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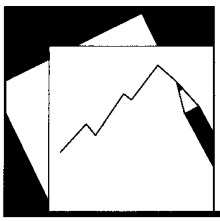

IMF Working Paper

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Andrew M. Warner

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Public Investment as an Engine of Growth

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Abstract

This paper looks at the empirical record whether big infrastructure and public capital drives have succeeded in accelerating economic growth in low-income countries. It looks at big long-lasting drives in public capital spending, as these were arguably clear and exogenous policy decisions. On average the evidence shows only a weak positive association between investment spending and growth and only in the same year, as lagged impacts are not significant. Furthermore, there is little evidence of long term positive impacts. Some individual countries may be exceptions to this general result, as for example Ethiopia in recent years, as high public investment has coincided with high GDP growth, but it is probably too early to draw definitive conclusions. The fact that the positive association is largely instantaneous argues for the importance of either reverse causality, as capital spending tends to be cut in slumps and increased in booms, or Keynesian demand effects, as spending boosts output in the short run. It argues against the importance of long term productivity effects, as these are triggered by the completed investments (which take several years) and not by the mere spending on the investments. In fact a slump in growth rather than a boom has followed many public capital drives of the past. Case studies indicate that public investment drives tend eventually to be financed by borrowing and have been plagued by poor analytics at the time investment projects were chosen, incentive problems and interest-group-infested investment choices. These observations suggest that the current public investment drives will be more likely to succeed if governments do not behave as in the past, and instead take analytical issues seriously and safeguard their decision process against interests that distort public investment decisions.

JEL Classification Numbers: H54; E22; O40; O50

Keywords: Public Investment; Infrastructure; Economic Growth; Public Capital; Big Push

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Introduction

This is an empirical paper examining the degree to which public investment drives over the past four decades have successfully triggered higher economic growth, productivity and long term development. The general idea that public capital and infrastructure will boost economic growth is a prominent feature of government economic programs across the world. Most recently, the idea that infrastructure would revive growth was an important plank in the Egyptian government's economic revival program in August 2013 and the Indian BJP Party's election manifesto in the Spring of 2014. The idea has a long history. It was a prominent recommendation coming out of the big push models of the 1940's – 1960's and an important aspect of the state led development programs through the end of the 1980's. Today international financial institutions have endorsed the idea that there is an infrastructure gap in less developed countries and that closing that gap can revive economic growth in the face of declining demand from higher income countries[1]. Some call it the next big thing to drive development.

This paper separates out episodes of large public investment drives, also called investment booms, and tests whether economic growth was higher after those episodes than before. It also compares boom countries with those that never had such episodes. The paper considers alternative ways of identifying what constitutes a boom, and alternative ways of measuring booms. It considers evidence from World Bank projects, asking whether past surges in Bank lending were associated with improved project performance. Finally, the paper reviews case studies of five countries, three of which had major investment drives as defined above (Bolivia, Mexico, and Philippines), and two of which (many believe) used public investment successfully to spur development (Korea, and Taiwan province of China).

The econometric evidence reveals small positive and instantaneous associations between public investment booms and economic growth, but little long run impact. Several aspects of the evidence cast doubt on the idea that past booms triggered or accelerated GDP growth. Most of the positive association occurs immediately; a spending boom tends to be immediately associated with a rise in GDP this year, but not subsequent years. F-tests fail to reject that the long run impact, given

[1] The evidence in this paper does not speak to the use of infrastructure to stimulate aggregate demand and pull rich countries suffering from Keynesian unemployment out of recession. Rich countries are not in the sample and no attempt has been made to isolate periods of deficient aggregate demand.

by the sum of the coefficients on lagged investment booms, is zero. This runs counter to two ideas. One is that the booms had a causal impact, since this kind of evidence is consistent with reverse causality, from GDP growth to investment booms, as spending is cut in slumps and increased in good years. This evidence also runs counter to the idea that the data is picking up long term productivity effects, since, given the long construction periods of public investments, these effects should show up in the data with lags of three or more years, or the estimated long run impacts should be positive. In addition, the estimated associations are small, certainly not of the magnitudes suggested by big push models.

Overall it is difficult to find a clear-cut example that fits the oft-repeated narrative of a public investment boom followed by acceleration in GDP growth. If anything the cases of clear-cut booms illustrate the opposite – major drives in the past have been followed by slumps rather than booms. Ethiopia in the past decade may prove to be an exception to this pattern. However, it is difficult to establish causality since public investment, GDP, and several other variables have risen together in Ethiopia in recent years. Rapid economic growth in Korea and Taiwan province of China began before their public investment drives, which were in fact modest, compared to the size of the economies. Well-known cases of growth revivals, such as China and Vietnam, were triggered by the abolition of price controls in the Agricultural sector, and were not preceded by major public investment drives.

Does this mean that infrastructure and public capital is not potentially productive? Probably not; but it strikes a blow against the idea that large pubic capital expenditures alone will have a positive impact, and it casts doubt on the overriding importance of spillovers and positive externalities that motivate big push initiatives. Furthermore, the case studies reveal many problems with past investment drives – mainly deep incentive problems, agency problems, a pervasive avoidance of rational analysis and even difficulty obtaining or collecting the critical data that would underpin rational investment choices. These cases suggest that whether or not future public capital drives will be more successful than past drives hinges on whether these kinds of problems can be overcome in the future.

The existing empirical literature on the impact of public capital has mainly focused on cross-country time series evidence and a production function framework to estimate the average relation between public capital (and infrastructure) and GDP. It has not focused specifically on major investment drives during which public investment rises significantly. Practical applications then

often take the first difference of the estimated relation in levels to simulate the impact of a rise in public capital, implicitly assuming that the relationship also holds under conditions of large booms in public investment.

There are reasons to expect that the impact of major increases in infrastructure spending will differ from the average impact observed in normal times. A major influential argument that booms should have higher than average impacts is based on the big push model. Historically, this has provided the most important intellectual justification for public investment drives in low income countries. The general idea is that if a critical mass of small investments is undertaken simultaneously the average social return will be much higher than the average private return, because they will create demand for each other, and overcome coordination failures that keep private market economies in a low-income equilibrium. A big program of public investment can achieve a big push itself or can stimulate numerous further private investments that together constitute a big push. On the other hand, there are reasons to expect the opposite, a lower impact of the booms than the average. One is a perverse selection effect. The on-the-shelf government investment projects that are pulled off-the-shelf once a major increase in spending is announced may be precisely those that were previously rejected on grounds of low impact. Hence a surge may select relatively-poor public investments. Rejected projects are likely to have the advantage of having already passed the feasibility stage of analysis and can thus be implemented quickly. More important, they are likely to still have constituencies that favored them within the bureaucracy. The second reason for lower-than-average impact of booms is that booms can change the behavior of governments. A government that rationally analyzes investments when the money is tight has less incentive to do so when money is loose. Special interest group pressure can be more influential as other constraints become less binding, such as the budget. A third reason to expect that the impact of changes is different is diminishing returns to additional capital. Additional roads added to a basic road network may have less impact that the initial roads that opened up access to major regions of the country.

Available data for this issue consists of both national-level evidence and investment-specific evidence. The national evidence consists in time series data on public investment expenditures in many countries. There are also some data on sub-national regions in some countries but generally too little to support cross-country generalizations. Lack of coverage is always an issue even with the national-level evidence, but samples that cover 40-50 developing countries are not unusual in the cross-country studies. Researchers have to make do with how the national authorities differentiate public capital expenditure versus public consumption expenditure. For example, education

expenditures are usually not defined as public investment. Yet while the definitions are not uniform across countries, the bulk of expenditures fall on items such as roads and power infrastructure which are treated as capital goods in virtually all countries.

The (non) availability of investment-specific evidence on the impact of public investments is a separate topic in itself. Micro evidence covers the gamut from basic data on how much was spent, on what it was spent, what were the measureable outcomes, and how much were the outcomes valued. As some of the scholarly articles reveal, even basic data is difficult to track down, such as how much was spent. And this is long before the discussion turns to rate of return estimates or impact studies with control groups. Research in this area is bedeviled by the fact that governments that implement major public investment drives frequently leave no hard data behind on the impact of their investments; and governments that collect good data frequently do not attempt major investment drives. The most organized, publically available, evidence are the World Bank's records on the public investment projects it has financed since the early 1970's. The Bank keeps performance ratings for most projects, rated on a subjective scale and, for a declining subset of projects, also keeps estimates of the economic rate of return. Moreover, the World Bank arguably experienced a public investment boom of its own in the 1970s as McNamara launched a campaign to increase lending to developing countries and increase the Banks efforts. Hence the paper also adds this evidence to the more commonly used national evidence.

Reviewing recent empirical work, Aschauer (1989), used U.S. time series evidence to argue that the impact of public capital on output was large and partially explained the post-1973 productivity slowdown. According to his estimates, the exponent on public capital in a production function, or the elasticity of output with respect to public capital, was approximately 0.3. Subsequent empirical work showed lower impacts or even zero (see the review essay by Gramlich, 1994). Calderon and Serven (2010) estimated that African countries could boost annual economic growth by approximately 1.5 percentage points per year by cutting in half their infrastructure deficit with respect to other regions of the world (see their figure 4a). Gupta, Kangar, Papageoriou and Wane (2011) estimate that the average elasticity of output with respect to public capital is approximately 0.15, based on cross country data for lower income counties. Motivated in part by this kind of evidence, International Institutions have endorsed the idea that infrastructure will revive or restore economic growth. In 2013 the African Development Bank called on its members to prioritize infrastructure investment to stop its growth from flattening (Reuters July 9th 2013). The IMF routinely endorses the

removal of infrastructure deficits in less developed counties as "critical to support high and inclusive growth" (Statement of Managing Director, October 2013).

Causality between public capital stocks and GDP can run in both directions. The most frequently used relation is the production function, in which causality runs from capital to output. For the reverse, higher GDP may mean greater demand for the amenities provided by public capital or higher GDP may mean more revenue for all public expenditures including public capital. Canning and Pedroni (2008) conclude that "in general both long run and short run causality is bi-directional, with infrastructure responding to GDP per-capita but GDP per-capita also responding to infrastructure shocks".

It is possible in theory for countries to have too much infrastructure. Public capital expenditures can divert resources from other more valuable uses, or require financing that crowds-out private capital spending. Devarajan, Swaroop and Zou (1996) show evidence that a shift in government expenditures from current to capital spending (holding overall government spending constant) lowers the long run growth rate of the economy if the initial share of spending on capital expenditures is too high. Other authors present a framework in which there is a growth-maximizing level of infrastructure stocks, so that a rise in infrastructure from below this level will increase growth and a rise from above will reduce growth (Canning and Pedroni, 2008). The negative impact happens if the direct gain from having greater infrastructure is outweighed by the diversion of resources from other productive uses. According to the empirical results in Canning and Pedroni (2008) some developing counties have too much infrastructure.

The potential for sharply diminishing returns for some forms of public capital is widely acknowledged. Fernald (1999) finds evidence that the major highway construction in the United States in the 1950's and 1960's, associated with the interstate highway system, raised productivity significantly in transport-intensive industries. However, after this was completed in 1973 he finds no evidence that returns on further road building was abnormally high. Studies using data from geographical regions in the United States, using data only available after 1970, have found little evidence that public capital enhances regional productivity, as there is little or no empirical relation between productivity growth and public capital growth (Holtz-Eakin (1994) and Hulten and Schwab(1991)). Hulten (1996) suggests that further investments in already-developed transportation networks can impact the regional distribution of economic activity without any major impact on overall productivity.

Popular impressions of the productivity of infrastructure are influenced by what are arguably special cases. Examples include major investments that resolved bottlenecks – the Eire canal, the Hoover Dam, Post-war reconstruction in Europe. High returns are plausible for such investments, but the unanswered question is what fraction of actual public investment really address genuine bottlenecks rather than routine investments? Finally, consider the case of post-war reconstruction. During war, the bridges, roads, ports and airports that are targeted tend to be those that are strategically and economically important. It should not be surprising that these structures tend to have high impacts when restored to operation.

A final reason that public capital, which seems so self evidently productive in some contexts, can nevertheless fail to have the anticipated impacts, is that decision makers lack the incentive to select socially beneficial investments. Although it is often convenient to assume that governments attempt to maximize economic growth or strive to be on the efficient production possibility frontier when selecting government investments, the issue is not established. The testimony of government officials frequently contradicts the idea that governments maximize overall social welfare. Devarajan, Swaroop and Zou (1996) regard the behavior of governments as an important open question, and mention that their results would be consistent with the government having "white elephants" in the objective function. Romp and de Haan (2007) note the strong variation across counties in the share of public capital spending in GDP and endorse the view of Estache (2006), "there is strong anecdotal evidence now that politics matter."

Researchers that examine government behavior frequently reject the unitary decision model out of hand. For analysts that have worked in government, the quote attributed to Patinkin (1993) is commonplace:

> *"I cannot accept the view.. of government as a single, monolithic unit choosing policies to achieve an optimum for it. A democratic government – and frequently even a non-democratic one – is a coalition. Sometimes it is a formal coalition of several political parties (as in Israel, which indeed has never had a government which was not such a coalition); and sometimes an informal one (as in the United States in which each of the different parties is in effect a coalition of different interests)."*

Once government decisions are seen as the outcome of a bargaining process, it is possible that rational behavior by government officials nevertheless yields socially inefficient outcomes. Moreover, Keefer and Knack (2007) show evidence that public investment is "dramatically higher in

governments with low-quality governance and limited political checks and balances." They attribute this to the fact that public investment is conducive for rent-seeking. Robinson and Torvik (2005) present a model in which loss-making projects are politically attractive to politicians because they can affect voting outcomes in their favor. These points underscore that the question of the impact of public investment is also about the behavior of governments when they spend the money.

Framework

The forcing variable in this paper is public investment effort by the government, represented by big changes in either the public investment ratio (I/Y) or public capital growth. The identification strategy is to select episodes of big and obvious changes in public investment on the hypothesis that they reflect exogenous decisions by the public authorities to boost GDP growth. This hypothesis is supported by two considerations. The first is the sheer size of the investment boom episodes chosen for the analysis in this paper. During the boom episodes selected, the average difference across all 24 episodes between the minimum and maximum investment ratio was just over 13 percentage points of GDP. The mean duration of the booms was just over 14 years. The second item in support of the hypothesis is that, where secondary sources exist, they corroborate the notion that the booms were policies deliberately chosen by the governments to accelerate development. Egypt's intention to boost public infrastructure investments in transport and communications after 1972 is spelled out in its draft five year plan for the period 1973-78 (World Bank, 1972). Morocco's investment boom was announced in the King's speech in August 1971 and implemented in its third national plan for the period 1973-77(World Bank, 1974). In October 1970 the Nigerian government adopted a four-year reconstruction and development plan covering the period 1970 to 1974 to "prime development through reconstruction" (World Bank, 1971). As discussed later in this paper, the booms in Bolivia, Mexico and the Philippines also were part of deliberate government plans.

The rest of this section shows a simplified framework to argue that, if public investment spending is the forcing variable, variation in public investment such as happen in a boom will trace out the production function relation between public capital and output. This is formally similar to the well-known point in a supply and demand model that the parameters of the supply curve can be identified by shifts in demand and vice versa.

The following is a deliberately stripped-down and simplified version of a macroeconomic model to focus on issue at hand. Much is familiar: a production function with the stock of public capital as a factor of production and an accumulation equation for public capital. The private capital stock and the labor force are held constant for simplicity. In addition to the production relation, a

macroeconomic equilibrium condition is added stating that spending on consumption and investment exhausts output and a public finance equation is added stating that tax revenues must be sufficient to finance any public investment spending (this is the simplest form that the second relation between public capital and GDP may take). What differs from a standard framework is that, following Buffie, Berg, Patillo, Portillo and Zanna (2012), additional parameters are introduced to represent different kinds of government inefficiency. As in Buffie, et al. (2012), the "s" in the capital accumulation equation captures the idea that spending may be lost through corruption. Even though I_z is budgeted, kickbacks, diversion of funds, and over-invoicing, means that only a fraction, s, is actually devoted to capital accumulation (0<s<1). Another kind of inefficiency is poor investment selection but not illegal corruption: although the elasticity of output with respect to public capital is potentially ψ, in practice poor project selection results in an elasticity of $\varepsilon\psi$ (0< ε <1). This kind of inefficiency refers to the quality of public decision-making: the extent to which due-diligence is really used to find high-impact investments, the extent to which data are collected to analyze prospective investments; the extent to which this information really counts in public decision making etc.

The exogenous policy parameter is either the tax rate or the rate of public investment spending. Given the public budget constraint, equation(1.4), only one of these can be freely chosen. Let Z and K stand for public and private capital, L for labor and I_z for public investment spending. The model is summarized as follows:

$$Y = AZ^{\varepsilon\psi}K^{\beta}L^{\alpha} \tag{1.1}$$

$$Z = sI_z - \delta Z \tag{1.2}$$

$$C = Y - I_z \tag{1.3}$$

$$\tau Y = I_z \tag{1.4}$$

After substituting (1.4) into (1.2), the two equations (1.1) and (1.2) solve for the steady state values of output and the public capital stock, as shown in Figure 1. Consumption is then determined from (1.3). The steady state is stable and converges on an equilibrium given by point E in figure 1.

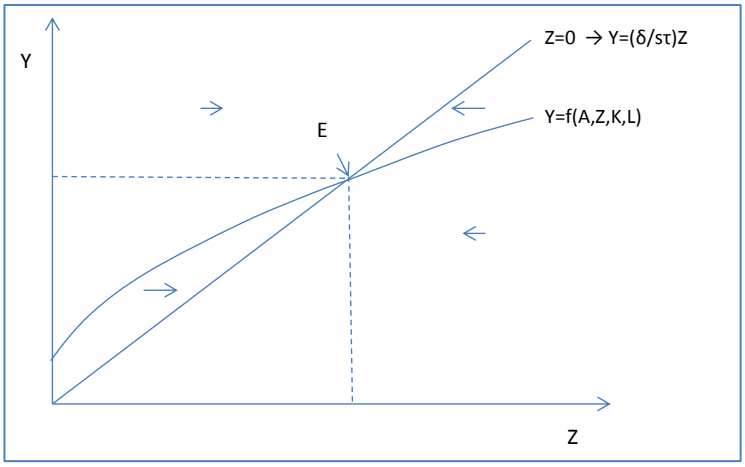


Figure 1: Simultaneous Determination of Output and the Public Capital Stock. Figure shows Output (Y), Public Capital Stock (Z), production function, F(A,Z,K,L), and "Z dot" = 0 locus.

