineral	1,299	1,305	6	0.50%	-0.29	78%
Nye	784	778	-6	-0.77%	-0.65	52%
Pershing	1,060	1,033	-26	-2.50%	-1.43	15%
Storey	3,474	3,553	79	2.27%	2.24	3%
Washoe	673	735	63	9.31%	9.38	0%
White Pine	1,311	1,256	-55	-4.17%	-0.96	34%

Table 6: Marginal Effects Single Equations

	Single Equation	SUR
LNPOWEMP	67.21	128.1
	(70.01)	(61.61)
LNUNEMP	-229.0***	-216.9***
	(64.53)	(64.42)
LNPOPDEN	98.22*	
	(49.62)	
LGPCB	0.859***	0.886***
	(0.0336)	(0.0327)
_cons	1429.9**	1018.7**
	(444.3)	(333.7)
N	221	221

Table 7: Simulation Results of Fiscal Model and Chances of a Negative Fiscal

	Per Capita Fiscal Balance (dollars)					Probability of a Negative Per Capita Fiscal Balance		
Counties	Base Avg.	EMP 1%	Change	T-Test stat	P-value	Base Avg.	EMP 1%	Change
NEVADA	88	148	60	2.31	0.02	19%	22%	-7%
Carson City	-14	289	303	15.66	0	54%	3%	-51%
Churchill	6	13	7	1.15	0.25	44%	39%	-6%
Clark	-4	-117	-113	-7.66	0	53%	86%	33%
Douglas	3	111	108	9.63	0	48%	10%	-39%
Elko	-47	78	125	12.19	0	73%	15%	-59%
Esmeralda	7	9	2	0.02	0.99	45%	45%	0%
Eureka	1,238	1,974	736	1.79	0.07	30%	22%	-8%
Humboldt	41	132	91	6.95	0	34%	8%	-26%
Lander	497	597	100	1.63	0.1	14%	6%	-8%
Lincoln	-237	-49	188	9.55	0	96%	66%	-30%
Lyon	-21	-43	-22	-2.55	0.01	68%	78%	10%
Mineral	-121	-121	0	-0.01	0.99	79%	78%	0%
Nye	-6	-15	-9	-0.91	0.37	53%	55%	2%
Pershing	17	70	53	2.62	0.01	45%	26%	-19%
Storey	106	118	12	0.17	0.87	35%	35%	0%
Washoe	26	-34	-60	-5.88	0	34%	67%	32%
White Pine	6	-187	-193	-3.94	0	53%	37100%	18%