

U.S. Infrastructure: 1929-2019

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Abstract

This paper examines the history of U.S. infrastructure since 1929 and in the process reports an interesting fact about the U.S. economy. Infrastructure as a percent of GDP began a steady decline around 1970, and the government budget deficit became positive and large at roughly the same time. The infrastructure pattern in other countries does not mirror that in the United States, so the United States appears to be a special case. The overall results suggest that the United States became less future oriented beginning around 1970. This change has persisted. This is the interesting fact. Whether it can be explained is doubtful.

1 Introduction

This paper examines the history of U.S. infrastructure since 1929 and in the process reports an interesting fact about the U.S. economy. Annual U.S. data for the 1929–2019 period on government fixed assets from the Bureau of Economic Analysis (BEA) show a large and close-to-monotonic decline in the size of infrastructure as a percent of GDP beginning around 1970 for most categories of infrastructure, both defense and nondefense. It is also the case, as will be seen, that the government budget deficit as a percent of GDP changed around 1970 from being close to zero to being large and positive.¹ This change in the deficit has been sustained except

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¹“Government” here means both the federal government and state and local governments. More will be said about this below.

for a brief period in the late 1990's. The deficit data thus show that the government began consuming more relative to its income around 1970, and the infrastructure data show that the government began investing less as a fraction of GDP around the same time.

This paper also examines the history of infrastructure for other countries using annual data for the 1960–2017 period from the International Monetary Fund (IMF). It will be seen that no other country has a pattern similar to that of the United States, namely a roughly monotonic decline in the ratio of infrastructure to GDP beginning around 1970. The United States appears to be a special case in this regard, although some countries have seen large declines beginning somewhat later.

The overall results thus suggest that the United States became less future oriented, less concerned with future generations, beginning around 1970. This change has persisted. This is the interesting fact. Whether it can be explained is unclear. A brief discussion of this issue is in Section 6.

Most of the work using the BEA and IMF data has been concerned with estimating the effects of infrastructure on aggregate output. Aschauer (1989) used an early version of the BEA data to examine whether private sector total factor productivity was affected by public sector infrastructure. Ford and Foret (1991) examined this question for other countries using the IMF data. Munnell (1992) is an early review article. A large literature followed Aschauer (1989), and much of this literature has been summarized in a meta study by Bom and Ligthart (2015). They reviewed 68 studies for the 1983–2008 period. A later study using panel time series data is Calderón, Moral-Benito, and Servén (2015). This question, while interesting, is not of concern here. Rather, the focus is on the historical patterns of infrastructure—category by category for the United States and country by country for the other countries. It does not appear that this type of examination has been done before. There is, of course, currently much discussion about the sad state of U.S. infrastructure, with many examples, but little historical analysis. At the time of this writing there is a government policy response to the U.S. infrastruc-

ture problem in the works in the form of a \$1 trillion bill making its way through Congress.

Section 2 discusses the BEA data and presents the U.S. graphs. Section 3 discusses the IMF data and presents the international graphs. The U.S. data on the government budget deficit are then discussed in Section 4. Section 5 discusses the size of possible shortfalls. Section 6 contains speculation.

2 BEA Data and Graphs

The BEA data are taken from Table 7.2 from the Fixed Assets Accounts Tables, dated September 2, 2020. These data are index numbers, and they were converted to 2012 dollars by using the nominal values for 2012 from Table 7.1. The two main categories in the BEA data are defense and nondefense. Nondefense includes both the federal government and state and local governments. Within defense are structures, and intellectual property products (IPP), and equipment. Within equipment are aircraft, missiles, ships, vehicles, electronics, and other. Within nondefense there are also equipment, IPP, and structures. Within nondefense structures there are many categories. The ones examined here are educational, transportation, power, highways and streets, sewer systems, water systems, and an aggregation of all the rest, denoted “all other.” The transportation category includes air passenger terminals, runways, land passenger terminals, mass transit, docks, and marinas.

In terms of notation, let D denote defense. The three subcategories are structures (S), IPP (I), and equipment (E). So three variables are DS , DI , and DE . Under DE there are six subcategories mentioned above, denoted $DE1$, ..., $DE6$. Let N denote nondefense. In BEA Table 7.2 nondefense is disaggregated into federal and state and local, and for present purposes these have been aggregated. The three subcategories are the same as for defense, so three variables are NE , NI , and NS . Under NS there are the seven subcategories mentioned above, where the seventh is “all other,” denoted $NS1$, ..., $NS7$. The fixed asset data are constructed

using the perpetual inventory method—see U.S. Department of Commerce (2003) plus discussion on the BEA website: *www.bea.gov*. The value of total government defense assets is $DS + DI + DE$, and the value of total government nondefense assets is $NE + NI + NS$. The value of total government assets is $D + N$. For reference, this notation is listed in Table 1.

The reason that the federal government and state and local governments have not been treated separately is that much of the infrastructure investment done by state and local governments is financed by the federal government through grants in aid. The interest here is on total government infrastructure.

As noted in the Introduction, the infrastructure data have been divided by GDP for the analysis. Real GDP data were obtained from the BEA National Income and Product Accounts, Table 1.1.6, dated July 29, 2021. The data are in billions of 2012 dollars. They are available on an annual basis back to 1929. Let Y^a denote real GDP. Y^a is cyclical, and to avoid having the ratio of assets to GDP be cyclical because of this, a non-cyclical measure of GDP was constructed. $\log Y^a$ was plotted for the 1929–2019 period, and a peak-to-peak interpolation was done. The peaks were 1929, 1968, 2005, and 2019. In a few years, like 1943, 1944, and 1945, the actual value was above the line. The three annual growth rates between the peaks are 3.8, 3.1, and 1.7 percent. The non-cyclical measure of GDP was taken to be the exponential of the points on the interpolation lines. The results in this paper are unlikely to be sensitive to other measures of non-cyclical output. Y will be used to denote this non-cyclical measure of GDP, and it will simply be called GDP. Although the asset data are available back to 1925, only data since 1929 have been used because this is where the data on Y^a begin.

Figure 1 plots T/Y for the 1929–2019 period along with its mean over this period. The World War II years and the four years following clearly stand out, as expected. More interesting is the period after the war, say beginning in 1950. Figure 2 plots T/Y for the 1950–2019 period and the mean for this period. Between 1950 and 1969 the ratio is fairly flat, and then from 1970 on there is close to a

Table 1
Variable Notation

| | |
|------------|--|
| <i>DS</i> | Defense Structures. |
| <i>DI</i> | Defense Intellectual Property Products. |
| <i>DE</i> | Defense Equipment. |
| <i>DE1</i> | Aircraft. |
| <i>DE2</i> | Missiles. |
| <i>DE3</i> | Ships |
| <i>DE4</i> | Vehicles. |
| <i>DE5</i> | Electronics. |
| <i>DE6</i> | Other Equipment. |
| <i>NE</i> | Nondefense Equipment. |
| <i>NI</i> | Nondefense Intellectual Property Products. |
| <i>NS</i> | Nondefense Structures. |
| <i>NS1</i> | Educational. |
| <i>NS2</i> | Transportation. |
| <i>NS3</i> | Power. |
| <i>NS4</i> | Highways and Streets. |
| <i>NS5</i> | Sewer Systems. |
| <i>NS6</i> | Water Systems. |
| <i>NS7</i> | All Other Structures. |
| <i>D</i> | Total Defense. $DS + DI + DE$. |
| <i>N</i> | Total Nondefense. $NE + NI + NS$. |
| <i>T</i> | Total Infrastructure. $D + N$. |

- Nondefense includes federal and state and local.
- Units are billions of 2012 dollars.

monotonic decline. This figure, however, masks important differences between defense and nondefense. Figures 3 and 4 plot defense and nondefense separately.

Consider defense first. Defense infrastructure as a percent of GDP in Figure 3 has declined roughly monotonically from the mid 1950's. The decline is large, from 0.44 in 1950 to 0.08 in 2019. Does this decline pertain to all three subcategories of defense? The answer is yes for all three once the decline began, although for

