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THE DYNAMICS OF IDEA GENERATION FOR TECHNOLOGICAL PROGRESS AND ECONOMIC GROWTH

1. INTRODUCTION

In the contemporary landscape of global economic development, the intricate relationship between the generation of ideas, technological progress, and economic growth stands as a cornerstone of scholarly and practical interest.

This interplay is eloquently captured in the concept of Total Factor Productivity (TFP), or Solow's Residual (Solow, 1956), where economic output Y(t) is a function of capital K(t), labour L(t), and technological knowledge A(t) as shown in Figure 1:

$$\boxed{Y(t) = F\left[K(t), L(t), A(t)\right]}$$

Figure 1 - Aggregate Production Function (Acemoglu, 2012)

However, a critical aspect often needs to be explored: the nature of technological progress itself. As prominent economist Daron Acemoglu (2012) highlighted, *"Technological progress itself is exogenous, just a black box, outside the model and outside the influence of economic incentives. If technological progress is 'where it is at', then we have to study and understand which factors generate technological progress".*

This essay aims to delve into the complexities of idea generation, examining the challenges and potential strategies to enhance this process, thereby fuelling technological and economic growth in a rapidly evolving world. By connecting the dots, we will explore the relationship between economic growth, technological progress, and the generation of new ideas, with particular emphasis on the latter.

2. CHALLENGES IN GENERATING NEW IDEAS

Generating new ideas, a critical fuel for technological progress, is becoming increasingly arduous. The division of labour is heralded as a pathway to specialisation and efficiency. Adam Smith (1776) had already posited that *“the greatest improvements in the productive powers of labour, and the greater part of the skill, dexterity, and judgment with which it is anywhere directed, or applied, seem to have been the effects of the division of labour."* More recently, César Hidalgo (2015) extended this idea that to function, societies need to distribute know-how across brains to create new patents that drive economic complexity.

Nonetheless, this principle is now encountering a critical juncture. As detailed in "Are Ideas Getting Harder to Find?" (Bloom *et al.*, 2020), the marginal benefits of further specialisation might be diminishing. Given that exponential growth in research leads to exponential growth in technological progress, nonrival ideas lead to exponential growth in per capita income (Figure 2).

$$\underbrace{\text{Economic growth}}_{\text{e.g., 2\% or 5\%}} = \underbrace{\text{Research productivity}}_{\downarrow\text{(falling)}} \times \underbrace{\text{Number of researchers.}}_{\uparrow\text{(rising)}}$$

Figure 2 - Economic growth that emerges from idea-based growth models (Bloom *et al.*, 2020)

$$\text{Research productivity} := \frac{\dot{A}_t/A_t}{S_t} = \frac{\text{number of new ideas}}{\text{number of researchers}}$$

Figure 3 – The equation of research productivity (Bloom *et al.*, 2020)

By considering the Total Factor Productivity (TFP) as the main leverage for economic growth (Solow, 1956), the decrease in research productivity is currently offsetting the benefits that come from the increase in the number of researchers (see Figure 3), making the research productivity reduce by half every 13 years. This decrease in research productivity can be clearly seen in Figure 4.

