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Macroeconomic changes and mortality in Mexico

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Abstract While previous studies examine how the business cycle affects mortality in developed countries, less is known about this relationship in developing countries. In this paper, we investigate whether the procyclical nature of mortality in developed countries found by Ruhm (Q J Econ 115(2):617–650, 2000) and others is also present in Mexico. We assemble a unique panel data set that contains state-level data on mortality rates by age and cause of death, GDP per capita, and socioeconomic status. We find that for Mexico total mortality rates are procyclical, with the largest impact on those aged 20–49. While these findings are similar to those in Ruhm (Q J Econ 115(2):617–650, 2000), the effects of business cycles on mortality rates differ for several specific causes of death. These results suggest that whereas total mortality may be procyclical in both developed and developing countries, significant differences may exist for some causes of death.

Keywords Business cycles · Mortality rates · Developing countries · Mexico

JEL Classification C33 · E32 · I1

1 Introduction

In his seminal paper, Ruhm (2000) analyzes the relationship between business cycles and mortality in the U.S. Using state-level data from 1972 to 1991, he finds that

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upturns in state economic activity are associated with increases in total mortality.[1] The finding that mortality rates are procyclical was suggested by earlier works for the U.S. and the U.K. (Ogburn and Thomas 1922; Thomas 1927) and the U.S. (Eyer 1977), among others. In more recent papers, this procyclical relationship has been confirmed for longer periods in the U.S. (Tapia Granados 2005a), and in studies of Germany (Neumayer 2004), Spain (Tapia Granados 2005b), a group of five European countries (McAvinchey 1988), and for 23 developed countries within the Organization for Economic Cooperation and Development (OECD) (Gerdtham and Ruhm 2006).[2]

However, whereas the aforementioned studies investigate rich countries, less is known regarding the relationship between mortality and business cycles in developing countries. Studies for middle and middle-high income countries report a wide range of results from procyclical (Abdala et al. 2000; Khang et al. 2005), to procyclical and inconclusive (Rios-Neto and Carvalho 1997; Ortega-Osona and Reher 1997; Bravo 1997), to inconclusive (Palloni and Hill 1997), and to countercyclical (Lee 1997; Cutler et al. 2002). Most of these studies employ national data and a time series methodology that may be prone to omitted variable bias (see Ruhm 2000). While Cutler et al. (2002) and Abdala et al. (2000) use a panel approach, they do not use annual data.

The purpose of this paper is to investigate whether the procyclical nature of mortality in developed countries found by Ruhm (2000) and others is present in Mexico, a developing economy with one-fourth of the U.S. per capita income. Our results are obviously specific to Mexico. However, Mexico and other middle and middle-high income countries share similar levels of GDP per capita, private and public health spending as a fraction of GDP, and population age distribution. Further, these countries are currently experiencing an epidemiological transition away from infectious diseases.

We assemble a unique data set of state-level annual data for each of the 32 states in Mexico from 1993 through 2004. The data contain the mortality rate (total, by age group, and for several specific causes of death), measures of economic activity, and relevant control variables. While such state-level data can often be easily obtained for developed countries, they are typically not available for developing countries. The disaggregated nature of these data and the substantial time period they cover allow us to improve upon the previous literature by estimating panel level regressions that include year and state fixed effects.

We obtain three main results. First, total mortality rates increase (decrease) during economic expansions (contractions) for Mexico during this time period. This finding suggests that total mortality may be procyclical for some developing countries. Second, we find a larger effect of business cycles on the mortality rate for those aged 20–49 than on older cohorts. Third, while our first two results are similar to those for the U.S. in Ruhm (2000), interesting differences emerge in the analysis of specific

[1] Ruhm (2000) also uses individual-level data to determine the channels through which business cycles may affect mortality in the U.S. As individual-level data are not available for Mexico, we focus only on the analysis of state-level data.

[2] Gerdtham and Ruhm (2006) analysis excludes developing countries in the OECD such as Mexico and Turkey.

causes of death. For instance, increases in GDP per capita are associated with lower mortality rates for cancer and higher mortality rates for suicides.

Caution is warranted when attempting to generalize our findings to other developing countries. As noted above, Mexico is currently experiencing an epidemiological transition characterized by an increase in the prevalence of chronic diseases. Thus, our findings apply mainly to developing countries with middle and middle-high income levels.

