**Why Government Funded Research? A Brief on *Endogenous Growth Theory***

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**Problem:**

* Why should the government (federal or provincial) fund post-secondary research, or *any* research of any kind? Isn’t that something the private sector can and should handle?
* Alternatively: why should the federal or provincial government fund research grants that give money to corporations? Isn’t that just corporate welfare?

**Answer:**

* The reason that governments play an essential role in funding research and development is that the current leading growth model—*endogenous growth theory*—predicts that R&D investment will be *insufficient* if left only to the private sector.
* If businesses otherwise wouldn’t have raised the capital themselves, and if the alternative is an *underinvestment* in R&D, then research dollars going to private businesses shouldn’t be seen as corporate welfare. The alternative would be governments running most R&D functions in the country, which isn’t a viable option.
* **Student-specific framing:** 
  + Student human capital is an important enough component of the innovation ecosystem that we should be considered a priority line item in the federal budget.
  + Labour markets are increasingly rewarded “soft” or “higher order” skills, which are cultivated through the social sciences and humanities. Neglecting degrees in these fields is neglecting major returns on investment.

**1. What is *Endogenous Growth Theory*?**

* Traditional models of economic growth (ex: the “Solow-Swan model”) assumes that the main drivers of economic growth exist *outside* the model itself—that is to say, the actual cause can’t be studied by economics. For the Harrod-Domar model, this exogenous driver of growth was the savings rate. For the Solow-Swan model, it’s productivity increases, created by technological change, are a major driver of economic growth, alongside capital accumulation and population growth. Most modern economists agree that productivity is the key determinant of economic growth, but with an exogenous model, they can’t explain how productivity can increase (only that it must if growth is to continue).
* *Endogenous* growth theory, instead, says that the main factors of growth can be described *within* an economics model. Namely, this means that the sources of technological change and productivity improvements aren’t *unknown*: they can be explained in an economics framework.
  + And if *that’s* true, it means that technological change and productivity improvements can *respond to public policy*. Better policies lead to better technological change, which leads to better productivity, which leads to better growth.
* Nobel Prize winners (year) who worked on endogenous growth models:
  + Kenneth Arrow (1972)[[1]](#footnote-1),[[2]](#footnote-2)
  + Robert Lucas (1995)[[3]](#footnote-3)
  + Paul Romer (2018)[[4]](#footnote-4),[[5]](#footnote-5),[[6]](#footnote-6),[[7]](#footnote-7)
  + Daron Acemoglu (2024)[[8]](#footnote-8),[[9]](#footnote-9)

**2. What Are the Main Endogenous Drivers of Growth?**

* *Human capital*: the accumulated knowledge, skills, personality traits, and social connections that allow an individual to engage in productive work.
* *Knowledge systems*: anything that allows humans to learn, transmit, share, and modify knowledge.
* *Innovation*: new products (“product innovation”) or ways of organizing production (“process innovation”). This is the creation of technological change, with technology being defined as any practical use of knowledge (so, for example, better employee relations are referred to as “management technology.”[[10]](#footnote-10))

The process by which these factors influence each other (see Appendix) is that human capital and knowledge systems feed into one another, which drives product and process innovation. As new products and new ways of doing things enter the market, we start to be able to create the same number of things with less resources than before *or* create more things with the same number of resources, which means productivity has increased. And if productivity increases, then so does growth.

**3. What is the Government’s Role in this Model?**

There are two primary funding roles that the government must play. The first, which has been the subject of much of our advocacy and research, is the development of human capital. The second—and most relevant for the criticisms we’ve heard from Conservative MPs—is the *direct* funding of research.

In most endogenous growth models, the government has a key regulatory (such as ensuring anti-trust laws allow for sufficient market competition) and funding role to play in generating optimal growth levels. The focus for this brief is, of course, on the funding role, and the majority of endogenous growth models agree that governments have a vital role to play in funding research and development activities. Indeed, funding research and development is a *key* government priority, because the private sector will otherwise suboptimally invest in innovative activities.