Figure 1
Total Infrastructure/GDP (T/Y)
1929--2019

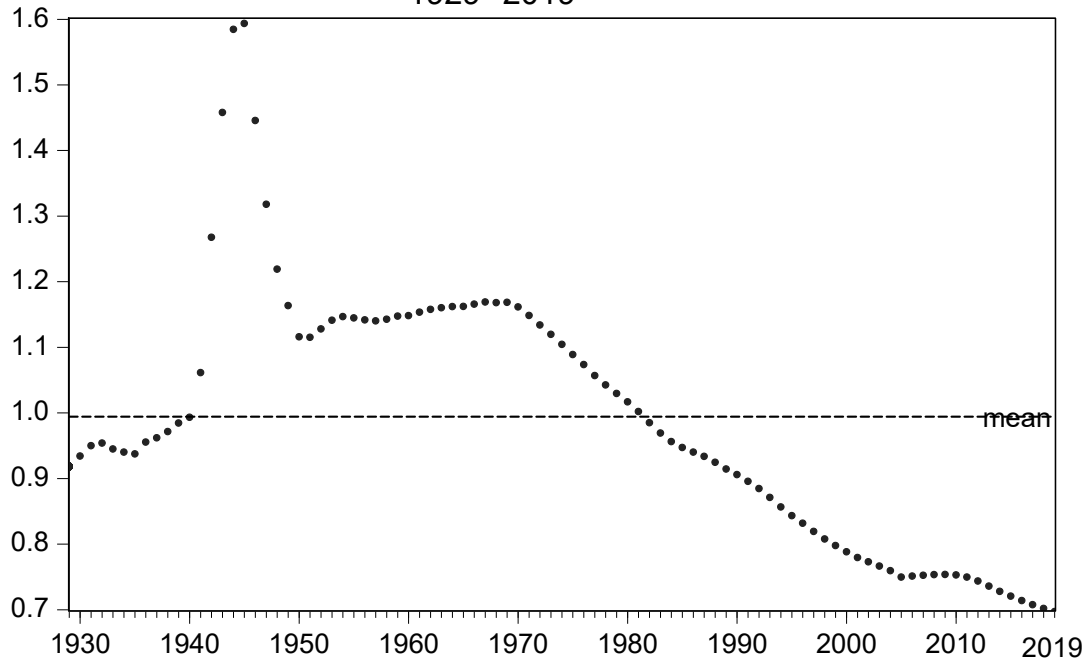


Figure 2
Total Infrastructure/GDP (T/Y)
1950--2019

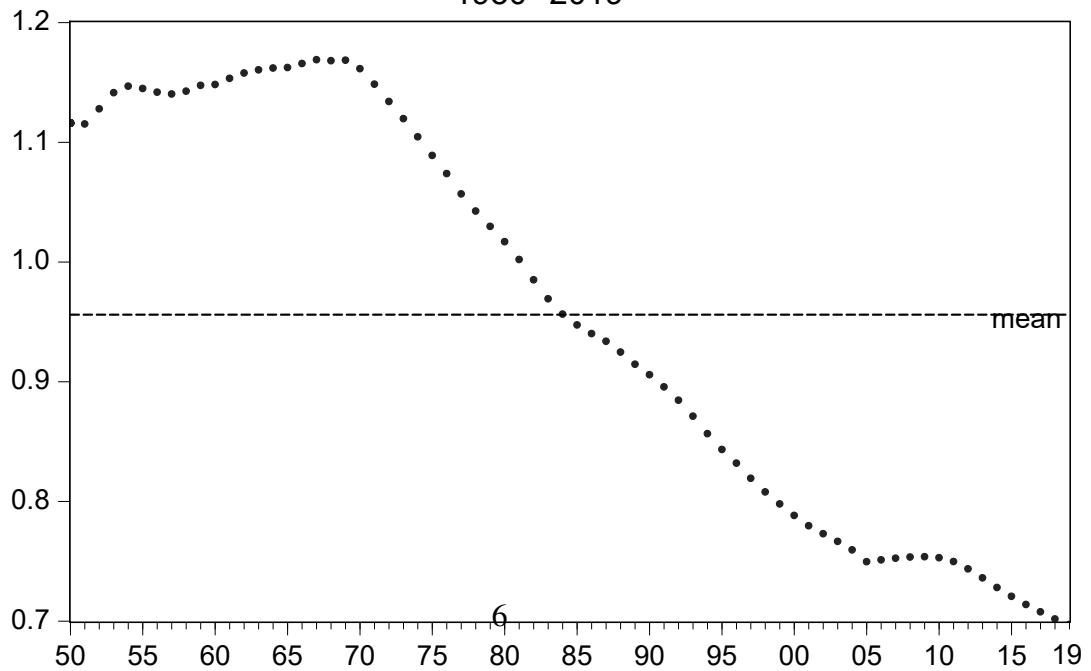


Figure 3
Defense/GDP (D/Y)
1950--2019

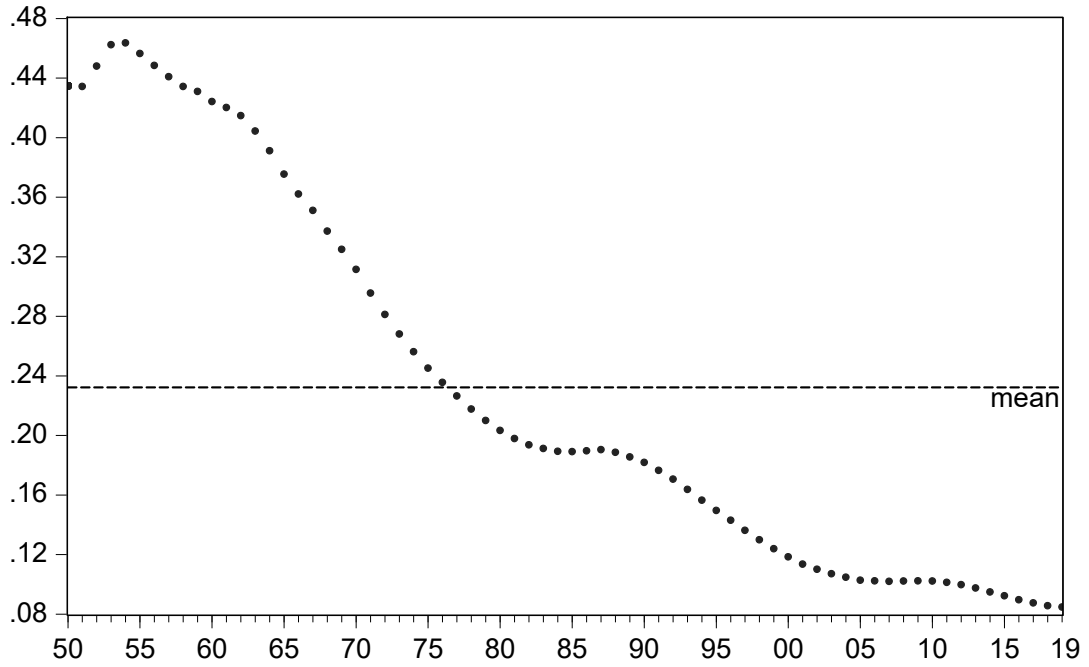
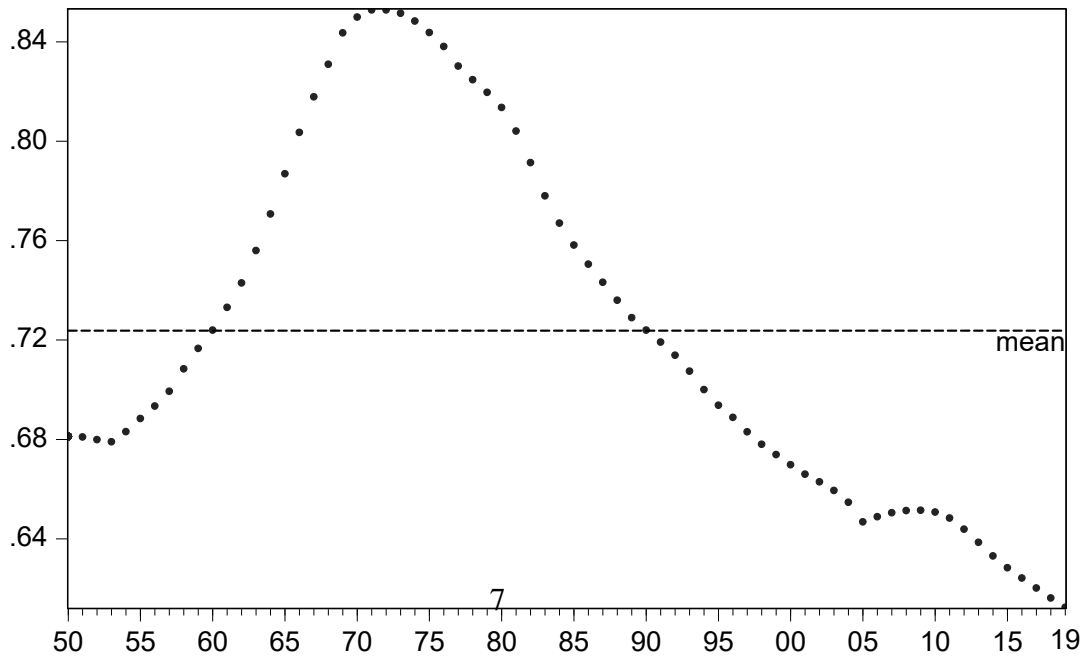


Figure 4
Nondefense/GDP (N/Y)
1950--2019



IPP the decline does not begin until the late 1980's—Figures 5, 6, and 7. What about the six subcategories for defense equipment—Figures 7a through 7f? (The plots in these figures begin in 1972, which is when the data begin.) For aircraft the fall is fairly steady until 2003, when the ratio flattens out. For missiles there is a rise in the 1980's through the early 1990's and then a decline until 2008, when the ratio flattened out. At least some of the decline reflects the effects of treaties. For ships there is roughly a monotonic decline until 2012, when the ratio flattened out. For vehicles there is a decline since 2011, but considerable variation before. For electronics there is again considerable variation with a positive trend. For other equipment there is also variation with a positive trend. Again the total defense equipment results are in Figure 7, which show a large overall decline.

The large decline in defense infrastructure may seem surprising, since many are of the view that the United States is spending too much on the military. The ratio D/Y in Figure 3 does level off in the 1980's before continuing to fall, which reflects the increased spending of the Reagan administration, but the overall trend is clearly downward. One might think that the downward trend is true of defense investment but not defense consumption, but this is not the case. The ratio of defense consumption to GDP has fallen from 0.1137 in 1969 to 0.0326 in 2019. (In this same period the ratio of defense gross investment to GDP fell from 0.0142 to 0.0084.)² The overall picture is thus of a substantial decline in defense spending as a percent of GDP since 1950.

Turn now to nondefense, which is perhaps of more interest recently. Figure 4 shows that there was a sharp increase in the ratio of nondefense infrastructure to GDP in the 1950's and 1960's and then roughly a monotonic decline from 1970 on. The early rise reflects in part the construction of the interstate highway system and the increase in educational infrastructure driven by the baby boom. The peak ratio was reached in the early 1970's and since then has declined roughly monotonically.

²Defense consumption and defense gross investment are taken from BEA Table 3.9.3, lines 18 and 19. These data are index numbers, and they were converted to 2012 dollars using the dollar values in 2012 in Table 3.9.5. They were then divided by Y .

