THE EFFECTS OF PUBLIC INVESTMENT
ON PRIVATE INVESTMENT IN
DEVELOPING ECONOMIES

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The literature on the impact of public investment in developing economies gives inconsistent results on whether it complements or crowds out private investment. Applying several pooled specifications of a standard investment model to a panel of developing economies for 1980 to 1997, this study finds that public investment complements private investment, and that, on average, a 10 percent increase in public investment is associated with a 2 percent increase in private investment. The results also indicate that private investment is constrained by the availability of bank credit in developing economies. The same empirical models are run on a panel of developed economies. In contrast to developing economies, public investment crowds out private investment in developed economies. The results show that in a number of important ways, private investment in developed economies is influenced by different factors than private investment in developing economies.

Keywords: developing economies; investment; capital markets; credit; public expenditure

1. INTRODUCTION

Private investment is necessary for economic progress, and an important but unsettled question is how public policy affects private investment. Public investment in infrastructure is widely believed to exert a positive impact on private investment. If this is the case, public...
investment may not only spur economic growth directly but also indirectly by promoting private investment. However, some literature suggests that public investment crowds out private investment, which would lead to substantially different policy conclusions with regard to public investment. This is an important and unsettled policy issue, which motivates this empirical examination of the effects of public investment on private investment in developing countries.

The literature on the impact of public investment in developing economies gives inconsistent results on whether it complements or crowds out private investment. Applying several pooled specifications of a standard investment model to a panel of developing economies for 1980 to 1997, this study finds that public investment complements private investment, and that on average a 10 percent increase in public investment is associated with a 2 percent increase in private investment. The results also indicate that private investment is constrained by the availability of bank credit in developing economies. The same empirical models are run on a panel of developed economies. In contrast to developing economies, public investment crowds out private investment in developed economies. The results show that in a number of important ways, private investment in developed economies is influenced by different factors than private investment in developing economies.

2. FACTORS THAT INFLUENCE PRIVATE INVESTMENT

A glance at the literature reveals that there are two major approaches to analyzing the effect of public investment on economic growth. The first is based on the neoclassical production function in which public capital enters as a separate input and on the productivity measures derived from the production function. The results of Aschauer (1989a, 1989b) and Munnell (1990) from the U.S. annual and state-level data respectively indicate that public nonmilitary investment spending, particularly on core infrastructure, has a substantial influence on output and the productivity of private capital. Furthermore, the analyses by Aschauer (1990) from data on industrial countries and Cashin (1995) from cross-country data provide some
support in favor of the earlier results. However, studies following those initial articles, such as Tatom (1991), Holtz-Eakin (1994), and Evans and Karras (1994) have found that public investment has a negligible impact on productivity. Khan and Reinhart (1990) and Khan and Kumar (1997) found that for developing countries, although public investment contributes to the productive performance of the economies, private investment has more influence on economic growth. Overall, the empirical studies using the “growth accounting” approach, while somewhat mixed, indicate that public capital investments contribute to economic productivity although they are not the major source of the economy-wide variations in productivity.

The second approach uses a model of private investment that incorporates public investment to capture the direct effect of public investment on private investment and also its indirect effect on economic growth through its effect on private investment. Studies by Greene and Villanueva (1991) for a panel of developing countries, Ramirez (1994) for Mexico, Odedokun (1997) for forty-eight developing countries, and Ramirez (2000) for a panel of Latin American countries found that public investment stimulates private investment. Blejer and Khan (1984) for a panel of developing countries and Oshikoya (1994) for a panel of African countries presented evidence that public infrastructure (represented by the expected public investment) has a positive impact on private investment, while noninfrastructure investment (the unexpected component) has a negative impact on private sector investment. Meanwhile, Wai and Wong (1982) for five developing countries and Nazmi and Ramirez (1997) for Mexico found that public investment crowds out private investment. The empirical literature suggests that public investment does affect private investment in developing economies; however, the question of whether public investment stimulates or crowds out private investment remains ambiguous.

Several competing mechanisms through which public capital investment may influence private sector investment have been identified in the literature, for example, by Barth and Cordes (1980), Blejer and Khan (1984), Aschauer (1989a, 1989b), and Ramirez (1994). Potentially the most significant mechanism—and the most compelling argument supporting public investment—is that public infrastructure
investment may have substantial spillover benefits for private investment. If public infrastructure investment is complementary to private investment, the rate of return to private sector investments will increase, leading private sector investors to undertake more capital investment. However, public investment may crowd out private investment if they compete for the same resources, and the crowding out may be more significant if public investments are made in state enterprises that produce output that is in direct competition with the goods and services provided by private sector. Sound theoretical arguments point in both directions, so whether public investment actually helps or hinders private investment is an empirical question.

Another key factor influencing private investment is uncertainty. The literature has dealt extensively with the impact of uncertainty and irreversibility on investment decisions (Abel 1983; Pindyck 1991; Caballero 1991; Dixit and Pindyck 1994; Abel and Eberly 1995). Assuming risk neutrality and competitive firms with constant returns to scale technology, earlier studies such as Hartman (1972) and Abel (1983) showed that a rise in uncertainty brings about an increase in the expected value of the marginal revenue products of capital, increasing investment. This is based on the assumption that firms can instantaneously and costlessly adjust their labor, with capital being the only fixed factor. When the irreversible nature of the investment decision is taken into account, this conclusion changes (see, for example, Bernanke 1983; Caballero 1991; Pindyck 1991; Dixit and Pindyck 1994). The effect of uncertainty on investment is ambiguous on theoretical grounds and depends on the assumptions used. The important implication from an empirical standpoint is that uncertainty might have a significant impact on both the long-run and the short-run dynamics of investment behavior and so should be incorporated into an empirical analysis of the impact of public investment on private investment.