As illustrated in figure 2, the impact of a tax-financed public investment boom will normally be positive on both the level of steady state output and the steady state capital stock.

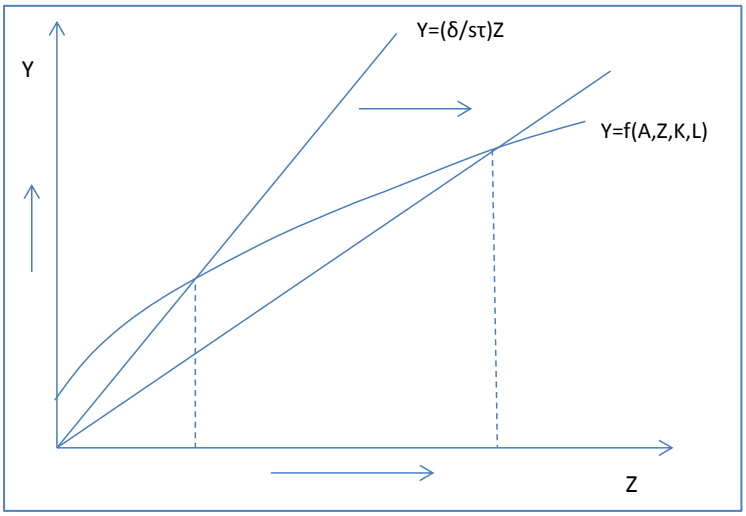


Figure 2. A tax-financed public investment drive (a rise in τ) will normally raise both the steady state stock of public capital and output.

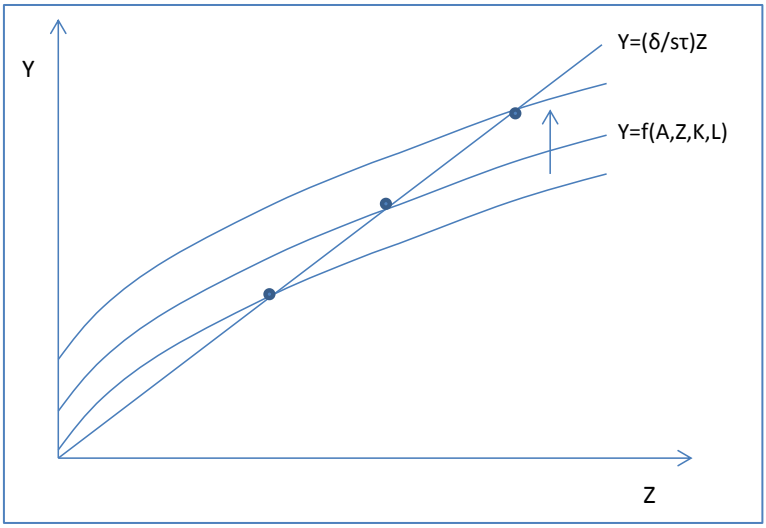


Figure 3. Growth driven by total factor productivity or private capital accumulation will yield a positive association between output and the public capital stock but will not trace out the production function. In this situation least squares estimates will over-estimate the impact of public capital on output.

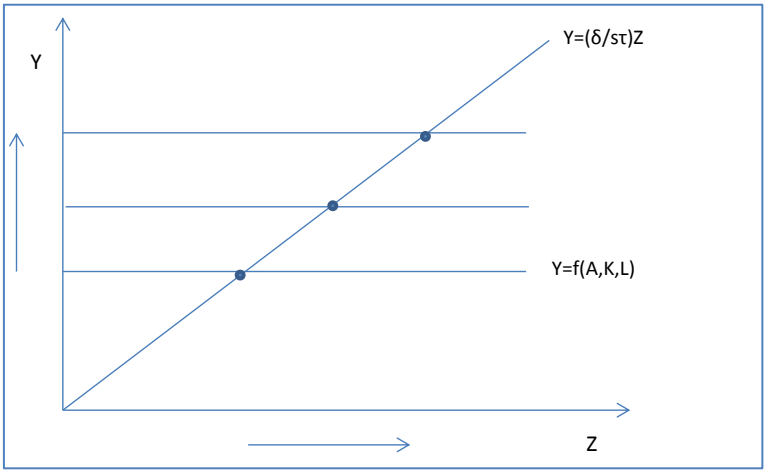


Figure 4. In the extreme case where public capital has zero impact on output, productivity growth will nevertheless create a positive association between the two, leading to the impression that a public investment drive will boost output when in fact it will have no impact.

As the model stands, there is simultaneous determination of GDP and the public capital stock. The model predicts a positive association between the two, as the two structural equations both contain positive relations between GDP and the capital stock, but interpretation of the empirical relation between the two variables is subject to the familiar problem. Least squares regressions of output on the stock of public capital would estimate some combination of the production function relation and the public finance equilibrium condition, rather than either relation alone.

We note two ways to attempt to separate empirically the production function relation from the public finance relation. The first is to identify episodes in the data in which public investment rose as a consequence of a deliberate policy choice; in which variation in I/Y is the forcing variable. We consider periods in the data in which increases in public investment were big and obvious as a signal that the increases were deliberate. We also search for narrative accounts of the high investment episodes to confirm whether they were the outcome of deliberate policy choice. In terms of the model, this approach may be seen as searching for countries and time periods in which the public finance equation shifted dramatically, as in the rise in τ illustrated in figure 2.

A second approach is to use the fact that most public investments are operational only several years after expenditures have occurred. For example, roads take several years to complete; hydropower dams and other large items of infrastructure can easily take more than five years. So we should expect important lags of several years between expenditures on public investment and completion of the capital stock that will actually affect output according to the production function relation. On the other hand when the government has extra revenue from a year of particularly good growth, and spends the surplus on public investment, we would observe a contemporaneous rise in both GDP and public investment, in other words with no lag.

This idea may be expressed formally by modifying the public finance equation in the model. Imagine that tax revenue must be apportioned each year between public investment and current expenditures G, which will be fixed by assumption to make the point.

$$\tau Y = I_z + \overline{G}$$

Dividing through by Y, we have:

$$\tau = \frac{I}{Y} + \frac{\overline{G}}{Y}$$

With the tax rate and current expenditures fixed, a positive shock to Y will be associated with a rise in the investment ratio, since G/Y will fall and hence I/Y must rise. Therefore any variable that causes the production function to vary from year to year, such as random events or productivity shocks, will induce a positive association in the same year between I/Y and GDP growth.

In contrast, suppose there is a lag between public investment expenditures and augmentation of the public capital stock that matters for production (such as a road). In this case a public investment boom, represented in the model by an exogenous rise in τ , will cause a contemporaneous rise in I/Y, but no immediate effect on output. Under this scenario we would observe no contemporaneous association between a change in I/Y and GDP growth. But we would observe an association between changes in I/Y and GDP growth with a lag of several years.

Hence there is a sharp contrast. Growth driven by shocks to the production function will give rise to a contemporaneous association between I/Y and GDP growth but no lagged association. Growth driven by a public investment drive will give rise to no contemporaneous association but a lagged association. This prediction will be used in the empirical section to help determine whether the evidence is consistent with growth being driven by public investment drives.

Empirical Section on the Impact of Public Investment Drives

This section examines empirical evidence on the association between major public investment drives and subsequent economic growth. The general empirical strategy is to select time periods in each country that correspond to public investment booms and then examine whether these periods are followed by higher economic growth than other periods.

The major idea being tested is that public capital surges will transform economies – provided they are really big. The notion is classically associated with ideas such as the take-off into modern economic growth, Rostow (1960), and the Big Push, Rosenstein-Rodin (1961) and Murphy, Shleifer and Vishny (1989). In the latter, public infrastructure drives serve as one method of overcoming coordination failures and insufficient levels of demand that hold back private investors. But some variant of the big push notion continues to be popular and is frequently implied when public infrastructure campaigns are announced. For example in September 2013 the government of Egypt announced $3.19 billion in additional infrastructure spending (1.2 percent of 2012 GDP) as the key component of a program that was forecasted to raise GDP growth by more than one percentage point, from 2.3 percent to 3.5 percent, reduce unemployment from 13.2 to 9 percent and reduce the government's budget deficit from 14 to 9 percent of GDP2. Further, the transformative power of infrastructure is widely asserted when big capital expenditure campaigns are promoted. Two points are worth noting, one is that public capital is usually presented as the exogenous force that will cause other things to move. Another is that the argument is often made unconditionally. Rather than cite conditions under which capital expenditures will be effective; public capital improvements are presented as though they will work even if there are other problems holding back economies.

Data

The sample covers 124 lower and middle income countries for which data on public and private investment is available from the WEO data base at the IMF for at least one year during the period 1960-2011. This is an unbalanced panel with an average of 30 observations per country[3].

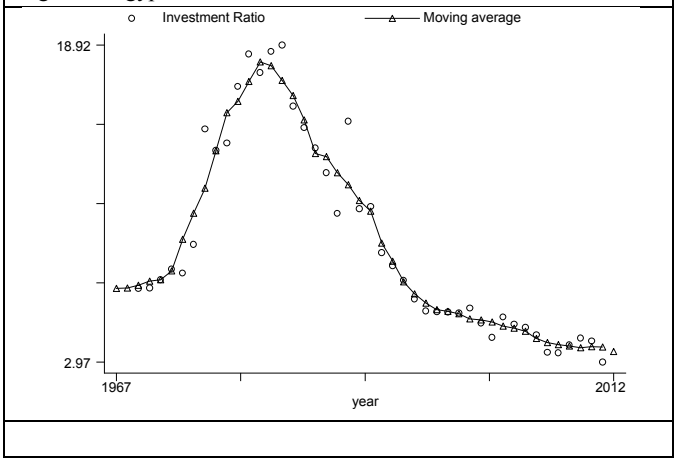
[2] Ahram Online, Thursday 12 September, 2013: (http://english.ahram.org.eg) "Egypt-to-spend-LE-bln-stimulus-on-housing,transport"

[3] Some obviously implausible data points such as zeroes were re-coded to missing.

Two kinds of data could arguably be used for this paper: data on the public investment ratio (public investment spending as a share of GDP) or data on growth of (estimates of) the stock of public capital. These two series will be closely related but not identical, as can be seen by rewriting the accumulation equation (K dot = I – delta K) as K growth=K dot/K = I/Y *(Y/K) – delta. This equation shows that both Y/K, the inverse of the capital output ratio, and depreciation, delta, can drive a wedge between growth in the public capital stock and the public investment ratio. However, since both Y/K and delta are slow-moving variables, high frequency fluctuations in I/Y should be mirrored in similar high frequency fluctuations in public capital growth.

There is no ultimately decisive argument for preferring either series over the other, so this paper will use both. An argument for using the investment ratio is that it is a direct measure of spending effort. A large, sudden and sustained rise in public I/Y is evidence that the public sector deliberately intended to increase public capital. Further, it is the basic raw data upon which estimates of the capital stock are built. If avoidance of measurement error is the prime criterion, the investment ratio should be preferred because whatever measurement problems it poses, the capital stock series will have greater measurement error because its computation requires an additional educated guess about the initial capital stock. The main argument for using growth in the public capital stock is that this variable directly affects output in widely-used production functions. Although the paper will use both kinds of data, it will rely on the investment ratio as the prime source for purposes of determining the precise timing of the investment booms, as it has lower measurement uncertainty. Data on the investment ratio together with its moving average is illustrated below for Egypt.

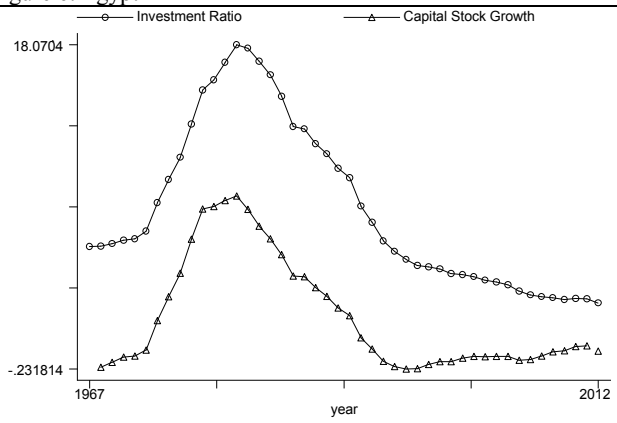
Figure 5. Egypt



The method for calculating the stock of public capital is described in detail in the appendix, but essentially starts with an estimate of the initial public capital stock that, given the observed public

investment rates, avoids implausibly large discrepancies between growth rates in the public capital stock and the public investment ratio[4]. An illustration of the data on the investment ratio and growth in the public capital stock series is illustrated below in the case of Egypt.

Figure 6. Egypt



Determining boom periods

Empirical testing requires a method for determining which episodes of high investment qualify as public investment booms. In some countries this is not a difficult task, such as Egypt, illustrated above, in which the data on investment in percent of GDP show a clear boom period in the 1970's. In Egypt, the period 1972-1992 would be one natural choice for the boom years. This uses the inflection point – the year in which the investment ratio first started to rise significantly – for the start of the boom and the end of the boom is the year in which the investment ratio came back down to the value it achieved at the inflection point. But not all countries are as clear as Egypt. The preferred method in this paper uses algorithms as well as observation of the data to determine the starting and ending years of the booms.

As the graph for Egypt illustrates, once having determined the boom period, the natural choice for the counterfactual years would be the rest of the sample, the non-boom years. In the case

[4] Note that the stock-flow identity for capital is a stable differential equation that will converge on a steady-state level no matter the initial guess of the capital stock, so an erroneously-high estimate for the initial capital stock will produce many years of negative growth in capital no matter the observed investment rates. Thus a large discrepancy between capital growth and investment rates can happen when the guess for the initial capital stock is far away from the steady state capital stock implied by the investment data for a particular country. The method in this paper attempts to avoid this by selecting an initial capital-output ratio close to the long run level.

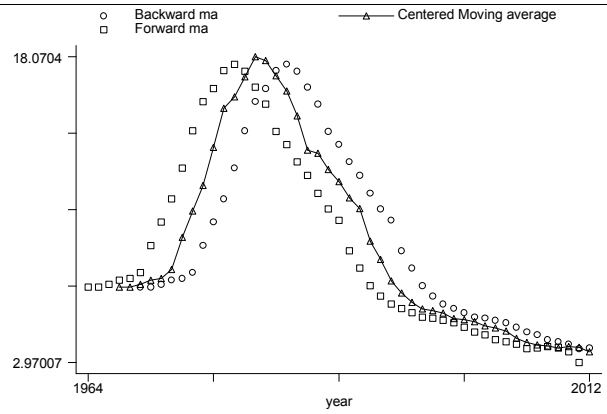
of Egypt this means the years before the boom, 1967-1971 and after the boom, 1993-2012. In the case of countries with no investment boom, the natural choice for the counterfactual would be all available years. One may distinguish two kinds of counterfactual periods: on the one hand the non-boom years in the boom countries and on the other all the years of data in the non-boom countries.

Now consider measurement of the boom variable. The preferred method here is a variable that takes the value 0 during the counterfactual period and I(t) – I(0) during the boom years, with I(0) standing for the value achieved in first year of the boom. For robustness purposes the paper also uses a simpler dummy variable (1 during the boom years; 0 otherwise).

Turning back to the selection of the boom years, the preferred method in this paper proceeded along the following steps. The first step was to calculate the (un-weighted) 5-yr forward and backward moving averages of the public investment ratio. Countries were deemed to be in the midst of significant investment booms when: (a) the (forward-backward) difference was high, exceeding the 80th percentile for three or more years; and (b) the (forward-backward) difference exceeded 4 percentage points of GDP. The first criterion captured whether the difference was high for that particular country and the second captured whether it was high in absolute terms. After identifying countries and years in which investment increased dramatically by these criteria, the start of the boom was determined with the assistance of graphs as the year in which the investment ratio first started its rise and the end of the boom was determined as the year in which the investment ratio fell back down to at least 120 percent of its level before the start of the boom. If the investment ratio never fell back to this level the country was considered to have experienced a continued long boom. Some judgment was used to select the precise years. The overall goal was to identify periods of unmistakable rises in the investment ratio that most observers would agree constitute boom years.

The figure below illustrates the 5-year forward and backward moving average in the case of Egypt.

Figure 7. Egypt



The capital growth data was then used to further check the dates for the boom periods. When the capital growth data corroborated the dating of the booms the dates determined by the investment ratio were retained. There were four cases in which the corroboration was not considered good enough (Eritrea, Iran, Lesotho, and Mauritania), and in these cases the country was not included in the sample. Further, in Lesotho and Mauritania the investment data also appear implausible (the investment ratio starts at 53 percent in Lesotho and reaches 71 percent in 1987; In Mauritania it reaches 53 percent in 1976). In other cases the lack of agreement of the series (I/Y and capital stock growth) occurred only for the first few years and stemmed from implausibly low initial values of the investment series for one or two years. In these cases the countries were retained for the analysis because the investment ratio data after the first years was plausible and showed a clear signal that there was a boom (Morocco, and South Africa).

Mozambique was stricken from the list of countries because its ostensible public investment boom occurred in the middle of its civil war. Angola was not included because the boom was not long enough. Ecuador was included because it missed qualification by a hair and it was deemed important to include countries that have had booms in recent years. In the end 21 countries were determined to have experienced booms according to the second method (see table 1).