2 Background information

Public health insurance in Mexico covers approximately 90% of the population. Health spending as a percentage of GDP is relatively low. In 2004, total health expenditures were 6.4% of the GDP, which was less than half of that in the U.S. (15.4%) and in the lower end of the range observed for similar countries (WHO 2007). The median age in Mexico is 26 (CONAPO 2007).

Like many other developing countries, Mexico is experiencing an epidemiological transition. There has been an increase in the prevalence of chronic diseases, such as diabetes, cardiovascular diseases, high blood pressure, and cancer, and a decrease in infectious diseases. This transition is reflected in changes in the top causes of death over time. In 1979, the top three causes of death were intestinal infectious diseases (10.0%), infectious respiratory disease (9.9%), and cancer (3.9%) (Rivera-Dommarco et al. 2001). In contrast, the top three causes in 2004 were heart disease (16.4%), diabetes (13.6%), and cancer (12.9%).

Total mortality rates have declined in Mexico from 1,600 per 100,000 inhabitants in 1950 to the mid-400s in recent years. The total national mortality rate decreased over 4% from 466 in 1993 to 446 in 2004, with a small upward trend from 2001 to 2004.[3]

The 1993–2004 period includes two critical events in the recent economic history of Mexico: the implementation of the North American Free Trade Agreement (NAFTA) in 1994 and the 1995 economic crisis. The opening of the Mexican economy during this time period is highlighted by the launch of NAFTA between Mexico, the U.S., and Canada. This treaty significantly reduced tariffs between the three countries and promoted regional economic integration.[4] While NAFTA has had a positive effect on overall trade and investment flows in Mexico (see Lustig 2001), its impact has varied considerably across states. These differential effects have contributed to the state-level variation in the growth of GDP per capita.[5]

The other essential aspect of the sample period is the 1995 crisis. Figure 1 presents the percentage changes in real GDP per capita at the national level and for each of the 32 states in Mexico using 1993 constant prices. The 1995 crisis was especially severe,

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3 The mortality rates used in our analysis do not include deaths of foreigners and people of unidentified age or gender. These deaths account for approximately 1% of all deaths in each year of our sample.

4 For example, since 2003 all industrial goods from the U.S. and Canada sold to Mexico have had a zero tariff.

5 Sanchez-Reaza and Rodriguez-Pose (2002) find that NAFTA significantly increased the dispersion of the state-level GDP per capita in Mexico.

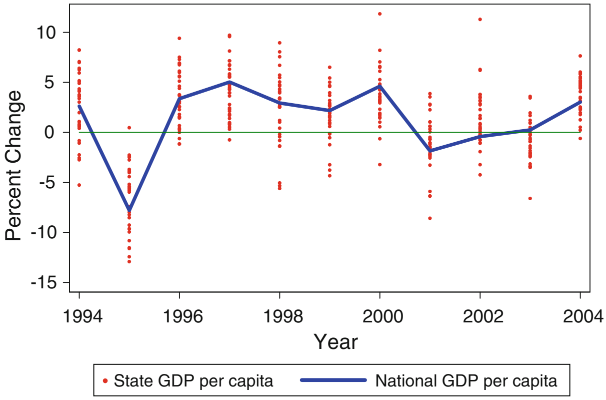

Fig. 1 Annual percent change in GDP per capita, 1994–2004. *Source*: Authors' calculations using INEGI (2008b) and SSA (1993–2004a)

with a decrease of national real GDP per capita of almost 8%. However, the economy recuperated relatively quickly with real GDP growth of 5% in 1996 and 7% and 1997. In contrast, during the 2001 recession the economy suffered only a small drop in real GDP of less than 1.0%. Yet, economic growth after this small recession was relatively low. Figure 1 also demonstrates that changes in real GDP per capita at the state level vary significantly. In each year there are both states with positive and negative GDP per capita growth.

3 Data and empirical specification

A goal of our empirical specification is to derive results that are comparable to those of the U.S. in Ruhm (2000). Therefore, we employ similar econometric specification and explanatory variables. Table 1 summarizes the data set used in the analysis. All of the variables are measured at the state-year level for each of the 31 Mexican states and the federal district, and cover the period 1993 through 2004. The variables we employ are typically difficult to obtain for developing countries. In particular, our data set is notable as it includes for a 12-year period detailed mortality rates, international and interstate migration rates, GDP per capita, and indicators of health care infrastructure and education for every state in the country.