Public investment may also play a countercyclical role in the economy, reducing the volatility of output demand and prices, giving rise to private sector investment. There are a number of reasons why uncertainty should be captured in a model of private investment in developing economies. Empirical studies add a proxy for uncertainty to a standard investment model, showing that increased uncertainty has an
adverse impact on the aggregate investment (Goldberg 1993; Price 1996; Aizenman and Marion 1996; Serven 1998).

Institutions may also have important effects on private investment, and institutions that protect and foster market exchange, such as the protection of property rights, low barriers to international trade, low taxes, and minimal regulatory barriers, are likely to encourage private investment. De Haan and Siermann (1998) compared various indices of economic freedom constructed by Scully and Slottje (1991) and Gwartney, Lawson, and Holcombe (1999) and found that the measured effect of these institutions on economic growth depends on the measure used. Dawson (1998), using the economic freedom index by Gwartney, Lawson, and Holcombe (1999), found that market institutions have a positive impact on economic growth, and encourage aggregate investment. Similarly, Vamvakidis (1998) undertook an analysis for eight African countries using the Gwartney, Lawson, and Holcombe index and showed that various components as well as the summary measure of economic freedom are positively related to the share of aggregate investment in GDP. Most previous studies have focused on the effect of economic freedom on economic growth, but some examine the possibility the impact may also be felt indirectly, through the impact of institutions on investment (Besley 1995; Dawson 1998; De Haan and Siermann 1998). This analysis uses the measure of economic freedom computed by Gwartney, Lawson, and Samida (2000) to try to capture these institutional factors that could affect private investment. Economic freedom, as defined by Gwartney, Lawson, and Samida means that property rights are protected, that people have freedom of exchange, that the government provides a stable currency, and that government intrudes minimally on the economy through taxation and regulation.

The availability of credit to the private sector is thought to be another key variable determining private investment activities especially in developing countries (Blejer and Khan 1984; Ramirez 1994). Credit constraints may be more binding in developing economies than the interest rate if credit is explicitly rationed or its availability is limited in other ways. However, investment may also be sensitive to the cost of capital after the structural adjustment reforms implemented in most developing nations in the late 1970s because such reforms led to
increases in real interest rates (Greene and Villanueva 1991; Guncavdi, Bleaney, and McKay 1998). Thus, the cost of funding investment projects as well as the availability of credit can be expected to play inhibiting roles on private investment in developing countries. There are arguments for including both the availability of credit and its cost in the model. The empirical analysis that follows accounts for institutions, using the Gwartney, Lawson, and Samida (2000) economic freedom index, uncertainty, credit, and costs of financing to investigate the impact of public investment on private investment in developing economies.

The central objective of this article is to investigate the determinants of private investment in developing and developed countries with a primary focus on the role of public investment. To this end, the study constructs an empirical framework for developing countries centered on the flexible accelerator model of private investment. The article then applies the same empirical framework to the sample of developed countries to analyze whether there are differences in investment behavior across developing and developed economies. The results obtained by comparing the impact of public investment on private investment in developing versus developed economies provides interesting insights for policy makers by showing that the impact of public investment on private investment varies depending on the stage of development. Public investment does have a positive impact on private investment in developing economies but not in developed economies.

3. THE EMPIRICAL MODEL OF PRIVATE INVESTMENT

The empirical model is based on a flexible accelerator investment model, which begins by assuming that the desired capital stock is proportional to the level of expected output (Blejer and Kahn 1984; Ramirez 1994):

\[ K^*_p = \alpha Y^*_p \]  

(1)

where \( K^*_p \) is the desired capital stock by the private sector in period \( t \). \( Y^*_p \) is the expected level of output in time \( t \) that can be thought of as fu-
ture aggregate demand. This assumption rules out the role of factor prices, which may be rationalized if the underlying production function is of the fixed-proportions form, or if relative factor prices remain relatively constant. The actual stock of private capital may not adjust completely to reach the desired level due to technical constraints and the time it takes to plan, decide, build, and install new capital. Such a dynamic structure in private capital behavior can be introduced through a one-period quadratic adjustment cost function (Salmon 1982),

$$\beta(K_{pt} - K_{pt}^*)^2 + (1 - \beta)(K_{pt} - K_{pt-1})^2,$$  \hspace{1cm} (2)

where $K_{pt}$ is the actual private capital stock. The first term indicates the cost of disequilibrium, and the second term the cost of adjusting toward equilibrium. Minimizing the cost of adjustment with respect to $K_{pt}$ yields a partial adjustment mechanism like the following:

$$K_{pt} - K_{pt-1} = \beta(K_{pt}^* - K_{pt-1}) \quad 0 \leq \beta \leq 1,$$  \hspace{1cm} (3)

where $\beta$ is the coefficient of adjustment. In this formulation, actual private capital adjusts to the difference between desired private capital in time $t$ and actual private capital in the previous period. Because the data on capital stock are not available for most of the developing countries, we can make use of the gross private investment definition, which is expressed as

$$PI_t = (K_{pt} - K_{pt-1}) + \delta K_{pt-1},$$  \hspace{1cm} (4)

where $\delta$ is the depreciation rate of the private capital stock and $PI_t$ is gross private investment. Rearranging, we get

$$PI_t = [1 - (1 - \delta) L]K_{pt},$$  \hspace{1cm} (4a)