Table 1: List of candidate countries, those that made the cut, and boom periods

	Start	End	Start	End
1 Algeria	2004	2011		
Angola	Poor Data			
2 Cote d'Ivoire	1970	1988		
3 Dominican Republic	1969	1980	1985	2003
4 Ecuador	2005	2010		
5 Egypt	1972	1991		
Eritrea	Poor Data			
6 Ethiopia	1999	2011		
Iran	Poor Data			
7 Jordan	1971	1985		
Lesotho	Poor Data			
8 Libya	1998	2011		
9 Malawi	1973	1983		
Mauritania	Poor Data			
10 Mexico	1973	1989		
11 Morocco	1972	1989		
12 Myanmar	1974	1989		
Mozambique	Civil War			
13 Nigeria	1970	1984		
14 Panama	1969	1979	2005	2011
15 South Africa	1970	1993		
16 Togo	1972	1988		
17 Trinidad & Tobago	1973	1986	2002	2011
18 Uganda	1984	2011		
19 United Arab Emirates	1990	2011		
20 Uruguay	1972	1985		
21 Venezuela	1972	1985		

To check the sensitivity of the results to the selection method, a second method was also used. This alternative method simply assigned years of high investment as boom years without attempting determine the precise start and end of the boom with the assistance of graphs. Under this method a boom was defined as a period when the investment ratio exceeded a pre-defined cutoff and stayed there for three or more years (the results shown later in the paper use the 70^{th} percentile for the cutoff). The boom was considered over when the investment ratio fell below the cutoff. The boom variable associated with this was a dummy that took the value 1 during boom periods.

In summary, the preferred selection method is to use 5-year forward and backward moving averages to identify major up-turns in investment and then refine the timing by observation of the data. The preferred variable for measuring the booms is a variable that takes the value $X - X(0)$ in boom periods and 0 in counterfactual periods. And two variables will be used for X: first the public investment ratio; and second public capital stock growth. X(0) stands for the value in the first year of the boom.

Of the 3591 data points, 335, or a little fewer than 10 percent, are rated as boom years. The boom variable based on public investment as a percent of GDP, $I/Y - I/Y(0)$, has a median of 4.90, and a maximum of 20.03. The boom variable based on public capital growth has a median of 4.36 and a maximum of 27.34.

Empirical Results

The results differ according to the time period under study, as post-1990 data, and specifically data that includes Ethiopia's boom show stronger results in favor of public investment than the rest of the sample. Hence this section starts with the evidence from the full sample and then specializes to the post-1990 evidence.

To summarize the questions and how they will be addressed, the impact of booms on growth will be addressed through growth regressions, using the two kinds of public investment variables. These are reduced form equations that capture both the direct impact of public capital booms on growth and the indirect impact (either positive or negative) through private investment. Evidence for crowding out, or crowding in, will be addressed separately through regressions explaining the private investment ratio as a function of public investment (among other control variables). As an overall strategy, the empirical sections strive to keep the list of right hand side variables constant across regressions to facilitate comparisons.

Table 2 shows a typical result when using the whole sample. The dependent variable is annual growth of real GDP per-person. The investment boom variable is labeled "Boom VarI" and uses data on the public investment ratio. The results show that the contemporaneous boom variable correlates positively with growth but first and subsequent lags are not statistically significant. (The fourth lag is statistically significant but as this result is not robust it will not be emphasized). According to the first regression, a rise in the investment/GDP ratio of 5 percentage points, which is approximately the median of the sample, is associated with an immediate rise in annual growth of 0.70 percentage points (0.14*5=0.70). The control variables have the anticipated signs except for financial depth. A higher black market exchange rate premium is associated with lower growth. Greater life expectancy is associated with higher growth. Financial depth as measured by assets of Banks as a share of GDP has a negative but not significant coefficient. Inflation is associated with lower growth. And finally, export growth is strongly associated with faster growth. The variable for export growth is measured as Px*X/Pm, so that growth in this variable is composed of two components, terms of trade growth and real export growth, and the estimated coefficient measures the combined effect of these two. The fit of the regressions, with the R-squared approximately 14 percent, reflects the high amount of noise in annual data and comes from the control variables rather than the investment boom variable.

It is worth emphasizing that even if the estimated effect in table 2 of investment on growth were causal there appears to be little staying power, as the estimated coefficients of lags of three or four years are negative; the estimated positive association dies out after a lag of one year. In public capital investments that take five years to complete, real productivity impacts that are triggered by the competed investment can only be felt in the sixth year. If anything, longer lags should be more important than short lags. Instead we see the opposite pattern which runs counter to the idea that the regressions are capturing the causal impact of higher public investment on long-term productivity.

Table 2. Regressions of Annual Growth in Real GDP per-person on the current and lagged public investment boom variable. The investment boom variable denoted "Boom VarI" = I/Y - I/Y(0) during a boom and 0 otherwise, where I/Y(0) is the public investment ratio in the year before the boom started.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
Boom VarI	0.14**				
	(2.29)				
Boom VarI (-1)		0.09			
		(1.27)			
Boom VarI (-2)			0.02		
			(0.23)		
Boom VarI (-3)				-0.05	
				(-0.80)	
Boom VarI (-4)					-0.12**
					(-2.02)
Black Market Exchange Rate Premium	-0.27***	-0.26***	-0.26***	-0.25***	-0.29***
	(-4.08)	(-3.80)	(-3.69)	(-3.58)	(-4.26)
Life Expectancy at birth (years)	0.03**	0.03**	0.03**	0.03**	0.03**
	(2.33)	(2.35)	(2.38)	(2.41)	(2.43)
Financial Depth (Deposit Bank assets % of GDP)	-0.01*	-0.01*	-0.01*	-0.01	-0.01
	(-1.92)	(-1.94)	(-1.80)	(-1.62)	(-1.61)
Inflation	-0.00**	-0.00**	-0.00**	-0.00**	-0.00**
	(-2.33)	(-2.34)	(-2.34)	(-2.34)	(-2.33)
Real Export growth (deflated by import price index)	0.09***	0.09***	0.09***	0.10***	0.09***
	(11.36)	(11.58)	(11.38)	(11.55)	(11.22)
Constant	2.54***	2.51***	2.45***	2.38***	2.53***
	(3.25)	(3.17)	(3.06)	(2.94)	(3.27)
Observations	1,824	1,792	1,759	1,723	1,687
R-squared	0.14	0.14	0.14	0.15	0.17

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Continuing with full sample but switching to the public capital stock growth variable gives stronger results for public investment booms but the main conclusion that most of the association is short run still holds (table 3).

Table 3. Regressions of Annual Growth in Real GDP per-person on the current and lagged public investment boom variable. The investment boom variable denoted "Boom VarK" = Kgrowth - Kgrowth(0) during a boom and 0 otherwise, where Kgrowth(0) is annual growth in the stock of public capital in the year before the boom started.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
Boom VarK	0.24***				
	(5.01)				
Boom VarK (-1)		0.16***			
		(3.10)			
Boom VarK (-2)			0.10*		
			(1.71)		
Boom VarK (-3)				0.05	
				(0.68)	
Boom VarK (-4)					-0.02
					(-0.32)
Black Market Exchange Rate Premium	-0.28***	-0.28***	-0.27***	-0.31***	-0.29***
	(-4.00)	(-3.98)	(-3.67)	(-4.49)	(-4.14)
Life Expectancy at birth (years)	0.03**	0.03**	0.03**	0.03***	0.03**
	(2.52)	(2.43)	(2.43)	(2.59)	(2.42)
Financial Depth (Deposit Bank assets % of GDP)	-0.01*	-0.01*	-0.01*	-0.01*	-0.01*
	(-1.85)	(-1.83)	(-1.68)	(-1.70)	(-1.72)
Inflation	-0.00**	-0.00**	-0.00**	-0.00**	-0.00**
	(-2.31)	(-2.31)	(-2.32)	(-2.30)	(-2.32)
Real Export growth (deflated by import price index)	0.09***	0.09***	0.10***	0.10***	0.10***
	(11.55)	(11.42)	(11.64)	(11.42)	(11.49)
Constant	2.24***	2.33***	2.26***	2.29***	2.39***
	(2.80)	(2.88)	(2.75)	(2.95)	(3.02)
Observations	1,744	1,707	1,671	1,635	1,595
R-squared	0.15	0.15	0.15	0.17	0.17

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The one or two-year lags are sometimes significant, as shown in table 3, but this result is not robust across regressions (see table 2 for example). The magnitude of the estimated short run association also varies across regressions, as the absolute values of the coefficients are larger in table 3 than in table 2. The other control variables have similar signs and magnitudes. Again long lags of

the investment boom variable are not significant, running against the idea that the finished investments were exerting long term, causal, impacts on productivity and growth.

Several robustness experiments did not overturn these broad conclusions. When the regression with the strongest result for the investment boom variable, the first regression in table 2, was re-estimated without natural resource intensive countries (Algeria, Mexico, Libya, Venezuela, Trinidad and Tobago and United Arab Emirates) the estimated coefficient on the contemporaneous boom variable was virtually the same. When re-estimated using only the variation of the positive values of the boom variable, excluding zero values, the estimated effect rose slightly: 0.38 (se=0.058).

Long run impact

This section asks whether there is evidence that the investment booms had a positive long run impact on the level of GDP. On the assumption that the association between investment booms and growth was causal, an assumption which stacks the deck in favor of finding a positive impact, is there evidence of a long run effect? Regressions were estimated with contemporaneous and five lags of the investment boom variable, as five years should be sufficient time for real effects on productivity to emerge.

Tables 4 and 5 summarize the evidence using the two ways of measuring public investment booms. Five regressions are shown in each table, each one dropping a different control variable to show any sensitivity of the result to the presence of specific control variables. Summing all the estimated coefficients on the boom variable and its lags gives the estimated long run impact on the level of GDP. This sum is essentially zero in table 4, averaging -0.02, with an average p-value of 0.71. This is not even close to statistical significance. The sum in table 5 averages 0.10 with an average p-value of 0.14, not significant at the ten percent level. Thus there is no robust evidence that the investment booms exerted a long-term positive impact on the level of GDP, even on the favorable assumption that causality ran from the booms to GDP.

Table 4. Tests of the long run impact of public capital booms on GDP (using I/Y to measure booms)

VARIABLES	(1)	(2)	(3)	(4)	(5)
Boom VarI	0.01	0.01	0.03	0.09	0.38
	(0.03)	(0.02)	(0.10)	(0.28)	(1.24)
Boom VarI (-1)	0.35	0.40	0.38	0.39	-0.11
	(0.76)	(0.82)	(0.79)	(0.80)	(-0.23)
Boom VarI (-2)	0.04	-0.09	-0.09	-0.10	-0.03
	(0.11)	(-0.24)	(-0.23)	(-0.25)	(-0.08)
Boom VarI (-3)	0.18	0.56	0.55	0.41	0.32
	(0.24)	(0.88)	(0.85)	(0.59)	(0.47)
Boom VarI (-4)	-0.85	-1.11	-1.08	-1.14	-0.59
	(-1.15)	(-1.70)	(-1.64)	(-1.61)	(-0.87)
Boom VarI (-5)	0.24	0.21	0.20	0.35	0.00
	(0.78)	(0.69)	(0.63)	(1.08)	(0.01)
Estimated long-run impact (sum of coefficients above)	**-0.03**	**-0.02**	**-0.01**	**0.00**	**-0.03**
F-stat for null that sum=0	0.33	0.15	0.08	0.00	0.39
p-value	0.56	0.70	0.78	0.96	0.56
Life Expectancy at birth (years)	0.04***		0.02**	0.04**	0.06***
	(2.80)		(2.04)	(2.40)	(4.04)
Financial Depth (Deposit Bank assets % of GDP)	-0.00	-0.00		-0.01	-0.01
	(-0.93)	(-0.27)		(-0.97)	(-1.04)
Inflation	-0.00**	-0.00**	-0.00**		-0.00
	(-2.41)	(-2.34)	(-2.30)		(-1.57)
Real Export growth (deflated by import price index)	0.09***	0.10***	0.09***	0.09***	
	(11.83)	(11.60)	(10.90)	(11.06)	
Log Black Market Exchange Rate Premium		-0.29***	-0.28***	-0.31***	-0.37***
		(-4.16)	(-3.98)	(-4.49)	(-5.13)
Constant	1.70**	4.21***	2.72***	2.08**	1.44*
	(2.21)	(19.04)	(3.63)	(2.36)	(1.73)
Observations	1,733	1,647	1,709	1,731	1,910
R-squared	0.16	0.19	0.19	0.17	0.06

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Tests of the long run impact of public capital booms on GDP (using Public Capital Growth to measure booms)

VARIABLES	(1)	(2)	(3)	(4)	(5)
Boom VarK	0.20	0.21	0.24	0.54	0.35
	(0.65)	(0.70)	(0.77)	(1.70)	(1.07)
Boom VarK (-1)	0.29	0.26	0.26	-0.39	-0.11
	(0.45)	(0.41)	(0.40)	(-0.60)	(-0.16)
Boom VarK (-2)	-0.54	-0.50	-0.47	0.30	0.01
	(-0.73)	(-0.68)	(-0.64)	(0.38)	(0.02)
Boom VarK (-3)	0.72	0.68	0.66	-0.08	0.07
	(0.85)	(0.81)	(0.78)	(-0.09)	(0.09)
Boom VarK (-4)	-0.42	-0.38	-0.51	-0.14	-0.02
	(-0.61)	(-0.56)	(-0.74)	(-0.20)	(-0.03)
Boom VarK (-5)	-0.15	-0.17	-0.06	-0.13	-0.23
	(-0.53)	(-0.59)	(-0.20)	(-0.41)	(-0.82)
Estimated long-run impact (sum of coefficients above)	**0.10**	**0.10**	**0.12**	**0.10**	**0.07**
F-stat for null that sum=0	1.65	2.47	2.50	3.03	1.92
p-value	0.20	0.12	0.11	0.08	0.17
Life Expectancy at birth (years)		0.02**	0.04**	0.05***	0.04***
		(2.06)	(2.39)	(3.51)	(2.86)
Financial Depth (Deposit Bank assets % of GDP)	-0.00		-0.01	-0.01	-0.00
	(-0.29)		(-1.00)	(-0.98)	(-0.95)
Inflation	-0.00**	-0.00**		-0.00	-0.00**
	(-2.31)	(-2.27)		(-1.53)	(-2.40)
Real Export growth (deflated by import price index)	0.10***	0.09***	0.09***		0.09***
	(11.30)	(10.68)	(10.74)		(11.50)
log Black Market Exchange Rate Premium	-0.32***	-0.31***	-0.34***	-0.41***	
	(-4.42)	(-4.16)	(-4.83)	(-5.44)	
Constant	4.13***	2.61***	1.95**	1.85**	1.47*
	(18.47)	(3.44)	(2.16)	(2.25)	(1.85)
Observations	1,555	1,615	1,634	1,793	1,635
R-squared	0.19	0.19	0.17	0.06	0.17

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Post-1990 evidence

Table 6 shows the different results for the boom variable when the sample is restricted to post-1990. The estimated association between public investment booms and subsequent growth is positive and statistically significant at all lags. The contemporaneous coefficient is 0.31 (t=3.14) rather than 0.14 (t=2.29). Notably, further lags are significant and the value of the estimated coefficient is still a fairly high 0.30 even after four years. The other variables have similar signs as before but financial depth and inflation are not statistically significant.

Table 6. Regressions of Annual Growth in Real GDP per-person on the current and lagged public investment boom variable. The investment boom variable denoted "Boom VarI" = I/Y - I/Y(0) during a boom and 0 otherwise, where I/Y(0) is the public investment ratio in the year before the boom started.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
Boom VarI	0.31***				
	(3.14)				
Boom VarI (-1)		0.33***			
		(3.42)			
Boom VarI (-2)			0.34***		
			(3.76)		
Boom VarI (-3)				0.30***	
				(3.17)	
Boom VarI (-4)					0.24**
					(2.40)
Black Market Exchange Rate Premium	-0.28***	-0.28***	-0.27***	-0.28***	-0.28***
	(-2.78)	(-2.76)	(-2.69)	(-2.81)	(-2.80)
Life Expectancy at birth (years)	0.03**	0.03**	0.03**	0.03**	0.03**
	(1.99)	(2.09)	(2.01)	(2.12)	(2.15)
Financial Depth (Deposit Bank assets % of GDP)	-0.01	-0.01	-0.01	-0.01	-0.01
	(-1.16)	(-1.11)	(-0.96)	(-1.03)	(-1.14)
Inflation	-0.00	-0.00	-0.00	-0.00	-0.00
	(-1.28)	(-1.28)	(-1.27)	(-1.30)	(-1.29)
Real Export growth (deflated by import price index)	0.09***	0.09***	0.09***	0.10***	0.09***
	(7.94)	(8.29)	(8.35)	(8.52)	(8.44)
Constant	2.55***	2.41***	2.45***	2.34***	2.34***
	(2.94)	(2.79)	(2.82)	(2.68)	(2.67)
Observations	1,180	1,174	1,169	1,161	1,151
R-squared	0.15	0.15	0.16	0.16	0.16

Sample is Post 1990

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7 shows the fragility of the findings in table 6, as the results change when using the public capital stock growth variable. The estimated coefficients on the lags of the investment boom variable are now not significant except for the fourth lag. The post-1990 sample has few countries with booms and thus greater sensitivity to specific country cases. Here Uganda's investment boom in the 1980s and 1990s is much larger when measured by capital growth than the investment ratio, driving the different results.