The dependent variable is the mortality rate (mort), which is calculated as the number of deaths in that state and year per 100,000 population. The mortality rates are constructed using mortality and population data from SSA (2007) and SSA (1993–2004a), respectively. The mortality data are based on administrative records. The World Health Organization (see Mathers et al. 2005) classifies the Mexican mortality data as "high quality," which is a higher rating than that given to data from Germany and some other developed countries. The population data are based on census data and state- and national-level rates of interstate and international migration, mortality, and fertility (see CONAPO 2007).[6]

[6] International migration rates are constructed using Mexican and international sources.

Table 1 Summary statistics ($n = 384$)

Variable	Mean	Std. Dev.	Min.	Max.
Death rate per 100,000 population				
All Causes	439.5	56.6	257.0	585.5
All Causes, 20–49 years old	192.5	34.7	126.2	318.6
All Causes, 50–64 years old	932.0	125.4	473.8	1346.8
All Causes, 65+ years old	4862.2	555.7	2236.3	7311.1
Major cardiovascular disease	96.1	22.6	37.7	154.1
Malignant neoplasms	53.4	10.1	23.2	74.3
Diabetes	45.1	12.6	12.1	89.4
Other accidents	23.2	6.3	11.4	51.5
Chronic liver disease and cirrhosis	21.8	9.8	5.1	46.4
Pneumonia and influenza	15.8	7.3	4.2	44.0
Motor vehicle accidents	15.4	4.6	2.9	32.0
Homicides	11.8	7.9	1.9	45.7
Suicides	3.9	1.9	0.6	9.7
Death rate per 1,000 live births				
Infant: deaths within first year	16.4	6.1	3.6	36.6
Explanatory variables				
GDP per capita[a]	13.6	6.5	5.6	37.8
% of population under 5 years old	11.2	1.2	7.8	14.0
% of population aged 65 and over	4.5	0.8	1.9	6.8
Average number years of schooling	7.3	1.0	4.5	10.0
Number of doctors per 1,000 residents	1.2	0.4	0.6	3.0
Government health spending per capita[a]	0.4	0.4	0.06	2.5
Net international migration rate[b]	−0.4	0.3	−1.3	0.2
Net interstate migration rate[b]	0.2	0.7	−1.4	2.9

[a] Thousand pesos at 1993 prices
[b] Per 100 residents

The mortality rates are computed for nine major causes of death[7] and four age groups (first year of life,[8] 20–49, 50–64 years, and 65 years and older). The highest mortality rate over the sample period is for major cardiovascular disease followed by cancer, diabetes, other accidents, and chronic liver disease and cirrhosis. The mortality rate from suicides is the lowest rate of those specified.

The explanatory variable of interest is state GDP per capita (gdpcap) which is used to measure economic fluctuations of the state economy. It is computed using state-level

[7] We investigate the eight causes of death included in Ruhm (2000) as well as diabetes. The mortality categories in Ruhm (2000) correspond to the ninth revision of the International Classification of Diseases, while our data is based on the tenth revision. We obtain perfect or almost perfect matches for the eight mortality categories that are common to our analysis and Ruhm (2000).

[8] The infant mortality mortality rate is calculated as the number of deaths per 1,000 live births.

GDP from INEGI (2008b) and the aforementioned population data from SSA (1993–2004a), and is measured in thousands of pesos at 1993 prices. There is considerable variation across states in changes in GDP per capita. For example, of the 10 states with the largest percentage increase in per capita GDP in 1993, only three were among the top 10 in 2004. Similarly, only three states that were among the 10 states with the smallest percentage change in per capita GDP in 1993 were among the bottom 10 in 2004.

The unemployment rate is an alternative measure of business cycles and is the featured explanatory variable in Ruhm's (2000) study for the U.S. However, there are a number of reasons why GDP per capita is a preferred measured of economic activity in Mexico. Negrete (2001) provides some background as to why the unemployment rate in Mexico, which averaged only 3% during the sample period, is a poor proxy for Mexican business cycles. First, in some areas (both rural and urban) of Mexico a significant portion of the population is always self-employed. During economic recessions, these individuals may experience lower earnings, but will not be considered unemployed. Second, Mexico has relatively flexible labor markets in which most of the adjustments to economic shocks come from changes in prices (wages) rather than quantities (employment).[9] Third, Mexico does not provide unemployment benefits, which makes it more likely that recently unemployed workers will turn to temporary work or self-employment and not be classified as unemployed. Fourth, some unemployed workers migrate to the U.S. during Mexican recessions, thus reducing the effect on the unemployment rate. Finally, in terms of the available data, state-level unemployment data are limited to the unemployment rate for the largest city in each state and thus do not reflect economic activity in other areas within the state. Moreover, these data are unavailable for some of the observations in our data.[10]