Why will private sector investment be suboptimal? There are three interrelated reasons:

* *Risk:*
  + Having *risk* refers to a state where you have imperfect information about future states of affairs and, thus, have to insure yourself against negative potential outcomes. If some action has a higher likelihood of leading to a negative outcome than a positive one, or the potential gains of an action are outweighed by losses, then most economic actors will avoid doing that action.
    - Arrow (1962a): in the real world, firms are unable to buy sufficient enough insurance against risk to properly invest in any risky activity, including “inventive” activities. By contrast, governments have “superior risk-bearing ability,” which means they’re more able to insure themselves against the potential losses of engaging in risky behaviour.
    - Imperfect information also means that information will be treated like a commodity, which is to say that anyone possessing information that others don’t have can earn a profit from said information. The problem is that information isn’t a pure private good: you can’t fully prevent other people from learning what you know, and you certainly can’t trade that information without the possibility of a third-party learning what you’re selling. This means there’s no market mechanism to ensure that scarce information gets where it’s most needed.
    - Innovation is very risky: the outcomes of innovation are, by its very nature, imperfectly known and it’s more likely that an innovation will flop than succeed. Additionally, information should optimally be free and as widely distributed as possible, but this would cut into the profit-margins of firms, so they’re less likely to invest in innovation as a result. Alternatively, mechanisms could be put in place to ensure that information is free, at the cost of creating a further disincentive for firms to invest in innovation.
    - Ultimately, in a free enterprise system will underinvest in innovation and research. Governments acting unilaterally are *one* possible avenue to make up this gap, though Arrow notes that government contracting activities have their own problems. He ends the article by suggesting an alternative source of innovation: “*There is really no need for the firm to be the fundamental unit of organization in invention; there is plenty of reason to suppose that individual talents count for a good deal more than the firm as an organization. If provision is made for the rental of necessary equipment, a much wider variety of research contracts with individuals as well as firms and with varying modes of payment, including incentives, could be arranged. Still other forms of organization, such as research institutes financed by industries, the government, and private philanthropy, could be made to play an even livelier role than they now do.”* The former could be framed as research grants to individual researchers, such as graduate students; the latter could be framed as increasing the importance of universities as a middleman to help turn government (and private) funding into commercialized research. In that case, the connection between graduate students and industry-university interactions would be important to highlight.
* *The Nature of Knowledge and Skills:* 
  + In economics, there are four types of goods, each categorized based on whether they are excludable (you can prevent another person from using it) and/or rivalrous (using a good reduces the total number of available goods).
  + Markets work best on pure private goods, which are excludable *and* rivalrous. Knowledge, however, is non-rivalrous and can only be excludable with extreme efficiency costs (ex: “tragedy of the anticommons”[[11]](#footnote-11)). Skills suffer from a somewhat different problem, in that skills are only scarce when skilled *people* are scarce.
    - Romer (1990): The production of knowledge or technology conflicts with traditional notions of supply and demand, but exogenous growth theories ignore this problem.
    - Emphasizes that no legal framework can ever make knowledge completely excludable, which means that if firms sell a product using non-excludable knowledge at marginal cost (i.e., their price is the efficient market price), the firm will never fully recoup the losses they incurred to make the good in the first place. Rivalrous knowledge can be introduced into an economics model, but only as the *product* of the use of knowledge—not knowledge itself.
    - As such, classical equilibrium—where an efficient market price is found and supply matches demand—is impossible. An alternative equilibrium is needed. This alternative model is one where governments either directly perform, or pay private firms to perform, basic research: the generation of non-excludable, non-rivalrous knowledge that subsequent goods are developed from.
    - Another implication is that firms only have an incentive to produce commercial inputs from basic knowledge if they can exploit what are called “Schumpeterian rents.”[[12]](#footnote-12) A Schumpeterian rent is profit that is derived from the fact that a good has no substitutes elsewhere in the market, which means that a firm can charge a much higher price for a good than they would in a perfectly competitive market. This leads to a situation of “monopolistic competition,” rather than perfect competition, meaning that markets are no longer perfectly efficient.
    - Governments thus play an essential role in financing basic research, as private firms lack the incentive to invest in things that aren’t immediately commercializable. Additionally, though, the presence of monopolistic competition means that markets means that the innovation system doesn’t possess the same incentives for efficient investment that are assumed by traditional, neoclassical economics models. If that’s the case, then government intervention doesn’t have the same inherent negative welfare implications: it’s more about whether the government is making effective decisions.
* *Creative Destruction:* 
  + Schumpeterian growth models are driven by frequent changes in market structure. This includes firms entering and exiting the market, monopolies being destroyed by new, innovative products, and entrepreneurs disrupting existing ways of organizing production. This process is referred to as “creative destruction.”
  + Schumpeterian growth models emphasize the important of innovation and innovators in driving economic growth, because of their disruptive nature. Faster growing economies have higher levels of innovation, meaning that they experience more frequent disruptions.
  + The impacts of these disruptions on the structure of markets, though, isn’t fully explored in many growth models.
    - Aghion and Howitt (1992): Assumes that private innovators are motivated to invest in research by capturing Schumpeterian rents, but that these rents are destroyed when a new firm creates an innovative product.
    - The value of a current research rent is negatively related to the possibility of a new innovative product appearing on the market. In other words, if firms expect a new invention to destroy their monopoly rents, they’ll be less incentivized to invest in research.
    - Creates the possibility of a “no-growth trap”: no inventions equals no growth. Firms will expect that an influx of new inventions will appear in the future to fill this inventionless gap, which discourages anyone from actually investing in research. Thus the economy never grows and there are no incentives for private business to move the economy out of this equilibrium.
    - An additional factor is that there will be an expectation that innovation brings higher wages for skilled workers, which erodes the monopoly rents of firms. Thus, firms will be less incentivized to invest in future research if more of their rents have to go to labour; but this has the effect of lessening the supply of skilled workers who actually create the innovations, because lower expected wages discourage individuals from investing in skills.
    - Therefore, laissez-faire economies risk having suboptimal levels of innovation, because a mixture of incentives prevents the market from reaching an efficient equilibrium.

