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Research productivity and secular stagnation: Is there a correlation between research productivity and economic growth in OECD countries?

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Abstract

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* Data supporting the results presented in this paper are available at: https://data.mendeley.com/datasets/yr4fyf5chj/2

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1. Introduction

Since the 2008 financial crisis and the slow recovery of advanced economies, secular stagnation has attracted renewed academic interest. Proposed explanations include demographic trends (Gordon 2018), weak aggregate demand (Summers 2014), and underinvestment in human capital and infrastructure (Eichengreen 2014). This paper examines the role of research productivity.

Research activity is central to endogenous growth models, yet recent evidence documents a sustained decline in research productivity across advanced economies (Bloom et al. 2020; Boeing and Hunermund 2020; Madsen et al. 2024). Table 1 shows a similar pattern for G7 countries, especially from the 1990s. The G7 is often viewed as the World's technological frontier. Together, these countries account for over 75% of all R&D spending in OECD.[4] Our measure of research productivity is TFP growth divided by the share of researchers in total employment (further details ahead).

Table 1

Average research productivity across decades

	Canada	France	Germany	Italy	Japan	U.K.	U.S.
1981-1990	0.383	1.763	0.623	1.573	3.674	0.240	1.737
1991-2000	2.628	3.306	3.864	6.080	1.140	3.763	2.731
2001-2010	0.081	-0.481	1.177	-2.023	-0.048	-0.642	1.102
2011-2019	-0.050	0.085	0.142	-1.481	-0.210	0.348	1.131

Notes: Research productivity is the growth rate of TFP divided by the share of researchers in total employment. TFP is calculated as a Solow residual from a Cobb-Douglas production function with capital and labor as inputs, and a capital share of 30%. Capital, labor and output data are from the Penn World Table 10.0. Data on the percentage of researchers in total employment is from OECD. The numbers shown are simple averages across each decade.

This paper estimates the relationship between economic growth and research productivity using a panel of OECD countries between 1981 and 2019. For the G7, we find robust evidence of a positive correlation between these variables: lower research productivity is associated with slower growth. The effect is statistically significant and quantitatively relevant. We do not find such a relationship for a sample of other 27 OECD countries.

It is important to stress that our results should be interpreted as correlations. The paper focuses on a proximate cause of growth rather than a fundamental one and does not address why research

[4] Data for 2019, from OECD (Gross domestic spending on R&D, millions of USD).

productivity has declined. Nevertheless, it highlights a quantitatively relevant mechanism that may motivate future work on the deeper drivers of declining research productivity.

2. Materials and methods

Our sample comprises 7 five-year intervals (1981-85, 1986-1990, …, 2011-15) and one four-year interval (2016-2019). We estimate a standard growth regression using a panel of countries, with research productivity (RP_{it}^1) as our key regressor:

$$g_{it} = \alpha + \rho \ln y_{it}^1 + \beta RP_{it}^1 + \gamma X_{it}^1 + \mu_i + \theta_t + \varepsilon_{it} \qquad (1)$$

where g_{it} is the average annual growth rate of GDP per worker (PPP) of country i over the interval t, from the Penn World Table (PWT) 10.0. Moreover, X_{it}^1 is a set of controls, μ_i are country fixed effects, θ_t are time effects and ε_{it} is the error term. As standard in the empirical growth literature, we also include the log of initial GDP per worker ($\ln y_{it}^1$) to account for convergence effects. For the regressors RP_{it}^1 and X_{it}^1, we use only the value for the initial year of each interval to mitigate simultaneity issues – hence the superscript "1". For instance, in the interval 2011-15, RP_{it}^1 and X_{it}^1 are based solely on data from 2011.

The vector X_{it}^1 includes investment, government consumption and trade (imports plus exports), all as shares of GDP, along with population growth, life expectancy and inflation.[5] The source is the World Bank's World Development Indicators.

We use data from 34 countries, divided into two groups. The first comprises the G7. Given their prominence in producing new technology, we expect stronger effects for this set of countries. The second group includes 27 other economies from OECD.[6]

2.1. Research Productivity

The knowledge production function lies at the core of endogenous growth theory. Specifically, the flow of new ideas ($\dot{A}$) depends on the existing stock of knowledge (A), an R&D input (Z) and a research productivity parameter (λ) (Ha and Howitt, 2007):

$$\dot{A} = \lambda A^{\phi} Z^{\sigma} \qquad (2)$$

[5] Some of these covariates can be mechanically affected by growth since GDP is in their denominator, leading to endogeneity. We avoid this issue by using only their value in the first year of each interval.