Table 7. Regressions of Annual Growth in Real GDP per-person on the current and lagged public investment boom variable. The investment boom variable denoted "Boom VarK" = Kgrowth - Kgrowth(0) during a boom and 0 otherwise, where Kgrowth(0) is annual growth in the stock of public capital in the year before the boom started.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
Boom VarK	0.31***				
	(2.76)				
Boom VarK (-1)		0.11			
		(1.00)			
Boom VarK (-2)			0.12		
			(1.15)		
Boom VarK (-3)				0.14	
				(1.49)	
Boom VarK (-4)					0.17**
					(2.07)
Black Market Exchange Rate Premium	-0.27***	-0.26***	-0.28***	-0.28***	-0.30***
	(-2.66)	(-2.60)	(-2.78)	(-2.79)	(-2.89)
Life Expectancy at birth (years)	0.03*	0.03*	0.03*	0.03**	0.03**
	(1.87)	(1.85)	(1.93)	(2.01)	(2.01)
Financial Depth (Deposit Bank assets % of GDP)	-0.01	-0.01	-0.01	-0.01	-0.01
	(-1.11)	(-1.12)	(-1.11)	(-1.17)	(-1.29)
Inflation	-0.00	-0.00	-0.00	-0.00	-0.00
	(-1.29)	(-1.29)	(-1.31)	(-1.31)	(-1.28)
Real Export growth (deflated by import price index)	0.09***	0.09***	0.10***	0.10***	0.10***
	(8.26)	(8.27)	(8.49)	(8.42)	(8.45)
Constant	2.61***	2.65***	2.55***	2.50***	2.51***
	(3.00)	(3.00)	(2.88)	(2.83)	(2.83)
Observations	1,171	1,164	1,156	1,146	1,135
R-squared	0.15	0.15	0.15	0.15	0.16

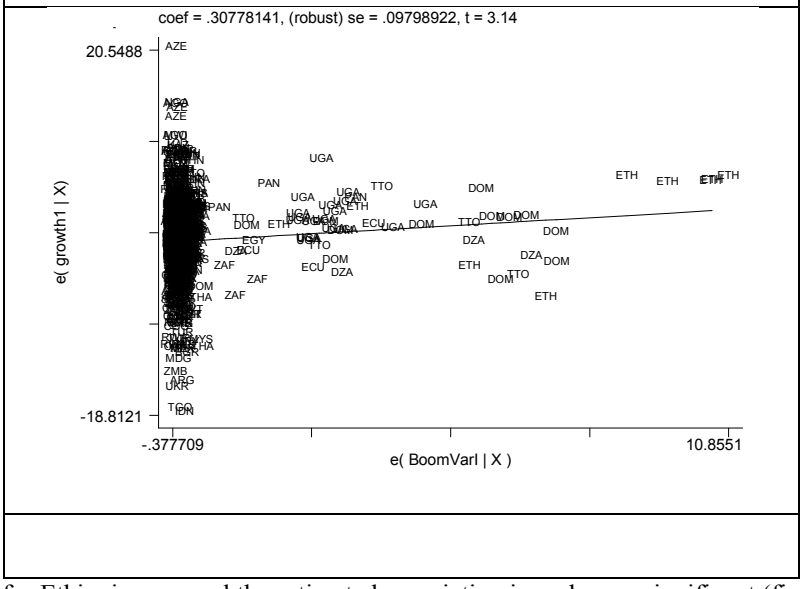
Sample is Post 1990

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

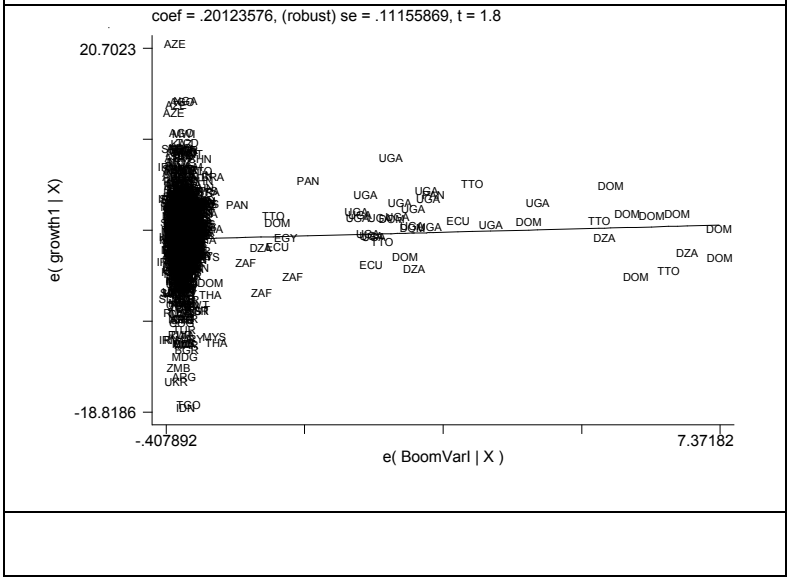
Further, the table 6 results are sensitive to the presence of a single country in the sample. Consider the estimated association found for the contemporaneous investment boom variable in table 6, a coefficient of 0.31. The influential data points behind this estimate are illustrated in figure 8, and show the importance of the Ethiopian observations.

Figure 8. Illustration of the estimated association between economic growth and the (contemporaneous) investment boom variable – regression (1) table 4.



With observations for Ethiopia removed the estimated association is no longer significant (figure 9).

Figure 9. Illustration of the estimated association between economic growth and the (contemporaneous) investment boom variable – with Ethiopia removed.



The positive post-1990 result in table 6 is driven by the Ethiopian data. Rather than suggesting a general tendency for all investment booms to perform better after 1990, it invites further research on the Ethiopian case specifically. The post-1990 evidence base is small as few countries have pursued major public capital spending booms in recent years.

In summary, while the full-sample results showed the association between the boom variables and subsequent economic growth to be small and probably not causal, the post-1990 sample appears at first blush to show more positive results. There are however few cases of booms after 1990, and the empirical results are sensitive to the inclusion of Ethiopia and Uganda in the sample. Ethiopia is a case of a boom that is not yet over, with both GDP and public investment rising together in the first years of the boom. The passage of time or further research is needed to shed light on whether the relation is causal. The Uganda case is difficult to assess because the results hinge on the data used to measure the investment boom – whether that is a case of investment-led growth remains an open question.

Sensitivity of the results to an alternative method of selecting boom years

To check the sensitivity of these results to the method of selecting boom years, a method of selection was tried that did not require observation of the data. Rather than selecting boom years by first selecting significant upturns in public investment and then establishing the precise dates by observation of the time series, the alternative simply defines a boom as occurring when the variable in question exceeds its 70th percentile for a specific country for at least three consecutive years. This second method was applied to both the public investment ratio as well as public capital growth, yielding two further sets of dates for boom years. The boom variables associated with this were simple indicator variables that take the value 1 during those years and 0 otherwise.

The three sets of boom years are quite different from each other. Let the preferred set of dates for booms used earlier in this paper be called "Set 1", the dates resulting from applying this second method to the investment ratio data "Set 2" and the dates resulting from applying this second method to the public capital growth data "Set 3". There are 363 observations defined as booms in Set 1. The probability of an observation being classified as a boom in Set 2 given that it was so classified in Set 1 is only 41 percent. The same probability for Set 3 is 49 percent. The probability of being defined as a boom in Set 3 given that an observation was so defined in Set 2 is 24 percent.

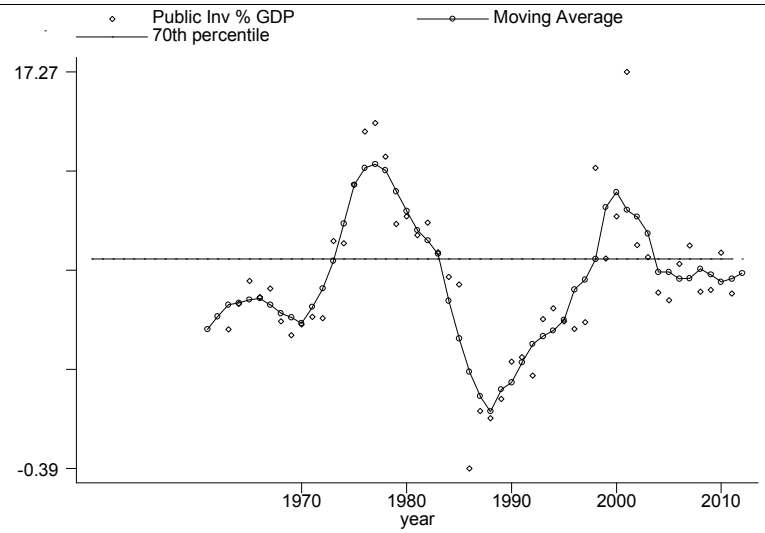
Regression results using the boom years as defined in Sets 2 and 3 and a 0/1 indicator variable for booms are shown in Appendix 1. Regression results using each of the four possible combinations are shown: for Sets 2 and 3; and for the full and post-1990 samples.

Focusing on results for the whole sample period (tables 1A (Set 2) and 1B (Set 3)), the major results are similar as when using the preferred method of selecting boom years (Set 1). The investment boom variable is sometimes not statistically significant at all. When it is significant, it is so for the contemporaneous term or the first few lags; never the longer lags. Results for the other right hand side variables are also similar.

Some differences emerge when focusing on regressions limited to the post-1990 sample, and the ultimate reasons are instructive about pitfalls in measuring booms, especially when they occur at the end of a sample period. Note that tables 1C ad 1D show huge apparent impacts of the booms on growth, both contemporaneous and lagged. As before there is sensitivity to a single country, Ethiopia, and the statistical significance of the contemporaneous association is eliminated once

Ethiopia is not included in the sample. On top of this the results are also sensitive to the presence of Nigeria and Panama. Nigeria is a case of inherent ambiguity about whether it experienced well-defined public investment booms, and if so, when exactly they started and ended. Nigerian public investment statistics are illustrated below.

Figure 10. Nigeria: Public Investment in Percent of GDP

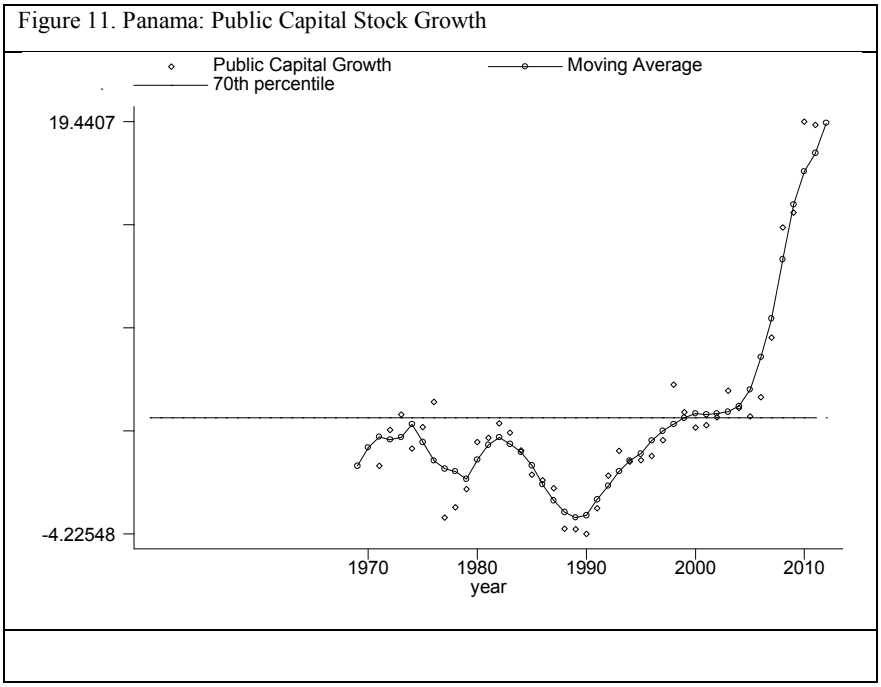


In this figure the data points are for public investment in percent of GDP, the line between the points is the moving average, and the horizontal line indicates the 70th percentile of the series. One possibly attractive approach to selecting dates for Nigeria's boom periods would be that Nigeria had two back-to-back public investment booms, one starting in 1970 and finishing in 1988 and a second starting in 1988 and finishing around 2004. But the problem with this method is that the entire period 1970-2004 would be rated as a boom period, despite the fact that public investment was very low during the middle of this period. Another approach would be to rate the first period as a boom but not the second, but the problem here is that the second period is clearly not a counterfactual period without a boom. A further alternative, rating all periods in which public investment exceeds a specific cutoff, such as the 70th percentile illustrated in the figure and adopted in the second method above (Set 2) is problematic because the beginning and end-points of the boom are arbitrary. In the figure above, the point at which the lines cross the 70th percentile is clearly not the start of either the first or the second boom period. Given these points we think the best approach is to consider Nigeria an inherently difficult case in which to identify boom periods and omit it from the empirical analysis.

For this reason we place low weight on the regression results in tables IC and ID that use data that rate the period around 2000 as a boom period in Nigeria.

Panama is a case that illustrates the razor's edge quality to the 2nd and 3rd method of rating boom years and also shows this method to be problematic for Panama. Note in the figure below that Panama experienced a clear boom that started after 2005. But because there was a plateau just before this and because the value of the capital growth variable during that period happens to be slightly above the 70th percentile cutoff, the alternative method of selecting booms (set 3 in this case) gives a misleading rating that Panama experienced a long boom between the years 2000 and 2011 (the ratings are based on the smoothed values of the series not the unsmoothed raw data).

Figure 11. Panama: Public Capital Stock Growth



Again, we believe that Panama illustrates why the first method for selecting boom years, which in Panama's case establishes the boom years as 2005-2011, is preferable to the other two alternative methods. For this reason we place low weight on the regression results in tables IC and ID based on the second and third methods.

To summarize, this section checked the robustness of the preferred method for selecting public investment boom years. As far as the results using all the data are concerned, the alternative methods delivered similar results as the first preferred method, despite the fact that the methods are quite different from each other. Different results were found using the post-1990 sample, but here

further investigation revealed that the post-1990 sample of countries was small and the results hinged on the presence of Ethiopia, Nigeria and Panama in the sample. Nigeria and Panama were investigated and we believe that the second and third methods are problematic for both countries, for different reasons. Therefore we believe that the regressions reported in Appendix I, tables C and D are based on inferior data for these two countries; this is not an issue of robustness but rather that the first method for selection of boom years is more accurate than the second or third.

Crowding in or crowding out?

The estimates presented so far have been reduced-form estimates in which the impact of public investment captures not only the direct productivity impact of public capital but also the improvement to productivity through stimulation of private investment. What does the data tell us about the association between public investment booms and private investment?

This section shows evidence that part of the explanation for the muted impact of public investment booms is that there appears to be crowding-out of private investment, as booms are associated with lower private investment expenditures as a percent of GDP. In table 6 and 7 private investment as a share of GDP is regressed on the public investment boom variable and the same control variables used in the growth regressions. What is noteworthy is that the public investment boom variable has a consistent and negative association with private investment rates, and this association does not diminish as the boom variable is lagged. Even after four years public investment booms were associated with lower private investment rates. Greater life expectancy, a lower black market exchange rate premium, and greater financial depth were associated with higher private investment rates. Financial depth is more strongly associated with higher private investment rates than it was with overall economic growth. The last two variables, inflation and export growth, show little association with private investment.

This evidence is important because it indicates that one reason for the muted impact of public investment booms in the past was crowding out of private capital formation. This runs counter to the presumption in models that use Cobb-Douglas specifications that public capital will stimulate private capital formation, and also undermines a key selling point of public investment booms – that they will stimulate private investment and thus have a magnified impact on the economy.

The estimates suggest that crowding out was actually higher post-90 than for the full sample, based on comparing results using the post-1990 sample (table 9) against the full sample (table 8). To gauge the magnitudes, other things constant a 5 percentage point rise in the public investment ratio was associated with a 2 percentage point decline in private investment using the whole sample results in table 9 (5*-0.4) and a 5.7 percentage point decline (5*-1.135) using the post-90 results.

Table 8. Evidence on Crowding Out. Regressions of Private Investment in Percent of GDP on the Public Investment Boom Variable and Other Controls. Full Sample.

VARIABLES	(1) No Lag	(2) Lagged one year	(3) Lagged two years	(4) Lagged three years	(5) Lagged four years
Boom VarI	-0.405***				
	(-4.155)				
Boom VarI (-1)		-0.389***			
		(-4.129)			
Boom VarI (-2)			-0.372***		
			(-4.319)		
Boom VarI (-3)				-0.350***	
				(-4.615)	
Boom VarI (-4)					-0.346***
					(-4.981)
Black Market Exchange Rate Premium	-0.625***	-0.619***	-0.615***	-0.588***	-0.580***
	(-7.260)	(-7.156)	(-7.071)	(-6.631)	(-6.374)
Life Expectancy at birth (years)	0.200***	0.200***	0.200***	0.200***	0.200***
	(12.307)	(12.269)	(12.236)	(12.045)	(11.850)
Financial Depth (Deposit Bank assets % of GDP)	0.024***	0.025***	0.025***	0.026***	0.026***
	(3.035)	(3.099)	(3.154)	(3.131)	(3.177)
Inflation	0.000	0.000	0.000	0.000	0.000
	(1.077)	(1.078)	(1.075)	(0.946)	(0.913)
Real Export growth (deflated by import price index)	0.005	0.005	0.005	0.004	0.004
	(0.557)	(0.543)	(0.537)	(0.459)	(0.413)
Constant	1.663*	1.629*	1.611*	1.567*	1.515
	(1.802)	(1.763)	(1.745)	(1.674)	(1.592)
Observations	1,730	1,728	1,727	1,693	1,659
R-squared	0.191	0.190	0.190	0.185	0.185

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9. Evidence on Crowding Out. Regressions of Private Investment in Percent of GDP on the Public Investment Boom Variable and Other Controls. Post-1990 Sample.

VARIABLES	(1) No Lag	(2) Lagged one year	(3) Lagged two years	(4) Lagged three years	(5) Lagged four years
Boom VarI	-1.135***				
	(-7.166)				
Boom VarI (-1)		-1.212***			
		(-7.245)			
Boom VarI (-2)			-1.248***		
			(-7.301)		
Boom VarI (-3)				-1.230***	
				(-7.265)	
Boom VarI (-4)					-1.230***
					(-7.134)
Black Market Exchange Rate Premium	-0.342***	-0.325***	-0.309**	-0.290**	-0.271**
	(-2.810)	(-2.671)	(-2.539)	(-2.370)	(-2.223)
Life Expectancy at birth (years)	0.197***	0.196***	0.195***	0.195***	0.195***
	(10.614)	(10.524)	(10.476)	(10.335)	(10.269)
Financial Depth (Deposit Bank assets % of GDP)	0.016*	0.016*	0.016*	0.017*	0.018**
	(1.754)	(1.781)	(1.797)	(1.878)	(1.993)
Inflation	-0.001	-0.001	-0.001	-0.001	-0.001
	(-1.130)	(-1.137)	(-1.150)	(-1.168)	(-1.236)
Real Export growth (deflated by import price index)	-0.001	-0.001	-0.000	0.000	0.001
	(-0.127)	(-0.061)	(-0.034)	(0.039)	(0.079)
Constant	2.422**	2.469**	2.477**	2.459**	2.388**
	(2.270)	(2.303)	(2.306)	(2.276)	(2.202)
Observations	1,193	1,191	1,190	1,181	1,170
R-squared	0.192	0.193	0.192	0.189	0.191

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A comparison of two major episodes: pre and post 1990

The regression evidence showed some results that differed depending on whether the sample included all the years or just the years after 1990. Although much of this difference was down to a few countries, Ethiopia primarily, it is notable that the booms tended to cluster either in the 1970s or the late-1990-2000 period.