Also, for empirical purposes, the partial adjustment mechanism can be specified in terms of $PI$ as

$$PI_t - PI_{t-1} = \beta(PI_t^* - PI_{t-1}).$$  \hspace{1cm} (5)
To add more dynamics to the specification, we assume that government investment and the other relevant variables affect the speed of adjustment at which the gap between the desired and actual gross private investment closes up in each short-run period (see Blejer and Khan 1984; Price 1996). Hence, a linear representation of $\beta$ can be defined as the following:

$$
\beta = a_o + \left[1/(P* - P_{t-1})\right](\gamma_1 G + \gamma_2 X),
$$

where $a_o$ is the intercept, $G$ is gross public investment, and $X$ is a vector of other relevant variables. An implicit assumption underlying equation (6) is that the lagged effects of these variables on private investment are also captured by the coefficient of adjustment. If public investment is complementary to private investment, it speeds up the adjustment of desired private investment to its actual level, and vice versa. Plugging (6) into (5) and rearranging, we get

$$
P_{t-1} - P_{t-1} = a_o(P* - P_{t-1}) + \gamma_1 G + \gamma_2 X.
$$

Note that equation (4a) in the steady state is given by

$$
P* = \left[1 - (1 - \delta) L\right] K^* + \nu_r.
$$

Inserting (1) into (8) and the resulting equation into (7), and rearranging, we obtain the following dynamic reduced-form equation for gross private investment that embodies public investment, as well as a set of other relevant variables.

$$
P_{t+1} = a_o[1 - (1 - \delta) L] Y^* + \gamma_1 G + \gamma_2 X + (1 - a_o) P_{t+1} + u_{t,r},
$$

where the subscripts $i = 1, \ldots, N$ and $t = 1, \ldots, T$ represent the cross-section and time-series dimension of the panel data, and $u_{t,r}$ is a random disturbance.

In this form, the model is quite flexible because it allows private investment to be specified not only as a function of the expected level of real output but also of several relevant variables. The coefficient of $Y^*$ captures the accelerator effect and is expected to be positive. As discussed earlier, the coefficient of $G$ can be negative or positive depending on which effect (substitution or complementary) is greater.
Also, the impact of uncertainty is ambiguous on theoretical grounds. While the cost of capital is expected to deter private investment, availability of credits to the private sector is expected to be positively influence private investment activities. Last, a favorable economic environment provided by the institutions is expected to have a positive impact on private investment.

Equation (9), however, is not in a readily estimatable form as it contains unobservable variables as well as qualitative factors that need to be measured. To proxy for expected output, $Y^\prime$, in equation (9), which is unobservable, a common practice is to fit an autoregressive process, from which the predicted values are taken to represent expected output (Blejer and Khan 1984; Ramirez 1994). However, this method requires a large set of time series data. Therefore, in this study, a first-order autoregressive model, AR(1), of the logarithm of real GDP is estimated for each country in the sample.

Finally, the rate of depreciation is unavailable for most countries to estimate equation (7). As discussed before, although the model can be estimated by nonlinear least squares (NLLS) to obtain estimates of the depreciation rate, the use of NLLS with panel data raises several issues. For example, in the case of nonlinear panel data models with fixed effects, there is a possibility that a solution to the problem cannot be reached (Hsiao et al. 2000, 1). Thus, the arbitrarily chosen value of 5 percent depreciation rate was used, following the studies by Blejer and Khan (1984), Ramirez (1994), and the references cited therein. Then, a sensitivity analysis was carried out using 0 and 5 depreciation rates, which revealed that the results do not differ significantly. Therefore, in the empirical model that follows, the depreciation rate is set equal to 0 percent.

3.1. PROXY FOR UNCERTAINTY

Several methods for the measurement of uncertainty have been proposed in the literature. However, as Serven (1998) and Dehn (2000) argued, the uncertainty measures obtained from either the sample variation (variance or standard deviation of a variable in question) or the estimation of a univariate autoregressive specification have their shortcomings. The former approach does not allow unpre-
dictable and predictable components to be distinguished. Estimating the predictable movements from the previous values of the stochastic variable in question tends to overstate the level of uncertainty. The latter approach distinguishes between predictable and unpredictable shocks but implicitly assumes that these components do not vary over time. However, uncertainty may be greater during the bad than the good states of the economy and thus may vary over time in a systematic way.

Given these criticisms, the generalized autoregressive conditional heteroscedasticity specification (GARCH) has become a popular way to model volatility because it not only separates out the predictable and unpredictable components but also allows for heteroscedasticity in the unpredictable component. Following the lead of the studies by Price (1996), Serven (1998), and Dehn (2000), a simple univariate model of GARCH (1, 1) is specified to obtain uncertainty measures,

\[ x_t = \phi_0 + \phi_1 t + \phi_2 x_{t-1} + \nu_t; \quad t = 1, \ldots, T; \quad (10) \]

\[ \sigma_t^2 = \zeta_0 + \zeta_1 \nu_{t-1}^2 + \zeta_2 \sigma_{t-1}^2, \quad (11) \]

where \( \nu_t \sim N(0, \sigma) \) and \( \sigma_t^2 \) shows the variance of \( \nu_t \) conditioned on an information set up to period \( t \). The fitted values of the conditional variance provide a proxy for uncertainty. At this point, another important issue is to determine, in equation (9), what variable(s), \( x_t \), should be chosen to have their volatility represent uncertainty. Many macroeconomic variables may be viewed as a source or an indicator of uncertainty, and in this study, the rates of inflation, output growth, and the real exchange are used as the main indicators of overall macroeconomic instability. First, the conditional variances of these variables are obtained by estimating the above GARCH process for each country. Second, following the analysis of Serven (1998), a summary measure of uncertainty is constructed using the conditional variances of the variables as volatility measures. To this end, a principal component analysis is carried out for each country across time, which allows us to combine the volatility measures into a single proxy for uncertainty that retains most of the variation in these measures.
4. THE PANEL DATA

