How Does Population Growth Contribute to Rising Energy Consumption in America?

Allan Mazur
Syracuse University

The contribution of American population growth to rising energy consumption is analyzed for the period 1947-91. Energy consumption is disaggregated into electricity and nonelectricity consumption, and by end-use sectors: residential and commercial, industrial, and transportation. Population growth has been relatively unimportant as a contributor to yearly fluctuations in energy consumption. However, whereas energy changes induced by nonpopulation factors are erratic, sometimes adding consumption and sometimes subtracting, population growth consistently adds to consumption. As a result, depending upon which energy sector is considered, population growth may have a dominant role in the longterm growth of consumption.

Currently there is considerable debate over how important population growth is compared to other causes of rising resource consumption and pollution. Much argument focuses on whether or not population is the *primary* driver and seems to have reached a dead end (Mazur, 1991). To move ahead it is worthwhile examining in detail the experience of the United States, the dominant economy in the world and one with relatively good data on population and resource consumption. Here I estimate how population growth, compared to other factors, has contributed to rising American energy consumption since World War II (Figure 1).

Please address correspondence to Dr. Mazur, Public Affairs Program, The Maxwell School, Syracuse University, Syracuse, NY 13244.

Population and Environment: A Journal of Interdisciplinary Studies
Volume 15, Number 5, May 1994

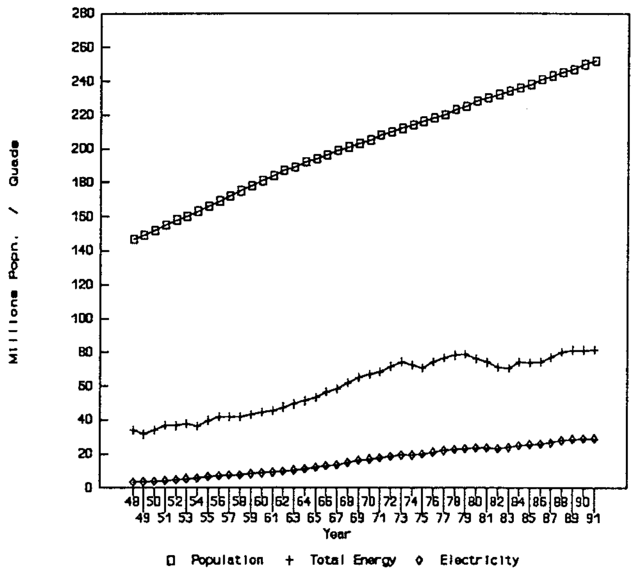

FIGURE 1. U.S. population, total energy consumption, and electricity consumption, by year.

METHOD

The total energy consumed by the nation in a year (E) equals the product of per capita energy consumption (e) and total population (P). If e and P are independent of one another, then differentiating this identity produces $dE = e\,dP + P\,de$. The term $e\,dP$ is the portion of change in energy consumption that is due to changing population. The term $P\,de$ contains all other sources of change including alterations in personal habits of consumption, and improvements in efficiency of use. In effect, the change in energy consumption is decomposed into a "population component" ($e\,dP$) and a "nonpopulation component" ($P\,de$).

All terms in this equation can be estimated from historical statistics for the United States on population (Bureau of the Census, 1981; 1991) and energy (Bureau of the Census, 1975; Dept. of Energy, 1992). Although there are data on electric utility generation since 1902, I begin with 1947 when adequate accounts of total energy consumption begin. Since 1973, total energy consumption (including electricity consumption) is disaggregated into end-use sectors: residential and commercial, industrial, and transportation. A conversion factor of 10,331 Btu per kilowatt-hour was used to express electricity in Quads (quadrillion Btus).

YEARLY FLUCTUATIONS

Population and nonpopulation components were calculated for each year's change in total energy consumption. Each year's components were divided by total energy consumption that year, thus expressing them in terms of proportional change. These components are plotted by year in Figure 2.

The plot of the population component is smooth and nearly level but with a slight downward slant since 1947. In contrast, the plot of the nonpopulation component is erratic, and its yearly fluctuations are on average 2.5 times larger in absolute magnitude than the yearly fluctuations due to population. Energy consumption due to nonpopulation factors actually decreased in several years prior to 1960, then rose every year from 1961 to 1973, and then again dropped in several years since 1973, the beginning of the OPEC oil embargo.