[6] Australia, Austria, Belgium, Chile, Czech Republic, Denmark, Spain, Estonia, Finland, Greece, Hungary, Ireland, Iceland, Korea Republic, Lithuania, Luxembourg, Latvia, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Slovakia, Slovenia, Sweden, Turkey.

where $0 \leq \phi, \sigma \leq 1$. Pioneer models (Romer 1990; Aghion and Howitt 1992) produce implications that are at odds with empirical evidence. For instance, Romer (1990) assumes $\phi = 1$ and sets $Z = L_A$, the number of workers engaged in R&D. This implies that growth should accelerate as a result of the observed increase in the number of scientists and engineers engaged in R&D in developed countries – something not supported by the data.

The literature offers two main fixes: (i) assume decreasing returns to current knowledge, that is, $\phi < 1$ (Jones 1995); (ii) in the context of Schumpeterian growth, retain $\phi = 1$, but allow the R&D input to be spread more thinly across an increasing number of sectors (Aghion and Howitt, 1998). That arises through horizontal innovation, where the number of sectors depends on the size of the population. The R&D input could then be proxied by the share of R&D workers in total employment, L_A/L.

Ha and Howitt (2007), Madsen (2008) and Venturini (2012) find empirical support for the Schumpeterian specification (ii) using data from developed countries. Following them, we assume $\phi = 1$ and $Z = L_A/L$. Then, similarly to Bloom et al. (2020), equation (2) can be used to infer the research productivity parameter:

$$\lambda = \frac{\dot{A}/A}{(L_A/L)^{\sigma}} \qquad (3)$$

This forms the basis for our RP variable featured in equation (1). We capture $\dot{A}/A$ using the growth rate of TFP, computed as the Solow residual from a Cobb-Douglas production function with capital and labor as inputs and a capital share of 30%. Output, capital and labor data are from the PWT 10.0. L_A/L is the number of researchers per employed worker, sourced from the OECD's Main Science and Technology Indicators.

In our baseline regressions, we set $\sigma = 1$. Ha and Howitt (2007) show that, under the Schumpeterian specification, $\sigma = 1$ provides the best fit for the comovement between TFP growth and R&D intensity in G5 countries between 1953 and 2000.[7] In this case, RP is simply TFP growth divided by the share of researchers in total employment; decade averages appear in Table 1. For robustness, we experiment with three other values of σ – 0.25, 0.50 and 0.75.

3. Results

Table 2 displays estimates of equation (1). All specifications include country fixed effects. Columns (1)-(3) show results for G7 countries, while columns (4)-(6) focus on the set of other OECD economies.

In column (1), we only have RP_{it}^{1} as a regressor, besides the fixed effects. Estimates indicate that research productivity and growth are tightly correlated for the G7 sample. In column (2), we add

[7] See their Table 7.

the log of the initial value of GDP per worker and time effects to the regression. The inclusion of time effects is important since RP_{it}^{1} could be capturing changes in the overall technological frontier instead of research productivity in a given country. The coefficient of RP_{it}^{1} becomes smaller, but gains statistical significance with the addition of these regressors. This result is also robust to the inclusion of the controls X_{it}^{1} listed in the previous section (column (3)).

Table 2

Regression results

Dependent variable: average annual growth rate of GDP per worker × 100

	G7 countries			**Other OECD countries**		
	(1)	(2)	(3)	(4)	(5)	(6)
RP_{it}^{1} $[\beta]$	0.183**	0.155***	0.136***	0.003	0.000	-0.007
	(0.064)	(0.040)	(0.027)	(0.008)	(0.005)	(0.007)
$\ln y_{t}^{1}$ $[\rho]$		-4.713	-10.552***		-3.822	-7.538***
		(2.659)	(2.079)		(2.719)	(2.194)
Effect on the long-run level of log GDP per worker						
$-\beta/\rho$		0.032**	0.013***		0.000	-0.001
Time effects	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes
R^2	0.27	0.68	0.75	0.00	0.40	0.49
N	55	55	51	141	141	138

Notes: All regressions include country fixed effects. Numbers in parentheses are standard errors robust to heteroskedasticity; p-values for $-\beta/\rho$ were obtained through the delta method. *p < 0.1; **p < 0.05; ***p < 0.01.

Since the estimated values for ρ are negative, we can calculate the effect of research productivity on the long-run level of GDP per worker, which is $-\beta/\rho$. The table shows that this ratio is also positive and statistically significant at conventional levels for G7 countries (p-values calculated using the delta method).

In contrast, the correlation between RP_{it}^1 and growth is much weaker for non-G7 economies, as shown in columns (4)-(6), which are analogous to (1)-(3). The coefficient β and the long-run effect $-\beta/\rho$ are much smaller in magnitude and statistically insignificant for this set of countries.

We implement a couple of robustness checks. First, we consider different interval lengths to construct our panel. Second, we estimate our main regressions with alternative values of σ in equation (3) to calculate research productivity. Our main message remains. See the Appendix for results and discussion.