Table 10. List of Boom episodes and division into two groups: pre and post-1990

	Boom Period					
			I/Y - I/Y(0)			
Country	Start	End	Mean	Max	"Pre-90" Sample	"Post-90" Sample
Algeria	2004	2011	5.37	8.75		x
Cote d'Ivoire	1970	1988	5.19	9.08	x	
Dominican Republic	1969	1980	6.07	12.50	x	
Ecuador	2005	2010	3.29	6.36		x
Egypt	1972	1991	5.82	10.52	x	
Ethiopia	1999	2011	7.73	11.10		x
Jordan	1971	1985	9.67	16.85	x	
Libya	1998	2011	12.71	17.45		x
Malawi	1973	1983	3.26	6.69	x	
Mexico	1973	1989	3.50	6.62	x	
Morocco	1972	1989	4.70	8.44	x	
Myanmar	1974	1989	5.12	9.95	x	
Nigeria	1970	1984	3.95	7.09	x	
Panama	1969	1979	2.23	5.33	x	
South Africa	1970	1993	3.36	6.67	x	
Togo	1972	1988	9.08	20.03	x	
Trinidad & Tobago	1973	1986	3.87	7.93	x	
Uganda	1984	2011	3.15	5.55	x	
United Arab Emirates	1990	2011	3.81	6.36		x
Uruguay	1972	1985	3.33	6.99	x	
Venezuela	1972	1985	4.01	8.88	x	
Countries with a second boom period						
Dominican Republic	1985	2003	4.63	7.64		n.c.
Panama	2005	2011	3.49	7.24		x
Trinidad & Tobago	2002	2011	4.38	8.15		x
Mean			5.07	9.26		

Is there evidence that the modern booms differ in their scope and impact from the older booms? This section investigates this by dividing the booms into two subsets. Table 10 shows descriptive statistics on the boom episodes. There are 24 episodes. Of these the mean size of the boom, as measured by the deviation of the public investment ratio from its value at the start of the boom, was 5.07 percentage points of GDP. For example, since the median public investment ratio prior to the booms was close to 5 percent of GDP, a typical boom would see a rise in the public investment ratio from 5.0 to 10.07 percent of GDP. The maximum across all countries averaged 9.26 percentage points of GDP. Three countries, listed at the bottom, were found to have experienced two separate boom episodes. Of the 24 countries, 16 had booms that were predominately pre-1990; 7 had booms that were predominately post-1990; and the Dominican Republic's second boom is not classified into either group since it spanned the period 1985-2003.

Figure 12. Comparing Public Investment Booms before and after 1990: Public Investment in percent of GDP, medians for groups of countries, graphed against years since the start of each boom.

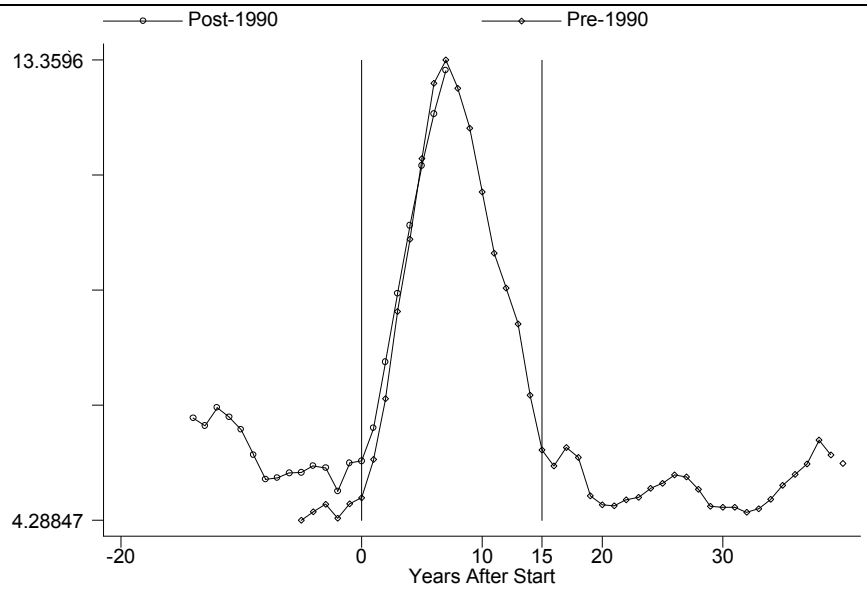
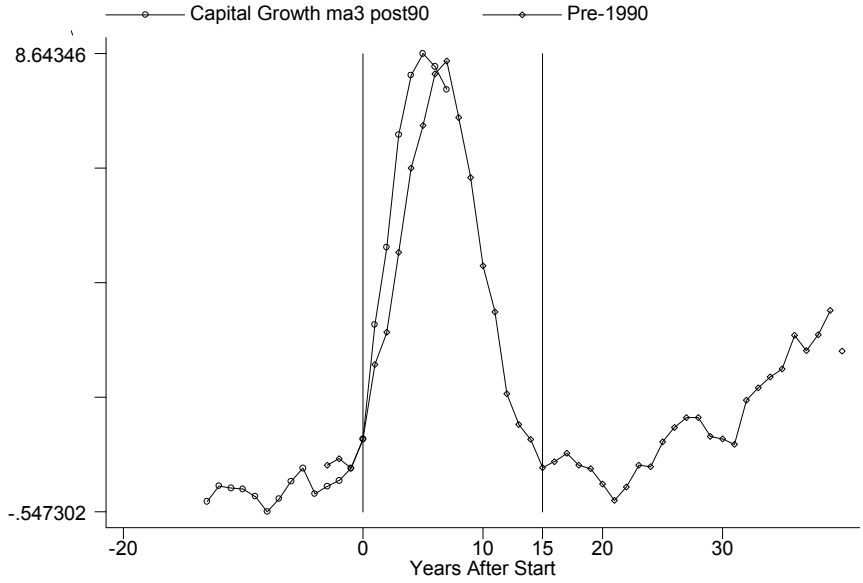


Figure 12 shows a comparison of the public investment booms between the 16 countries in the pre-1990 group and the 7 counties in the post-1990 group. The data are the within-group median values of public investment as a share of GDP, where each countries data was synchronized with t=0 corresponding to the first year of their investment boom. After taking the median across countries, the data were smoothed over time by taking a centered 3-year moving average. For the 16 country group, values are shown only if the number of countries over which the median is calculated is 10 or

greater. For the 7 country group, values are shown only if the number of countries is 6 or greater. The figure shows the strong rise in the median public investment ratio in both episodes. For the booms that started before 1990, the median length of the boom, illustrated in the figure, was 15 years.

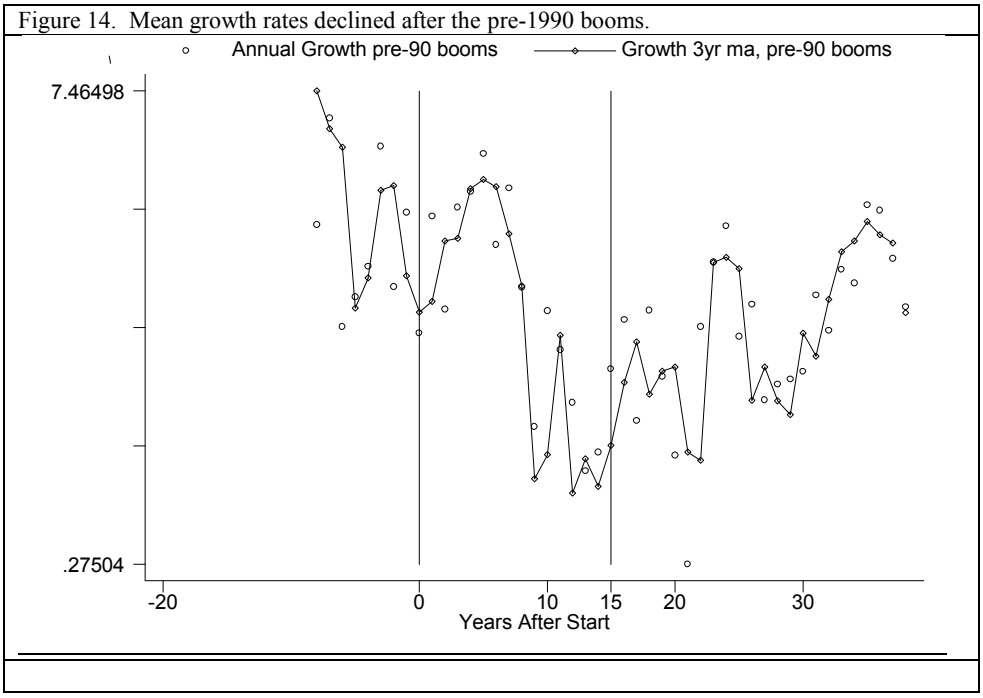
In figure 13 the same comparison is shown using the public capital growth data. The figures look remarkably similar except that when measured by capital growth, the seven post-90 boom countries had a sharper rise at the beginning of the boom.

Figure 13. Comparing Public Investment Booms before and after 1990: Public Capital Stock Growth, medians for groups of countries, graphed against years since the start of each boom.



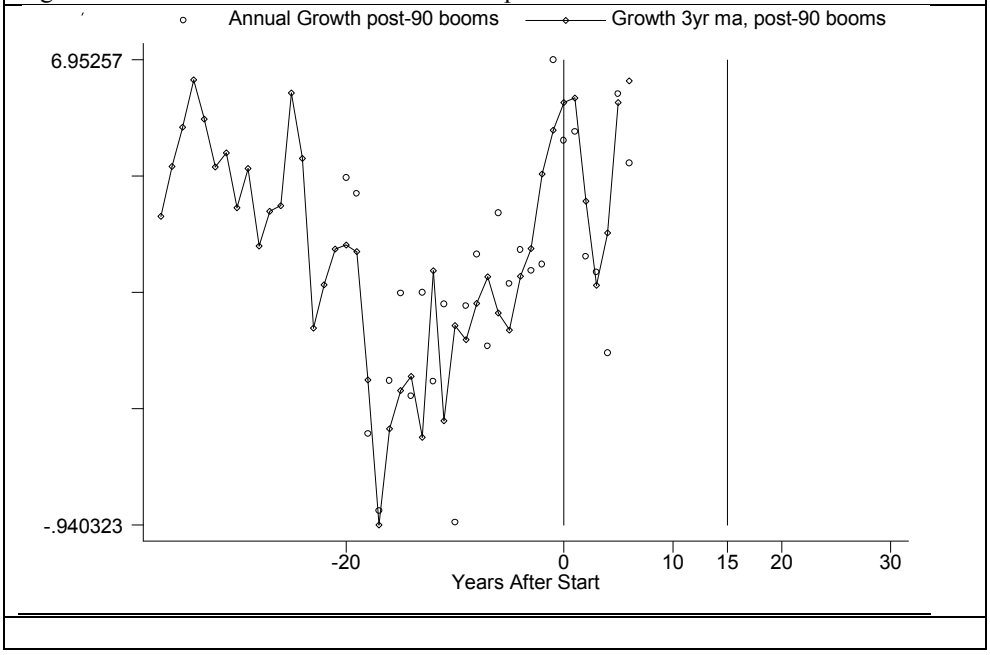
Next consider growth performance for the two groups of countries. In figure 14 median growth for the 16 pre-1990 countries is graphed against number of years since the start of the booms, along with a line that shows the centered 3-year moving average of those growth rates. The 15-year boom period is marked by vertical lines at the start and the end (years 0 and 15). Note that during this 15-year boom period GDP growth rose during the first 5 years before falling sharply in the later years of the boom. Thus during the earlier booms, GDP and public investment tended to both rise together during the first 5 years of the boom before deviating in the middle of the boom period as GDP began to collapse.

Figure 14. Mean growth rates declined after the pre-1990 booms.



Now consider the same figure for the group of post-1990 countries.

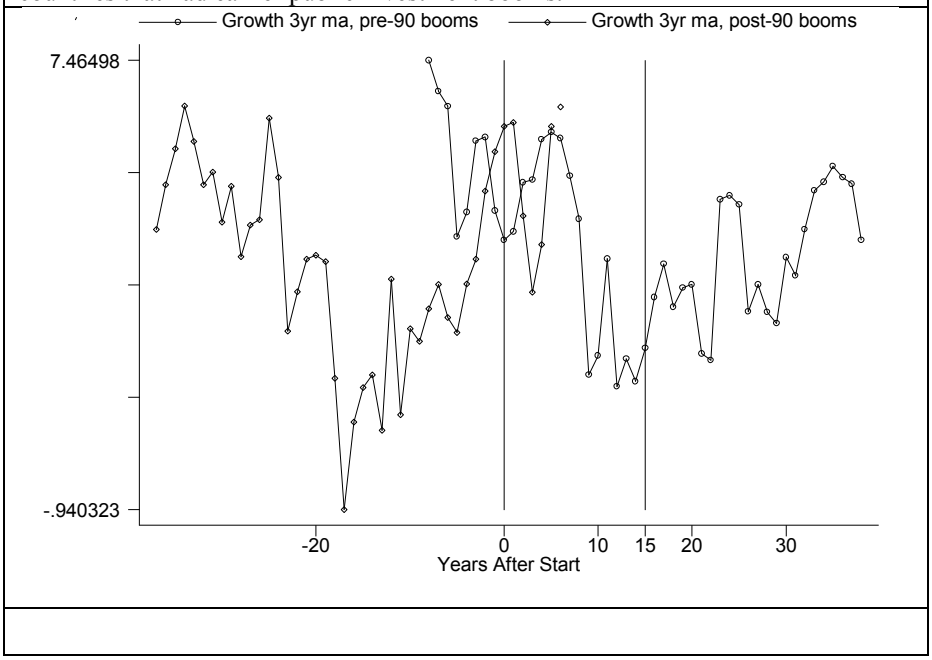
Figure 15. The limited data we have after the post-1990 booms so far shows no decline



Note that for purposes of comparison with the previous graph, the same lines at the 0 and 15-year mark are drawn. The post-1990 booms are not yet over, so the booms in the figure terminate when the data ends, rather than when the data come back down to pre-boom levels. Nevertheless focusing on the 15-year period, the data are erratic but still show higher growth on average in the first years of the boom than the immediate

pre-boom period. This is similar to the pre-90 results, in which GDP and public investment rose together in the early years of the boom. It is too early to say whether the slump in growth that hit the pre-90 countries will also occur with the post-90 booms. To facilitate a comparison of the growth for the two sets of countries, figure 16 below shows median GDP growth in the same figure, plotted by the years since the start of the boom:

Figure 16. For the years immediately after the start of the booms, mean economic growth in the recently booming countries is not hugely different than it was for the countries that had earlier public investment booms.



The evidence from the post-1990 booms is rather thin – seven countries and six years of GDP growth data after the booms commenced in which all seven are represented. What we can say is that average GDP growth had been increasing for several years before the public investment booms commenced, unlike the 1970s. Further, mean growth has remained high in the first years of the booms, as it did in the 1970s. We cannot claim that the association is causal, as everything tends to rise together during boom times. Examining individual countries, in only one of the seven, Ethiopia is there evidence that the acceleration in GDP growth came several years after the start of the public investment boom; the rest show both variables growing together. And there is not yet sufficient evidence to say whether the current public investment booms will see the same collapse in GDP growth as occurred six or seven years into the earlier booms.

Five Case Studies:

Mexico

Mexico experienced its major upsurge in public investment in the 1970's[5]. After two decades of what became known as the period of Stabilizing Development, including high growth and low inflation, the new administration of Luis Echeverria had accepted the popular view that growth had done too little to promote employment and distribute gains equitably (a judgment that appears unsupported by later evidence, see Buffie table 2.10 p. 409). The new government promoted a program of "shared development." A mild slump in growth in 1971 gave a new impetus to factions within the government that were pushing for a major increase in public investment, both as way to promote shared development and as a business cycle stimulus.

President Echeverria decided to shift and lend his full support to a large increase in public investment starting in 1972. At the outset, this was to be financed through domestic sources with a major tax reform to reduce evasion, broaden the tax base and increase revenues from State Owned Enterprises. By the end of 1972 however, the tax reform floundered and was abandoned. The investment program was not scaled back, marking the first of many stages in which the program was continued in spite of events that might have prompted a re-think. Overall public expenditure increased from 20.5 percent in 1971 to 32 percent in 1976. Capital expenditures by the SOE's increased at an annual rate of 29 percent. Despite the failure of the tax reform, government revenue nevertheless increased, in part due to bracket creep bringing about higher average tax rates. But rather than curtail government borrowing in the face of better than expected revenues, borrowing increased, as the fiscal deficit grew from 2.5 percent of GDP to 10 percent in 1975. During this time federal government employment doubled in six years, increasing the weight of an interest group in favor of maintaining high expenditures.

There was dissention within the government in the face of mounting deficits. Yet once again the expenditure plans survived. The dissenting Ministry, the Ministry of Finance, was simply stripped of decision making authority over the expenditure plans, as authority was moved to the President's office, the Minister of Finance was fired, and the program continued unabated. Yet a balance of payments crisis emerged by 1976, and the government agreed to an adjustment program

[5] This section draws heavily on Buffie (1988).

with the IMF in 1976. The government was in the process of implementing the programmed cutbacks under the IMF program when major new Oil reserves were discovered during 1977-8.