Is there empirical evidence to back up the theory? Yes, with two highly supportive studies and two moderately supportive meta-regression analyses.

* Dimos, C. and Pugh, G. 2016. “The effectiveness of R&D Subsidies: A Meta-Regression Analysis of the Evaluation Literature,” *Research Policy* 45(4): 797-815.
  + Perform a meta-regression analysis to determine the efficacy of R&D subsidies (i.e., direct government funding to private firms for R&D).
  + They find no evidence of additionality—meaning that public R&D subsidies induce further private funding—but also find no evidence that public subsidies crowd-out private funding, meaning public subsidies do address a market failure in the form of private underinvestment.
* Bloom, N., Van Reenan, J., and Williams, H. 2019. “A Toolkit of Policies to Promote Innovation,” *Journal of Economic Perspectives* 33(3): 163-184.
  + Note that the social returns to R&D far exceed the private returns (60% to 15%), which shows a lack of ability for firms to fully internalize the costs (or benefits) of research. This provides justification for substantial public subsidies, especially for basic research.
  + Notes, too, that financial constraints can prevent firms from investing in innovative projects, though they also note that governments often lack information on the quality of a research project. They recommend against governments unilaterally *dictating* which projects to choose.
  + Note, too, the high correlation between private sector innovation and proximity to research-intensive universities, which they see as evidence that substantial basic research subsidies should go to universities first.
  + Finally, certain intellectual property policies can help commercialize innovation. Professors who own the rights to their innovations are more likely to commercialize, suggesting that knowledge which otherwise would have remained “in the ivory tower” ends up finding practical, commercial applications.
* Dimos, C., Pugh, G., Hisarciklilar, M., Talam, E., and Jackson, I. 2022. “The Relative Effectiveness of R&D Tax Credits and R&D Subsidies: A Comparative Meta-Regression Analysis,” *Technovation* 115(1): 102450.
  + In contrast it first study, they find evidence of positive additionality (crowding in) for both tax credits and subsidies, albeit both numbers are small.
  + Again, evidence suggests that both forms of government support mitigate a market failure in the financing of innovation.
  + Suggest that the benefits of subsidies increase over time as researchers, governments, and businesses interact and learn from one another. Positive relationships between the three sectors facilitate greater, positive impacts of government support for research.
* Fieldhouse, A.J. and Mertens, K. 2023. “The Returns to Government R&D: Evidence from U.S. Appropriation Shocks,” *Federal Reserve Bank of Dallas Working Paper.* 
  + Government non-defense R&D funding (i.e., research support that doesn’t involve the Pentagon) has substantial public returns: $1 of government funding has a ROI of $1.50 to $3.00.
  + Importantly, government R&D support directly increases total factor productivity: both the labour productivity component and potential output increases as a result of this spending.
    - This also shows that government support for research is *non-inflationary spending*: the productivity increases offset any increase in prices resulting from a shift in demand.
  + Also suggests that the slowdown in productivity growth in the United States has been caused by decreasing public R&D investment since the 1960s.