3.1. Magnitudes

We now assess the quantitative importance of the estimated effect of research productivity. We focus on the G7 sample and use the coefficient β from column (3) of Table 2. A one standard deviation increase in RP_{it}^1 (equal to 4.32 for this set of countries) is associated with a contemporaneous growth rate higher by $4.32 \times 0.136 \approx 0.59$ percentage points. These are relevant figures, given the mean growth rate of 1.48% within the G7 sample. Moreover, such an increase in RP_{it}^1 would translate into a 5.8% higher level of GDP per worker in the long run.[8]

We now look at individual countries. For instance, average research productivity in the U.S. went from 2.73 in the 1990s to 1.13 in the 2010s (see Table 1). Our estimates imply that contemporaneous growth would be 0.22 percentage points higher if this decrease did not occur.[9] Again, we can see the quantitative relevance here, since the actual growth rate of GDP per worker was 1.09% during the 2010s. In Table 3, we replicate this exercise for the other G7 countries and find even larger impacts.

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[8] $\exp\{4.32 \times 0.013\} - 1 = 5.8\%$.

[9] For the U.S., we simulated an increase of research productivity from 1.13 (2010s average) to 2.73 (1990s average). Using the estimates in column (3) of Table 2, the impact on contemporaneous growth is $0.136 \times (2.73 - 1.13) \approx 0.218$ percentage points, and the impact on the long-run level of GDP per worker is $\exp\{0.013 \times (2.73 - 1.13)\} \approx 2.08\%$. Values for the other countries were obtained analogously.

Table 3
Simulated effects for the 2010s using research productivity at 1990s levels

	Actual growth rate 2011-2019 (%)	Effect if research productivity remained at the same level as 1991-2000	
		Change in contemporaneous growth rate (p.p.)	Change in long-run level of GDP per worker
Canada	0.388	0.364	3.51%
Germany	0.235	0.506	4.91%
France	0.608	0.438	4.24%
Italy	0.267	1.028	10.24%
Japan	-0.718	0.184	1.76%
U.K.	0.801	0.464	4.50%
U.S.	1.094	0.218	2.08%

Notes: Actual growth rates are from the PWT 10.0. In the simulations, we evaluate the impact of changing research productivity by the difference between 1991-2000 and 2011-2019, as shown in Table 1. The effects on contemporaneous growth and the long-run level of GDP per worker are obtained using the estimates in column (3) of Table 2.

4. Conclusion

Recent studies have uncovered a fall in research productivity over time. Endogenous growth theory suggests this would lead to slower growth, as observed in advanced economies characterized by secular stagnation. We evaluate this link using a panel of OECD countries between 1981 and 2019. For G7 economies, we find a strong correlation between research productivity and GDP per worker growth rates.

Policies that improve R&D efficiency – by enhancing knowledge diffusion, reducing duplication, and strengthening scientific capabilities – could help counter these pressures. Examples include incentivizing transparency in science and innovation processes; or supporting the development of general-purpose technologies, which could spur further innovation across multiple sectors.

Our results, however, should be interpreted with caution. Although we take steps to mitigate simultaneity within each time interval, these measures do not eliminate other sources of endogeneity in the relationship between research productivity and growth. Slow-moving determinants of long-run development (such as culture or institutions) may influence both variables. Common strategies in the empirical literature aimed at establishing causality, with the use of lagged values as instruments, are unlikely to address this concern, since even long lags are not plausibly exogenous in the presence of such persistent factors. Further work is therefore needed to uncover the causal effects of research productivity on growth.

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Appendix for "Research productivity and secular stagnation: Is there a correlation between research productivity and economic growth in OECD countries?"

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This appendix presents two sets of robustness checks. Specifically, we estimate our main regressions using (i) alternative lengths for our time intervals, and (ii) alternative values for the parameter σ when constructing our research productivity measure using equation (3).

A. Alternative Lengths for Time Intervals

Our baseline results are based on a panel with 7 five-year intervals and 1 four-year interval. The use of multiyear intervals is commonplace in the empirical growth literature, since it mitigates the influence of short-term fluctuations. Lengthy intervals, on the other hand, lead to a reduction in sample size. In this paper, we tried to balance this tradeoff using mainly five-year intervals. Influential papers in the literature follow a similar strategy – see, for instance, Islam (1995), Caselli, Esquivel and Lefort (1996) and Barro (2003).

This choice is, nonetheless, arbitrary. We deal with this issue by considering different interval lengths to construct our panel. Specifically, we estimate equation (1) using 3, 4 and 6-year intervals, along with our 5-year baseline. Here our panels have intervals of the same length. In this sense, we exclude the 2016-2019 interval from our baseline. For comparability, the different panels cover a similar time frame – they all start in 1981 and end in 2015 or 2016.

