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Note to the Office for Budget Responsibility

Government R&D spending and potential output

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4th October 2024

1. Introduction and summary

In the recent report (Suresh et al. 2024) on the effects of government spending on potential output, the OBR welcomed comments and suggestions on the development of modelling to account for the effects of different types of public investment within the general modelling framework.

Research and development (R&D) is a potentially important public investment that might generate transformative technical change. This note argues:

a. there is evidence that government R&D spending has a higher output elasticity and rate of return than the figure used in the OBR report.
b. There is also evidence that government R&D positively affects private investment through "crowding in" private R&D.

Based on this evidence, this note suggests that R&D spending should be counted differently when calculating the effect on potential output.

2. Conceptual framework

The OBR report (Suresh et al. 2024), referred to as 'the report' throughout this note, explains that the effect of public capital on output is determined by a range of parameters of which an important one is the output elasticity of government capital. The following is an attempt at briefly summarising the report to place the R&D evidence in context.

The report assumes a production function of the type:

$$Y^{PRIV} = AL^{\beta}\left(K^{PRIV}\right)^{\gamma}\left(K^{GOVT}\right)^{\alpha} \quad (1)$$

where Y is output, L and K are labour and capital inputs, A is an index of technology and the superscripts $PRIV$ and $GOVT$ refer to private and government respectively. I have written this in terms of private output since this measure is mostly used in the empirical work upon which the report draws, see below.

Define the extra (potential) output of a change in government capital, K^{GOVT} on private sector output, Y^{PRIV}, holding other inputs constant, as the marginal product $MP=\partial Y^{PRIV} / \partial K^{GOVT}$. Writing this in terms of the elasticities gives:

$$MP = \frac{\alpha Y^{PRIV}}{K^{GOVT}} \tag{2}$$

Where α is the elasticity of private output with respect to government capital.

Suppose now the government invests £1 in K^{GOVT} at t=0. What is the net present value of that investment? Suppose further the investment is implemented right away and so raises the capital stock at that time. The extra output so created is then the raised capital stock, times MP. The extra output next period is the raised capital stock next period times MP etc. The link between these capital stocks is that the raised capital stock next period is the part of the raised capital stock this period that remains next period, i.e. the non-depreciated part of the raised capital stock this period. The net internal rate of return then of a £1 investment is the discount rate, r, such that this flow of benefits is worth zero over the n periods of the project and so is calculated as (see paragraph 4.21):

$$\left(\sum_{t=0}^{n} \left(\frac{1-\delta^{GOVT}}{1+r} \right)^{t} \right) \frac{\alpha Y^{PRIV}}{K^{GOVT}} - 1 = 0 \tag{3}$$

Which when n tends to infinity gives:

$$r = \frac{\alpha Y^{PRIV}}{K^{GOVT}} - \delta^{GOVT} \tag{4}$$

Where δ is the depreciation rate and intuitively, a higher depreciation rates lowers the IRR.

There is one immediate complication. The calculation of the rate of return used in the report also considers an assumed 10-year profile of implementation lags leading to the equation below:

$$\left(\sum_{t=0}^{10} \theta_t \left(\frac{1-\delta^{GOVT}}{1+r} \right)^{t} \right) \frac{\alpha Y^{PRIV}}{K^{GOVT}} - \delta^{GOVT} - 1 = 0 \tag{5}$$

Where θ is an assumed share of investment coming on stream over the first ten years of a project.

3. Calculation of rate of return

To calculate *r,* some studies estimate the MP directly whilst others estimate the output elasticity, α. The OBR approach is to use this second approach.

K^{GOVT} and Y^{PRIV} are measured (albeit imperfectly) in the national accounts whilst α can be estimated from the econometric literature by looking at the statistical relation between the variables in equation 1.

The elasticity, α, used in the report is 0.1, drawn from (Bom and Ligthart 2014). As they note, "*The output measure used as dependent variable also varies across studies. Most studies use real gross output of the private sector or real gross domestic product (GDP) exclusive of public sector output*". Thus, in equation 1, private sector output is on the left-hand side.

Table 4.2 of the report states that government capital is 55% of GDP. For this calculation, I believe the relevant figure, following equation (1), should be the ratio of government capital to private output. In paragraph 2.17, 82% of GDP is market sector output.

ONS data (ONS 2023) Table 1.1.1 shows the gross capital stock of government is, in 2022, £1,474bn. Nominal GDP in 2022 was some 2,500bn. Using 82% of market sector output, this gives a gross public capital to GDP ratio of 0.59, but a market sector output ratio of 0.72. (The gross capital stock is used here since, paragraph 3.9, that better captures the capital services).

With a depreciation rate of 0.04, using (4) gives a rate of return of 0.11/0.72-0.04= 11%, a bit above the 8.7% in the report (paragraph 4.24). This is to be expected since the 8.7% in the document uses an additional discount due to implementation time lags.