Total energy consumption can be divided into sectors: electricity consumption versus nonelectric energy consumption; and after 1973, by end use (i.e., residential and commercial, industrial, and transportation). Similar plots were prepared for each of these sectors, however these are not shown because their appearance is similar to Figure 2 except for the following points. First, while changes in electricity consumption from nonpopulation factors were erratic, as they are in every other sector, there were few years in which electricity consumption actually fell due to nonpopulation factors; such falls were more common in the other energy sectors, especially before 1960 and after 1973 (as in Figure 2). Also, while in every sector the nonpopulation component was greater in absolute magnitude than the population component, the size of this ratio varied across sectors: Yearly fluctuations in residential and commercial consumption due to nonpopulation factors were on average 1.9 times larger than those due to population growth; they were 2.3 times larger for transportation, 2.6 times larger for nonelectric energy consumption, 3.1 times larger for electricity, and 4.5 times larger for industrial consumption.

Thus, in terms of yearly fluctuation in energy consumption, we may conclude that nonpopulation factors dominate population growth, causing average changes ranging from 1.9 to 4.5 times bigger, depending on sector. However, since nonpopulation factors are nearly as likely to diminish

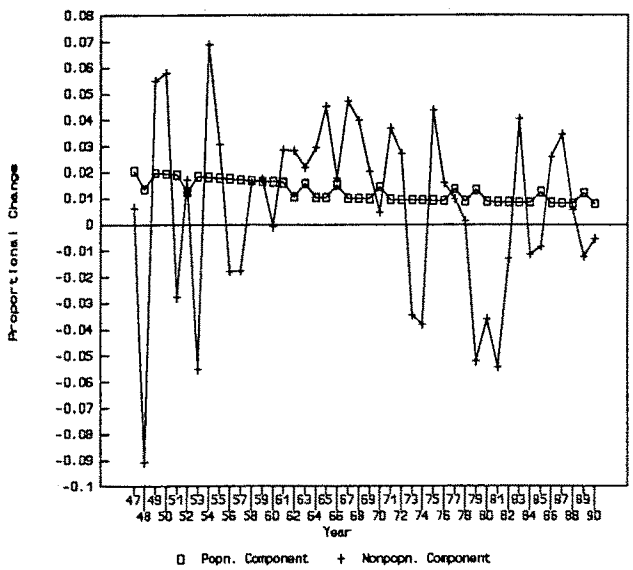

FIGURE 2. Population and nonpopulation conponents of yearly energy consumption.

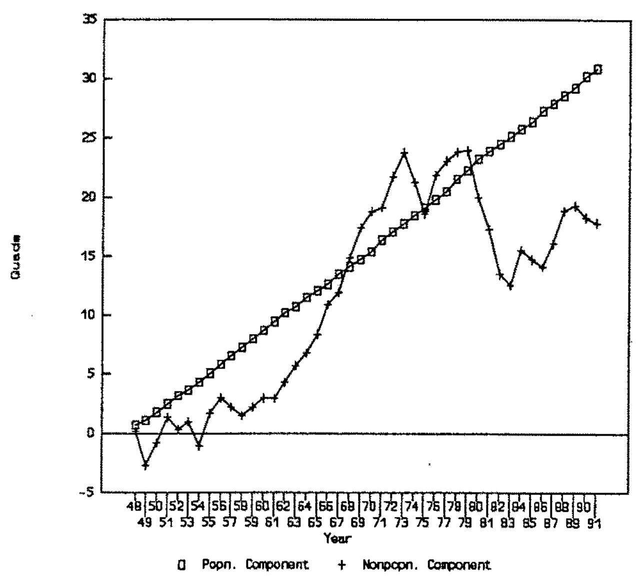

FIGURE 3. Integrated energy growth for population and nonpopulation components.

consumption as to increase it (except in the electric sector), whereas population growth invariably drives energy consumption upward, the effect of population growth, integrated over many years, may dominate nonpopulation factors—an example of "slow and steady wins the race."

