Voluntary Extinction

Literature Review

ENV 299/399: Simulating Complexity, Chaos, and Emergence

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Introduction

The world has suffered a decrease in fertility rates over recent decades. One-half of the population lives in countries where the total fertility is lower than 2.1 births per woman. Countries and policy-makers face increased pressure, as some countries have reached record-low birth rates. Many European countries are experiencing rates between 1.0 and 1.4, with family sizes of 1.4 to 1.6 per woman born in the mid-1970s (Sobotka *et al*., 2019) and South Korea has even reached rates as low as 0.70 in 2023.

Economic uncertainty, cultural shifts, work-life balance challenges, and educational and career pursuits are factors leading to this lack of fertility (Wilkins, 2019). This decrease in fertility rates can pose many consequences on our society, including straining pension systems and healthcare resources and affecting other sectors like agriculture (Albuquerque & Lopes, 2010).

As a result, many governments have increasingly tried to implement family-friendly and more inclusive housing policies and incentivize certain behaviors, like increased paternal involvement in the household (Fanelli & Profeta, 2021). However, even though certain countries have been able to apply successful policies to increase fertility rates, finding the most appropriate approach for each situation and evaluating the response to each measure is complicated, as individual policies are often embedded in a wider institutional and cultural context (ELA, 2022). Hence, this literature review aims to understand the underlying causes of the recent decrease in fertility and to assess the efficacy of these policies, including assessing the compatibility of different policy instruments.

Causes of low fertility rates

Gender roles have an impact on childbirth intentions as research shows that, in general, females tend to have a lower willingness for childbirth than males (Kim & Kim, 2023). Ji and Jung (2021) revealed that although having multiple children is an incentive for men, this is not the case for women. One of the reasons for this is that women often need to bear additional childcare burdens as primary caregivers in the household and the only way to

prevent fertility from falling to even lower levels could be through improvements in gender equality (Hellstrand *et al*., 2021). The reason for this is that a non-egalitarian patriarchal society allows men to avoid actual caregiving by providing monetary support for the family through taking on paid work in the labor market (Alderotti *et al*., 2021). Meanwhile, women usually take on a more suppressed role and are expected to provide unpaid care work for the family (Lee, 2016). To prevent sacrificing career opportunities in favor of care work in the household, there has been a widespread postponement of fertility in most high-income countries which has been linked to rising educational enrollment and career building (Hellstrand *et al*., 2021) and in mothers' education levels (Hur, 2021). However, as childbearing age increases additional factors come into play, as health concerns also lower child-bearing intentions (Yi *et al.*, 2020).

In addition to the role of gender equality in the household, occupational factors impact workers' childbearing intentions as well (Yi *et al*., 2020). Family-friendly workplace policies that grant guaranteed maternity leaves and on-site childcare centers are proven to be effective in increasing workers' childbearing intention (Kim & Parish, 2022). However, it is shown that, especially in Asian countries, the majority of working women are often deprived of family provisions at their workplaces (Kim & Sun, 2017). Consequently, poorly implemented childbirth incentives in workplaces hinder employees' childbirth intentions.

Aside from the heavy childcare burden falling on women, the household's socioeconomic resources are also proven to be influential in family-building decisions. There is a negative association between increased economic uncertainty and short-term parenthood intentions (Fahlen & Olah, 2019). However, some research has conflicting views on the importance of job security in shaping fertility intentions: Lim (2021) claims that a husband's employment security has a strong positive association with fertility intention. But Ji and Jung (2021) found that even men who hold a temporary work position receive work-family gains and consequently also have increased fertility intentions, although temporary work may imply that the husband's employment security is unstable. Furthermore, securing stable

housing arrangements also plays a significant role as it is shown that an increase in real estate prices leads to a decline in births among people who do not yet own any (Dettling & Kearney, 2014).

Impact/Consequences of low fertility rates

Low and decreasing fertility rates can impact countries in a variety of ways. Through aging, it can impact economies and healthcare directly or indirectly (Kim & Sun, 2017; Nakatani, 2019). Additionally, a disparity is observed between rural and urban areas in both these sectors.

Although an economy may experience growth under an aging population, the consensus is pessimistic. First, economic impacts can be estimated with projections. Both Ortega-Gil *et al*. (2022) and Albuquerque and Lopes (2010) predict potential for economic growth under aging. The latter decomposes the growth into sectors: In the case of Portugal, health, pharmacy, and real estate may gain importance, while education and social security services will lose importance. These studies exhibit the possibility that aging can stimulate economic growth. Ultimately though, it is widely believed that if populations decline, quality of life and economies will stall (Jones, 2020). This is particularly evident in Japan with demographic imbalances, depletions of the labor force, decreases in national incomes, increased income inequality between generations, and strained pension systems (Hong & Schneider, 2020).