4.1. THE SAMPLE OF DEVELOPING COUNTRIES


Bouton and Sumlinski (2000) compiled the ratios of public and private investment to GDP for fifty developing countries spanning from 1970 to 1998. In this study, the panel is chosen to be balanced, which requires complete data from each country for the entire time span. A balanced panel is used because we obtain the conditional variances of several indicators over time for each country to construct a proxy for uncertainty. This is important because if a set of countries in the sample is subject to the same shocks in a specific time period, then the conditional variances are likely to be influenced and different depending on the availability or unavailability of data during that specific period. In this case, the proxy of uncertainty would be affected with respect to the time period used across each country in the sample if an unbalanced panel were employed. Therefore, to eliminate the effects of the specific time period chosen and to capture only the volatility in the rates of growth, exchange rates, and inflation in construction of an uncertainty measure, the same time span is chosen across all countries in the panel.

Only twenty-one of the fifty have the complete data for the 1970 to 1998 periods. However, because of the data limitations on the other remaining variables compiled from IFS, only six countries have complete data for the 1970 to 1998 periods. As a result, we restrict the time span to the years 1980 to 1997, for which complete data for nineteen developing countries are available (Bangladesh, Belize, Chile, Costa Rica, Ecuador, Guatemala, India, Kenya, Korea, Malaysia, Malawi, Mauritius, Mexico, Pakistan, Philippines, Thailand, Tunisia, Turkey, and Venezuela).
and Uruguay). Because of the diversity of countries in the sample (four from Africa, seven from the Western Hemisphere, and eight from Asia, including Turkey), the country set appears to be fairly representative of developing countries around the world.

Institutional differences are proxied by the economic freedom index computed by Gwartney, Lawson, and Samida (2000). In their construction of the index, they used as the components the size of government (consumption, transfers, and subsidies), the structure of the economy and the use of markets, monetary policy and price stability, freedom to use alternative currencies, legal structure and property rights, freedom to trade with foreigners, and freedom of exchange in capital and financial markets. From these components, a summary measure of economic freedom was constructed, using principal component analysis. The measure was indexed from 1 to 10, with 10 being the most favorable environment of economic freedom. The index is available in five-year intervals (1980, 1985, 1990, 1995, and 1997). The empirical model transforms the index into the annual observations by interpolating the five-year intervals. The full description of the variables is reported in the appendix.

4.2. THE SAMPLE OF INDUSTRIAL COUNTRIES


According to the classification of the International Monetary Fund, there are twenty-three industrial countries. There are seventeen countries that have complete and reliable data on gross public investment; however, due to the lack of the data on other relevant variables taken from IFS, only twelve developed countries have complete data for the entire period from 1980 to 1996 (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Netherlands, Portugal, Spain, Sweden, and the United Kingdom).
5. EMPIRICAL RESULTS

5.1. MEASURING UNCERTAINTY

Uncertainty is modeled as unpredictable changes in the inflation rate, real exchange rate, and GDP growth rate. To distinguish predictable and unpredictable components in these variables, equations (10) and (11) are estimated for each variable and country in the sample, using data for industrial countries from 1981 to 1996 and for developing countries from 1981 to 1997. After obtaining the fitted values of the conditional variances of these variables, a summary proxy for uncertainty is constructed to represent overall macroeconomic instability by performing a principal component analysis to weight the conditional variances of these variables for each country across time. For the majority of countries, the first principal component has positive loadings on the unpredictable component of each variable. The largest weights correspond respectively to the inflation, the real exchange rate, and growth rate uncertainty measures. The first principal component accounts for around 60 percent of the variation in the individual uncertainty measures for developing countries and roughly 50 percent of the variation for industrial countries. Because the first principal component accounts for a high percentage of the variation in the conditional variances and has positive loadings for a majority of the countries, the first principal component is used as a summary measure of uncertainty.

5.2. RESULTS FROM THE SAMPLE OF DEVELOPING COUNTRIES

In panel data applications, how one treats country-specific effects is an important issue because cross-sectional specific effects are a potential source of bias and inconsistency in estimates. In particular, the presence of the lagged dependent variable in the flexible accelerator model raises concerns over the consistency and unbiasedness of the estimated coefficients. Therefore, four empirical specifications—pooled-ordinary least squares (OLS), fixed effect, random effect
(GLS), and system two-stage least squares—are estimated to see whether the results are robust to different estimation methods. Using a panel of nineteen developing nations over the 1982 to 1997 period, equation (9) is estimated by all four pooled estimation methods, and the results are presented in Table 1. For interpretation purposes, first, several diagnostic tests are performed to identify which pooled specification(s) are preferred. Then, the results are interpreted with the emphasis on the preferred specification, but are contrasted with the results from the other pooled specifications.