Higher oil revenues once again gave the government breathing space and an opportunity to shift to a fiscally sustainable expenditure program. Instead the prospects of higher oil wealth prompted further international borrowing and another ratcheting up of public expenditures. Public investment rose from 7.2 to 10.8 percent of GDP between 1977 and 1981. International borrowing continued, oil prices started to decline in 1981, and the major debt crisis and crash came in 1982[6].

A critical issue is that there appears to have been little effective information at the time whether the investments were paying off, so positive performance data cannot explain the continued support for the expenditure program. A significant part of public investment was conducted under the auspices of secretive Public Enterprises. With the benefit of hindsight, it is clear that many investments were very poor, as claimed in Buffie (1988):

> *"And though little hard data exists on the productivity of State Owned Enterprises, there is little doubt that many of the public sector investments undertaken in this period were fundamentally unsound and have subsequently yielded very low social returns."*

Figure 17. Public Investment Expenditures in Mexico, percent of GDP

[6] The account in the paragraph is based on Buffie (1988).

Bolivia

Bolivia's public investment spree in the 1970s (illustrated in figure x below) was not a stand-alone investment drive but instead occurred as part of a larger national policy of state-led development. The overall vision was described in the "Socioeconomic Strategy for National Development" presented by the government of General Ovando in 1969. This strategy remained influential in spite of changes in administration over the 1970's and into the early 1980s. It called for deploying surpluses of public enterprises, many of which produced natural resources, to fund investments in agriculture, other industries, public capital and social spending. Strategic sectors of the economy were reserved for public enterprises, foreign direct investment was rejected and industrialization was to be boosted via regional trade with Bolivia's Andean neighbors. Later, President Banzer's five-year development plan of 1975 expected the public sector to account for over 70 percent of total national investment. Nevertheless, the plan was not necessarily hostile to the private sector, as private firms implemented and profited from many of the investment projects. Private sector enterprises instead may be seen as one of the vested interests that benefited from an expansion of investment projects funded by public enterprises.

Figure 18. Public Investment Expenditures Bolivia, percent of GDP

Petroleum export revenues turned out to be much lower than forecasted in the development plans. Whether or not this curtailed the program somewhat, it is clear that there was a shift to alternative means of financing. Foreign debt of public sector institutions debt rose significantly during this period, and there was increasing use of public-sector guarantees, which create implicit liabilities and potential future debt of the public sector even if they do not show-up immediately on

the books as government debt. Moreover it is worth mentioning that this accumulation of debt was not obviously a centrally-planned development. Public sector enterprises appear to have continued with their investment programs, regardless of financial problems, and borrowed abroad to do so, on the backs of implicit or explicit state guarantees. As in the case of Mexico and the Philippines, these developments are consistent with the view that there were forces pushing for a continuation of the investment programs that found a way to continue despite problems.

There were groups in the Bolivian government aware of the risks of runaway investment projects, but their voices were not decisive. In 1974 a National System of Projects was established via government decree. Investment Projects were to pass through multiple layers of screening, first by the National Committee of Projects, then by the National Council of Economic Planning, composed of several cabinet ministries and associated undersecretaries. There was to be social cost-benefit analysis, a search for sources of financing, and oversight of implementation. The system was cumbersome and overly complex. In any case, as Morales and Sachs (1988) report,

> *"..vested interests were able to circumvent the procedures and get their projects to the [National Council] directly. Several Reforms of the National System of Projects were proposed between 1976 and 1986, but to no important effect."*

In addition to this evidence which suggests resistance within the government to rational investment screening, there is also evidence that the raw material for any kind of rational decision making, basic information on performance, was simply not collected or obscured by complex cross-subsidization, especially within the public enterprises.

> *"For several reasons however, it is very difficult to evaluate with any accuracy the performance of individual (public) enterprises. There are simply too many distortions in financing and pricing to make such a retrospective analysis feasible. Complex cross-subsidies among the state-owned enterprises distort the measured profitability of individual firms."*

What actually happened was very far removed from basic principles of rational government decision making. Morales and Sachs (1988) confirm many of the tell-tale signs of a decision process infested by interest-group pressures and a government disinterested in effective implementation:

> *"The deficiencies of planning were nowhere more revealed than in the execution of public investment projects. A full evaluation of investments in the very capital-intensive projects has yet to be made. Ideally, information should be gathered for an ex ante and ex post evaluation of each major project undertaken in the 1970s and up until 1985. Short of*

that, we may note the following points. First, many large projects responded more to noneconomic factors (prestige, national security, etc.) than to profitability, measured either in private or social terms. Second, grave mistakes were made in evaluating the endowments of natural resources. For example, overoptimistic assessments of oil and mineral reserves led to overinvestment in these industries. Third, the cost-benefit analyses performed before undertaking the projects were either incomplete or were ignored in the implementation phase. Fourth, the large projects were typically financed with expensive suppliers' credits and foreign bank loans. The conditions of repayment were, from the start, likely to create problems in the cash-flow stream. Fifth, when the projects were financed with official loans, delays in disbursements often disrupted the investment schedules. Sixth, the execution of the projects was extremely poor, with frequent but avoidable long delays in deliveries and construction."

Korea

This account of Korea's growth strategy and the role of public investment is based on the memoirs of Kim Chung-yum (2011), who held a number of positions in the Korean government starting in 1944, including Minister of Finance, Minister of Commerce and Industry in the 1960's and Chief of Staff to President Park Chung Hee from 1969-1978.

After the Korean War (1950-1953) the overriding concern of public investment policy was post-war reconstruction. During the War the extent of useable paved roads had decreased from 1066 Kilometers in 1944 to 580 Kilometers in 1951, and a total of 1466 bridges were destroyed. This rebuilding effort was financed in part by foreign aid through the International Cooperation Administration (ICA) and US AID and in part by Korean government funds to cover labor costs (p. 274). Hence this effort did not put the Government heavily in debt.

The analytical task facing a government in selecting efficient investments is likely to be much easier during post-war reconstruction than in normal times. During the war the enemy targets precisely the highest value infrastructure. The reconstruction effort therefore automatically focuses on high-return investments, those that have proven their worth before the war. In contrast, if a government decides to build infrastructure ahead of the growth process, it has to forecast where the high return investment will be, an inherently more difficult and uncertain problem.

After reconstruction ended, the rapid growth in the early 1960's caused bottlenecks which brought the infrastructure problems to the fore of the policy discussion, showing the accommodative stance of infrastructure policy:

> *"During the First Five-Year Economic Development Plan from 1962 to 1966, transportation volume increased dramatically due to Korea's rapid economic growth, which resulted in greater social and economic activity, often creating congestion and bottlenecks. Korea's inadequate transportation capacity could not keep pace with the unexpected and rapid economic rise through 1964, and began to hinder economic growth. The supply of critical materials was delayed, causing repeated fluctuations in price. This became the main topic of economic discussions to stabilize prices, and sparked much debate between ministries and government agencies on the state of Korea's network of railways and freight trucks, and its traffic volume. Upgrading Korea's transportation infrastructure suddenly took precedence." (p 276-7)*

After several years, President Park announced a major national reconstruction plan in April 1967.

> *President Park, April 1967: "I will carry out the national reconstruction plan. Under the Second Five-Year Economic Development Plan, I will seek to build expressways and ports, and to develop the basins along four major rivers: the Han River, the Nakdong River, the Geum River and the Youngsan River." At a press conference on May 2, he said: "The national reconstruction plan is one of the basic initiatives to modernize Korea. I will seek to build major expressways, connecting Seoul to Incheon, Gangneung, Busan and Mokpo." (p. 281)*

However initial estimates indicated that this plan would be prohibitively expensive:

> *"Japan spent about 800 million won per kilometer of road to build the Tomei Expressway between Tokyo and Nagoya. If the same unit of cost was applied to estimate the total cost of the Seoul-Busan Expressway stretching 430 km, Korea would need to spend 350 billion won. This was more than twice the total national budget of 164 billion won in 1967." (p. 286)*

In an attempt to discipline costs the government solicited estimates from a variety of sources, including from the private sector (Hyundai Construction). What is noteworthy is the high variance in cost estimates and that the line ministries tended to have the higher estimates. The estimates were: Ministry of Construction (65 billion Won); the Military Engineering Office of the Army (49 billion); the Ministry of Finance (33 billion); Hyundai Corporation (28 billion); and the Seoul Metropolitan Government (18 billion). The Economic Planning Board was unable to develop an estimate.

A National Expressway Construction Planning and Research Committee was established to prepare a plan to build the Seoul-Busan Expressway with a budget of 33 billion, including a 10 percent reserve. Critically, the plan had to accommodate the budget:

> *"From the committee's perspective, they had to work within a fixed budget in drawing up a construction plan rather letting the plan dictate the construction costs." (p. 287)*

Construction work was unusually rapid. The first section of the highway was completed well before the original plan (December 1968 rather than June 1971) and the final cost was 42.9 billion Won as compared with the 33 billion estimate.

> *"The total construction cost of the expressway was 42.9 billion won, exceeding the initial estimate of 33 billion won, largely due to several changes and increases in the cost of raw materials. However, the unit cost per kilometer was just 0.1 billion won, representing one eighth of the cost of the Tomei-Meishin Expressway in Japan. The Seoul-Busan Expressway held historical significance because it was constructed at the lowest cost and in the shortest amount of time ever in the world with Korea's own technologies." (p. 293)*

The Korean case illustrates a number of general points. It provides examples of three major episodes of public investment policy: post-war reconstruction; the reaction to bottlenecks revealed by the growth process; and third, a big push planning process in which infrastructure is expected to lead

economic development in the form of the highway construction program. In fact the highway program is best seen as a hybrid between the latter two. It certainly was a reaction to perceived infrastructure inadequacies that emerged by the mid-1960s. At the same time, its huge magnitude makes it hard to exclude that there was a big-push element to it as well.

The Korean highway program also illustrates extraordinary implementation, use of competitive bids to discipline costs, even to the point of going outside government and probably playing the groups off against each other in an effort to obtain objective estimates. The final cost overrun, even at 30 percent, was extraordinarily low for public investments, in which 200-400 percent cost overruns are not uncommon. The highway program also illustrates a prudent financing strategy. Although the first sections were financed with tax revenue, later sections were increasingly financed via tolls on the previously-constructed sections. It also helped that Korea was growing during this period, so public revenues were growing.

Finally the highway construction program also had solid economic justification since it focused first on connecting the two major urban centers. It thus accommodated the urban-centered growth that market forces were driving forward, and did not attempt to push economic development to different geographic regions that were lagging behind in the growth process. In this sense it swam with the tide of the market rather than against it.

Overall, in spite of the large highway construction program in the 1970's Korean data indicate that Korean public expenditures never showed the sharp upsurges seen in many other countries. Public investment has never boomed in Korea: staying at approximately 5 percent of GDP for several decades.

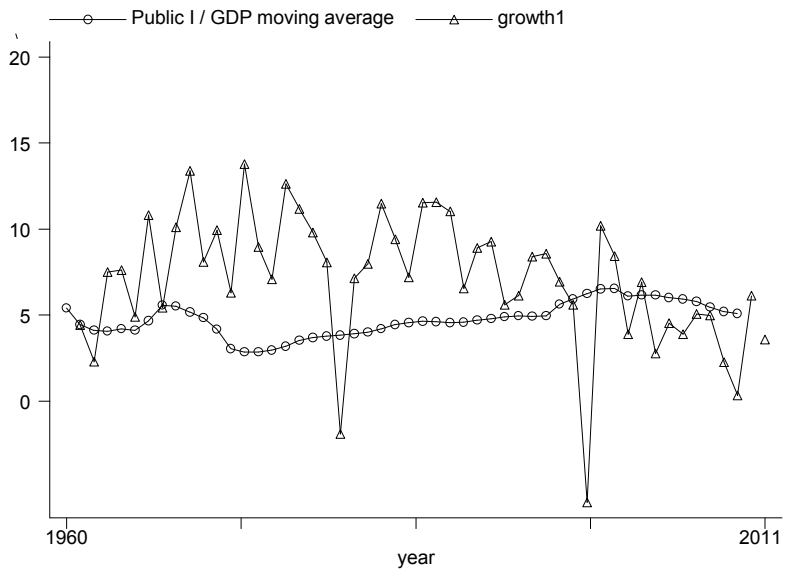


Figure 19. Korea; Public Investment Expenditures in percent of GDP (3-yr moving average) and annual GDP growth.

Taiwan province of China

The role of public investment in Taiwan province of China's growth is based on the account of Kuo-Ting Li, known as the "Father of the Economic Miracle", who held the positions of economic minister from 1965 to 1969 and finance minister from 1969 to 1976. His account of the policies and the underlying strategy appears in "Evolution of Policy behind Taiwan's Development Success", originally issued in 1978 and reissued with revisions in 1995.

In this volume the most telling piece of evidence is of the ten chapters, none is devoted to infrastructure policy. There is no mention of the use of public investment as a leading force to drive development, getting out ahead of the growth process. Instead the account begins with the four successive four-year plans beginning in 1953. Growth over each of the four planning periods averaged 7%, 7%, 9.5% and 10.1% respectively. Import substitution was followed in the 1950's followed by a switch to export promotion in 1960 with the implementation of the "Statute for the encouragement of Investment", augmenting customs rebates for imported inputs for export industries and a devaluation of the NT dollar from 36.38 to 40. By the mid-1960s infrastructure was "relatively backward" and the tax system was "inadequate", both acting as a "drag on further development" (see page 83).

This was the point at which the government addressed the infrastructure needs through export processing zones, providing adequate infrastructure for the export industries in specialized zones. Between 1966 and 1969 export processing zones were established in Kaoshing, Nantze and Taichung (page 83).

A notable feature of Taiwan's approach to financing infrastructure was the use of Postal Savings. A fraction of postal saving deposits were transferred via the Central Bank to public utilities for infrastructure investments, such as electricity, transport systems, and water resources (p. 119). This provides an automatic mechanism whereby infrastructure investment rises as a share of the economy as household saving rise.

Taiwan did have a public investment upsurge, called the "Ten Major Construction Projects", but this occurred in the 1970's, years after rapid economic growth had begun, as is clear from the figure below which shows growth of approximately ten percent in the 1960's. Li mentions this only in passing (p. 84), as the Investment Statute was amended in 1973 to allow for it's financing. At the time the Premier, Chiang Ching-kuo, believed the country lacked key infrastructure. The list of

projects undertaken reveals that many of the investments supported exporting or would benefit a wide-variety of industries.

- National highway No1 (with link to national airport)
- Electrification of Western Railway
- North-link line railway
- Chiang Kai-shek International Airport
- Taichung Port
- Su-ao Port
- China Shipbuilding Corporation Shipyard, Kaohsiung
- China Steel Factory
- Oil refinery and industrial park
- Nuclear Power Plant

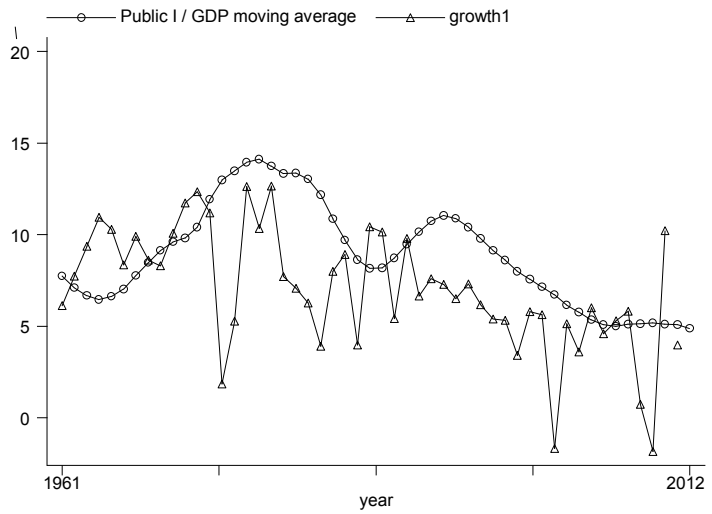


Figure 20. Taiwan province of China: Public Investment Expenditures in percent of GDP (3-yr moving average) and annual GDP growth

Li's summary of the overall strategy stresses pragmatism - government interventions were used to address issues when they arrived, and were abandoned when the original motivation disappeared. On the overall lesson to be drawn for other countries he stresses adherence to market signals over the long term. "I would go so far as to suggest that the experience of Taiwan and the

other NICs strongly suggests that a key transferable element of successful economic growth policy is allowing the development of free markets." (p.259)

Although Li does not mention public investment strategy explicitly, it is clear from these passages that the strategy that would have been consistent with the overall guiding philosophy would be use public investment to accommodate growth; to ratchet-up investment after problems emerged, not before. The two instances in which the Taiwanese government took the initiative on public investment were first, the use of export processing zones in 1966 (which entailed construction of improved infrastructure confined to a specific zone) and second, the ten major projects initiative after 1973. Both were reactions to perceived inadequacies after growth had occurred for many years.

Philippines

The surge in public investment in the 1970s in the Philippines was closely connected with the imposition of martial law in 1972, and the desire to create favor able economic conditions to legitimize the imposition of what was being presented to the public as "constitutional" authoritarianism. The Marcos administration had promised renewed economic growth a new society and the conquest of mass poverty. In the event, public investment spending rose from 1.6 to 7.2 percent of GDP between 1972 and 1982.

Figure 21. Public Investment Expenditures in Philippines, percent of GDP

This was to be investment-led growth. The Marcos administration commissioned proposals for investment projects and asked each ministry to develop lists of bottlenecks in each of their areas. Planning was to be guided by the newly created National Economic and Development Authority (NEDA). The program received favorable reviews from the donor community, if not outright endorsement. A World Bank Country Economic Report confidently endorsed the idea that to raise growth to 7 percent a year public investment would have to rise to at least 5 percent of GDP.

Simultaneously Marcos began to use the public investment program as a vehicle to consolidate political authority and foster a class of crony-capitalists and public employees loyal to his administration, especially in the military. Important methods included kickbacks, overpricing, high consultant fees and simply diversion of funds. The expansion of State Owned Enterprises was an important part of the strategy. Their accounts were separate from the normal accounts of the

government; their employees could be paid higher salaries than in the civil service; and lucrative seats on corporate boards could be offered to political allies. The number of state owned enterprises increased from 30 to 96 between 1972 and 1984, and many of the 96 were actually holding companies overseeing approximately 149 subsidiaries. The military budget grew by a factor of four. Road building was transferred to the military at inflated prices.