Overall, this phenomenon can be explained by fewer people entering the workforce and an increased burden to support the elderly (Hong & Schneider, 2020; Parsons & Gilmour, 2018). As these are both consequences of aging, this evidence suggests that low and decreasing fertility impairs the economy.

In addition, due to aging, low fertility negatively affects healthcare systems. To begin, Parsons and Gilmour (2018) and Cheng *et al.* (2020) both model an increase in the dependency ratio and mortality respectively — higher dependency ratios and mortality rates burden healthcare systems as more resources are required to support the older population.

These projections are supported by both Nakatani (2019) and Tanaka and Iwasawa (2020), who report the increasingly strained Japanese healthcare systems, such as increasing medical costs, and a lack of caregivers, physicians, and medical services. Hence, more seniors needing medical care will further worsen the issue. However, it is projected that healthcare advancements and growth in aging nations are still attainable (Albuquerque & Lopes 2010; Ortega-Gil *et al.* 2022). In conclusion, evidence and modeling suggest there is impending pressure on health systems in low-fertility countries.

Finally, low fertility rates affect the economy and healthcare in urban and rural areas differently. To begin, rural economies are at risk of shrinking, as farmers in countries like Japan are not succeeded by their families (Poungchompu *et al*., 2012). This is due to decreasing fertility rates and shifting attitudes. Likewise, rural Japanese elders and families have pressures on personal support systems, due to inadequate rural healthcare (Tanaka & Iwasawa, 2010). On the other hand, the urban situation presents differently. Despite having lower fertility rates than rural areas, urban areas can continue to achieve growth and urbanization (Lerch, 2019; Jones, 2020). This is thanks to both rural-to-urban migration and international migration, which can raise fertility in urban areas (Lerch, 2019; Baffour *et al.*, 2023). Thus, urban areas will still maintain the possibility for growth in population and economy that rural areas may not. Furthermore, evidence shows that urban areas typically receive higher-quality medical services with greater ease (Tanaka & Iwasawa, 2010; Hirayama & Miyazaki, 1996, Clark *et al*., 2021). Therefore, as countries, it is also likely that the already under-serviced rural healthcare systems of Japan will face more stress than their urban counterparts.

Solutions

There are a range of approaches to reduce the impact of decreasing birth rates. Governments have been constantly trying to find solutions and apply policies that will limit the decrease in birth rates such as financial incentives, housing regulations, childcare

subsidization, and increased parental leaves (Zhang *et al.,* 2021). Yet, finding the most effective policy for each situation is often a complex task (Zheng *et al.*, 2023).

Some research focuses on studying the different approaches and the clusters of countries with comparable packages of family policies. Sobotka *et al*. (2019) found the following in Europe:

- Nordic countries have focused mainly on providing support for working parents with small children and boosting fathers' involvement in care,
- Continental European countries, like Germany and France, have aimed for more conservative policy models with gradual support of women's employment and work-family reconciliation.
- Some Eastern European countries have favored supporting early childcare provision.

Yet, measuring their long-term impact is challenging as the period fertility reflects changes in both family size and the timing of births (Hellstrand *et al.*, 2021). So quantum and tempo effects need to be considered when new policies are implemented.

When deciding which kind of policy to apply, it is important to understand the situation and needs of the region (Zheng *et al.,* 2021). For instance, the 2007 German maternity leave reform, which changed maternal compensation and introduced earnings-related benefits, successfully achieved substantial pro-natal effects, including discontinuous jumps in monthly birth rates and an increase in the probability that higher-educated women would have children. The motivation behind this policy was that "highly educated and high-earning women have fewer children over a lifetime than their less-educated and lower-earning peers" due to their higher opportunity cost of having children (Raute, 2019). Generally speaking, significant reforms in public health care and parental leave have substantial and lasting effects on fertility, illustrating how family-friendly policies contribute to improving fertility rates across countries in Europe (Bergsvik *et al*., 2021).

Another possible solution is boosting immigration, which lowers the dependency ratio and increases birth rates, depending on factors like country of origin (Baffour *et al*., 2023). However, according to projections from Bermingham (2001) and Parsons & Gilmour (2018), immigration is ineffective for most countries given the large numbers required to reverse the decline in their populations. For instance, South Korea would need to accept 93.6 million people per year to offset its aging (Bermingham, 2001).