4. Should a different rate of return be used for government R&D investment?

Within this framework a different rate of return might be used for government R&D investment for at least two reasons.

First, what is the evidence that the rate of return, calculated in an equivalent way, for government R&D spending is higher than that implied by the 0.11 output elasticity/0.087 rate of return? Second, as this calculation is done for *given* private sector K, is there any evidence that public R&D "crowds in" private capital? If one or both of these statements are true, then I believe there is a case for counting government R&D differently.

It must of course be pointed out that another condition must hold for government R&D to be treated differently. It is of course that for any government spending to be treated differently it would have to be counted as investment spending, that is, regarded as creating an enduring asset. R&D spending is now so treated in internationally-agreed National Accounts.

Further, the OBR estimates are based on the output elasticity, the K/Y ratio for the particular asset and implementation lags. Thus, a comparison of other rates of returns to that here needs to take account of these features.

Given that R&D is treated as an investment, I believe there are two broad sets of reasons why it might be treated differently from other government investments.

a. Rates of return to public R&D spend is higher than the central rate of return to public investment cited in the OBR paper

Frontier Economics (2023) is a convenient summary of the literature on rates of return and controls for publication bias. In their report (p.38ff) they assess papers that regress public R&D on private output, controlling for private inputs. They quote "*The most relevant evidence remains the study by Haskel et al (2014) which estimates a social return to public R&D of around 20%.*" (Haskel, Hughes, and Bascavusoglu-Moreau 2014). This comes from an estimate of using outputs measured by 6 non-agricultural private sector industries. An elasticity is not estimated since public sector R&D is assumed not to depreciate and hence the rate of return can be read off from the regression.[1]

The Haskel *et. al* (2014) report states that other findings suggest public R&D spend generally has higher returns than private. Since private returns to all investments are generally close to the 8% used in the report, evidence supports the idea that public R&D has a higher rate of return then the average implied by the 0.1 output elasticity in the report.

One detailed question is what exactly public R&D is, that funded by the public sector or performed in the public sector? The public R&D spend in much of this research work is that performed in the public sector, in the UK, predominantly public research centres and universities (as opposed to R&D funded by the government and performed by the private sector, see Haskel, Hughes, and Bascavusoglu-Moreau 2014) for a discussion. What of implementation lags? The estimate of the coefficient is based on a three-year lag on public sector R&D spend. Therefore, the rate of return takes into account implementation lags.

b. Public sector R&D "crowds in" private sector R&D

As the report points out, the 0.11 evidence base is a partial equilibrium exercise establishing the marginal impact of public sector investment holding private sector investment constant. The rate of return would be increased were that public sector investment to "crowd in" private sector investment.

The report assumes the bulk of government spending does not have this characteristic. It would however appear that government R&D spend is an exception. Quite a large body of evidence, discussed in detail in (BEIS 2020) suggests that public sector R&D does in fact crowd in private sector R&D. There is of course a sound economic logic for this, namely that to the extent public sector R&D funds basic research which the private sector would not fund for perfectly understandable appropriation reasons, one might imagine that without that basic research private sector R&D would be severely curtailed.

[1] Instead of estimating an output elasticity from the percentage change in the public sector R&D capital stock, the ratio of public sector R&D investment to output is entered as a regressor, and hence the coefficient is a direct estimate of the rate of return to that investment.

5. Summary

This note argues that government R&D, which is treated as an investment, has a higher rate of return than that used in the OBR report for total government investment, and potentially crowds in private spending. It should therefore be counted differently when calculating the effect on government investment on potential output.

References

BEIS. 2020. "The Relationship between Public and Private R&D Funding." https://assets.publishing.service.gov.uk/media/5efef09c3a6f4023c607da31/relationship-between-public-private-r-and-d-funding.pdf.

Bom, Pedro R.D., and Jenny E. Ligthart. 2014. "What Have We Learned from Three Decades of Research on the Productivity of Public Capital?" *Journal of Economic Surveys* 28 (5): 889–916. https://doi.org/10.1111/JOES.12037.

Frontier Economics. 2023. "Rate of Return to Investment in R&D A Report for the Department for Science, Innovation and Technology." https://www.frontier-economics.com/media/015adtpq/rate-of-return.pdf.

Haskel, J, A Hughes, and E Bascavusoglu-Moreau. 2014. "The Economic Significance of the UK Science Base: A Report for the Campaign for Science and Engineering." *Working Papers*, May. http://ideas.repec.org/p/imp/wpaper/13751.html.

ONS. 2023. "Capital Stocks and Fixed Capital Consumption, UK - Office for National Statistics." https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/bulletins/capitalstocksconsumptionoffixedcapital/2023.

Suresh, Neetha, Rachel Ghaw, Ronnie Obeng-Osei, and Tom Wickstead. 2024. "Public Investment and Potential Output ." https://obr.uk/docs/dlm_uploads/Public-investment-and-potential-output_August-2024.pdf.