Thus by the mid-1970's a number of vested interests had been created or had emerged with lucrative interests in the continuation of the public investment program. The program acquired considerable inertia, as is apparent with how it was continued despite a series of funding crises through the 1970's. In 1975 international commodity prices collapsed. Nevertheless the decision was taken to continue with the investment program, albeit with a shift towards energy-related investments. Government investment rose as a share of GDP from 3.4 to 4.3 percent. External borrowing rose sharply to finance the program. The critical factor to understand about the incentives that grow up around a public investment program is that their interests are primarily in the execution of the works, the construction phase, not in the ultimate outcomes of the investments themselves, whether they are profitable or whether they address important social externalities.

> *"The result was that profits in many of the investment projects undertaken during the Marcos years were made at the investment and construction stage and not from profitable operation of the facilities constructed." P. 471.*

Again in 1980 there was a second terms of trade shock caused principally by the oil price. The government responded with an increase in the public expenditure program. By now the donor community had become less supportive, but the government pressed ahead in a hugely ambitions series of Major Industrial Projects. The project was slated to be financed with foreign equity inflows, but when these did not materialize as forecasted, the projects were partially scaled back with the rest financed through foreign loans.

The following is a summary of points that emerge from the case studies:

- *No evidence of rational decision process. Non-existent analytics and data.*
    - *The reviews of Bolivia, Mexico and Philippines make clear that even basic data to judge the quality of investments was frequently not available (for example, how much was spent, on what and by whom).*
    - *None of the examples show evidence of rational public decision-making based on comparison of alternative investments using project analysis.*
    - *There is one mention of cost-benefit analysis (Bolivia) which mentions that the results were ignored in implementation.*
    - *In Bolivia complex cross-financing and cross-subsidization schemes made it extremely difficult for outsiders to make sense of basic facts.*
    - *Micro-evidence on the impact of investments ex-post is never cited – presumably it does not exist.*
    - *Presidential leadership seemed to be important in Korea and Taiwan, but in the other cases there is no evidence that the government acted as a single decision maker – rather a coalition of interests and a series of decentralized decisions is a more accurate characterization of the decision process.*
- *Distorted incentives.*
    - *The case of the Philippines makes clear that most of the groups involved in implementing the investment campaign stood to profit from simply doing the program, not from whether or not the program had positive economic consequences.*
    - *Important interest groups that favor the investment programs, other than the sponsoring government department or state enterprise, include politicians and government officials of the regions in which the investments were located, private firms and their sub-contracting suppliers that performed the construction, professional consultants and laborers that worked on the investments.*
    - *In two of the cases state enterprises were used as the vehicle to implement part of the public investment drives. Possible motives include less stringent reporting requirements than on-budget expenditures; ability to borrow based on own collateral; political patronage as supporters could be appointed to boards of public enterprises.*
- *Inertia – programs continue despite problems.*

- *Obstacles cause a shift to alternative financing methods rather than curtailment of the program. This included a shift to foreign borrowing (Bolivia, Mexico, and Philippines) or borrowing backed by public guarantees (Bolivia, Mexico).*

- *In one example (Mexico), rather than curtail the program in the face of financing difficulties, the Finance Minister was fired for opposition to the program, and the program continued to be run out of the President's office.*

- *The examples invite the generalization that there is a ladder of financing options that tend to be pursued step by step. At the outset domestic taxation or tax reform will be a prominent part of the plan, (Mexico) followed by domestic borrowing, or borrowing from other sources backed by public guarantees and finally foreign financing.*

- *Initial justifications for programs always based on forecasts of benefits that are too high – this is so common it may rise to the level of the iron law of public investment*.

  - *The initial justifications must involve forecasts, and all narratives state that forecasts were overoptimistic – there is no example given of a forecast alleged to be too conservative.*

The World Bank's Project Investment Upsurge

The vast majority of World Bank lending is for public investment schemes (roads, bridges, irrigation systems, soil drainage, ports, technical assistance, training, land titling, agricultural extension etc.) Further, the World Bank had its own public sector investment surge, in the 1970's under McNamara. Figure22 below shows that increase in the total number of projects approved each year.

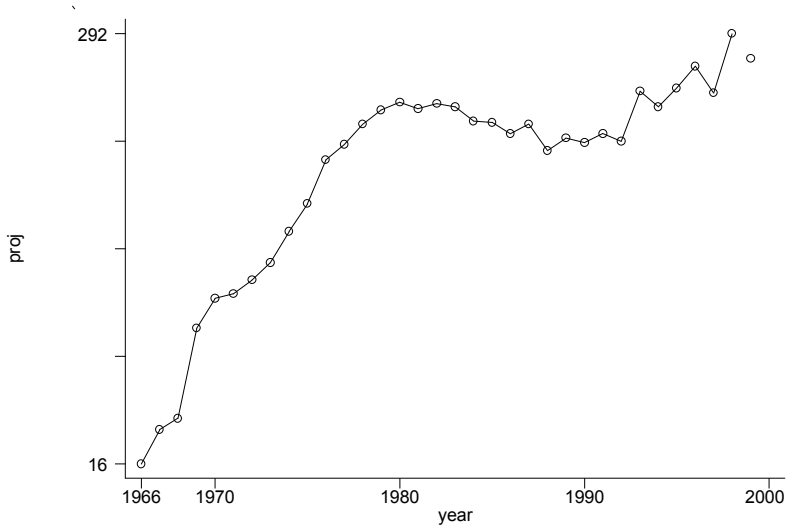


Figure 22. Number of projects approved each year at the World Bank

Projects are also given a performance rating at the Bank. These ratings are on a 1-6 scale, with 6 indicating a highly satisfactory project and 1 indicating a highly unsatisfactory project. However, there is a long lag in this evaluation process. The group of projects approved in, say, 1979, will on average take 7 years to complete and then another year to be given a performance rating. So the full verdict on projects approved in 1979 may only be fully available by 1990. It may take as much as ten years for a sufficient percentage of the cohort to be completed and evaluated in order to form a judgment on the overall performance of that cohort.

The figure below plots the average performance of a cohort of projects over time against the year in which the cohort of projects was approved. As can be seen, there was a steady decline in project performance over the decade of the 1970's.

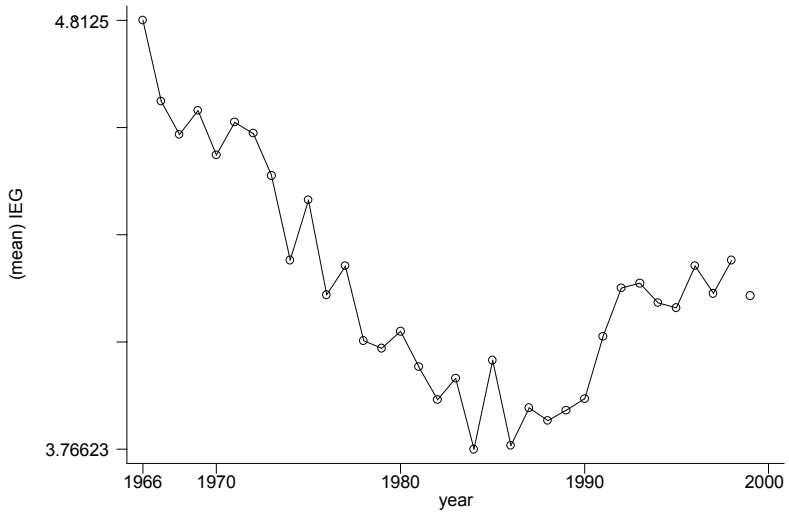


Figure 23. Average Performance Rating of World Bank Projects, by year of approval

These two pieces of evidence mean that project performance was inversely associated with the amount of lending during the 1970's. The surge in financing for public sector investment projects over the 1970's under the leadership of Robert McNamara was associated with a sharp decline in perceived performance.

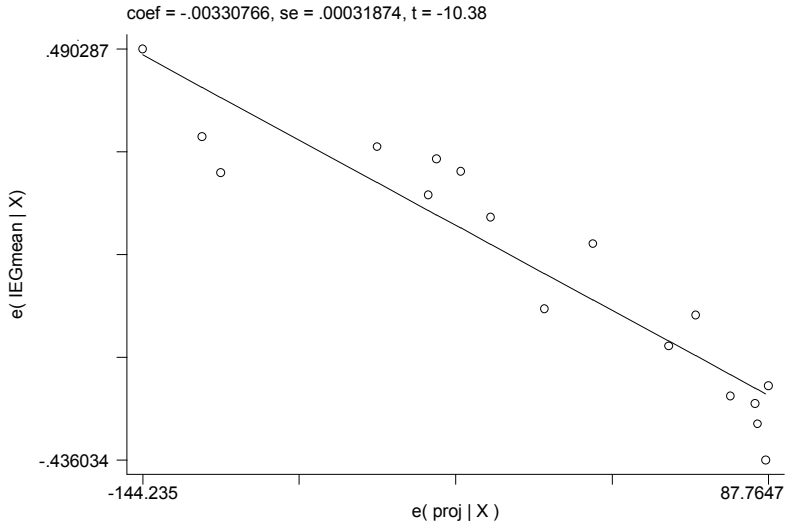


Figure 24. Inverse association between number of projects approved and mean performance rating at the World Bank, 1966-1982

Summary and Conclusions

This paper has examined whether major public investment drives in the past have served to promote or accelerate national economic growth. It is not about whether in theory public investment drives could accelerate growth, but rather whether in practice, with real governments deciding how to spend the funds and implementing investments, they have in fact accelerated growth. The answer appears to be "probably very little". This conclusion pertains to the drives – the big increases in public capital spending – not necessarily to routine levels of public investment. And furthermore the evidence here is not about whether public capital can promote growth by averting the emergence of bottlenecks. Major public investment campaigns continue to be advocated in several countries as a major trigger for economic growth, and on this issue, whether they have in fact triggered growth, the evidence for a positive effect of public capital on GDP or GDP growth is weak.

One fact we know for sure about public investment is that it takes several years to finish the investments. It is important to distinguish between real output effects that are triggered by demand or spending, possibly through Keynesian channels, from the real output effects that are triggered by completed capital investments. It is the later that people have in mind when they write production functions with public capital, or when they endorse major public capital expenditure programs to accelerate economic growth over the long term. Therefore if public capital affects output in this latter sense we should observe that GDP growth responds with a lag of several years to expenditures on public investment. Instead the evidence using the whole sample of data fails to support this. Although it is not unusual to find a contemporaneous positive association between the public investment boom variables and GDP growth, lag terms are mostly not statistically significant. This pattern runs against the idea that the regressions are capturing the causal impact of higher public investment on long-term productivity. The contemporaneous positive association has a non-causal explanation, namely that governments tend to spend more on investments during boom times. In addition, higher public capital expenditures could boost GDP immediately through stimulation of aggregate demand in economies operating below capacity. This latter effect is causal; it's just not the long term impact on supply envisaged by proponents of public capital surges.

Some of the regression results using post-1990 data appeared at first to contradict this conclusion; however, further investigation showed that this result was driven by the inclusion of Ethiopia in the sample. Uganda also provided a possible counterexample but this turned to be sensitive to which investment data was used for Uganda. Panama is a further case where an apparently contrary result

hinged on accepting a clearly inadequate method for measuring a boom. The sensitivity of some of the results to the presence of Ethiopia in the sample is not meant to diminish the result but rather suggests that further research is necessary for Ethiopia specifically. This does not appear to be a generalized post-1990 result.

These results were checked by using different methods for measuring boom periods. These simply defined booms as being periods of high public investment without attempting any precise timing. As far as the results using all the data are concerned, the alternative methods delivered similar results, despite the fact that the methods were quite different from each other. This was not the case for the post-1990 data, but, as mentioned above, this hinges in issues with specific countries.

The paper also found evidence that the public capital booms served to crowd-out private capital accumulation, whether looking at the whole sample or the evidence from the post-1990 booms. This therefore provides one reason for finding low effects overall of public capital booms.

The paper then turned to case studies of five countries, three of which had public investment booms, Bolivia, Mexico and Philippines, and two of which are known for their rapid rate of economic growth, Taiwan province of China, China and South Korea.

Regarding the three countries with investment booms, the narratives suggest the following points:

- There is no evidence that rational selection of public investments according to sound economic criteria was ever seriously followed.
- Predictions about prices, costs and impacts were always too optimistic. There is no mention a forecast that was too sober.
- With the benefit of hindsight it is clear that the returns on investments and the impacts were very low, probably negative. At the time of implementation however, there was confusion or lack of information about basic facts. In Bolivia, who was doing what was obscured by complicated cross-subsidization and financing schemes.
- Expenditure plans were rarely curtailed in the face of financing problems. Instead new forms of financing were sought so that the programs could continue. Once started, there appears to have been considerable inertia in the investment programs.
- Public investment programs were vulnerable to abuse, especially when conducted under the auspices of semi-independent public enterprises.

Regarding the two rapidly growing countries, the narratives suggest the following points:

- Korea never had a public investment drive when measured in terms of public investment in percent of GDP, which remained roughly constant at five percent throughout the period. Nevertheless Korea's highway program, initiated in the late 1960s, may be construed as a deliberate attempt to accelerate growth through public investment. Taiwan province of China's public investment drive commenced in 1973. Both drives occurred after rapid growth had begun, not before.

- In both cases, leaders stated that the impetus for the investment drives came as a result of congestion caused by several years of rapid growth. This is consistent with a strategy of waiting for bottlenecks to emerge, and then addressing them, rather than forecasting where the bottleneck will be in advance.

- Both programs appear to have been focused and disciplined: Taiwan province of China's infrastructure projects were focused on facilitating exports; Korea's highway program was limited initially to connecting the country's two main urban areas. Korea limited the cost overrun to 30 percent; an extraordinarily low figure.

The final piece of evidence came from the experience of project lending at the World Bank. The Bank pursued a major increase in the number of projects it financed in the 1970s. When the performance rating of each cohort of projects became apparent several years later, it emerged that there was a sharply negative association between number of projects financed in a given year and the average performance rating for that cohort of projects. This is consistent with the idea that there were diminishing returns to investment project lending, and may be suggestive of what happens when countries ramp up the number of investment projects financed under their own public investment drive.

Taking everything together, these results argue that there isn't an extensive and positive evidence base on which to support the idea that a large public investment drive will unconditionally trigger or accelerate economic growth. To those that advocate major increases in public investment it poses the question – on what empirical grounds do they base the expectation that the drive will work?

The evidence casts doubt on the notion that the economic mechanisms emphasized by big push theories, namely coordination failures, increasing returns to scale, spillovers, are major and primary constraints to development facing low-income countries, such that addressing them alone will stimulate economic growth. To be sure, in theory public capital investment can be very

productive at extremely low levels of public capital, as when it is the difference between a power grid that functions versus one that is dysfunctional. It can be very productive after wars or major natural disasters, when it is reconstructing structures that were essential to the pre-war economy. And public capital can be very productive when it is directed at resolving bottlenecks and major binding constraints. However there is no guarantee, nor evidence, that the bulk of expenditures during public investment booms will be about bottleneck investments or essential structures that have high economic returns. If anything the evidence and the case studies point in the other direction. The boom periods in the past appear to be times when public capital has been especially unproductive.

Is the evidence here relevant for the future? To address this question, note that the case studies revealed five major problems with past public investment surges. One is the problem of incentives, as key actors are likely to benefit from accomplishing the investment itself rather than from whether the investment is socially worthwhile. A second is the failure to collect key information, either at the appraisal stage or ex-post, and the associated failure to act on the basis of evidence. A third is the problem of chronically over-optimistic forecasts, and the lack of safeguards against self-serving analysis or interests that have an incentive to promote unrealistic forecasts. A fourth is shallow or non-existent economic analysis. A fifth is the use of public enterprises as vehicles for conducting investment projects, which facilitated lower levels of transparency and scrutiny compared to regular government expenditures. Whether future booms are likely to find success hinges on which of these problems have been overcome sufficiently. The reader may draw his or her own conclusions. The use of public enterprises as vehicles for public investment projects has diminished over the past thirty years. However, the incentives of major players such as politicians and leaders of construction firms have not changed. The use of objective data and evidence to guide government decisions is still not widely practiced. And over-optimistic forecasts and analysis are still widespread. These observations suggest that the current public investment drives will be more likely to succeed if governments do not behave as in the past, and instead take analytical issues seriously and safeguard their decision process against interests that distort spending decisions.

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Appendix I: Regression results using second method for selecting boom years and indicator (0/1) variable for booms.

