EC331: Research in Applied Economics

Assignment 1: Project Proposal

Maximilien Delaporte
(U2126980)
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1. Project Outline

1.1. Research Theme

"*The Impact of Artificial Intelligence on Fertility, Innovation, and Growth: How could the automation of childcare affect economic growth?*"

1.2. Research Motivation, Significance, and Contribution to the Literature

The recent emergence of widely available generative artificial intelligence (AI) models, such as OpenAI's GPT series, has showcased their transformative capabilities across a diverse range of sectors – from research and manufacturing to entertainment. This development has propelled AI into the public spotlight, fuelling both excitement and critical discourse about its potential impact on the future of humankind, whether positive or negative.

In the field of economics, literature on AI's potential effects tends to focus on prominent topics such as the changes AI would bring to human capital accumulation, the replacement of labour with capital through automation, and the implications of these on economic growth. However, AI's vast potential across virtually every production sector makes it incredibly challenging to predict exact outcomes, and its novelty means the academic community has yet to reach a clear consensus.

Because of its revolutionary potential, it is crucial that policymakers and economists understand as many potential effects of AI as possible and how they may interrelate, so that economic policy can accurately maximize the benefits and minimize the downsides of the AI revolution.

I was particularly inspired when I learned about the Semi-Endogenous Growth (SEG) model in my applied macroeconomics class this year – a framework which appears frequently in academic papers discussing AI's impact on growth. During the same course, I also explored Doepke *et al.* (2023)'s model of endogenous fertility, which can be integrated into the SEG model. Combining these insights, I realized that there is an unexplored aspect regarding AI's effects on population growth.

A hypothesis that has not been thoroughly studied is that AI could bring significant changes to the household dynamics of fertility, which in turn affects economic growth. If this hypothesis holds true, it could significantly influence the way we understand the implications of AI technology's development. In the few papers that discuss AI on fertility, arguments have been made about it impacting different parameters which contribute to fertility through changes in labour market dynamics, but not about AI changing the dynamics of fertility itself. The reason they give for that is that AI cannot contribute to the production of humans, but nothing is said about AI's potential to change household dynamics through the automation of certain parenting tasks. This came to me as a surprise as multiple observable phenomenon seem to point towards the possibility of automating at least certain parts of childcare and education: the start of an automation-focused transition

of certain elder care clinics in Japan, one of ChatGPT's most prominent uses being as an aid for education, the increasing use of '*smart-home*' gadgets, etc. These changes are all relatively new and the kinks of how AI will be implemented to automate household, educational, or certain parenting tasks haven't yet been worked out. Nonetheless, if we consider that AI could soon replace complex non-routine jobs (which is the basis for most of the literature on the subject), it doesn't seem abnormal to think that it could also replace similar non-routine tasks within households. This gap in the literature motivates the present study. In filling it, we take a small step toward explaining the effects of AI on all the – so far overlooked – factors that contribute to growth.

1.3 Objective & Methodology

This paper aims to contribute to the better understanding of AI's impact on both economic growth and fertility. The objective is to establish a model (based on the SEG model) that enables future research to explain changes in both variables within an economy where AI is has developed enough to contribute to (1) labour output, (2) idea production, and (3) parenting tasks. To do so, we will first focus on how economists currently see AI affecting economic growth, keeping population growth exogenous. Next, we will look at recent papers which discuss AI's impact on fertility, draw inspiration from them, explain the relevance of our approach, and how it differs from theirs. After mentioning other potentially relevant models, we will construct our own using mechanisms scattered throughout the existing literature. The structure of our model should resemble that of a standard SEG model, with endogenous fertility and endogenous automation of tasks in all the model's sectors: final good production, idea production, and childcare.

2. Literature Review

The standard SEG framework identifies population growth as the key long-term source of economic growth, primarily because it helps mitigate the decreasing returns associated with idea production. Jones (2022) warns that recent data indicate a worldwide slowdown in population growth, which poses a threat to sustained economic growth. In his paper, he briefly mentions AI's potential as a new driver of sustained growth, by possibly replacing population growth in mitigating the decreasing returns of the SEG model's idea production function. In this case, this is done by implementing a task-based approach (which is discussed later) into the dynamics of idea creation. If the assumption of this being possible holds, our prediction is twofold: (1) AI automation can bring level-effect shocks to fertility through its alteration of labour-market and idea production dynamics, and more importantly (2) the development of AI can bring growth-effect shocks to fertility by disrupting household dynamics through the automation of parenting tasks. While we aim to construct a model which captures the interplay of these two phenomena, our main focus is on the latter, due to it currently not being described in the literature.

2.1. AI in the Semi-Endogenous Growth Model

The foundational framework for modelling AI automation in SEG models stems from Zeira (1998) and Acemoglu & Restrepo (2018). Zeira's (1998) partial equilibrium model serves as a cornerstone by highlighting the sector-heterogeneity of the labour-replacing nature of technological advancements. The paper introduces this concept through the inclusion of two different intermediate goods – later broadly referred to as "tasks" – in the economy's production function, which are each transformed into final output by a *different* combination of labour and capital where the labour factor share is decreasing with automation. Building on this, Acemoglu & Restrepo (2018) advance the literature by providing a dynamic framework where automation reduces labour demand in existing tasks while new tasks emerge in which labour has a comparative advantage, possibly sustaining labour's role in production. Their approach integrates automation's displacement and new task creation into a general equilibrium setting, addressing factor shares and long-term labour market trends. This '*task-based*' approach bridges Zeira's (1998) model and subsequent SEG models by offering a richer perspective that captures the nuance of automation's impacts on labour, innovation, and macroeconomic outcomes. Their later papers (2020, 2022) extend this framework by empirically analysing automation's labour market impacts: the 2020 study quantifies job and wage losses from industrial robots, while the 2022 paper links automation-driven task displacement to rising U.S. wage inequality. In short, Zeira (1998) and Acemoglu & Restrepo's (2018) task-based approach deepen the theoretical foundations for understanding AI's role in economic restructuring and have since been embedded in growth models to explore AI-driven innovation and knowledge production.