Figure 5
Defense Structures/GDP
1950--2019

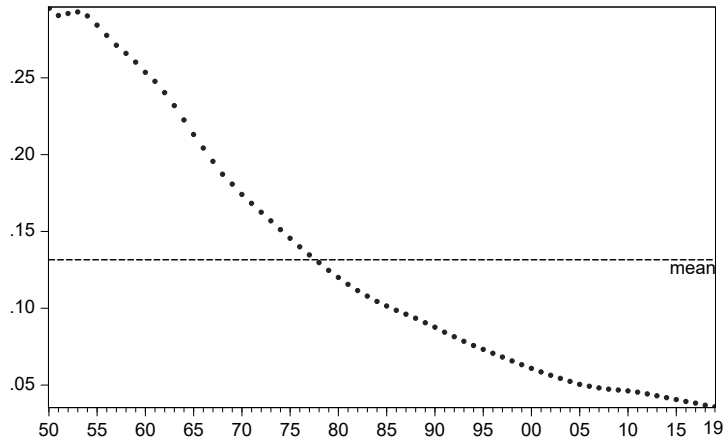


Figure 6
Defense IPP/GDP (DI/Y)
1950--2019

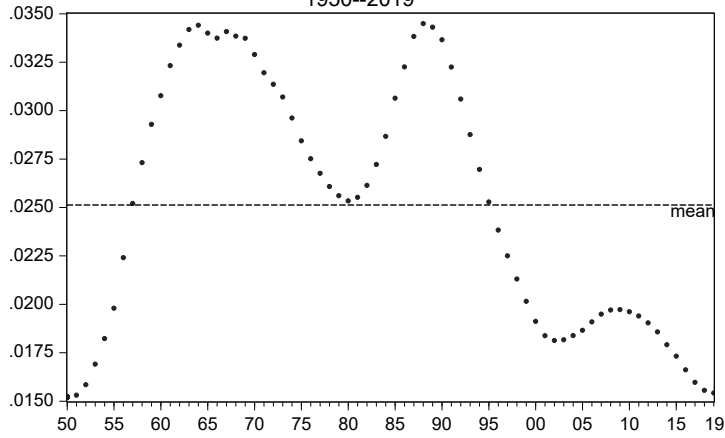


Figure 7
Defense Equipment/GDP
1950--2019

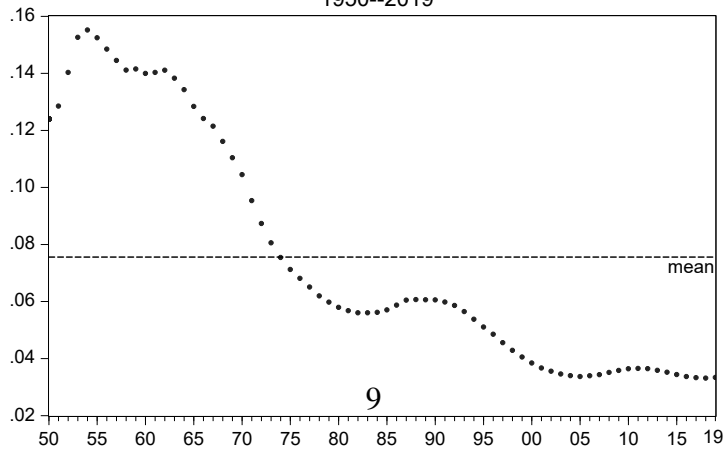


Figure 7a
Defense Aircraft/GDP (DE1/Y)
1972--2019

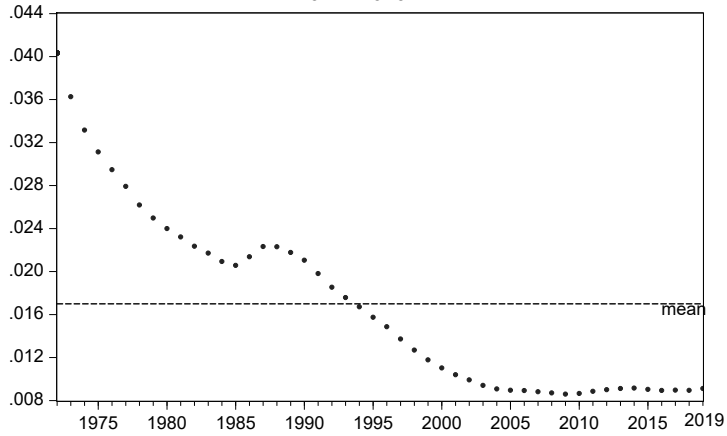


Figure 7b
Defense Missiles/GDP (DE2/Y)
1972--2019

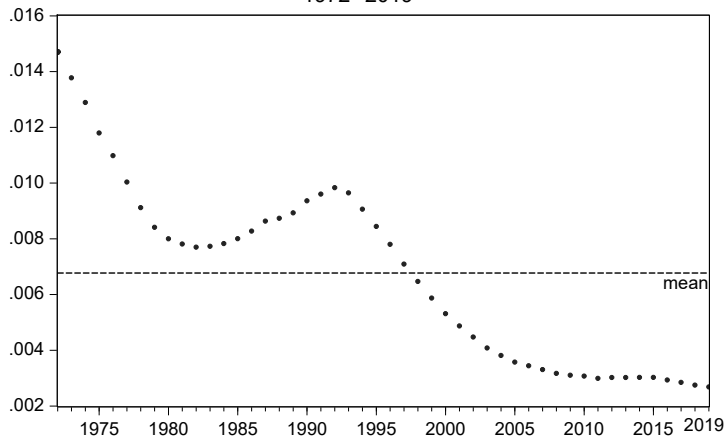


Figure 7c
Defense Ships/GDP (DE3/Y)
1972--2019

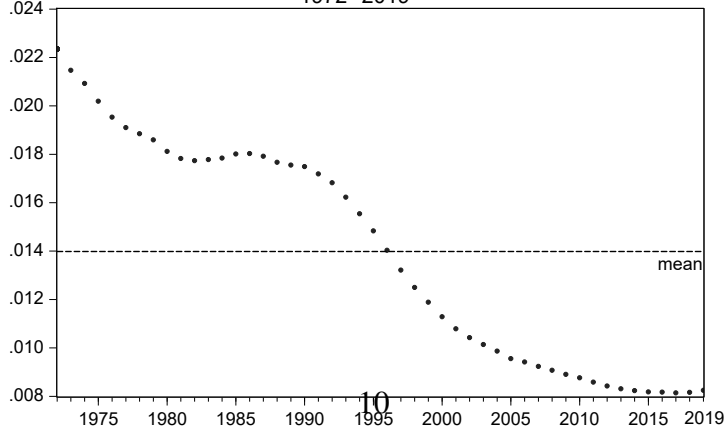


Figure 7d
Defense Vehicles/GDP (DE4/Y)
1972--2019

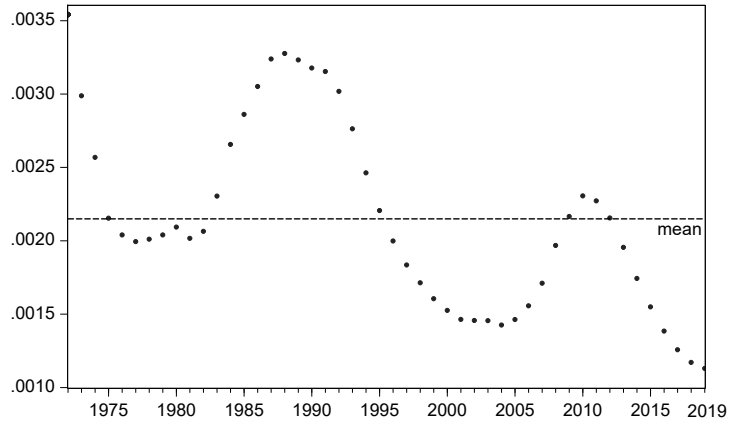


Figure 7e
Defense Electronics/GDP (DE5/Y)
1972--2019

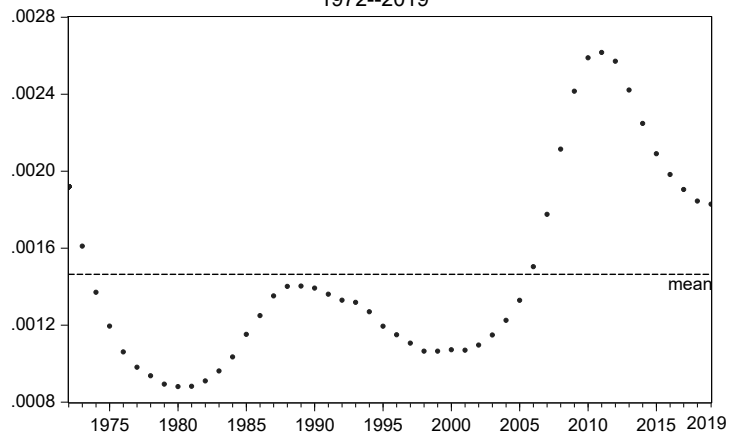
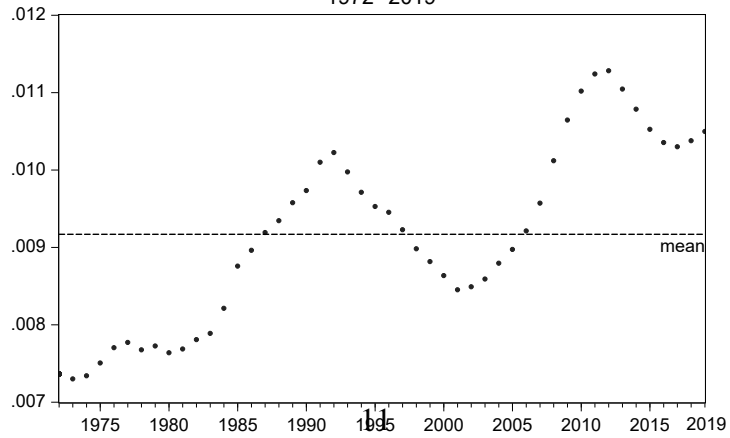


Figure 7f
Defense Other Equipment/GDP (DE6/Y)
1972--2019



The ratio was 0.85 in 1971 and 0.61 in 2019, a large decline.

It is informative to look at the subcategories for nondefense. These are in Figures 8, 9, and 10. Equipment and IPP do not show a decline since 1970, but they are very small as a fraction of GDP. The equipment ratio is 0.009 in 1970 and 0.020 in 2019. For IPP the ratio is 0.047 in 1970 and 0.044 in 2019. Almost all of nondefense is structures, plotted in Figure 10, which shows the roughly monotonic decline since 1970. Figures 10a through 10g show plot for the seven subcategories of structures. Education rose until 1970, fell until 1996, and then has had a gradual rise after that. As noted above, some of the rise before 1970 reflects investment in education for the baby boomers. Transportation has risen throughout the period, a dream for people interested in infrastructure—Figure 10b. The bad news is that transportation is a small category relative to, say, highways and streets—Figure 10d. Highways and streets rose until 1970, again partly reflecting the construction of the interstate highway system, and then declined from 1970 on. Power in Figure 10c, a small category, has declined since the mid 1980's. Sewer systems in Figure 10e rose until 1980 and then declined. Water systems in Figure 10f has declined since 1970. Finally, “all other” in Figure 10g rose until 1980 and then began the decline. Again, the results for total nondefense structures are in Figure 10, which show the aggregate decline since 1970.