We employ additional explanatory variables to control for factors that are thought to affect mortality. We use the percent of the population aged 0–4 (%popunder5) and the percent of the population aged 65 and older (%popover65) to control for the age of the population. During the sample period, the percent of the population in the younger cohort was on average 2.5 times that of the older segment. We employ the average number of years of schooling for those 15 years and older (yrsschool), obtained from SEP (2007), to control for the tendency of education to reduce mortality.[11]

We also include four control variables beyond those used by Ruhm (2000) to reflect additional characteristics potentially relevant to mortality in Mexico. First, Mexico is characterized by a significant amount of international and interstate migration flows, which may impact mortality rates.[12] As migration tends to be higher among younger

[9] Negrete (2001) points out that the relatively low unemployment rates observed in Mexico reflect flexible labor markets. For example, the average unemployment rate during our sample period was 3.0% in Mexico while it was 7.0% for all of the OECD countries (INEGI 2008a and OECD 2008).

[10] Specifically, we are missing unemployment data for the states of Baja California Sur (1992–1995), Coahuila (2003–2004), Hidalgo (1992–1996), Queretaro (1992), Quintana Roo (1992–1995), and Tlaxcala (1992–1993).

[11] Ruhm (2000) includes explanatory variables to control for racial differences. Given Mexico's relatively homogenous population, these controls are not necessary.

[12] We define migration as the inflow of individuals moving to the state.

individuals, an increase in migration may lead to an increase in the total mortality rate.[13] To control for this potential effect, we include as explanatory variables both the net international (intmig) and net interstate (statmig) migration rates obtained from CONAPO (2006).

Second, the availability of health care may be an important determinant of mortality. We consider resources in the public health care system as the majority of Mexicans receive their care from these institutions.[14] We include two measures of public health care: the per capita levels of public health spending and the number of doctors. We include both of these variables to capture different aspects of the public health care system. Public health spending is useful because it represents the total amount of public resources that are devoted to health care. However, it also includes expenditures that may not necessarily affect mortality in the short-term, such as administration, research and development, and physical and human capital investment. Thus, we also employ the number of doctors per capita because, while this variable only reflects one aspect of health care, it reflects resources that may directly affect short-term mortality. The number of doctors per capita (doctorscap) is constructed using the number of doctors in direct contact with patients from SSA (1993–2004b) and the population data from SSA (1993–2004a).[15] The state-level public health spending per capita (healthspcap) is computed using public health spending reported by SSA (2008) and is deflated at 1993 prices. Public health spending at the state level includes the spending of the social security system, as well as federal and state government spending in health care at the state level.[16]

We include state fixed effects to control for any state-specific factors that do not vary over the sample period. Likewise, year fixed effects are used to control for any national factors that are specific to a given year and do not vary across the states. As Ruhm (2000) notes, this specification requires that economic conditions vary across states independently over the sample period. This condition appears to be satisfied for Mexico. As noted above, NAFTA has had differential effects throughout Mexico and has contributed to variation in GDP per capita growth across states. Further, we do not observe any significant correlation between annual growth rates and initial levels of development or geographic location. For example, during the 1995 crisis the state that suffered the smallest economic contraction was Zacatecas, a low-income state in the center of Mexico. In contrast, the state that was least affected in the 2001 recession was Quintana Roo, a high-income state in the southeast of the country.

The coefficients are estimated via ordinary least squares. The natural log of the mortality rate is used as the dependent variable and the observations are weighted by

[13] According to Consejo Nacional de Poblacion (CONAPO) (2005), roughly 95% of the Mexican population that migrates to the U.S. is under 65 years of age.

[14] According to SSA (2005) in 2004 about 70% of all 68.2 million people who used health services were treated by the public sector.

[15] We also use SSA (1993–2004a,b) to compute the number of nurses per capita and number of hospital beds per capita since they may also reflect the supply of health care in a given state. However, these measures were found to be highly collinear with the number of doctors per capita and are thus not included in the regressions.