The first column of Table 1 reports OLS estimates that do not control for country-specific effects and thus assume that all parameters are constant across cross-sectional units. The second column presents fixed-effect (FE) estimates, which account for country-specific effects, allowing for the constant term to differ across countries systematically. Both specifications include fixed time effects. The joint test of the time effects reveals that the time effects are significant; however, ignoring the time effects has no significant effect on the estimates. The estimated coefficient of the lagged dependent variable is much smaller than the pooled-OLS estimate, a result that accords with the theoretical prediction. The bias in the coefficient of the lagged dependent variable goes in opposite direction in these specifications (Nerlove 2000). While pooled-OLS yields an upward-biased estimate of the lagged dependent variable, the FE estimate is downward-biased. That is, these estimators define lower and upper bounds for the unbiased coefficient of the lagged dependent variable. The estimates range from between 0.35 and 0.79, so the unbiased estimate should lie in between these limits. As seen from the table, the results from the pooled-OLS and the FE regressions appear to be considerably different. An $F$ test is performed to test whether the differences in constant terms capture the differences across countries. The calculated $F$ ratio with 18 and 278 degrees of freedom is 7.11, while the critical $F$ values are 2.07 and 1.67 at 1 and 5 percent levels, respectively, which suggests that the hypothesis of a common constant term across countries should be rejected. The $F$ test shows that the panel is not sufficiently homogeneous across countries to use the pooled-OLS estimator. Accordingly, the FE is preferred to the pooled-OLS when comparing only these two estimators. Also it is worth noting that the Lagrange
## TABLE 1: Determinants of Private Investment in Developing Countries

*Balanced Sample: 1982-1997; Number of Countries: 19*

<table>
<thead>
<tr>
<th>Dependent Variable: Real Private Investment&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pooled-OLS</th>
<th>Fixed Effect</th>
<th>Random Effect</th>
<th>SYS-2SLS&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.399 (0.174)**</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>∆ expected real GDP&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>1.271 (0.591)**</td>
<td>1.209 (0.327)***</td>
<td>1.297 (0.199)***</td>
<td>1.764 (0.441)***</td>
</tr>
<tr>
<td>Real public investment&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.115 (0.062)*</td>
<td>0.231 (0.094)**</td>
<td>0.007 (0.014)</td>
<td>0.204 (0.07)***</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>-0.167 (0.215)</td>
<td>-0.024 (0.179)</td>
<td>-0.038 (0.128)</td>
<td>-0.188 (0.308)</td>
</tr>
<tr>
<td>Real credit&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.115 (0.045)**</td>
<td>0.30 (0.091)***</td>
<td>0.015 (0.012)</td>
<td>0.291 (0.061)***</td>
</tr>
<tr>
<td>Economic freedom</td>
<td>0.020 (0.021)</td>
<td>-0.082 (0.053)</td>
<td>-0.0001 (0.006)</td>
<td>-0.022 (0.034)</td>
</tr>
<tr>
<td>Uncertainty&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-0.031 (0.018)*</td>
<td>-0.024 (0.011)**</td>
<td>-0.032 (0.011)***</td>
<td>-0.036 (0.015)***</td>
</tr>
<tr>
<td>Lagged private investment&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.785 (0.085)***</td>
<td>0.348 (0.084)***</td>
<td>0.982 (0.013)***</td>
<td>0.549 (0.054)***</td>
</tr>
</tbody>
</table>

### Summary Statistics

- **Total panel observations**: 304
- **Adjusted R²**: Pooled-OLS 0.996, Fixed Effect 0.997, Random Effect 0.995, SYS-2SLS NA
- **Wald p-value all regressors**: Pooled-OLS 0.000
- **S.C.1 LM (chi-squared)**: Pooled-OLS 0.47, Fixed Effect 1.85, Random Effect 1.17
- **S.C.2 LM (chi-squared)**: Pooled-OLS 3.75, Fixed Effect 4.09, Random Effect 4.11
- **Pooling F-statistic**: Pooled-OLS 7.11***

(continued)
<table>
<thead>
<tr>
<th>Dependent Variable: Real Private Investment&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Balanced Sample: 1982-1997; Number of Countries: 19</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pooled-OLS</strong></td>
<td><strong>Fixed Effect</strong></td>
</tr>
<tr>
<td>Hausman (Wald statistic)</td>
<td>—</td>
</tr>
<tr>
<td>Sargan test (p-value)</td>
<td>—</td>
</tr>
<tr>
<td>Time effect (F-statistic)</td>
<td>2.10***</td>
</tr>
</tbody>
</table>

**NOTE:** OLS = ordinary least squares. SYS-2SLS = system two-stage least squares. Figures in parentheses are heteroscedasticity consistent standard errors except for the SYS-2SLS. The bold column shows the preferred specifications.

<sup>a</sup> Expressed in logarithms.
<sup>b</sup> Instruments are the twice-lagged values of all regressors.
<sup>c</sup> ∆ expected GDP = \( Y_e t – (1 – 0.00) Y_e t–1 \) where depreciation rates are chosen to be 0 percent and \( Y_e \) is the predicted values obtained from estimating a univariate first-order autoregressive (AR[1]) process for real GDP for each country, which are taken to represent the expected real GDP. The definition of this variables is the same in all tables.
<sup>d</sup> First principal component of the conditional variances of the log of real exchange rate, inflation rate, and growth rate obtained from a univariate generalized autoregressive conditional heteroscedasticity specification (GARCH) (1, 1) process for each country is used as a summary proxy for uncertainty. The definition of the uncertainty is the same in all tables.
<sup>e</sup> S.C.1 LM and S.C.2 LM show the Lagrange multiplier (LM) test statistics for the first- and second-order serial correlation, respectively.

*10 percent significance level. **5 percent significance level. ***1 percent significance level.
multiplier (LM) tests are performed for first- and second-order serial correlation, which reveals the absence of these problems in the data sample.