Results are in Table A. We present only regressions with the complete set of covariates – country and time fixed effects, initial GDP per worker and controls X_{it}^1, in addition to the research productivity measure. Our main conclusions are maintained using panels with 3 and 4-year intervals. The coefficient of RP_{it}^1 remains positive and significant for the G7, with stable magnitudes across the first three specifications. There is an expected loss of significance when using 6-year interval, given the reduction in sample size. However, the coefficient of RP_{it}^1 is still much larger for the G7 than for the sample of other OECD countries.

B. Alternative values for σ

We now present regression results using alternative measures of research productivity based on equation (3). In particular, we consider three distinct values for the parameter σ (0.25, 0.50 and 0.75), along with our baseline $\sigma = 1$. To make coefficients comparable across specifications, we normalize research productivity by its standard deviation. We call this normalized variable $\widehat{RP}_{it}^{1}$.

Specifically, for the G7, $\widehat{RP}_{it}^{1}$ is research productivity divided by its standard deviation within this set of countries. A similar adjustment was undertaken for the sample with other OECD countries. The coefficient β now indicates the change in growth associated with a one-standard deviation increase in research productivity.

Table B shows that our main results are robust to the changes in the parameter σ. Once more, all regressions include the full set of covariates featured on the right-hand side of equation (1). For the G7 sample, the coefficient of $\widehat{RP}_{it}^{1}$ is positive and significant in all cases, with a relatively stable magnitude across the different specifications. This does not hold for the panel with other OECD countries, in which the correlation between growth and research productivity is much weaker.

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Table A

Robustness checks: Alternative interval lengths

Dependent variable: average annual growth rate of GDP per worker × 100

	Time interval length							
	3 years		4 years		5 years (baseline)		6 years	
	G7	Other OECD	G7	Other OECD	G7	Other OECD	G7	Other OECD
RP_{it}^1 [β]	0.148	-0.012	0.135	0.001	0.131	-0.001	0.011	-0.007
	(0.048)**	(0.006)*	(0.054)**	(0.008)	(0.028)***	(0.007)	(0.036)	(0.006)
$\ln y_t^1$ [ρ]	-13.110	-9.521	-16.644	-9.718	-15.118	-9.813	-22.179	-8.315
	(2.724)***	(2.227)***	(2.616)***	(3.011)***	(2.720)***	(2.617)***	(2.799)***	(2.268)***
$-\beta/\rho$	0.011*	-0.001**	0.008***	0.000	0.009***	-0.000	0.000	-0.001
R^2	0.61	0.34	0.72	0.36	0.84	0.56	0.83	0.54
N	76	204	51	138	44	114	39	105
Intervals included	1981-1983, 1984-1986, …, 2014-2016		1981-1984, 1985-1988, …, 2013-2016		1981-1985, 1986-1990, …, 2011-2015		1981-1986, 1987-1992, …, 2011-2016	

Notes: All regressions include country fixed effects, time effects and vector of control variables X_{it}^1. Numbers in parentheses are standard errors robust to heteroskedasticity; p-values for $-\beta/\rho$ were obtained through the delta method. *p < 0.1; **p < 0.05; ***p < 0.01.

<u>Table B</u>

Robustness checks: Alternative values for σ in equation (3)

Dependent variable: average annual growth rate of GDP per worker × 100

	σ = 0.25		σ = 0.50		σ = 0.75		σ = 1.00 (baseline)	
	G7	Other OECD	G7	Other OECD	G7	Other OECD	G7	Other OECD
$\widehat{RP}_{it}^{1}$ $[\beta]$	0.677	-0.191	0.659	-0.157	0.628	-0.124	0.587	-0.098
	(0.160)***	(0.193)	(0.138)***	(0.155)	(0.119)***	(0.121)	(0.117)***	(0.096)
$\ln y_t^1$ $[\rho]$	-10.372	-7.278	-10.402	-7.429	-10.467	-7.512	-10.552	-7.538
	(2.172)***	(2.128)***	(2.130)***	(2.163)***	(2.096)***	(2.187)***	(2.079)***	(2.194)***
$-\beta/\rho$	0.065***	-0.026	0.063***	-0.021	0.060***	-0.016	0.056***	-0.013
R^2	0.76	0.50	0.76	0.49	0.75	0.49	0.75	0.49
N	51	138	51	138	51	138	51	138

Notes: All regressions include country fixed effects, time effects and vector of control variables X_{it}^{1}. The variable $\widehat{RP}_{it}^{1}$ is research productivity adjusted by its standard deviation, calculated from the set of countries used in each regression. Numbers in parentheses are standard errors robust to heteroskedasticity; p-values for $-\beta/\rho$ were obtained through the delta method. *p < 0.1; **p < 0.05; ***p < 0.01.