**4. Students as an Investment Vector**

*4.1. Contribution of Student Human Capital to Canadian Productivity*

Human capital remains the most important investment a government can make (see also: [*GSA Explainer on Human Capital*](file:///C:\Users\ajkemle\OneDrive%20-%20University%20of%20Calgary\GSA%20Explainer%20on%20Human%20Capital.pptx)). Trying to directly quantify the value of student human capital to Canada’s economy is difficult, however. The following is a back-of-the-envelope calculation based on the following article:

* Martin, F. 1998. “The Economic Impact of Canadian University R&D,” *Research Policy* 27(1) 677-687.

*Dynamic economic impact of university R&D = Total Factor Productivity (TFP) increases resulting from R&D spending*

*Student contribution to dynamic impact = increases to TFP resulting from human capital accumulation*

*Total graduate student contribution (plus spending from student tuition and fees):*

* **$6,254,812,500**

*Total undergraduate student contribution (plus spending from student tuition and fees):*

* **$4,955,546,875**

*Total aggregate student contribution:*

* **$11,210,359,375**

*Canadian GDP in 1997[[13]](#footnote-13):*

* **$655,990,000,000**

*Percentage of Canadian GDP from student TFP enhancements:*

* **(11,210,359,374/655,990,000,000) x 100 = 1.71%**

*Canadian GDP in 2023:*

* **$2,140,000,000,000**

*Student Contribution to 2023 GDP if % holds constant:*

* **$36,594,000,000**

In other words, if approximately 1.7% of Canada’s GDP is attributable to productivity enhancements from the human capital of students, then in 2023 this would equal **$36.6 billion**. Note that this doesn’t include contributions to Canada’s GDP through day-to-day consumption. Note, too, that it’s entirely possible the percentage contribution from students has *increased*, due to declining private sector investment in R&D and Canada’s unique reliance on higher education contributions to R&D. This number likely substantially underestimates the total contribution of students to Canada’s economy.

*4.2. Increasing Importance of “Soft-Skills”*

There’s growing evidence that labour markets are rewarding so-called “soft skills” or “higher order skills”—personality traits, motivations, critical thinking skills, and teamwork—at an increasing rate.

A sampling of the academic literature:

* Heckman, J.J and Kautz, T. 2012. “Hard Evidence on Soft Skills,” *Labour Economics* 19(4): 451-464.
  + Soft skills predict life achievement to a greater extent than traditional “cognitive skills” like IQ, though the importance of cognitive ability increases with the complexity of tasks.
  + Authors focus on benefits of early childhood interventions for building soft skills, but implication is that individuals who are better cooperators, more intrinsically motivated, and are more curious have higher lifetime earnings.
* Denning, D.J. 2022. “Four Facts about Human Capital,” *Journal of Economic Perspectives* 36(3): 75-102.
  + **“Fact #4: Higher-Order Skills Such as Problem-solving and Teamwork Are Increasingly Economically Valuable, and the Technology for Producing Them Is Not Well Understood.”**
  + “Higher order skills” involve applying existing knowledge to new situations, evaluating multiple sources of evidence, and collaborating with others in turning knowledge into concrete action. “Lower order” cognitive skills involve memory and recall.
  + *Lists experimental studies that directly tie social and teamwork skills to higher productivity levels*.
  + On-the-job experience in areas like communication and time management, as well as social skill training sessions for entrepreneurs, also show increasing productivity levels. One interpretation (not explicitly laid out in the paper) is that there’s some suggestive evidence that adults can still learn and improve these skills.
  + Good economic decision-making requires counterfactual thinking (i.e., the consideration of alternatives).
  + Cognitive empathy predicts strategic sophistication, allowing participants to solve complex problems quicker (ex: reaching Nash Equilibrium in a game theoretic environment more quickly).
* Deming, D.J. and Silliman, M.I. 2024. “Skills and Human Capital in the Labour Market,” *NBER Working Paper* (pre-print).
  + Builds a multi-dimensional model of human capital formation that takes into account the importance of “non-cognitive” skills and their development over a person’s educational lifecycle.
  + Model helps distinguish wages and productivity of workers who are able to better make collaborative decisions with those who can’t.
  + Model helps explain why teamwork, social skills, and good “economic decision-making” all predict higher lifetime earnings.

The main implication of these studies is that degree streams which rely heaviest on “soft” or “higher order” skills will start seeing increasing lifetime returns, and one of the most consistent mechanisms explaining these increasing returns is the connection between soft/higher order skills and productivity. These degree streams may teach in unconventional ways (ex: reading from works of fiction) and may not produce physical technology in the way engineering program might. However, the skills these students acquire create productivity gains and, thus, increase the economic returns for themselves and their firms, community, or local economy.