Another approach to the specification of the country-specific effects is to assume that they are random and thus contribute to the overall variance of the error term. The third column reports the random effect estimates (RA). The signs and magnitudes of the RA estimates are considerably different from those of the FE and pooled-OLS. However, as noted earlier, if the country-specific effects are correlated with the regressors, the RA estimator is inefficient and inconsistent while the FE estimator is consistent. To test the efficiency of the RA estimates, Hausman and Taylor (1981) suggested a comparison of the RA and FE estimates. If the differences in the coefficients are random, then the country-specific effects are uncorrelated with the regressors, and hence the RA estimates are consistent and efficient. The Wald ratio (with 7 degrees of freedom) is 87.6, so the hypothesis that country specific effects are uncorrelated with the regressors is rejected at any conventional level of significance. As a consequence, the RA estimates are unreliable. In this case, the country-specific effects need to be treated as fixed. However, in panels with a finite time horizon, the FE model yields inconsistent estimates due to the use of the lagged dependent variable as a regressor (called Nickell bias; see Nickell 1981). Similarly, although efficient, the pooled-OLS estimates are inconsistent and potentially biased because they ignore the country-specific effects that may be correlated with the right-hand-side variables. Therefore, the next step is to address the source of bias and inconsistency by performing an instrumental variables procedure.

The fourth column of Table 1 reports system two-stage least squares estimates (SYS-2SLS) which relaxes the assumption that the explanatory variables are exogenous and thus attempts to correct for both the simultaneity bias (endogeneity problem) and the bias coming from the correlation between the country-specific effects and the regressors. The SYS-2SLS regression assumes that all right-hand-side variables are endogenous and instruments for them by their twice-lagged values. As seen from the fourth column, the estimated coefficient of the lagged dependent variable is 0.55, which lies between bounds estimated by the FE and pooled-OLS. However, in the
presence of second-order serial correlation in the errors across the time dimension of the panel, the twice-lagged values cannot be used as instruments. Thus, an LM test is performed, which indicates the absence of second-order autocorrelation. Also the Sargan test that evaluates the orthogonality between the instruments and residuals is carried out for the validity of the instruments employed. The test involves the null of optimal instruments against the alternative of nonoptimal instruments. The test statistics and the related \(p\)-values of these tests are presented at the bottom panel of Table 1. According to the LM and Sargan tests, we fail to reject the nulls of both no second-order serial correlation and optimal instruments. Thus, these results provide support for the validity of the instruments. It is also worth noting that the use of instruments despite their validity results in inefficient estimates; however, because the instrumental variable technique yields unbiased and consistent estimates, the SYS-2SLS is chosen as the preferred specification (the bold column of Table 1). Therefore, the results will be interpreted by focusing on the SYS-2SLS estimates, but comparing these results to the other pooled specifications.

As seen from the fourth column, the signs of the coefficients on the conventional determinants are consistent with the theoretical expectations. The estimated coefficient of expected GDP is quite large and significant, indicating the presence of a strong accelerator effect in the developing economies. This result is found in virtually all previous studies. Recall that expected GDP represents the first term in the modified accelerator model, which is \([Y_{e,t} - (1 - 0) Y_{e,t-1}]\), where the depreciation rates, \(\delta_e\), are chosen to be zero and expected GDP is the predicted values obtained from fitting an AR(1) process of the logarithm of real GDP separately for each country. However, using real GDP instead of expected GDP or a 5 percent depreciation rate instead of 0 has little effect on the estimates. Furthermore, while the coefficient on real credit available to the private sector is significantly positive, the coefficient on the real interest rate has the correct sign but is insignificant, which reinforces the findings of earlier studies that the availability of credit rather than the cost of financing investment projects is more binding in developing countries.

Regardless of the econometric specification employed, the results also indicate that the impact of public investment on private invest-
ment is positive and significant, implying that public investment stimulates private investment in developing countries. Interpreting the coefficient from the SYS-2SLS specification, holding everything else constant, a 10 percent increase in public investment increases private investment by 2.04 percent. Overall, there is strong evidence in favor of a complementary relationship between public capital formation and private investment, which is in agreement with the finding of Greene and Villaneuva (1991), Ramirez (1994), and Oshikoya (1994).

The coefficient on lagged private investment shows the speed of adjustment, implying that the gap between the actual and desired levels of private investment closes by 45 percent within a year. The results regarding the summary measure of uncertainty are quite robust across different pooled specifications. This measure of macroeconomic uncertainty has a negative impact, and the magnitude of this effect is approximately the same (−0.03) in all pooled specifications. The impact of institutional differences, as measured by the economic freedom variable, is insignificant in all specifications. This may result from the presence of the other regressors such as expected GDP, the availability of credit to the private sector, and government investment that may be highly correlated with the economic freedom index, obscuring any effect that the economic freedom measure might have on the private investment.

The results consistently indicate that public investment has a positive and significant impact on private investment in developing countries. The signs of the significant variables all go in the expected direction and show that in all specifications, macroeconomic uncertainty has a negative impact on private investment. The interest rate is not significant, but credit availability to the private sector is, suggesting that credit availability exerts a binding constraint on private investment that makes the cost of financing less important in explaining cross-country differences. This result may also indicate that the real interest rate might be a poor proxy for the user cost of capital in view of severe controls over nominal interest rates often imposed by governments in developing countries, in which case real interest rates reflect merely the changes in inflation rates.
5.3. RESULTS FROM THE SAMPLE OF INDUSTRIAL COUNTRIES

The same empirical model is applied to the panel of industrial countries to see whether private investment in developing and industrial countries responds differently to the same variables. There is one difference in the specification. Because of the structure of the financial sector in developing economies, the empirical model for developing countries includes the availability of private sector credit as one of the standard determinants. The rationale behind the inclusion of credit availability is that the quantity of external funds is more binding than the cost of funds, because of the absence of well-functioning financial markets in most developing countries. However, these same quantity constraints are unlikely to be present in developed economies, so the cost of capital plays the rationing role in developed economies. Therefore, credit availability is not included in the model applied to the sample of industrial countries.