INTEGRATED CHANGES

To evaluate this possibility, yearly changes in total energy consumption due to each component (population and nonpopulation) were summed over the years since 1947 (Figure 3). Since the population component is nearly constant from year to year, its integrated contribution to energy consumption moves smoothly upward. The integrated contribution from nonpopulation factors has a more interesting history. During the 1950s, nonpopulation factors caused little energy growth, certainly less than population did. There is a reversal in the 1960s when nonpopulation factors caused a steep increase in energy consumption, far exceeding population growth in importance. Then, in another turnaround, nonpopulation factors again reduced energy consumption, first briefly after 1973, then more strongly after 1979, in what are obviously responses to the oil shocks of those years. Nonpopulation factors again contributed to energy growth in the mid-1980s, a time of economic boom, but they back off once more with the recent recession.

Figures 4 and 5 show the strikingly different histories of electricity and nonelectric energy. At least since 1947, nonpopulation factors have dominated electricity growth, causing increases nearly every year and, over the period 1947-91, contributing 2.4 times as much as population growth to the increase in electricity. For nonelectric energy, population growth has been the dominating force except for the period 1961-75, when nonpopulation factors were strongly pushing consumption upward in all energy sectors. Over the whole period 1947-91, population growth accounts for the entire increase in nonelectric energy consumption.

Figure 6 shows the integrated (population and nonpopulation) contributions to energy consumed for the three end uses: residential and commercial, industry, and transportation. (Consistent data are available only since 1973, the year of the first oil shock.) As usual, population growth contributes persistent if slow growth to energy consumption. Nonpopulation factors reflect the trends already noted for total energy consumption (Figure 3) after 1973: first a brief downturn and recovery, then a longer downturn after 1979, an upturn accompanying the economic boom of the mid-1980s, and finally another downturn with the recent recession. Of

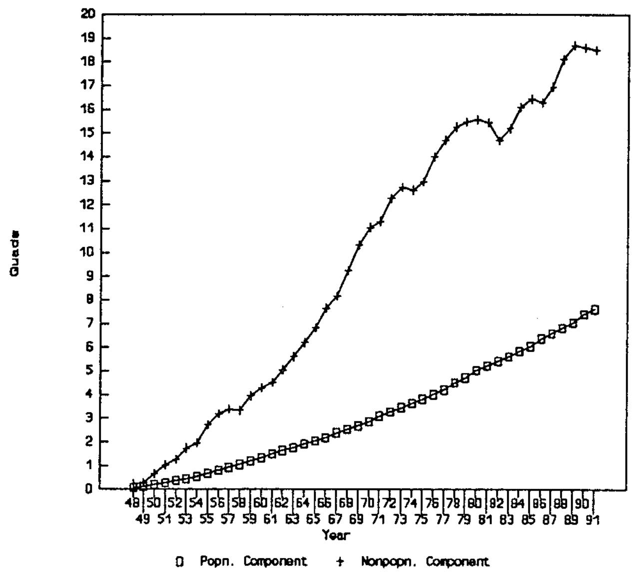

FIGURE 4. Integrated electricity growth for population and nonpopulation components.

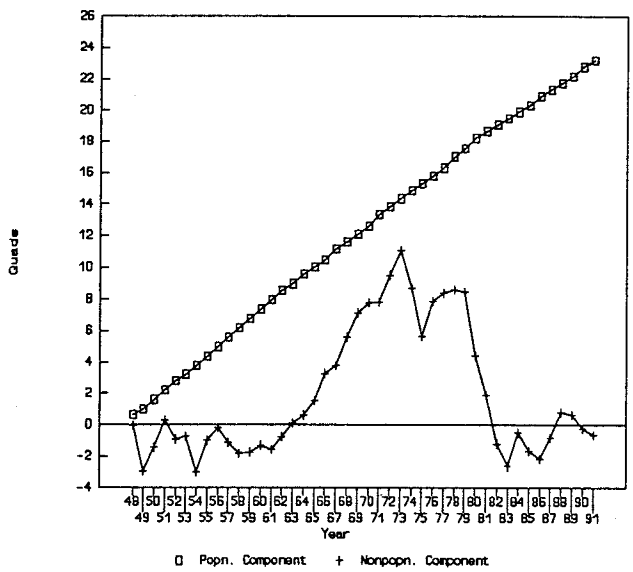

FIGURE 5. Integrated nonelectric energy growth for population and nonpopulation components.