The return to lower-order cognitive skills might actually be *declining* due to the rapid progress of artificial intelligence (A.I.), which has automated many tasks that predominantly rely on memory and recall. Meanwhile, generative A.I. programs like Chat-GPT seems to act more as a *compliment* to human soft skills rather than a substitute. Thus, enhancing the level of soft skills will likely allow us to make increasing productivity gains by partnering with A.I.

If a government wants to grow the economy, it will want a post-secondary system that supports these degree streams. Importantly, it won’t defund or delegitimize degree streams that engage in counterfactual reasoning or learn through measures that enhance cognitive empathy, such as reading works of fiction. The more theoretically-oriented natural sciences, social sciences, and humanities all fit the description of degree streams that prioritize soft or higher order skill sets. As such, Canada’s post-secondary system should celebrate the education that students in these degrees, and recognize that in the age of A.I., these skills are only going to get more important.

Additional points:

* Knowledge diffusion is important: a decline in the ability for knowledge to diffuse through the economy (from patenting activity) is directly associated with a decline in business dynamism, and in turn drops in productivity and innovation.[[14]](#footnote-14) Teamwork and communication skills will help the diffusion of knowledge and, thus, help improve market dynamism and innovation.
* Countries on the technological frontier (i.e., that are closer to the bleeding edge of innovative technologies) are even more reliant on basic research education than those further from the frontier.[[15]](#footnote-15) This implies that the value of basic research only increases as economies become more innovative—and, thus, continual and increasing investments in basic research education in order for a country to remain internationally competitive.

**Appendix:**

*The drivers of economic growth*

Knowledge Systems

Innovation

Productivity

Growth

Human Capital

1. Arrow (1962a): <https://www.nber.org/system/files/chapters/c2144/c2144.pdf> [↑](#footnote-ref-1)
2. Kenneth J. Arrow. “The Economic Implications of Learning by Doing,” The Review of Economic Studies, Vol. 29, No. 3 (Jun,1962b): 155-173. <https://doi.org/10.2307/2295952> [↑](#footnote-ref-2)
3. Robert E. Lucas. “On the mechanics of Economic Development,” Journal of Monetary Economics 22, no. 1 (1988): 3–42. <https://doi:10.1016/0304-3932(88)90168-7>. [↑](#footnote-ref-3)
4. Paul M. Romer, “Human Capital and Growth: Theory and Evidence,” Carnegie-Rochester Conference Series on Public Policy 32 (March 1, 1990): 251–86, <https://doi.org/10.1016/0167-2231(90)90028-J> [↑](#footnote-ref-4)
5. Paul M. Romer, “Endogenous Technological Change,” Journal of Political Economy 98, no. 5, Part 2 (October 1, 1990): S71–102, <https://doi.org/10.1086/261725> [↑](#footnote-ref-5)
6. Paul M. Romer, “The Origins of Endogenous Growth,” Journal of Economic Perspectives 8, no. 1 (February 1, 1994): 3–22, <https://doi.org/10.1257/jep.8.1.3>. [↑](#footnote-ref-6)
7. Richard R. Nelson and Paul M. Romer, “Science, Economic Growth, and Public Policy,” Challenge 39, no. 1 (January 1, 1996): 9–21, <https://doi.org/10.1080/05775132.1996.11471873>. [↑](#footnote-ref-7)
8. Acemoglu, Daron (2009). "Endogenous Technological Change". Introduction to Modern Economic Growth. Princeton University Press. pp. 411–533, [↑](#footnote-ref-8)
9. Acemoglu (2009): <https://www.nber.org/papers/w32190> [↑](#footnote-ref-9)
10. Bloom, Sadun, and Van Reenan (2016): <https://www.nber.org/papers/w22327> [↑](#footnote-ref-10)
11. Heller (2013): <https://scholarship.law.columbia.edu/cgi/viewcontent.cgi?article=2779&context=faculty_scholarship/1000> [↑](#footnote-ref-11)
12. Named after Austrian economist Joseph Schumpeter. [↑](#footnote-ref-12)
13. The year the article was submitted. [↑](#footnote-ref-13)
14. Akcigit and Ates (2019): <https://www.nber.org/system/files/working_papers/w25756/w25756.pdf> [↑](#footnote-ref-14)
15. Aghion, Akcigit, and Howitt (2013): <https://www.nber.org/system/files/working_papers/w18824/w18824.pdf> [↑](#footnote-ref-15)