[16] This variable does not include federal spending that cannot be attributable to any particular state, such as administrative expenses of the SSA and other federal health institutions.

the square root of the state population. The main estimating equation is:

$$\begin{aligned}\ln(\text{mort}_{i,t}) = \beta_0 + \beta_1\text{gdpcap}_{i,t} + \beta_2\%\text{popunder5}_{i,t} + \beta_2\%\text{popover65}_{i,t} \\ +\beta_4\text{yrsschool}_{i,t} + \beta_5\text{healthspcap}_{i,t} + \beta_6\text{doctorscap}_{i,t} \\ +\beta_7\text{intmig}_{i,t} + \beta_8\text{statmig}_{i,t} + \gamma_t + \eta_i + \epsilon_{i,t}\end{aligned} \quad (1)$$

where i indexes the state and t indexes the year. The γ_t terms are the year fixed effects, the η_i are the state year effects, and $\epsilon_{i,t}$ is the error term. The error terms are clustered at the state level to account for the possibility of correlated disturbances within each state.

4 Results

4.1 Total mortality

Table 2 details the coefficient estimate for the GDP per capita for a number of specifications employed by Ruhm (2000) in which the state-level total mortality rate is the dependent variable.[17] The first three rows contain the results for specifications in which the full sample is utilized. The basic specification refers to the model described in Eq. 1. The next two rows correspond to modifications to this model, specifically when state-specific time trends are added and when the mortality rate is measured in levels, rather than logs. The bottom three rows refer to results in which the basic specification is employed but the sample is subset into three groups, based on population and population growth. The results based on the data for Mexico are detailed in the second column, while the U.S. results from Ruhm (2000) are included in the third column for comparison. As noted above, an important distinction between our regressions and those in Ruhm (2000) is that we use GDP per capita, rather than the unemployment rate, as the measure of economic activity. However, as a robustness check we replaced GDP per capita with the unemployment rate and obtained similar results with opposite sign. If our results are consistent with Ruhm (2000), the coefficients will have the opposite sign.

As noted above, government health spending, migration, and the number of doctors may be related to the macroeconomy, their inclusion in the regression may influence our estimate of the effect of GDP per capita on mortality. To check for this possibility, we estimated the model without these control variables and found that the results were unchanged.

Generally, the procyclical relationship between business cycles and mortality found for the U.S. in Ruhm (2000) appears to hold for Mexico. For instance, the coefficient in the basic specification suggests that a 1,000 peso increase in state GDP per capita is associated with a roughly 1% increase in the total mortality rate. The corresponding result in Ruhm (2000) is that a 1% point increase in the state unemployment rate is related to a 0.5% decrease in the total mortality rate in the U.S.

[17] The coefficient estimates for all explanatory variables are available from the authors upon request.

Table 2 Effect of a 1000 peso increase in state GDP per capita (Mexico) or a one percentage point increase in the state unemployment rate (U.S.) on mortality

Specification	Coefficient on economic measure (Standard error)	
	Gonzalez and Quast Mexico	Ruhm (2000) U.S.
Full sample		
Basic	1.08** (0.38)	−0.52*** (0.05)
With state-specific time trends	2.01** (0.52)	−0.54*** (0.04)
Mortality rate in levels	4.630* (1.838)	−4.574*** (0.429)
Subsamples		
Ten largest states	1.07 (0.69)	−0.57*** (0.09)
Ten fastest growing states	2.01*** (0.34)	−0.80*** (0.09)
Ten slowest growing states	−0.19 (0.79)	−0.57*** (0.10)

Statistical significance level: * 5%, ** 1%, and *** 0.1%. Significance levels of Ruhm (2000) estimates are calculated by authors. In Gonzalez and Quast, the number of observations for the full sample is 384 and 120 for the subsamples. In Ruhm (2000), the number of observations is 930 for the full sample, 200 for the largest states and 180 for the fastest and slowest growing states. The dependent variable for both columns is the logarithm of the mortality rate per 100,000 population, except in the row labeled, "Mortality rate in levels." The economic activity measure used in the second column is state GDP per capita, while the measure used in the third column is the state unemployment rate. The additional explanatory variables used in the second column are listed in the "Explanatory variables" section of Table 2. The additional explanatory variables used in the third column are the percentage of the state population who are black and Hispanic, under age 5 and 65 and older, are high school dropouts, have some college education, and are college graduates. For the estimates in both columns, state and year fixed effects are included and the observations are weighted by the square root of the state population. The errors in the second column are clustered by state. Except for when the mortality rate is measured in levels, the coefficient estimates (and their standard errors) are multiplied by 100, which corresponds to the percent change in the mortality rate associated with a one unit increase in the economic activity measure