3 IMF Data and Graphs

The Fiscal Affairs Department of the International Monetary Fund has compiled data on the stock of public capital in 189 countries. The data are annual, and for most countries they begin in 1960. They end in 2017. Data are also available for GDP. The units are in 2011 international dollars. Let T denote the capital stock and let Y denote GDP for a given country. For the results in this section Y is actual GDP. It has not been adjusted for cyclical variation.

Figure 8
Nondefense Equipment/GDP (NE/Y)
1950--2019

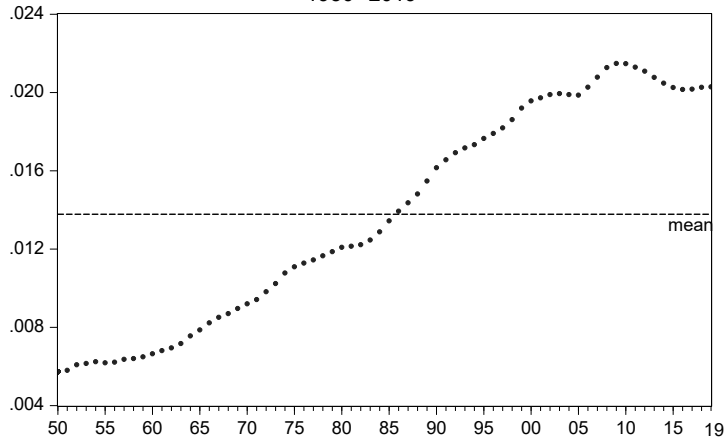


Figure 9
Nondefense IPP/GDP (NI/Y)
1950--2019

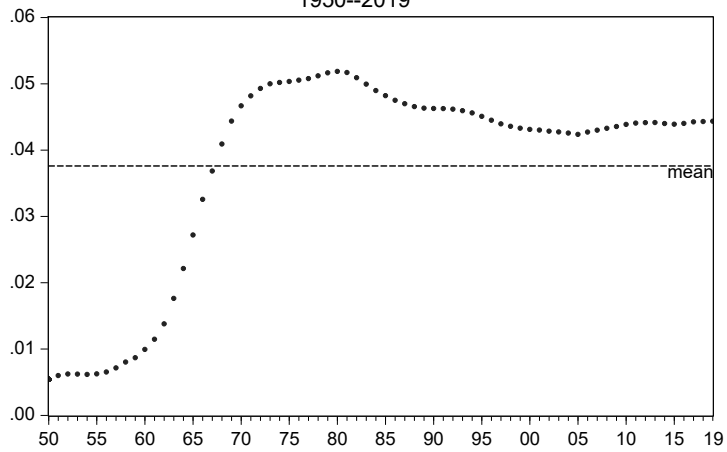


Figure 10
Nondefense Structures/GDP (NS/Y)
1950--2019

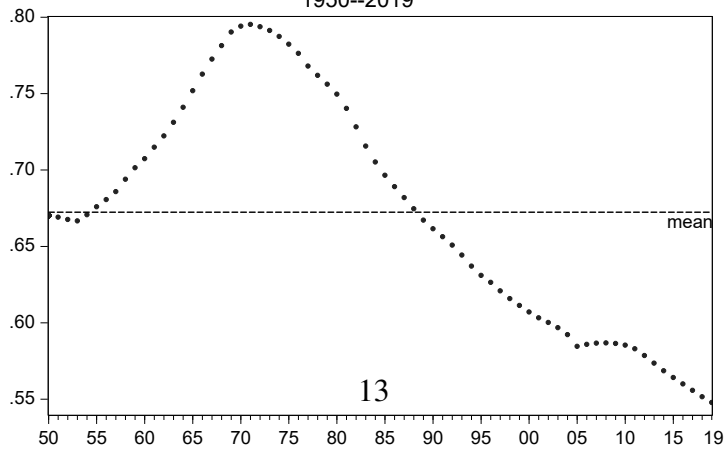


Figure 10a
Nondefense Educational/GDP (NS1/Y)
1950--2019

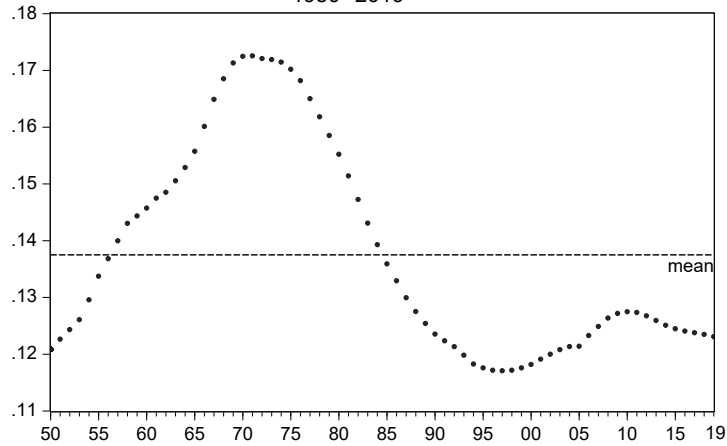


Figure 10b
Nondefense Transportation/GDP (NS2/Y)
1950--2019

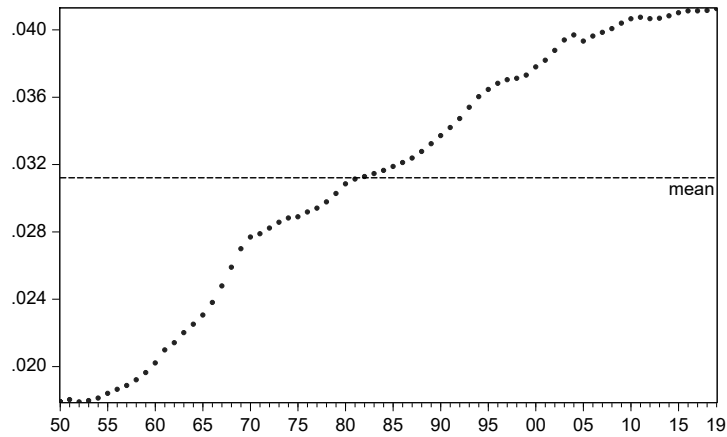


Figure 10c
Nondefense Power/GDP (NS3/Y)
1950--2019

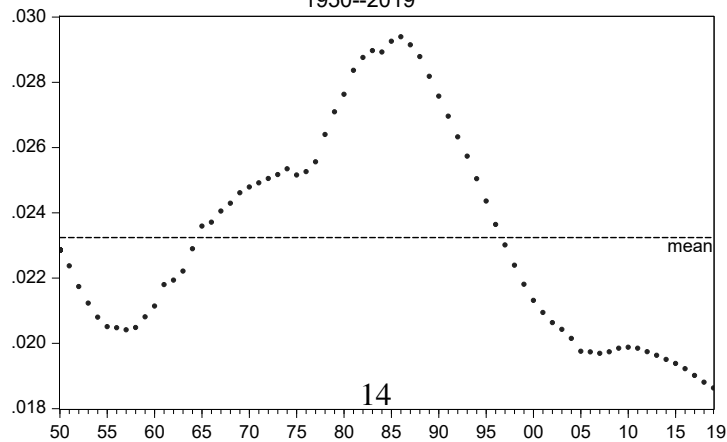


Figure 10d
 Nondefense Highways and Streets/GDP (NS4/Y)
 1950--2019

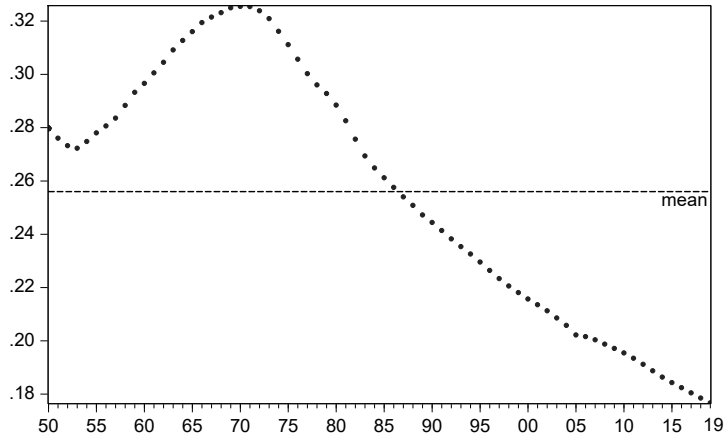


Figure 10e
 Nondefense Sewer Systems/GDP (NS5/Y)
 1950--2019

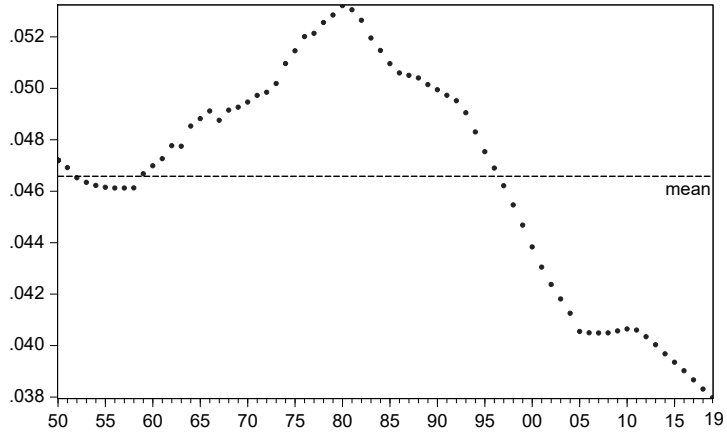


Figure 10f
 Nondefense Water Systems/GDP (NS6/Y)
 1950--2019

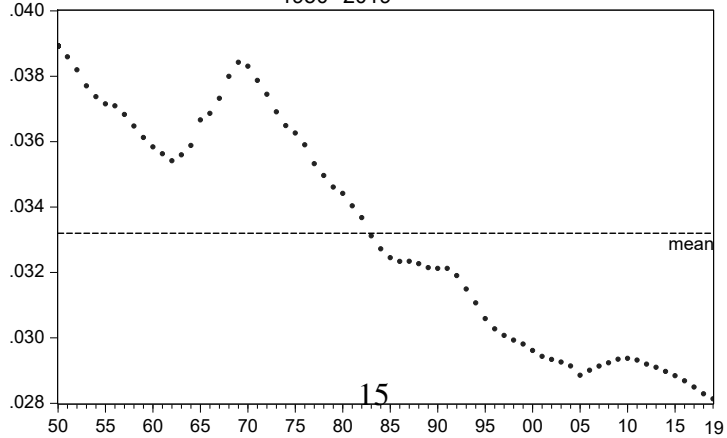
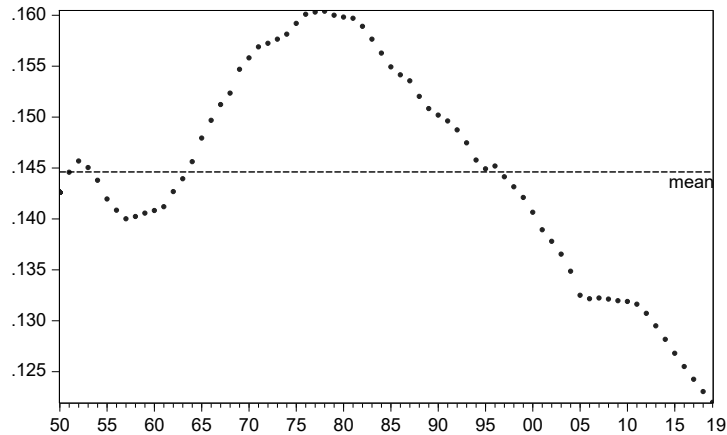