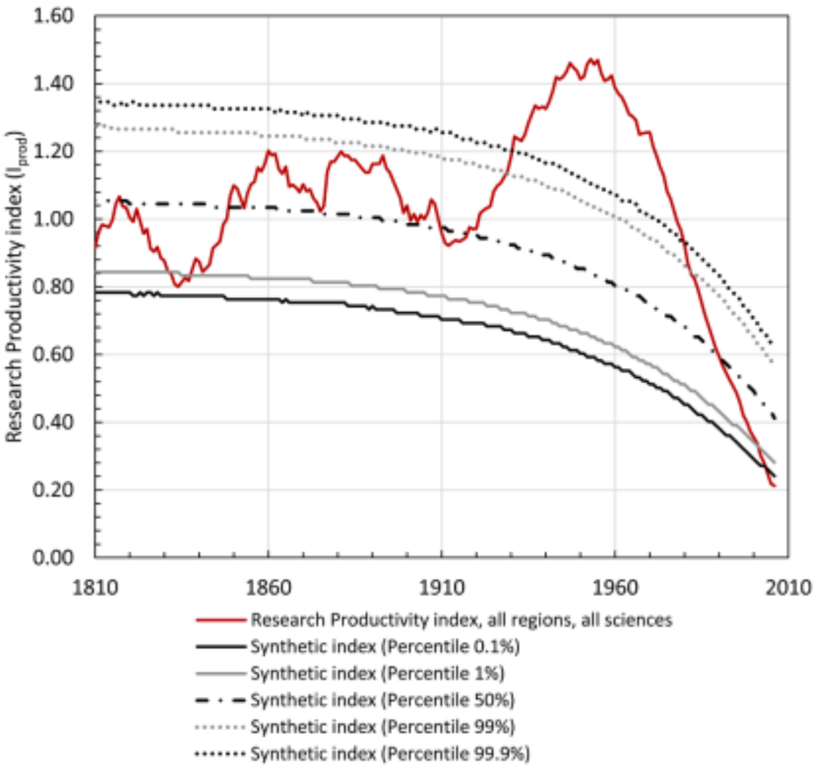


Figure 4 - Research productivity index (Cauwels and Sornette, 2022)

With that also comes the incentives for creating new ideas vis-à-vis the best practices to foster creative environments. The economic pressure to develop new ideas that can be transformed into products as fast as possible produces a psychological hindrance that negatively affects how researchers might perform in the creation of new ideas. The case of the Bell Labs illustrates that (Georgescu, 2022). After becoming one of the most innovative hubs of the planet with an account of eleven Nobel Prizes, four Touring Awards and inventions like the transistor, the laser, and the photovoltaic cell, it fell into decay after being acquired by a giant telecommunications corporation that, on the haste of developing new products, got exactly the opposite of that. By losing its main cultural aspects like sustaining research simultaneously as a focused and non-distracted activity with the "non-scheduled area of work", translating to no deadlines, objectives, or progress reports, it lost the ability to explore creativity at its greatest.

This phenomenon suggests a need for a paradigm shift towards recombination—a fusion of diverse specialised knowledge to foster novel ideas. The challenge lies in transcending traditional boundaries of specialisation to harness the synergistic potential of varied expertise and sustaining environments that allow for the best use of human intelligence and creativity.

From a social viewpoint, the polarisation of ideas poses a significant impediment. The deep ideological divides hinder the cross-pollination of ideas, particularly at the extremes of the spectrum, which is an essential element for practical creativity (Csikszentmihalyi, 1996). This polarisation reduces the diversity of thought and limits the collaborative spirit essential for innovation.

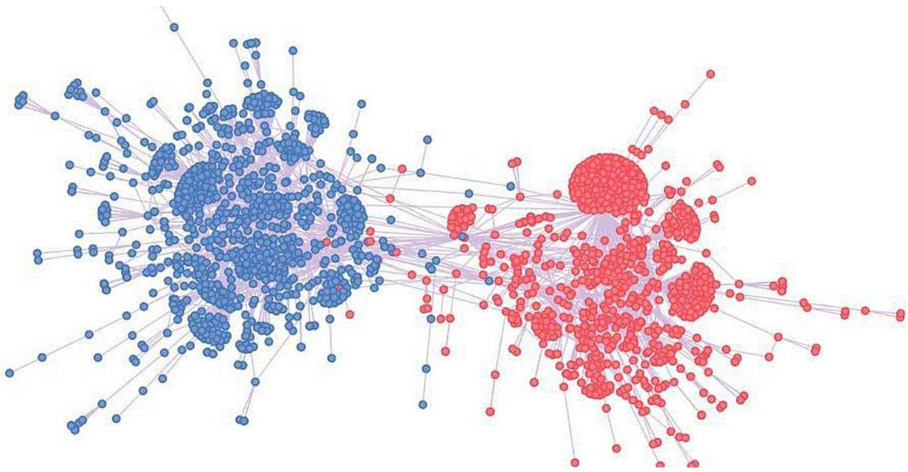


Figure 5 – The structure of a polarized discussion on Twitter or Facebook (Hampson, 2021)

Additionally, the growing influence of social media on intellectual engagement cannot be overlooked, as research equates social media's impact to that of 'the new smoking' (Sridhar, 2023), and the dangers of its addictive nature and encouragement of shallow, scattered thinking over deep, focused contemplation (Carr, 2011). This superficial approach to information consumption and interaction undermines the depth of thought required for meaningful idea generation. The challenge is navigating and mitigating these social and technological trends, contributing to a less contemplative, more fragmented intellectual landscape.