While it is possible to discern that the direction of the effect is similar between the results here and in Ruhm (2000), it is somewhat difficult to compare the magnitude of the effects. One means of comparison is to compare the elasticities. Calculated at the sample averages, the results in Ruhm (2000) indicate that for the U.S. a 1% increase in the state unemployment rate leads to a 0.035% decrease in the mortality rate. Our estimates suggest that a 1% decrease in state GDP per capita in Mexico is associated with a 0.14% decrease in the mortality rate. However, this is obviously a crude comparison due to differences in the explanatory variables. Therefore, we also compute the elasticity with respect to the unemployment rate, with the caveats regarding the unemployment rate described above. We find that at the sample average the unemployment rate elasticity for Mexico is −0.021% which is lower in magnitude than the corresponding −0.035% found in Ruhm (2000) for the U.S.

The modifications to the basic specification yield interesting results. In both of the full sample modifications, the procyclical relationship persists. One point of departure with Ruhm (2000) is that the inclusion of state-specific time trends leads to a larger coefficient on the Mexican estimate. Differences also emerge with Ruhm (2000) results when the sample is subset. Whereas Ruhm (2000) finds a relatively consistent effect across the three subsets that he uses for the U.S., it appears that for Mexico the 10 fastest growing states experience the largest effect of business cycles on mortality. The effects in the other two subsets are not statistically different from zero. It should be noted that the sample size in the subsets for the Mexico data are roughly one-third less than those in Ruhm (2000).

4.2 Mortality by age and specific cause

Table 3 details coefficient estimates in which the dependent variable is based on specific age groups and causes of death. The coefficients are based on regressions as specified in Eq. 1. The corresponding U.S. results from Ruhm (2000) are again also provided, with the earlier caveat that the Ruhm (200) coefficients are for the state unemployment rate, rather than the state GDP per capita.[18]

The results by age suggest that the effects of changes in GDP per capita are strongest among those aged 20–49. For this cohort, a thousand peso increase in annual GDP per capita is associated with a roughly 2.3% increase in mortality. While mortality appears to be procyclical for all of the age groups under 65 years of age, the relationship is only statistically significant for the 20–49 year olds. The finding of the strongest effect among those in their early middle age is consistent with those for the U.S. in Ruhm (2000). However, Ruhm (2000) finds that the mortality rate for the oldest cohort is procyclical, while we find it is countercyclical (albeit statistically insignificant).

The lower section of Table 3 contains the regression results when the mortality rates for specific causes of death are employed as the dependent variable. The effects of changes in state GDP per capita vary by the cause of death. Increases in state GDP per capita have a negative effect on the mortality rates of cancer, flu/pneumonia, and other accidents. Conversely, such income increases have a positive association with vehicle accidents, suicides, and homicides. There appears to be virtually no relationship between GDP per capita and the mortality rates for heart disease and diabetes.

A comparison of these results to Ruhm (2000) offers a mixed picture. In contrast to our results, Ruhm (2000) does not find any effect of state GDP per capita on cancer mortality in the U.S., but does find a procyclical effect on heart disease. However, our results here similar to those in Ruhm (2000) in that the mortality rates of liver disease, vehicle accidents, and homicides are procyclical.

On the surface, our results appear to contrast with the findings for Mexico by Cutler et al. (2002). Namely, whereas they find that economic crises lead to increased mortality rates for the very young and very old, we do not find a relationship between GDP per capita and mortality for these groups. However, their model differs significantly from ours. Specifically, they employ a difference-in-differences approach, in which the variable of interest is the difference in the percent change in mortality in the years prior to a crisis to the percent change in mortality during the crisis. Assuming that the mortality rate of 30–44 year old males would not be affected by an economic crisis, they use this cohort as the control group and employ this mortality rate as a benchmark by which to compare the relatively young and the relatively old. They find that the

[18] The two middle age groupings differ slightly in Ruhm (2000) where they are 20–44 year old and 45–64 year old.