Figure 10g
 Nondefense All Other Structures/GDP (NS7/Y)
 1950–2019



The IMF categorizes countries into 1) low income developing countries (LIDC), 2) emerging markets (EM), and 3) advanced economics (AE). Four aggregates have been used here. First, countries were excluded from all aggregates if they had any missing data from 1970 on. Countries were used if they had missing data only between 1960 and 1969, where they simply were not included in the aggregates for these years. This left 137 countries out of 189. For each year the values of the capital stock were summed to get an aggregate capital stock, and the values of GDP were summed to get an aggregate GDP value. The ratio of the aggregate capital stock to aggregate GDP was then computed. This was done for all countries, all LIDC countries, all EM countries, and all AE countries. The United States was excluded from all calculations.

Figures 11–14 contain the aggregate plots: Figure 11 is for all 137 countries; Figure 12 is for the LIDC countries; Figure 13 is for the EM countries; and Figure 14 is for the AE countries. Figure 11 shows that for the sum of all countries the ratio of public capital to GDP rose sharply between the mid 1970’s and the mid 1980’s. It was at an all time high in 2017. The aggregate is driven by the EM countries in Figure 13, where the ratio has a similar pattern over time. For both the LIDC

Figure 11
All Countries, Public Capital/GDP
1960--2017

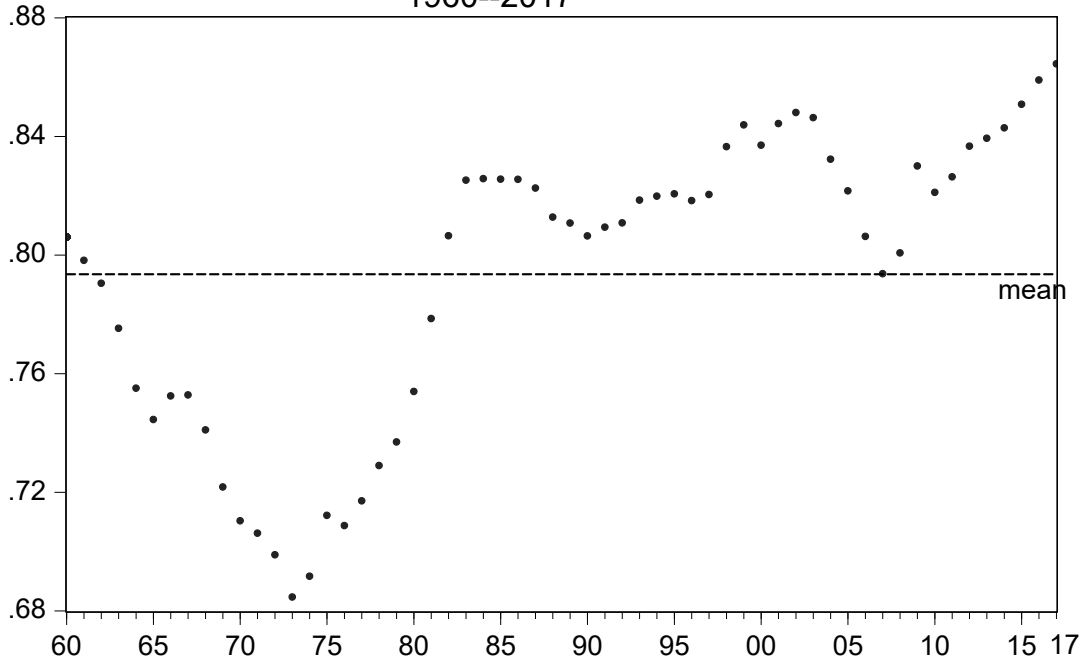


Figure 12
LIDC Countries, Public Capital/GDP
1960--2017

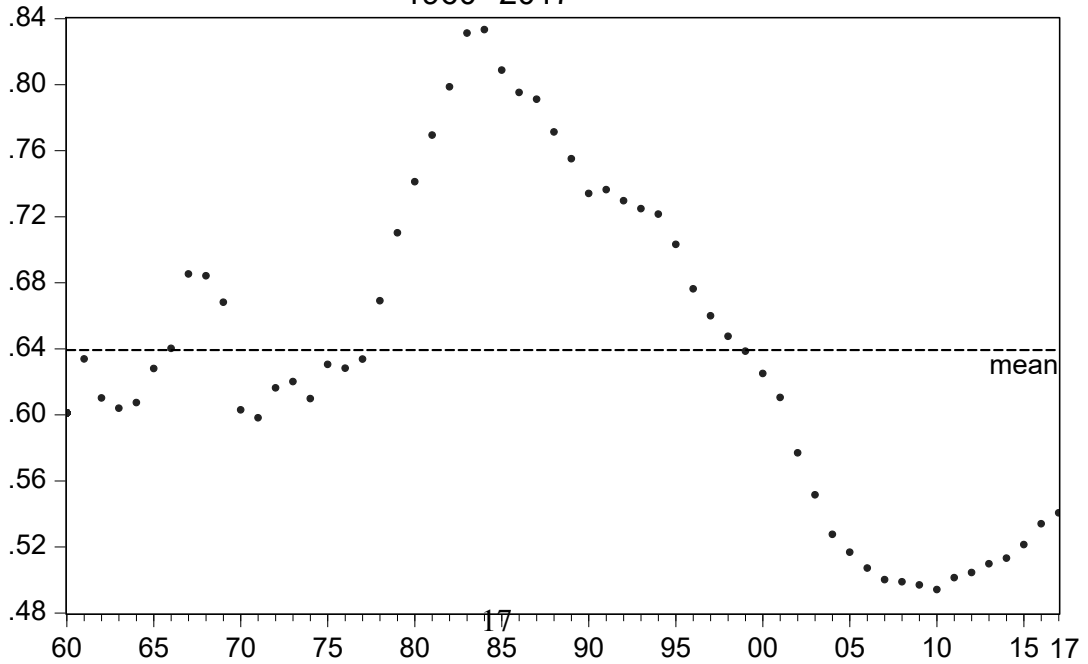


Figure 13
EM Countries, Public Capital/GDP
1960--2017

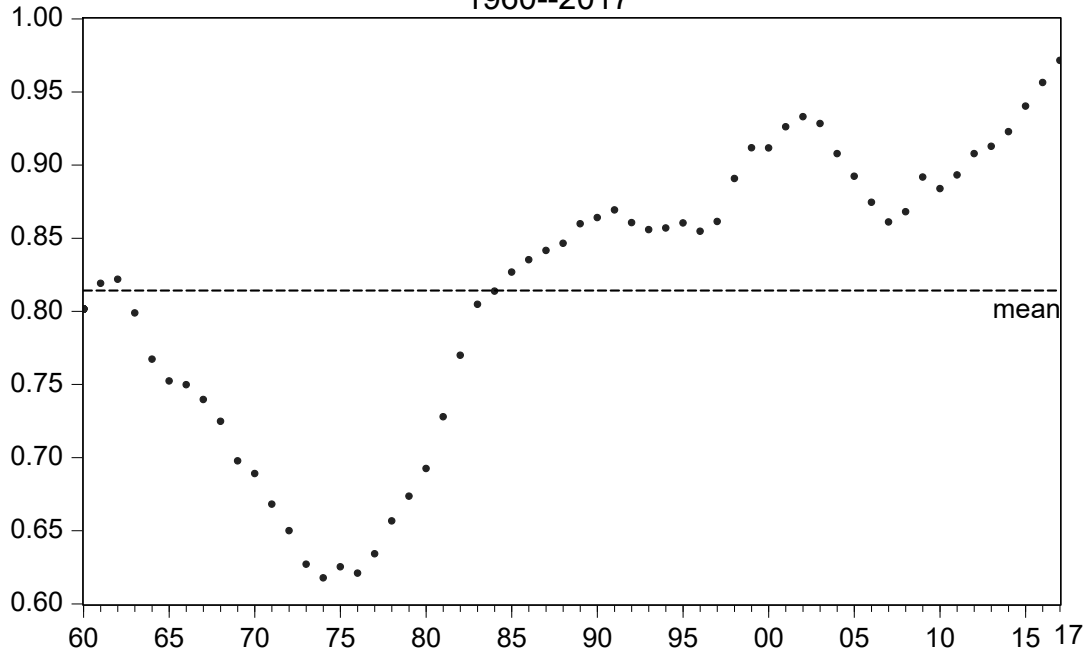
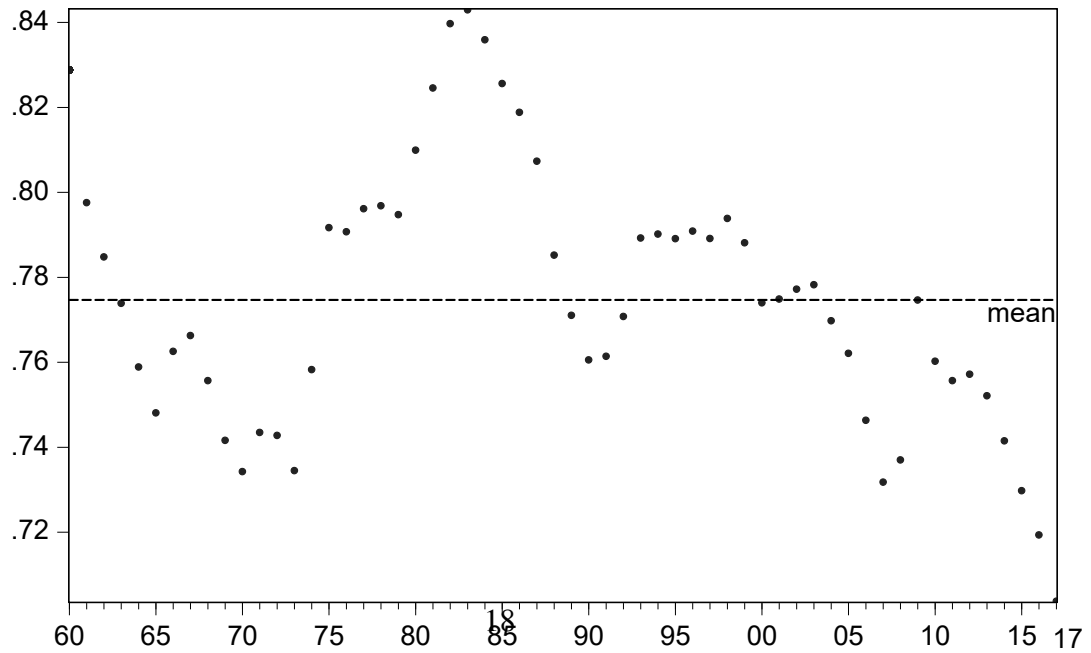