Various pooled specifications of the model are estimated using a panel of twelve industrial countries over the periods 1982 to 1996. Table 2 reports the results. Once again, the Hausman-Taylor test reveals that the country-specific effects are correlated with the right-hand-side variables. Thus, both the pooled-OLS and random effect specifications are inconsistent. Furthermore, the fixed effect estimates are also inconsistent and potentially biased because of the presence of the lagged dependent variable as a regressor. The LM tests indicate the presence of the first order serial correlation problem in both pooled-OLS and FE specifications. Given this and the problems mentioned before, we once again turn the focus on the SYS-2SLS estimator. In an effort to correct for the correlation between country effects and the regressors, and for the endogeneity problem, the SYS-2SLS regression instruments for all regressors by their twice-lagged values. The LM test indicates the absence of either first- or second-order serial correlation, and the Sargan test reveals that instrumentation is optimal, supporting the validity of the instruments. The results of these tests are reported at the bottom panel of Table 2. Overall, even though the FE and SYS-2SLS estimates are fairly similar, the SYS-2SLS is the preferred specification because it yields consistent and unbiased estimates, and is free of the first- or second-order serial correlation problems.
### TABLE 2: Determinants of Private Investment in Industrial Countries

<table>
<thead>
<tr>
<th>Dependent Variable: Real Private Investment&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pooled-OLS</th>
<th>Fixed Effect</th>
<th>Random Effect</th>
<th>SYS-2SLS&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.147 (0.11)</td>
<td>--</td>
<td>-0.196 (0.06)**</td>
<td>--</td>
</tr>
<tr>
<td>∆ expected real GDP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.988 (0.58)*</td>
<td>1.206 (0.74)</td>
<td>0.945 (0.24)**</td>
<td>1.952 (0.377)**</td>
</tr>
<tr>
<td>Real public investment&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.024 (0.02)</td>
<td>-0.078 (0.04)**</td>
<td>0.018 (0.01)**</td>
<td>-0.074 (0.045)*</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>-0.168 (0.29)</td>
<td>-0.055 (0.32)</td>
<td>-0.187 (0.24)</td>
<td>-0.499 (0.474)</td>
</tr>
<tr>
<td>Economic freedom</td>
<td>0.019 (0.01)</td>
<td>0.048 (0.01)***</td>
<td>0.022 (0.006)***</td>
<td>0.037 (0.022)*</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>0.003 (0.007)</td>
<td>0.001 (0.007)***</td>
<td>0.003 (0.006)</td>
<td>-0.001 (0.009)</td>
</tr>
<tr>
<td>Lagged private investment&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.980 (0.02)***</td>
<td>0.824 (0.05)***</td>
<td>0.987 (0.009)***</td>
<td>0.84 (0.048)***</td>
</tr>
</tbody>
</table>

**Total panel observations**: 180

**Adjusted $R^2$**: 0.997, 0.997, 0.997

**Wald (p-value) all regressors**: --

**S.C1 LM (chi-squared)**<sup>c</sup> : 4.09**, 4.91**

**S.C2 LM (chi-squared)**<sup>c</sup> : 3.31, 3.98

**Pooling F-statistic**: 1.39

**Sargan test (p-value)**: 0.472

**Hausman (Wald-statistic)**: --

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**NOTE**: OLS = ordinary least squares. SYS-2SLS = system two-stage least squares. Figures in the parentheses are heteroscedasticity consistent standard errors except for SYS-2SLS. The bold column shows the preferred specifications.

<sup>a</sup> Expressed in logarithms.

<sup>b</sup> The instruments are twice lagged values of all regressors.

<sup>c</sup> S.C1 LM and S.C2 LM show the Lagrange multiplier (LM) test statistics for the first- and second-order serial correlation respectively.

*10 percent significance level. **5 percent significance level. ***1 percent significance level.
As seen from the last column (SYS-2SLS), the signs of the standard variables are as expected. The results indicate that while there is a strong accelerator effect on real output, the real interest rate is negative, but insignificant. Public investment has a significant and negative effect on private investment. The magnitude of the coefficient is –0.074, implying that a 10 percent increase in public investment leads to a 0.7 percent decrease in private investment in industrial countries. This result appears to be consistent with the findings of Erenburg and Wohar (1995) for the U.S. case. They found that, using the securities valuation (or Tobin's $q$) model of private investment, public investment spending has a negative effect, although using the accelerator model and the neoclassical model, there is no effect of public investment on private investment.

The results also show that the effect of economic freedom is significantly positive, and that a 1-index-point increase in economic freedom affects private investment by approximately 0.04 percent, leading to the conclusion that economic freedom plays a significant role in determining private investment activities in industrial countries. The summary measure of uncertainty is found insignificant in all specifications. Finally, the estimated coefficient of the lagged dependent variable is 0.84, which suggests that actual private investment adjusts to its desired level by 16 percent within a year. The estimated speed of adjustment is rather lower than the one found in developing countries. This means that private investment in developing countries adjusts more rapidly to its long-run level than in industrial countries.