Table 3 Effect of a 1,000 peso increase in state GDP per capita (Mexico) or a 1% point increase in the state unemployment rate (U.S.) on age- and cause-specific-mortality

Mortality rate	Coefficient on economic measure (Standard error)	
	Gonzalez and Quast Mexico	Ruhm (2000) U.S.
Age-specific		
Infants	0.13 (1.11)	−0.0062*** (0.0016)
20–49 year olds	2.32*** (0.63)	−0.0203*** (0.0016)
50–64 year olds	0.53 (0.44)	0.0003 (0.0009)
$\geq$ 65 year olds	−0.43 (0.41)	−0.0032*** (0.0005)
Cause-specific		
Heart disease	−0.02 (0.58)	−0.46*** (0.08)
Cancer	−0.81*(0.38)	0.04 (0.06)
Flu/pneumonia	−2.23 (1.55)	−0.66** (0.23)
Liver disease	2.12 (1.45)	-0.39^{+} (0.23)
Vehicle accidents	3.50^{+} (1.75)	−3.02*** (0.22)
Other accidents	−0.72 (1.13)	−1.66*** (0.20)
Suicide	6.75** (1.95)	1.27*** (0.22)
Homicide	4.72** (1.63)	−1.89*** (0.35)
Diabetes	−0.10 (1.80)	na (na)

na Not available. Statistical significance level: $^{+}$ 10%,* 5%, ** 1%, and *** 0.1%. Significance levels of Ruhm (2000) estimates are calculated by authors. The number of observations in the Gonzalez and Quast regressions is 384. For the Ruhm (2000) results, the number of observations is 930, except for the homicide regression, which has 922 observations. For both columns, the dependent variable is the logarithm of the total mortality rate per 100,000 population, except for the infant mortality rate, which is per 1,000 live births. The economic activity measure used in the second column is state GDP per capita, while the measure used in the third column is the state unemployment rate. The additional explanatory variables used in the second column are listed in the "Explanatory variables" section of Table 2. The additional explanatory variables used in the third column are the percentage of the state population who are black and Hispanic, under age 5 and 65 and older, who are high school dropouts, who have some college education, and who are college graduates. For the estimates in both columns, state and year fixed effects are included and the observations are weighted by the square root of the state population. The coefficient estimates (and their standard errors) are multiplied by 100, which corresponds to the percent change in the mortality rate associated with a one unit increase in the economic activity measure

rate of decline in mortality for the young and old fell (and sometimes was reversed) during the economic crises. At first glance, this appears to contrast with our finding that the relationship between GDP per capita and mortality is strongest among the middle-aged cohort and is procyclical.

However, upon further analysis, the two sets of results are roughly consistent. Cutler et al. (2002) note that the mortality rate for 30–44 year old males actually falls at a greater rate during economic crises than in the period prior to the crisis. Thus, their results do not preclude a procyclical relationship for this cohort. Further, as they use this cohort as their control group in the difference-in-difference analysis, the relative increase in mortality that they find for the very young and very old is due in part to the decrease in the mortality rate for middle-aged males. Therefore, while they differ somewhat, our findings and those in Cutler et al. (2002) are not inconsistent.

Table 4 Effect of a lagged 1,000 peso increase in state GDP per capita (Mexico) or a lagged one percentage point increase in the state unemployment rate (U.S.) on age- and cause-specific-mortality

Type of mortality	Gonzalez and Quast Mexico			Ruhm (2000) U.S.		
	t	$t+2$	$t+4$	t	$t+2$	$t+4$
Total	1.3*	1.8*	0.8	−0.6*	−0.6*	−0.4*
Age-specific						
Infant	1.1	2.6	1.1	−0.6*	−0.8*	−0.7*
20–49 year olds	1.8*	3.1*	3.9*	−1.7*	−2.6*	−2.9*
50–64 year olds	1.3*	1.4*	0.2	−0.4*	0.0	0.8*
65+ year olds	0.5	0.5	−1.1*	−0.2*	−0.4*	−0.3*
Cause-specific						
Heart disease	−0.01	1.0	−0.1	−0.6*	−0.5*	−0.3*
Cancer	−0.9	0.1	−1.2	−0.0	0.0	0.3*
Flu/pneumonia	1.0	−0.5	−1.7	−0.4	−1.4*	0.5
Liver disease	3.0	2.3	2.9	−0.6	−0.4	0.5
Vehicle accidents	2.0	8.9*	15.2*	−2.7*	−4.0*	−3.2*
Other accidents	1.8	0.4	−1.6	−1.5*	−2.2*	−2.2*
Suicides	3.5	4.2	9.5	1.1*	1.4*	1.4*
Homicides	2.5	6.4*	7.9*	−2.4*	−3.3*	−2.2*
Diabetes	1.1	−0.8	−2.9*	na	na	na