3. STRATEGIES FOR FOSTERING IDEA GENERATION

In response to the challenges of generating new ideas, exploring and implementing strategies that can invigorate the process of innovation is essential. Cross-pollination and recombination in ideas are pivotal in overcoming the stagnation caused by excessive specialisation (Grodal and Thoma, 2014). This approach requires significant educational and research infrastructure changes to facilitate more dynamic and interdisciplinary interactions. To foster an environment where diverse ideas can merge and evolve, educational systems and research institutions must encourage interdisciplinary studies and collaborative projects.

These reforms should aim to break down the silos of specialisation, allowing for a richer exchange of knowledge and perspectives. Mathematically, the probability of discovering valuable ideas can be increased through combinatorial growth (Jones, 2021). Visually, the highlights of Paul Baran (1962) highlights the importance of redundancy and connectivity to demonstrate how distributed networks can maintain performance over centralised ones.

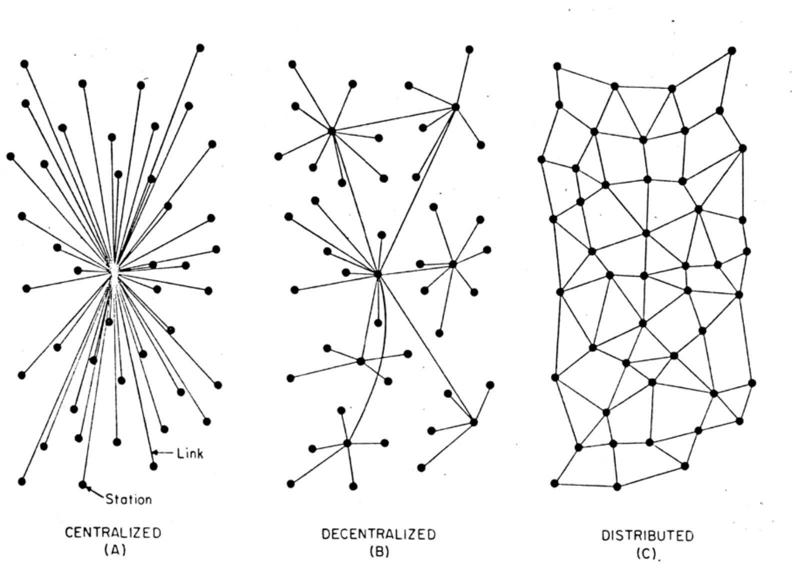


Figure 6 – Centralised, decentralised and distributed networks (Baran, 1962)

We exponentially expand the number of possible ideas by introducing more elements or concepts that can be combined in various ways. This expansion, akin to adding more ingredients to a recipe, increases the chances of stumbling upon highly productive or innovative ideas (Jones, 2021). The key is the diversity and quantity of elements at play, which enhances the likelihood of forming combinations that yield significant value or breakthroughs. However, only new connections might not harvest the full advantages of complexity. Weaver (1948) introduces a new category of scientific problems known as "organised complexity," distinct from the traditional categories of "problems of simplicity" and "disorganised complexity." He argues that many real-world problems fall into this new category, characterised by a significant number of interrelated variables, thus defying solutions by simple equations or individual action. Thus, there is a need for interdisciplinary approaches and the development of new scientific methods to address these complex problems through collaboration.