Building on these foundations, Aghion *et al.* (2019) integrate the task-based approach of AI automation into SEG models, emphasizing the impact of automation on both final goods *and* idea production. This framework, referenced by Jones (2022), allows us to model the possibility of AI replacing *all* human tasks within the SEG model. By highlighting AI's potential to mitigate the decreasing returns in idea production, it challenges the notion that

population growth is the sole driver of sustained economic growth in the SEG framework. However, this framework has limitations. Both papers mention a – "non-trivial" according to Jones (2022) – chance of a *singularity* occurring. A mathematical scenario where the model predicts that the stock of knowledge, and ultimately the economy, grows infinitely in finite time. This outcome depends on several questionable assumptions, including positive exponential population growth and the fraction of automated tasks increasing rapidly enough to equal the decreasing returns parameter of the idea production function. While the concept of a singularity may have entertaining science-fiction-like implications, its occurrence is problematic because it reveals a flaw in the current modelling of AI automation. In practice, both the notions of infinite growth of ideas in finite time, as well as of a "best idea" (as described in Jones (2022)), seem unfeasible, from a physical standpoint if nothing else. The conditions in which singularities occur, however, are not, which limits the model's applicability.
As a result, Aghion *et al.*'s (2019) framework restricts our analysis of AI's impact on fertility and growth by forcing us to set significant limits on AI's capacity to replace humans. This is because in the context of our study, the possibility of a singularity presents troublesome implications: the economy doesn't reach a Balanced Growth Path (BGP), which renders AI's impact on growth through fertility irrelevant if growth becomes infinite – especially if we expect AI to automate certain parental tasks, which we could assume would only boost the already infinite economic growth. Ideally, we would need to find or construct a model which includes the endogenous automation of idea creation, but which eliminates the possibility of a singularity occurring without imposing arbitrary bounds on what AI could potentially achieve.

Gries & Naudé (2020) bring a refreshingly nuanced angle by proposing a new type of SEG model where idea creation is exogenous, but the diffusion of these ideas into the economy is endogenously determined through market dynamics. This approach departs from existing literature by shifting the determinant of the economy's growth rate from the *supply* of new technologies to the *demand* for them. Specifically, they treat the rate of idea creation (g_A) as exogenous, while endogenous market frictions - such as adoption costs and institutional barriers - restrict the diffusion of those ideas. This mechanism effectively mitigates the singularity problem encountered in Aghion *et al.* (2019), as it allows us to prevent infinite growth by accounting for realistic delays and obstacles in technology adoption, rather than setting arbitrary bounds to its development.

Their model also provides pertinent insights into labour market dynamics, illustrating how the pace at which new technologies are adopted can impact employment rates, wage structures, and the demand for different skill levels. This is particularly relevant for our study as it aligns with examining how AI influences not just economic growth but also demographic factors like fertility.

However, to use their model as a baseline for our research, significant modifications are necessary. We need to make the population size non-static to endogenize idea creation, reflecting how a changing population affects innovation. Additionally, endogenizing population growth is crucial for integrating our fertility model into the framework. While these changes add complexity, they are essential for accurately capturing the interplay between AI, fertility decisions, and economic growth. By adapting their model in this way,

we aim to explore how AI-driven technological diffusion influences fertility rates and, in turn, shapes long-term economic trajectories.

2.2. AI and Endogenous Fertility:

As mentioned in part (1.2.), the literature on AI's effect on fertility is very scarce, and the few papers that *have* been published haven't gained much traction.

Wei and Xie (2022) present a model where AI impacts fertility through mechanisms different from those we aim to explore. Their model examines how AI indirectly influences fertility by altering the time cost associated with childbearing due to changes in labour market dynamics and household income structure. While this is an interesting perspective, it is not the mechanism we intend to analyse. In their work, AI is treated as a technology that automates labour market tasks but does not directly participate in the automation of idea creation or, more relevantly, parenting tasks. Although their paper offers valuable insights into the interaction between AI, fertility, and growth, its focus on indirect mechanisms and the time-cost trade-off limits its relevance to our objective of integrating AI more directly into the population growth aspect of the SEG framework. (Other academic papers with similar framework limitations are referenced in part (3.2.))

Our best bet so far for constructing our model for endogenous fertility would be to use Doepke *et al.* (2023) as a baseline model, incorporating the task-based approach from Zeira (1998) and Acemoglu & Restrepo (2018) into the completion of parenting tasks, in a way which resembles how we will incorporate it into the creation and implementation of ideas. The main intuition being that the level of AI automation and its implementation into parenting tasks (both endogenously defined by our SEG model) disrupts current endogenous fertility dynamics. In doing so, we test the hypothesis that AI's development has the potential to create much more consequential effects (positive or negative) to population growth than the ones that the literature currently highlights.

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