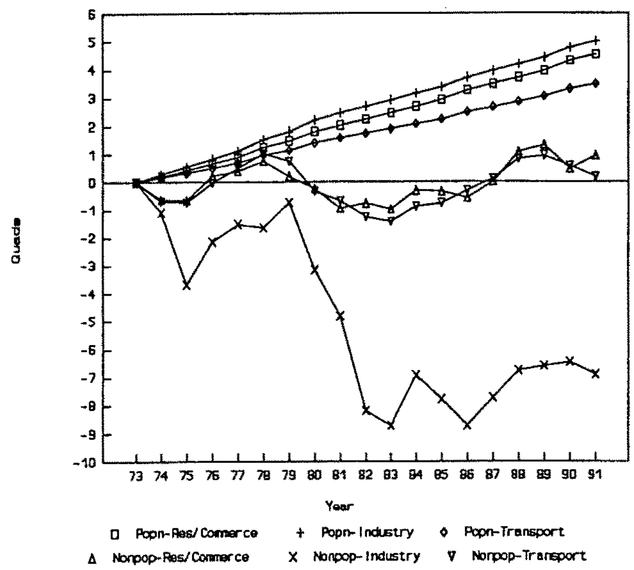

FIGURE 6. Energy growth by end use: population and nonpopulation components.

special note is the extreme downturn in industrial consumption after 1979, far greater than for other end uses. Since these industrial decreases are sustained during the mid-1980s when the economy was strong, they probably reflect substantial improvement in efficiency and perhaps a shift in the labor force from industrial to service jobs.

DISCUSSION

In the United States since 1947, under the assumptions of this analysis, population growth has been relatively unimportant as a contributor to yearly fluctuations in energy consumption. Nonpopulation factors contributed from 1.9 to 4.5 times as much as population growth to yearly changes in energy use, depending upon the sector.

However, whereas energy changes induced by nonpopulation factors are erratic, sometimes adding consumption and sometimes subtracting, population growth consistently adds to consumption. As a result, depending upon which energy sector is considered, population growth may have a dominant role in the longterm growth of consumption. Electricity, the most rapidly growing sector, has been increasing since World War II for reasons that are mostly unconnected to population. On the other hand, the overall increase in nonelectric energy from 1947 to 1991 is wholly attributable to population growth. Prior to 1960 and since 1973, while non-population factors have often contributed to diminishing consumption (especially in industry after 1979), population growth has exerted a contrary upward push.

The primary conclusion to be drawn is that population growth does not act in a simple way to increase resource consumption, even in a single country during a relatively short time period. Rather than debating whether population is or is not the primary culprit behind resource depletion and pollution, it would be more fruitful to specify the ways in which population and other factors interact to exacerbate these problems.

This analysis is limited by the assumption that per capita energy consumption (e) and population (P) are independent, which permitted the decomposition of changing energy consumption into population and non-population components. While this assumption is reasonable over modest changes in population, it is less plausible over large changes. Perhaps a more realistic model would include some constant level of energy consumption (E_{BASE}) that is needed to maintain a society's basic intrastructure, and which is not much affected by marginal additions to or subtractions from total population. Then total energy consumed would be $E = E_{BASE} + fP$, where f is the energy consumed by each additional person at the margin; and it follows that $f < e$. In this case, the population component, $f\,dP$, might be considerably less than the component ($e\,dP$) estimated in this analysis, and contributions from population growth would be overstated.

ACKNOWLEDGEMENT

I appreciate the critical advice of Charles Hall, Duke Kao, and Eugene Rosa.

REFERENCES

Bureau of the Census (1981; 1991). *Statistical abstract of the United States*. Washington, DC: U.S. Government Printing Office.

Bureau of the Census (1975). *Historical statistics of the United States, colonial times to 1970*. Washington, DC: U.S. Government Printing Office.

Dept. of Energy (1992). *Monthly energy review*. Washington, DC: U.S. Government Printing Office.

Mazur, A. (1991). *Global social problems*. Englewood Cliffs, NJ: Prentice-Hall.