Figure 14
AE Countries, Public Capital/GDP
1960--2017



countries in Figure 12 and the AE countries in Figure 14 the ratio has fallen since the mid 1980's.

Figures 15a–15l contain plots for 12 individual countries. One question of interest for present purposes is whether these plots exhibit a pattern since 1970 similar to that for the United States in Figure 2, namely a roughly monotonic decline, ending roughly at the smallest value in the period. Five of the 12 plots end roughly at the smallest value: France, Germany, India, the Netherlands, and the United Kingdom. For none of these does the decline begin in the early 1970's. For India the decline begins in the mid 1990's; for the United Kingdom the decline begins in the early 1980's; , and for Germany, the Netherlands, and the United Kingdom the decline begins in the mid 1980's; and for France there is considerable fluctuation ending at a low point.

Some of the plots are somewhat erratic, which could be partly due to measurement error. Of the 7 plots that did not end at roughly the smallest value, Italy, Mexico, and Spain ended in 2017 above the mean over the whole period, whereas Canada, China, Japan, and Korea ended at roughly the mean. Driving the decline of the ratio for all the AE countries in Figure 14 are the declines for France, Germany, the Netherlands, and the United Kingdom. Offsetting this in part are the increases for Italy and Spain.

Figure 16 is a plot for the United States using the IMF data on both the capital stock and GDP. (GDP in this case has not been adjusted for business cycles.) The plot is similar to that in Figure 2, which is encouraging regarding the accuracy of the data. The decline begins more or less in 1970, although there is some decline in the 1960's. There are also more fluctuations going down. The ratios are also smaller using the IMF data. For example, in 1970 the ratio is 0.973 for IMF and 1.161 for BEA. In 2017 it is 0.627 for IMF and 0.708 for BEA. The decline between 1970 and 2017 is somewhat larger for BEA than for IMF: 0.453 versus 0.346. Probably the BEA data are more reliable.