The reason for running the same empirical models for developing and developed economies was to see if the determinants of private investment were similar regardless of the stage of development, and the comparison has uncovered some interesting differences. Economic freedom has a statistically significant effect in developed nations, but not in developing nations. In addition, uncertainty has a negative impact in developing economies, but not in developed economies. Most important for present purposes, public investment has a positive impact on private investment in developing economies, but a negative impact on private investment in developed economies. Thus, there does appear to be empirically relevant differences in the determinants of private investment depending upon the level of development.
6. CONCLUSION

The existing literature offers inconsistent conclusions on the impact of public investment on private investment in developing economies, with some studies suggesting that public investment stimulates private investment (Greene and Villanueva 1991; Ramirez 1994; Odedokun 1997; Ramirez 2000; Blejer and Khan 1984; Oshikoya 1994) and others suggesting that public investment crowds out private investment (Wai and Wong 1982; Nazmi and Ramirez 1997). This article examines that question using a sample of nineteen developing economies from various parts of the world and compares that sample of developing economies with a group of twelve developed economies to look for similarities and differences in the impact of public investment on private investment. The empirical results suggest that public investment has a positive impact on private investment in developing economies. The results for the sample of developing countries indicate that a 10 percent increase in public investment would increase private investment by about 2 percent.

The comparison of developed economies with developing economies in the same empirical framework offers some interesting insights into the nature of private investment in developing economies. In developing economies, where there are often constraints to obtaining capital in addition to just the cost of capital, the interest rate was not a statistically significant determinant of private investment, whereas the availability of credit showed a consistently positive effect on investment. In developing economies, because of credit controls and other imperfections in the credit market, private investment appears to be constrained by a lack of funds available to be borrowed. Quantity constraints may be why the interest rate does not show up as a statistically significant determinant of investment, but government-controlled interest rates, or high and uncertain inflation rates, may also contribute in some countries. The constraining impact of real credit availability in developing economies shows that there are significant differences in capital markets in developed and developing economies. For developing economies to enjoy the same level of prosperity as developed economies, not only is more investment required, but capital markets must be developed to allow the market allocation of private investment.
Whereas the developing economies showed a consistently positive impact of public investment on private investment, public investment had a negative impact on private investment in developed economies. Again, this shows important structural differences between developed and developing economies. In developed economies, public investment may be competing with private investment, but more likely, the negative impact is due to the effect of a larger public sector, which tends to lower private sector productivity (Gwartney, Lawson, and Holcombe 1999; Gwartney, Lawson, and Samida 2000). Private investment in developing economies, in contrast, is positively correlated with the level of public investment. This may be because public investment provides infrastructure that is complementary to private investment, that public investment provides a stabilizing influence on the economy, or even that it provides information on investment productivity for private investors. The aggregated investment data used in this article do not allow a more detailed examination of the reasons why developed economies differ from developing economies in this regard, but it is significant to note that public investment has the opposite effect on private investment depending on the level of development.

These results show that in a number of important ways, private investment in developed economies is influenced by different factors than private investment in developing economies. Because of these differences, one cannot expect that policies that succeed at stimulating capital formation in developed economies will translate well to developing economies. Capital markets in particular appear to have different characteristics, so that would be a key area to focus on when considering policies that might stimulate private investment in developing nations.
APPENDIX
Description of Variables and Data Sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample of Developing Countries</th>
<th>Sample of Industrial Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y (real GDP)&lt;sup&gt;a&lt;/sup&gt; (IFS, lines 99b, 99bi)</td>
<td>Nominal GDP/GDP deflator</td>
<td>International Financial Statistics</td>
</tr>
<tr>
<td>GI (real gross public investment)</td>
<td>Ratio of gross public investment to GDP * real GDP</td>
<td>Government Finance Statistics</td>
</tr>
<tr>
<td>PI (real gross private investment)</td>
<td>Ratio of gross private investment to GDP * real GDP minus GI</td>
<td>IFC</td>
</tr>
<tr>
<td>Bank credit</td>
<td>Nominal bank credit/GDP deflator</td>
<td>IFS, line 32d</td>
</tr>
<tr>
<td>Uncertainty measure</td>
<td>The first principal components of the conditional variances of the rates of inflation, real GDP, real exchange</td>
<td></td>
</tr>
<tr>
<td>Inflation rate&lt;sup&gt;b&lt;/sup&gt;</td>
<td>The annual difference in the logs of the country’s CPI</td>
<td>CPIs from IFS, line 64</td>
</tr>
<tr>
<td>Real GDP growth rate</td>
<td>The annual difference in the log of real GDP</td>
<td></td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>Log (exchange rate * [CPI US/CPI])</td>
<td>Exchange rates from IFS, line ae</td>
</tr>
<tr>
<td>Cost of capital (real interest rate)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Log [(1 + nominal interest)/(1 + inflation)]</td>
<td>Nominal interest rates from IFS, lines 60b, 60l, 60</td>
</tr>
<tr>
<td>Institutions (Economic Freedom Index)</td>
<td>Five-year sequences are transformed into annual observations by interpolating</td>
<td>Annual Report of Economic Freedom of the World</td>
</tr>
</tbody>
</table>

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*For Turkey only, the data on nominal GDP and GDP deflator are taken from the national data sources (State Planning Organization 1997).*

*Due to the unavailability of complete data on CPI for Bangladesh and Tunisia, GDP deflator and Producer Price Index (PPI) are used respectively for those countries.*

*The definitions of interest rates are different across countries due to the lack of available data. The empirical model uses the money market (commercial bank) rate for India, Malaysia, Mauritius, Pakistan, Thailand, and South Africa; deposit rates for Bangladesh, Belize, Chile, Guatemala, Korea, Malawi, Mexico, Philippines, Turkey, Uruguay, Austria, Belgium, Germany, Ireland, Netherlands, Spain, Sweden, and the United Kingdom; discount rates for Colombia, Costa Rica, Ecuador, Kenya, and Tunisia; and deposit rates for Finland, France, Greece, and Portugal.*
REFERENCES


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