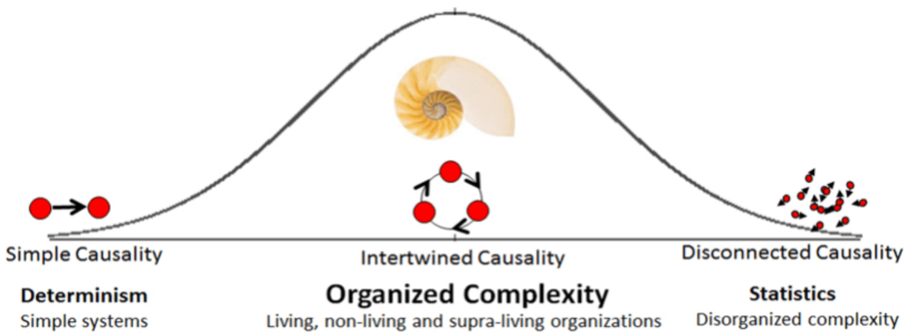
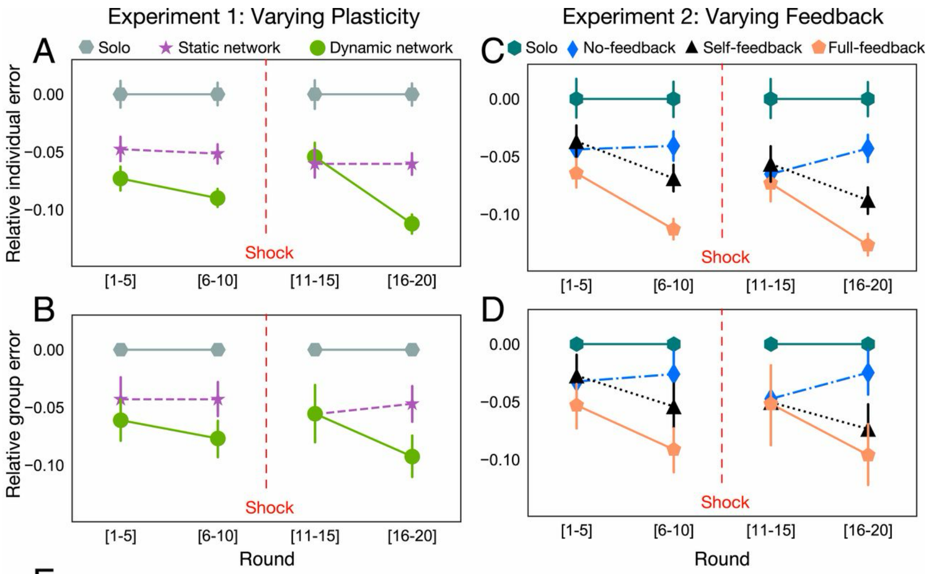


Figure 7 – Organised complexity (2019)

Drawing from Romer (1990), it is crucial to recognise that ideas are nonrival. They can be simultaneously used and developed by multiple entities without depletion. This characteristic of ideas is fundamental in driving exponential growth in research productivity and per capita income, as it allows for widespread dissemination and application of knowledge. From a practical standpoint, research (Almaatouq *et al.*, 2020) suggests that the structure and evolution of interpersonal communications are vital in promoting adaptive collective intelligence, as seen in Figure 8. Fostering these skills can enhance the capability of individuals and groups to effectively share and develop ideas, thereby boosting the overall idea-generation process.



E

	Condition	Individual error: Mean absolute error	Individual error: Standard deviation	Collective error: Mean absolute error	Collective error: Standard deviation
E_1	Solo (feedback)	**0.25 (baseline)**	0.22	**0.21 (baseline)**	0.11
	Static network	0.19	0.19	0.16	0.10
	Dynamic network	0.16	0.18	0.14	0.10
E_2	**Solo (no feedback)**	**0.26 (baseline)**	0.23	**0.21 (baseline)**	0.11
	No-feedback	0.21	0.20	0.18	0.12
	Self-feedback	0.19	0.2	0.16	0.11
	Full-feedback	0.16	0.18	0.14	0.11

Figure 8 - Individual and collective outcomes from varying plasticity and feedback (Almaatouq *et al.*, 2020)

Even though most breakthrough scientific discoveries come from STEM (science, technology, engineering, and mathematics), training scientists on conversational skills (Connolly and Rianoshek, 2002), for instance, might enhance their performance in coming up with new ideas by enhancing their ability to collaborate (Gordon, 2014).