Figure 15a
Canada, Public Capital/GDP
1961--2017

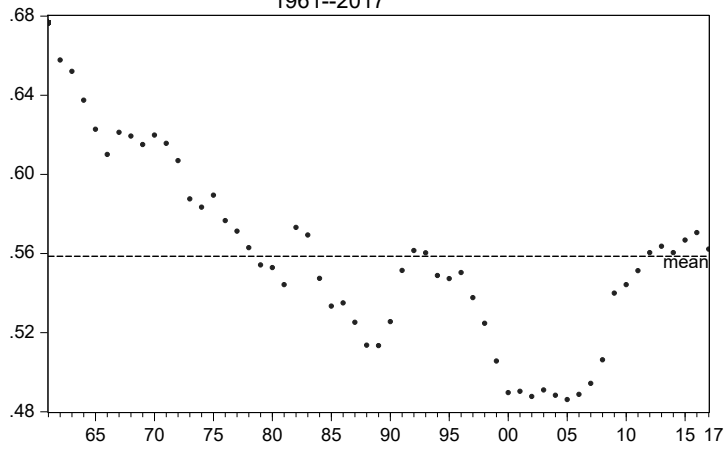


Figure 15b
China, Public Capital/GDP
1960--2017

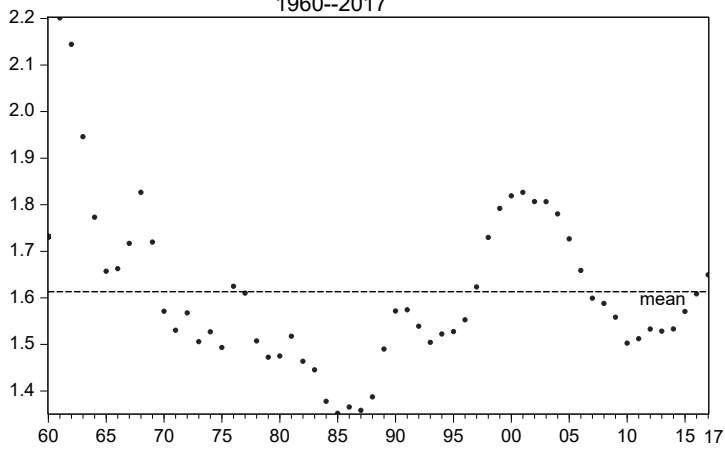


Figure 10c
France, Public Capital/GDP
1960--2017

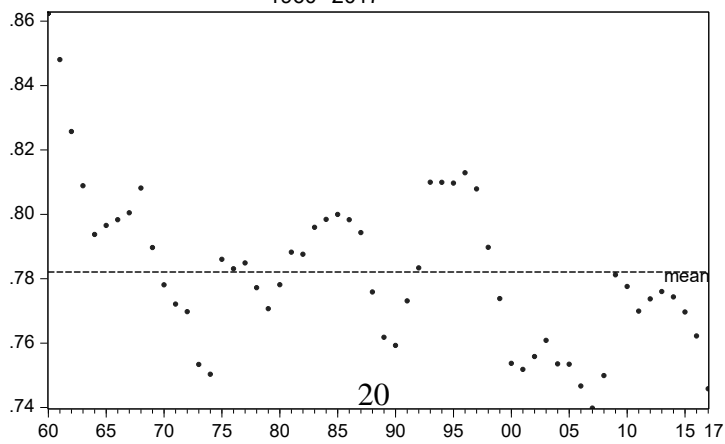


Figure 15d
Germany, Public Capital/GDP
1960--2017

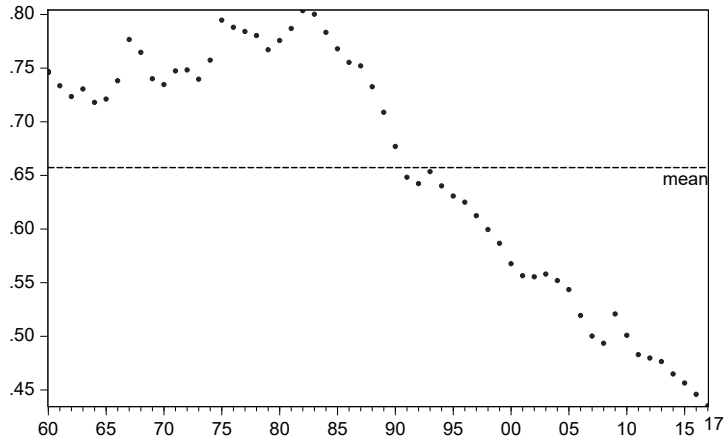


Figure 15e
India, Public Capital/GDP
1960--2017

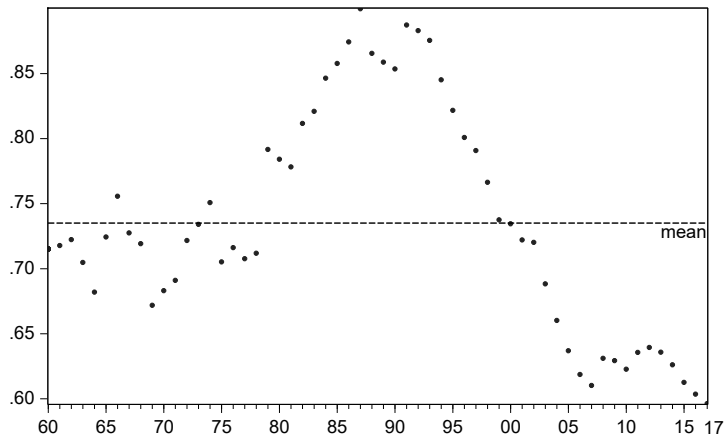


Figure 15f
Italy, Public Capital/GDP
1960--2017

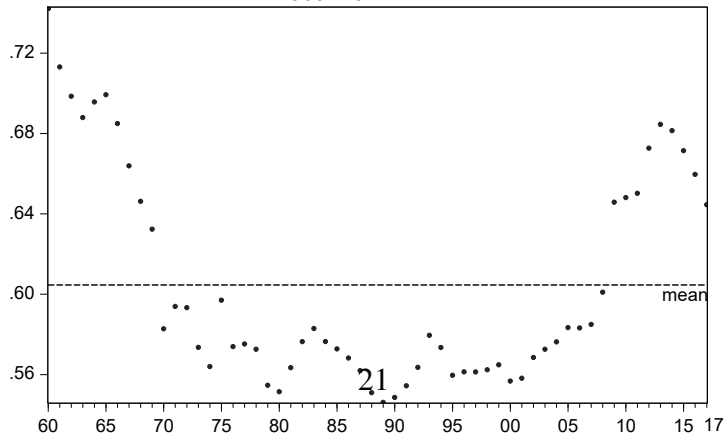


Figure 15g
Japan, Public Capital/GDP
1960--2017

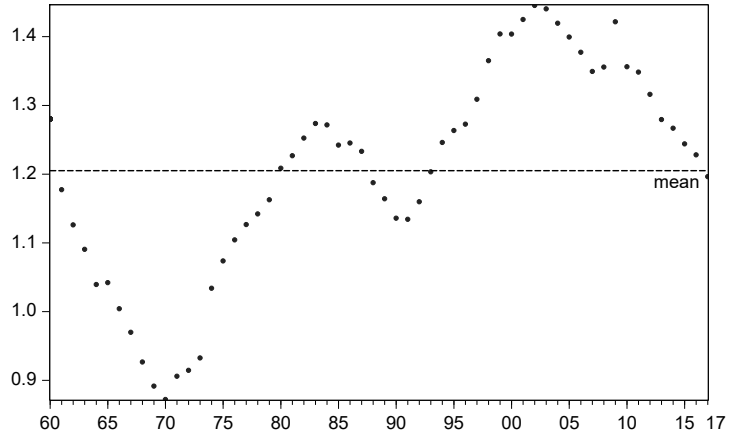


Figure 15h
Korea, Public Capital/GDP
1960--2017

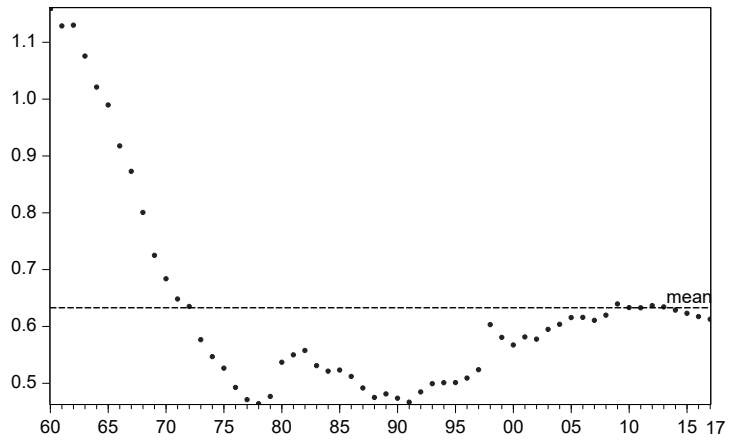


Figure 15i
Mexico, Public Capital/GDP
1960--2017

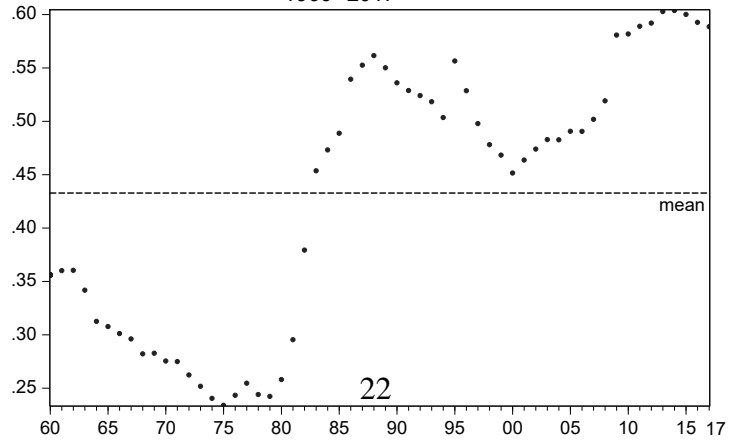


Figure 15j
The Netherlands, Public Capital/GDP
1960--2017

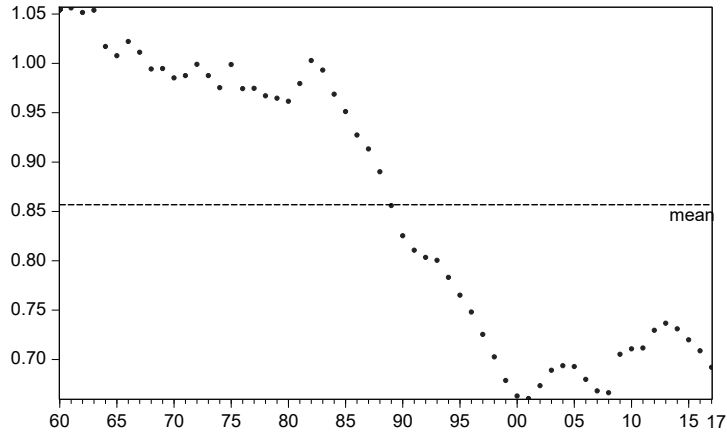


Figure 15k
Spain, Public Capital/GDP
1960--2017

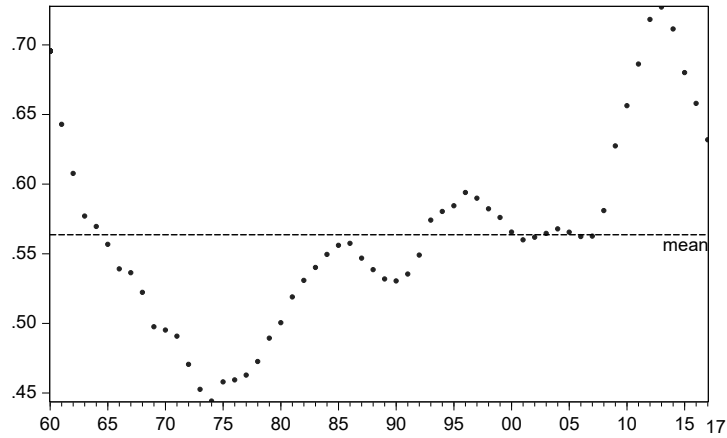


Figure 15l
United Kingdom, Public Capital/GDP
1960--2017

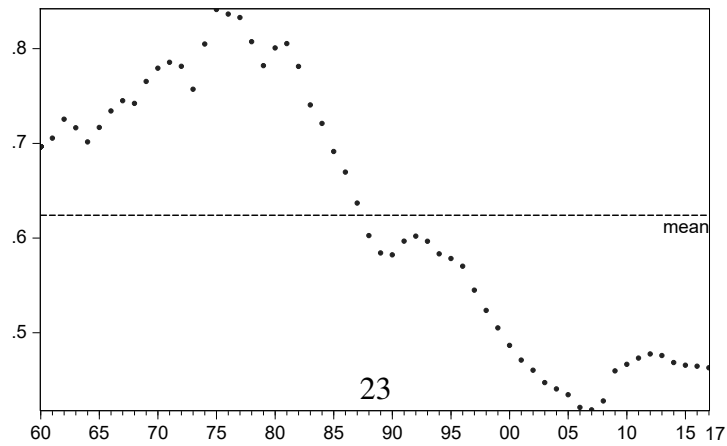
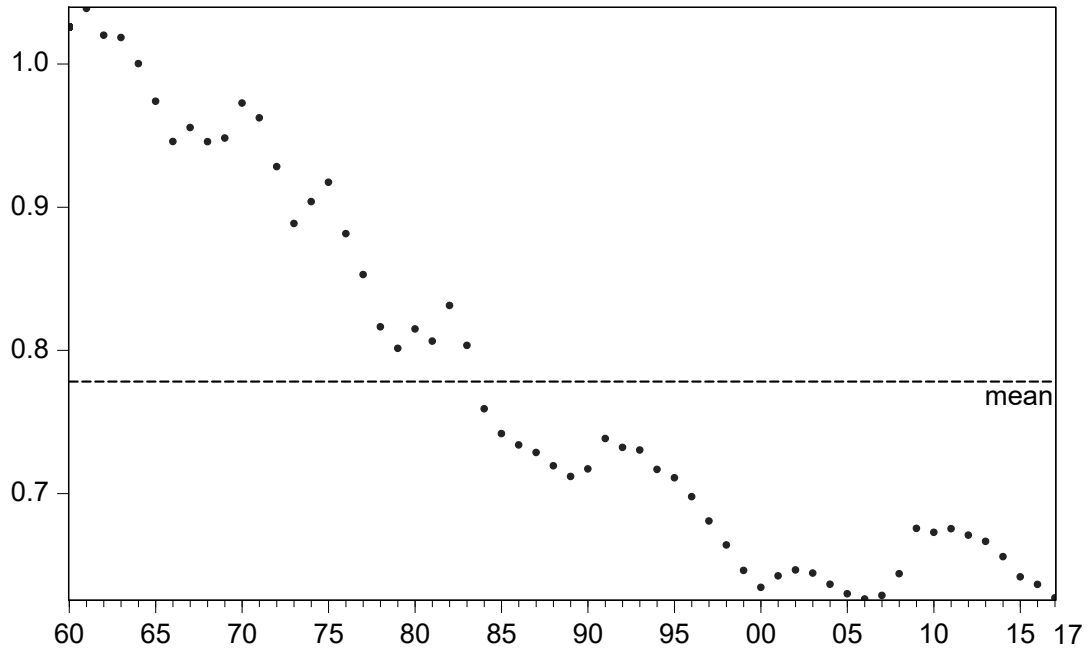


Figure 16
 United States, Public Capital/GDP
 1960--2017



4 The Government Budget Deficit

As noted in the Introduction, the government budget deficit as a percent of GDP became large and positive beginning in 1970. Figure 17 plots the government deficit as a percent of GDP for 1950–2019. The deficit data are taken from BEA Table 3.1 in the National Income and Product Accounts, dated July 29, 2021. The deficit is the negative of “net government saving” on line 31, which is the difference between current receipts and current expenditures. The main categories of current expenditures are consumption expenditures, current transfer payments, and interest payments. The deficit has been divided by the GDP deflator to put it in real terms, and then the deficit in real terms is divided by Y to compute the ratio. The GDP deflator is taken from Table 1.1.9, line 1, also dated July 29, 2021.