Table IA. Regressions of Annual Growth in Real GDP per-person on an alternative public investment boom variable and other regressors using the full sample. The investment boom variable is an indicator variable taking the value 1 during a public investment boom and 0 otherwise, where a public investment boom is defined to occur whenever I/Y exceeds its 70th percentile for three or more years.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
BoomI	0.69				
	(1.45)				
BoomI (-1)		0.12			
		(0.25)			
BoomI (-2)			0.03		
			(0.07)		
BoomI (-3)				-0.32	
				(-0.66)	
BoomI (-4)					-0.79*
					(-1.68)
Black Market Exchange Rate Premium	-0.20***	-0.20***	-0.20***	-0.19***	-0.20***
	(-3.61)	(-3.50)	(-3.47)	(-3.29)	(-3.65)
Life Expectancy at birth (years)	0.00	-0.00	0.00	-0.00	0.00
	(0.10)	(-0.01)	(0.05)	(-0.04)	(0.14)
Financial Depth (Deposit Bank assets % of GDP)	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
	(-7.85)	(-7.85)	(-7.90)	(-7.80)	(-8.01)
Inflation	-0.00**	-0.00**	-0.00**	-0.00**	-0.00**
	(-2.45)	(-2.46)	(-2.46)	(-2.46)	(-2.46)
Real Export growth (deflated by import price index)	0.10***	0.10***	0.10***	0.10***	0.10***
	(13.40)	(13.26)	(13.23)	(13.17)	(13.13)
Constant	4.29***	4.39***	4.36***	4.42***	4.33***
	(6.80)	(6.91)	(6.86)	(6.93)	(6.81)
Observations	3,143	3,135	3,127	3,118	3,109
R-squared	0.15	0.15	0.15	0.15	0.15

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table IB. Regressions of Annual Growth in Real GDP per-person on an alternative public investment boom variable and other regressors using the full sample. The investment boom variable is an indicator variable taking the value 1 during a public investment boom and 0 otherwise, where a public investment boom is defined to occur whenever public capital growth its 70th percentile for three or more years.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
BoomK	1.25***				
	(2.77)				
BoomK (-1)		1.42***			
		(2.99)			
BoomK (-2)			1.10**		
			(2.16)		
BoomK (-3)				0.70	
				(1.32)	
BoomK (-4)					-0.02
					(-0.04)
Black Market Exchange Rate Premium	- 0.20***	-0.20***	-0.19***	-0.21***	-0.20***
	(-3.53)	(-3.56)	(-3.39)	(-3.82)	(-3.60)
Life Expectancy at birth (years)	0.00	0.00	0.00	0.01	0.00
	(0.34)	(0.37)	(0.29)	(0.54)	(0.40)
Financial Depth (Deposit Bank assets % of GDP)	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
	(-7.93)	(-7.98)	(-7.89)	(-8.13)	(-8.01)
Inflation	-0.00**	-0.00**	-0.00**	-0.00**	-0.00**
	(-2.45)	(-2.44)	(-2.45)	(-2.44)	(-2.45)
Real Export growth (deflated by import price index)	0.10***	0.10***	0.10***	0.10***	0.10***
	(13.21)	(13.29)	(13.27)	(13.29)	(13.31)
Constant	4.13***	4.11***	4.16***	4.02***	4.11***
	(6.50)	(6.44)	(6.49)	(6.32)	(6.40)
Observations	3,119	3,109	3,099	3,089	3,079
R-squared	0.15	0.15	0.15	0.15	0.15

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table IC. Regressions of Annual Growth in Real GDP per-person on an alternative public investment boom variable and other regressors using only post-1990 data. The investment boom variable is an indicator variable taking the value 1 during a public investment boom and 0 otherwise, where a public investment boom is defined to occur whenever I/Y exceeds its 70th percentile for three or more years.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
BoomI	2.32***				
	(2.95)				
BoomI (-1)		2.86***			
		(3.64)			
BoomI (-2)			2.96***		
			(4.02)		
BoomI (-3)				3.16***	
				(4.39)	
BoomI (-4)					1.65***
					(2.89)
Black Market Exchange Rate Premium	-0.26***	-0.26***	-0.27***	-0.28***	-0.27***
	(-2.79)	(-2.79)	(-2.83)	(-2.91)	(-2.80)
Life Expectancy at birth (years)	0.02	0.02*	0.02*	0.02*	0.02*
	(1.60)	(1.72)	(1.74)	(1.81)	(1.65)
Financial Depth (Deposit Bank assets % of GDP)	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
	(-7.97)	(-8.02)	(-8.06)	(-8.16)	(-8.15)
Inflation	-0.00	-0.00	-0.00	-0.00	-0.00
	(-1.37)	(-1.37)	(-1.36)	(-1.36)	(-1.37)
Real Export growth (deflated by import price index)	0.10***	0.10***	0.10***	0.10***	0.10***
	(9.26)	(9.28)	(9.27)	(9.19)	(9.23)
Constant	3.22***	3.13***	3.11***	3.07***	3.20***
	(4.18)	(4.06)	(4.04)	(3.97)	(4.06)
Observations	1,743	1,742	1,741	1,740	1,738
R-squared	0.20	0.20	0.20	0.20	0.20

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

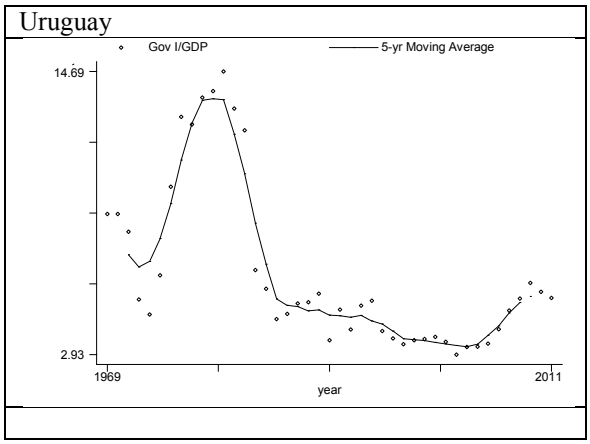
Table ID. Regressions of Annual Growth in Real GDP per-person on an alternative public investment boom variable and other regressors using only post-1990 data. The investment boom variable is an indicator variable taking the value 1 during a public investment boom and 0 otherwise, where a public investment boom is defined to occur whenever public capital growth its 70th percentile for three or more years.

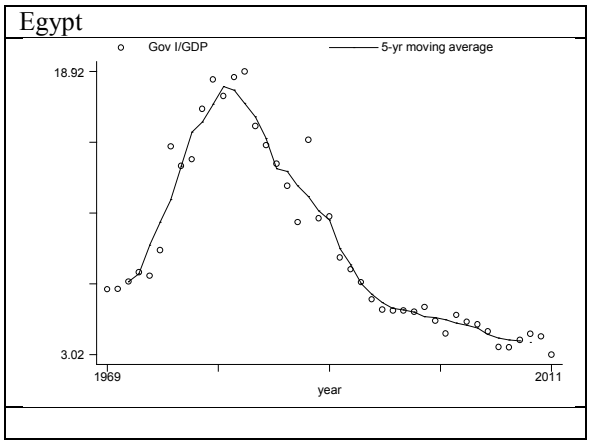
	(1)	(2)	(3)	(4)	(5)
VARIABLES	No Lag	Lagged one year	Lagged two years	Lagged three years	Lagged four years
BoomK	1.61***				
	(2.63)				
BoomK (-1)		2.32***			
		(3.61)			
BoomK (-2)			3.06***		
			(4.75)		
BoomK (-3)				2.92***	
				(4.16)	
BoomK (-4)					2.28***
					(4.43)
Black Market Exchange Rate Premium	-0.26***	-0.26***	-0.27***	-0.27***	-0.27***
	(-2.76)	(-2.77)	(-2.84)	(-2.83)	(-2.80)
Life Expectancy at birth (years)	0.02	0.02	0.02	0.02	0.02
	(1.45)	(1.49)	(1.58)	(1.60)	(1.54)
Financial Depth (Deposit Bank assets % of GDP)	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
	(-7.97)	(-7.95)	(-8.02)	(-8.06)	(-8.04)
Inflation	-0.00	-0.00	-0.00	-0.00	-0.00
	(-1.37)	(-1.37)	(-1.36)	(-1.36)	(-1.36)
Real Export growth (deflated by import price index)	0.10***	0.10***	0.10***	0.10***	0.10***
	(9.23)	(9.25)	(9.26)	(9.15)	(9.18)
Constant	3.35***	3.30***	3.24***	3.24***	3.29***
	(4.34)	(4.30)	(4.22)	(4.21)	(4.23)
Observations	1,742	1,741	1,740	1,738	1,736
R-squared	0.20	0.20	0.20	0.20	0.20

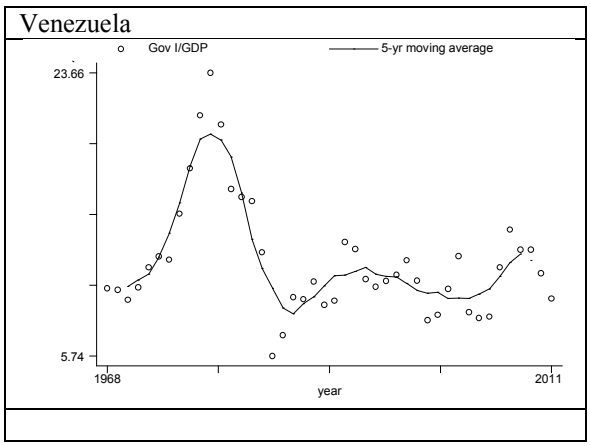
Robust t-statistics in parentheses

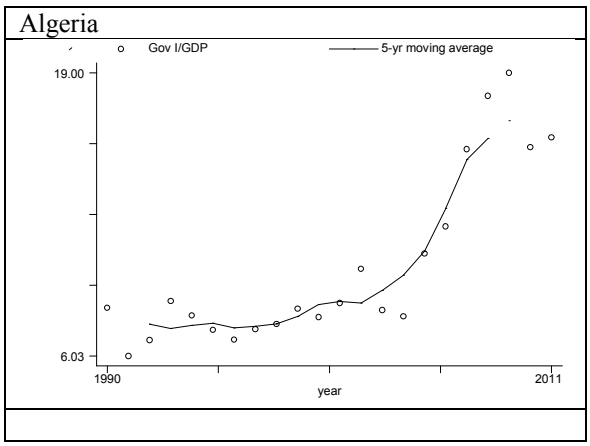
*** p<0.01, ** p<0.05, * p<0.1

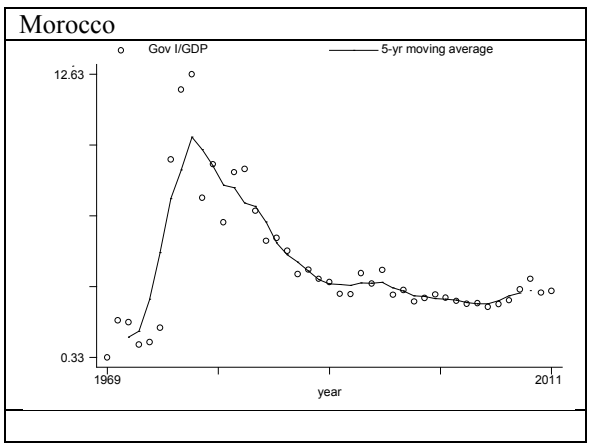
Appendix II: 18 selected examples of public investment booms

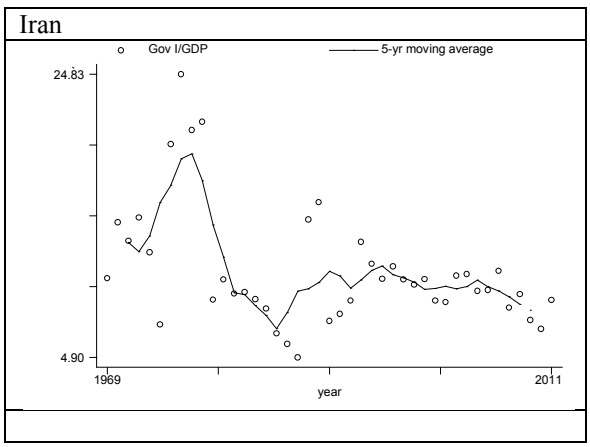






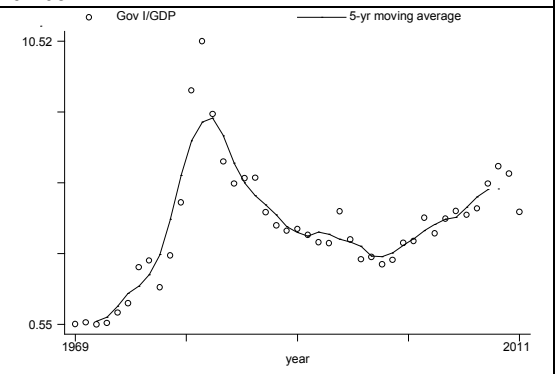




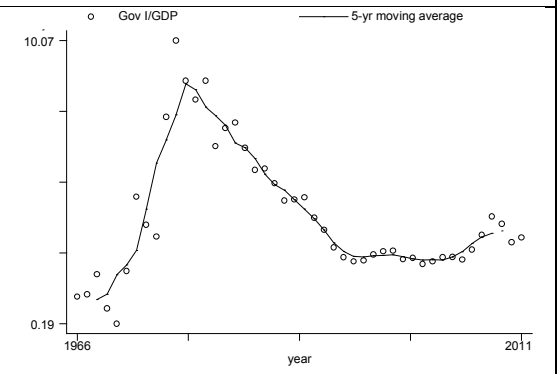


Nigeria

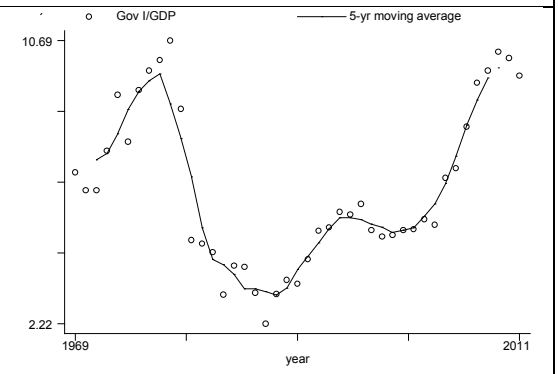
Mexico



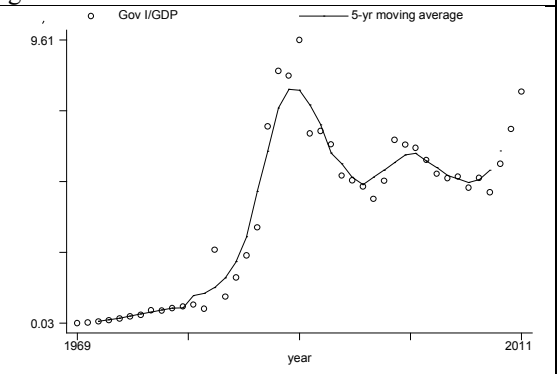
South Africa



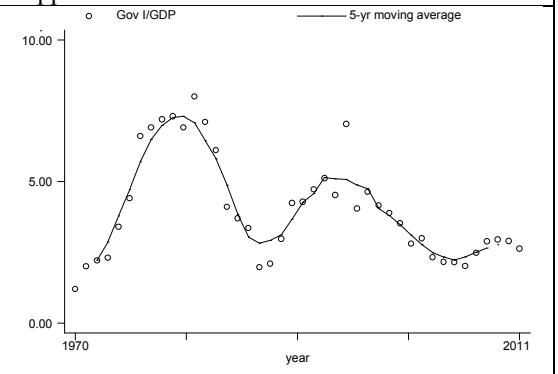
Bolivia



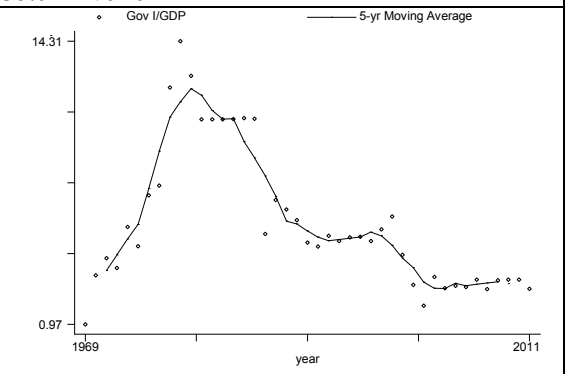
Uganda



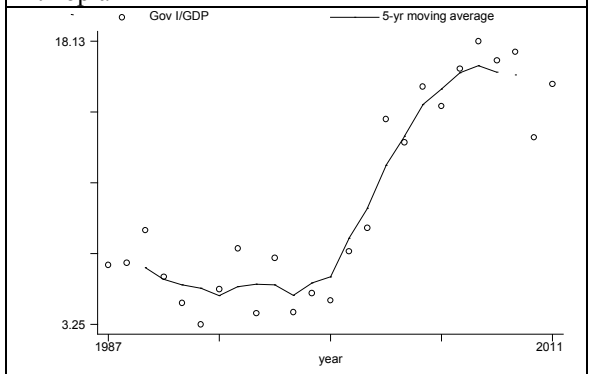
Philippines



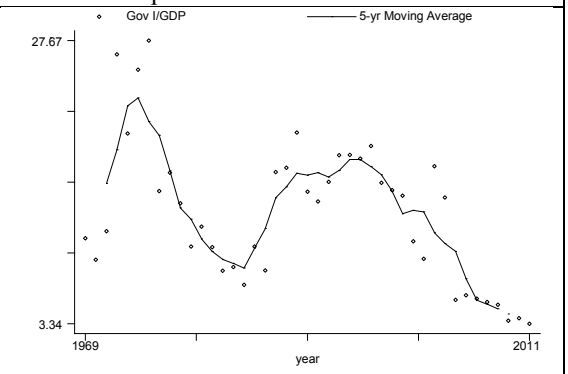
Cote D'Ivoire



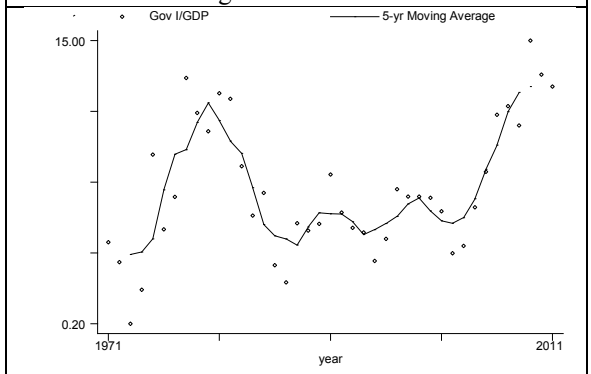
Ethiopia



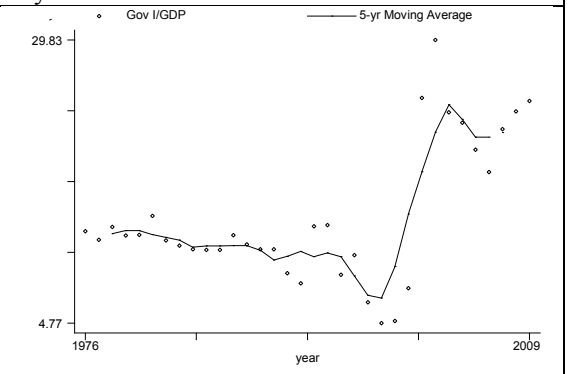
Dominican Republic



Trinidad and Tobago



Libya



Jordan