Given the adverse effects of social media on the depth of thought, especially among younger demographics, there is a pressing need to regulate its usage. Limiting children's and teenagers' access to social media can help avert the 'shallowness' of thought processes induced by these platforms (Carr, 2011). Such regulation could encourage more profound, contemplative thinking and learning habits, essential for innovative idea generation. Beyond mere restriction, it is also important to guide young users towards more meaningful and productive use of digital platforms. That could involve promoting educational content, encouraging creative expression, and facilitating constructive online interactions.

4. CONCLUSION

From the assumption that economic growth is inextricably linked with technological progress, the creation of new ideas is paramount to support this system from a practical economic approach, considering that this kind of growth might be the only one that can be environmentally sustainable given the potential zero marginal cost and nonrivalry of ideas.

Understanding how we can create incentives for the recombination of ideas to create new ones that revert the diminishing research productivity is crucial. Theories on how humans interact productively converge in the sense that the diversity of specialisations if constantly recombined, can lead to an increase in the generation of new ideas.

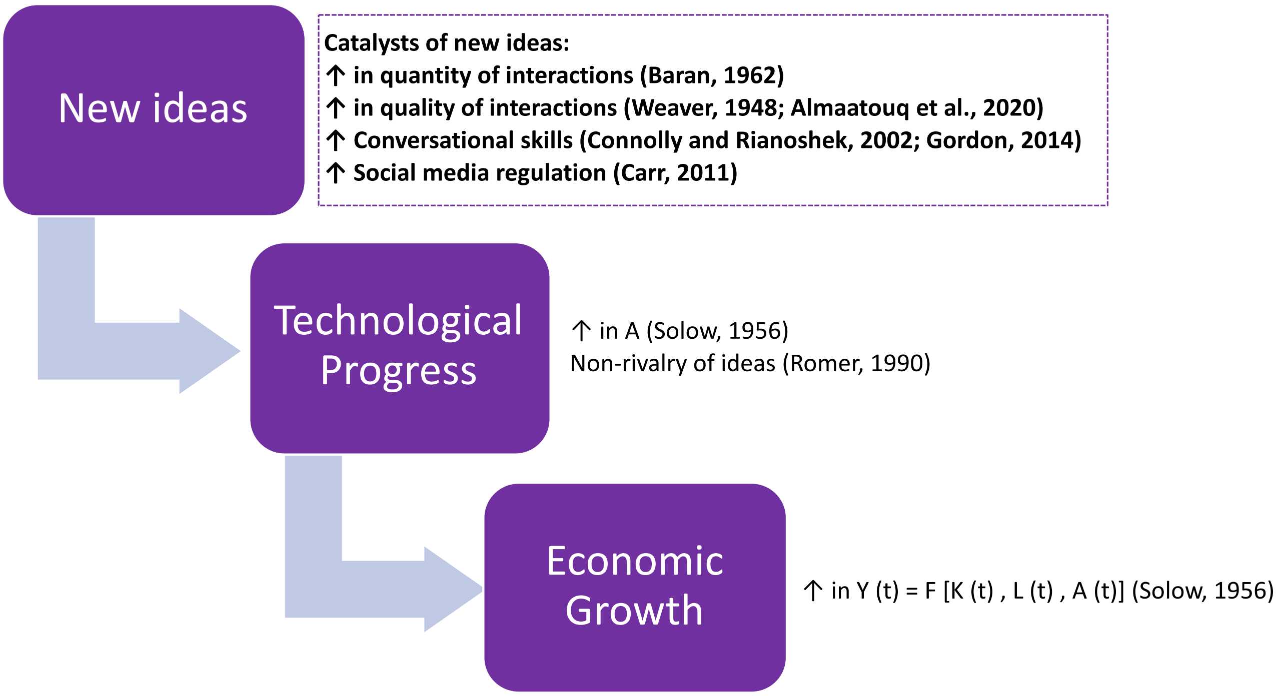


Figure 9 – Possible actions to foster new ideas and their impact (Penna, 2024)

The core idea of this article is to highlight the opportunities for changes in interactions between the scientific community and society in general that can be undertaken to foster new ideas as a driver for economic growth.

There are important caveats. It is still necessary to test this principle in different cultures and environments and have sufficient empirical data to guide broad-scale public policy on science, education, and business for the sake of new ideas. Also, economic growth is affected by a plethora of variables considered ceteris paribus for this analysis. The recommendation is that further discussions consider that.

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