na Not available. Statistical significant level: * 5%. The entries in each of the two sets of columns represent the percent change in the mortality rate to due to an increase in the economic activity variable beginning in year t and continuing through year $t + 4$. The two sets of estimates are based on regressions corresponding to the basic specification described in Tables 2 and 3. The sample size is 256 for the Gonzalez and Quast estimates and 726 for the Ruhm (2000) estimates

4.3 Model with lagged effects

The final set of results, detailed in Table 4, are derived from implementing a lagged model. As per Ruhm (2000), the values of state GDP per capita from the previous 4 years are simultaneously added as explanatory variables.[19] Columns two through four of the table detail the effect on the mortality rate for a sustained one thousand peso increase in state GDP per capita in the same year, after two years, and after 4 years. The final three columns detail the corresponding results from Ruhm (2000) for the U.S., in which the effects are those of a 1% point increase in the state unemployment rate.

The top row of the table indicates that, on average, a one thousand peso increase in state GDP per capita is associated with an increase in total mortality of 1.3% in that year. If the increase in GDP per capita is sustained 2 years, the cumulative effect is a 1.8% increase in the mortality rate, while if the increase is sustained for 4 years, the

[19] As a robustness check, lags of other lengths were also used. The results are largely unchanged from those presented in this section.

cumulative effect falls to 0.8%. This again concurs with the results in Ruhm (2000), where an increase in the unemployment rate is associated with a decrease in mortality.

Of the age groups analyzed, the effects appear to be strongest for those aged 20–49 years, for which a sustained one thousand peso increase in state GDP per capita is related to an increase in mortality of almost 4%. The point estimates of the effect on infant mortality are also substantial, but are not statistically different from zero. Again, these results are somewhat consistent with Ruhm (2000), in that the largest effects are associated with the 20–49 year old group and are procyclical.

Generally, the lagged effects in Ruhm (2000) analysis tend to be more statistically significant. This may be due in part to the larger sample size. Similarities between the two sets of results include a large effect on the mortality rate for the youngest cohort and that of the specific causes the effect on motor vehicle accidents is the largest. However, Ruhm (2000) finds no effect on liver disease and a countercyclical effect on suicides.

5 Conclusions

In this paper, we contribute to the literature by assessing if the procyclical relationship between the business cycle and mortality previously found for developed countries also holds for Mexico. We attempt to roughly follow Ruhm (2000) estimation strategy in order to compare our results on a similar basis. However, our analysis differs from Ruhm (2000) in that we have a shorter sample, use GDP per capita (rather than the unemployment rate) to measure economic activity, and include additional explanatory variables that may be pertinent to Mexico.

Our results may provide some initial insight into why the business cycle affects mortality. Changes in GDP per capita are likely to produce social changes which in turn may affect mortality. We find a positive relationship for causes of death that may be due to general social changes, such as automobile accidents, homicides, and suicides.[20,21] We also find that state GDP per capita is positively associated with the total mortality rate for those aged 20–49. Since the young and the middle aged tend to have a higher labor force participation rate, they may be more affected by changes in the business cycle.[22] Finally, we find that the coefficients for public health spending and the number of doctors do not have an statistically significant effect on the total mortality rate. However, without individual-level data to confirm the state-level results, it is difficult to assess the channels through which the business cycle affects mortality.

[20] Previous papers on other countries find a countercyclical relationship for suicides (e.g., Ruhm 2000; Tapia Granados 2005b). However, Hintikka et al. (1999) study of Finland and some econometric specifications in Neumayer (2004) analysis of Germany indicate a procyclical relationship. This suggests that the relationship between short-term changes in GDP per capita and suicides may vary across countries.

[21] The negative relationship between cancer mortality and GDP per capita could be due to income effects, in that increases in income allow individuals to afford expensive treatments that prevent death.

[22] In 2004, the labor force participation rate in Mexico was 23% for the 12–19 years group, 61% for 20–24, 74% for 25–34, 76% for 35–44, and 53% for 45 years and older (INEGI 2008a).

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