Figure 17
 Government Deficit/GDP
 1950--2019

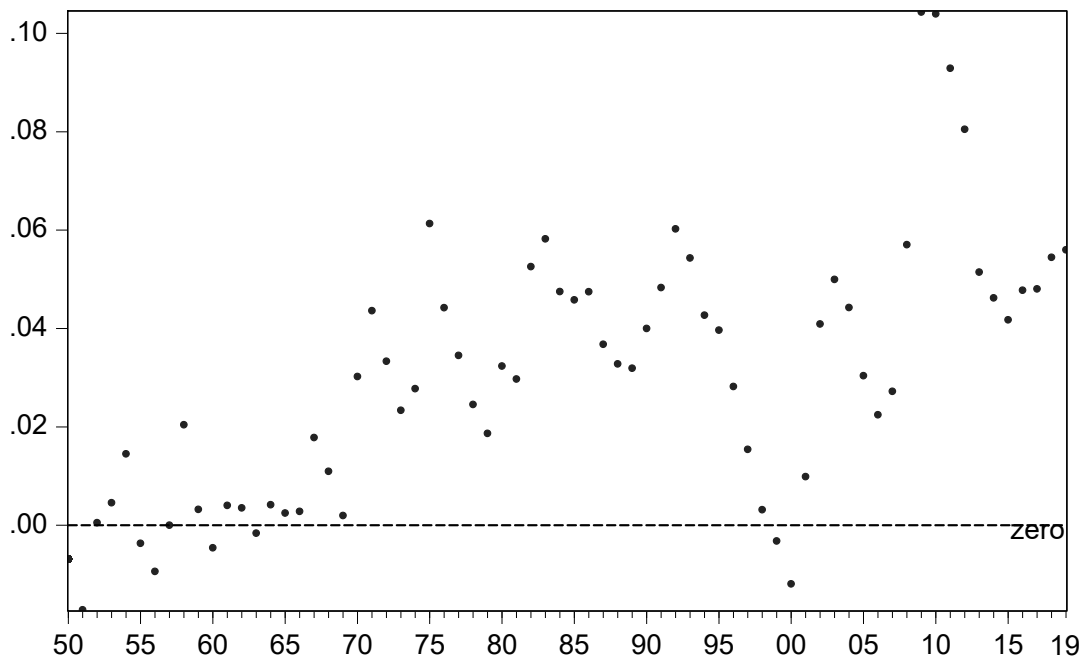


Figure 17 shows that the deficit as a percent of GDP hovered near zero until 1970, when it became positive. It has remained positive except for 1999 and 2000. The average of the ratio is 0.0024 for 1950–1969, 0.0378 for 1970–1989, 0.0352 for 1990–2009, and 0.0633 for 2010–2019. Figures 17a and 17b plot the same variable for the federal government and state and local governments separately. The data are taken from BEA Tables 3.2 and 3.3. The two figures show that the increase in the early 1970’s was from the federal government. State and local governments began contributing to the deficit in the early 1990’s. The contribution became larger beginning about 2000.

Figure 17a
Federal Government Deficit/GDP
1950--2019

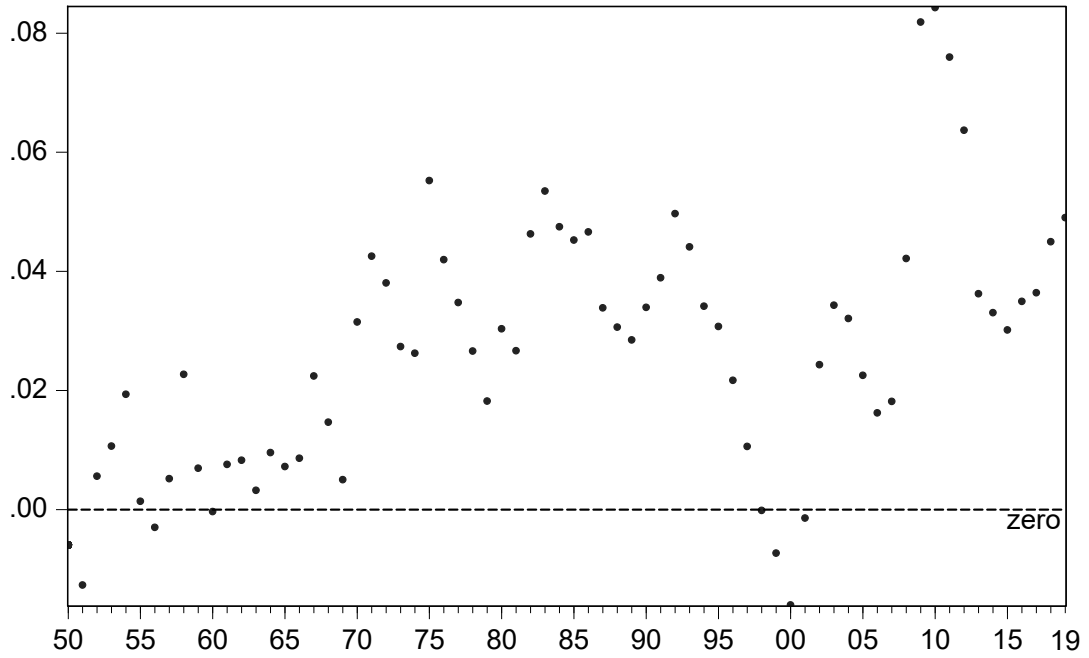
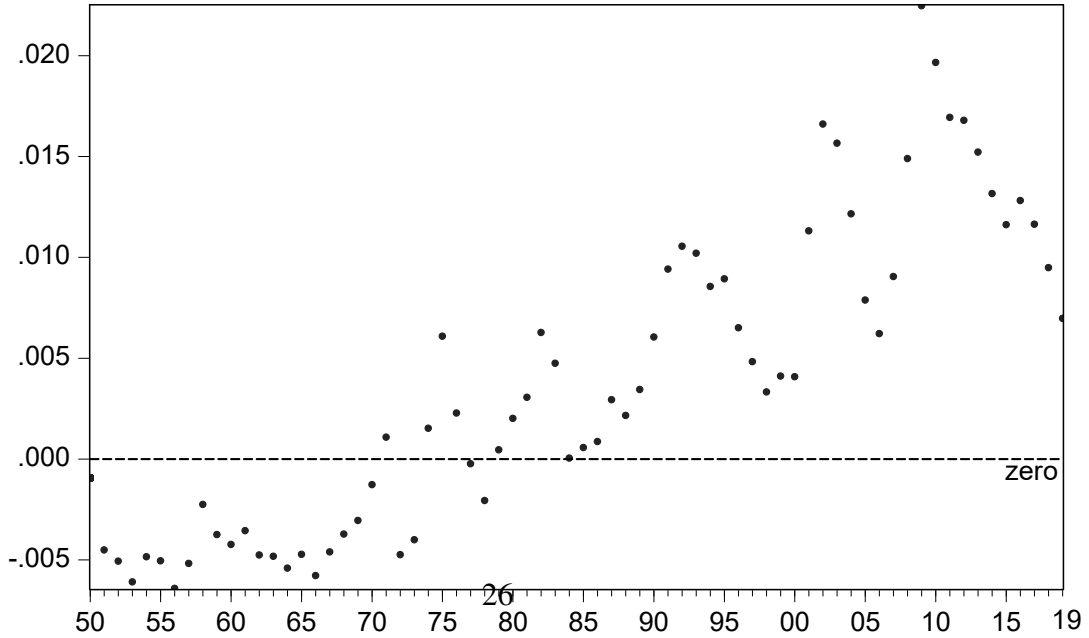


Figure 17b
State and Local Government Deficit/GDP
1950--2019



5 Infrastructure Shortfall?

With few exceptions the ratio of most categories of U.S. infrastructure to GDP is near an all time low, with declines that begin around 1970. The declines have been large. The decline is larger for defense than nondefense, but the nondefense decline is also large. Is this decline a cause for concern? The literature mentioned in the Introduction suggests that infrastructure may have a positive effect on aggregate output, so, other things being equal, declining infrastructure has a negative effect on output. Also, as discussed in the Introduction, the current political discourse is that infrastructure is too low. Without a model of the optimal size of infrastructure, however, it is unclear how big the problem is if there is in fact a problem. Developing such a model is beyond the scope of this paper.

One can, however, use the present results to consider possible shortfalls. Consider the ratio of nondefense infrastructure to GDP in Figure 4. In 2019 the ratio was 0.61. GDP (Y) in 2019 was \$19.0 trillion, so nondefense infrastructure was $0.61 \times 19.0 = \$11.6$ trillion. The mean ratio over the 1950–2019 period is 0.72, and so if the ratio in 2019 were at the mean, nondefense infrastructure would be \$13.7 trillion, \$2.1 trillion more. If the ratio were at the 1970 value, which is 0.85, nondefense infrastructure would be \$16.2 trillion, \$4.6 trillion more. These values are in 2012 dollars. The GDP deflator in 2019 was 1.123, so in 2019 dollars the two shortfalls are \$2.4 trillion and \$5.2 trillion. The infrastructure bill making its way through Congress at the time of this writing has incremental infrastructure spending over 10 years of \$550 billion (in 2021 dollars). This is about 25 percent of the shortfall to get back to the mean and about 10 percent to get back to the 1970 value. Using this metric the size of the bill is modest.

Another way of looking at this, if the \$550 billion were added to the stock in 2019 (rather than spread out over 10 years beginning in 2022 as will be the case if the bill is passed), the ratio of the stock of nondefense infrastructure to GDP would be about 0.64 rather than the actual value of 0.61. This gets the ratio back to its

value in 2013, again a modest improvement.

6 Speculation

As noted in the Introduction, the infrastructure results combined with the results for the government budget deficit suggest that the United States became less future oriented, less concerned with future generations, beginning about 1970. This change has persisted. The roughly monotonic decline in infrastructure as a percent of GDP since 1970 is remarkable. The government began consuming more relative to its income and investing less around 1970. This is not a pattern in other countries, so it could be something special about the United States. Can this change be explained? Can one build a structural model to explain it? The years 1968, 1969, and 1970 had many noticeable events: the early baby boomers moving into their 20's; the assassinations of Martin Luther King Jr. and Robert Kennedy; the beginning of the women's movement; the draft, the bombing of Cambodia, and unrest on college campuses; Woodstock; Stonewall. Did any of these increase the impatience of the country in a permanent way? There are likely stories that could be woven, undoubtedly more than one, but it is unclear whether anything could be tested. The question is probably too big, but the fact is interesting.³

³The year 1970 also saw the passage of the US Clean Air Act and the establishment of the Environmental Protection Agency—see Currie and Walker (2019) and Schmalensee and Stavins (2019) for a history. Did this have any affect on investment in infrastructure?

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