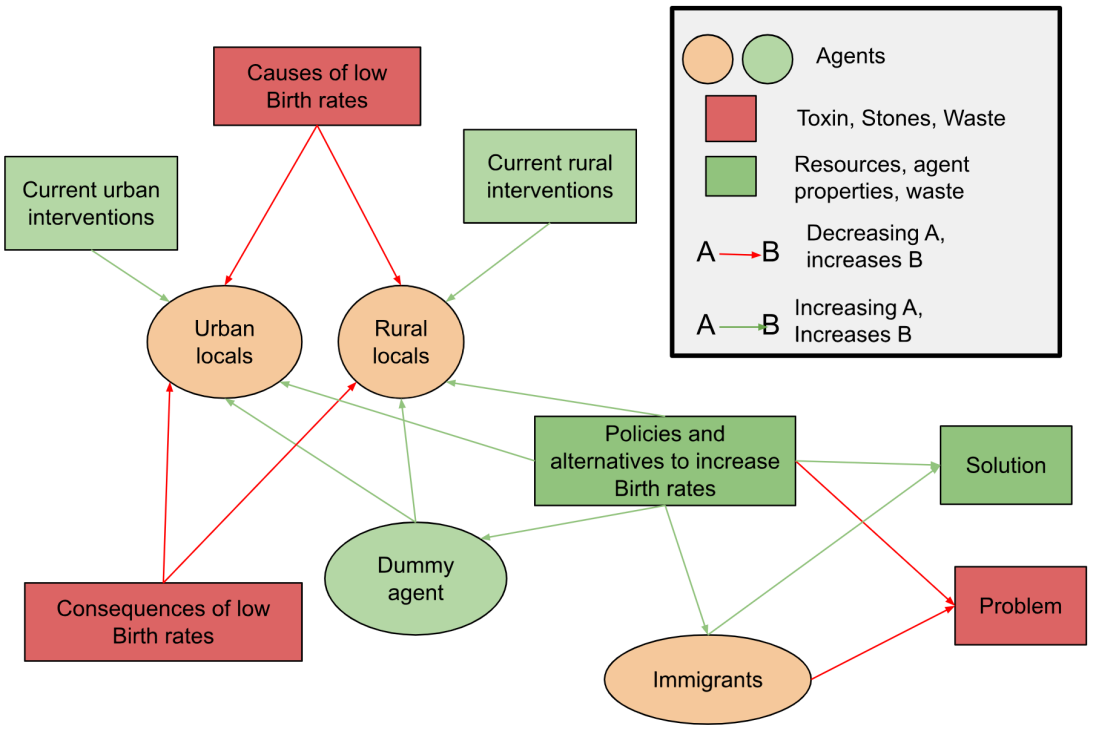
Conclusion and Research Question

The consequences of low birth rates do not only impact society broadly but also at an individual level, especially with a disparity between urban and rural areas. Disparity only increases when considering the different methods that researchers use to analyze low birth rates. In particular, quantitative predictions often have to simplify the complexities of a human population. Therefore, due to the limitations of modeling and poor government implementation, many past attempts at increasing immigration and fertility were unsuccessful. Future policy projections are also not encouraging. Thus, effective solutions remain to be seen, and it is important to find an effective but feasible resolution to limit the future consequences of low birth rates. This leads us to the following research question:

What are the Greatest Causes and Impacts of Low Birth Rates in Iceland, Italy, Japan, and South Korea? What Policies Successfully Mitigate and Reverse These Trends in Rural and Urban Areas?

Systems Diagram

Having now reviewed the existing literature and stated the research question, we will propose a model to study it. The model will look at the interaction of the population and immigrants with solution attempts:



This proposed model will have two kinds of agents: members of the population, and a "dummy" agent, which will be discussed later. Members of the population encapsulate both locals and immigrants. Local agents will be split into urban and rural agents and policies and resources will affect them differently. To model different countries, the properties of the agents, i.e. the proportion of rural and urban agents and the initial conditions of each agent, will be modified to reflect the current situation of the country. The model will also contain zones, used to separate rural and urban areas. These will simulate current resources that are available to/targeted at residents of the zone. Both kinds of agents, rural and urban, may consume any kind of resource, but the food and the resources aimed specifically at them will increase their energy and breeding chance by more than the alternatives. Moreover, agents switching zones will be affected by increased step energy requirements and reduced availability of the food and resources targeted at them.

Now, "causes of low birth rate" will be introduced as a new kind of food which will contain toxins. When agents consume this, the toxin may kill the agent and hence contribute to lowering the agent population. The concept of "causes of low birth rate" is designed to represent

all current factors that contribute to low fertility intentions that were discussed in the literature review. Additionally, the aging setting will be used to hinder fertility as agents will gradually have less energy to breed. This reflects the current state of these countries as one of the consequences of low fertility is an aging population. Moreover, we will allow agents to produce "bad waste" which will represent additional negative consequences of low birth rates including a higher healthcare burden and strained pension systems. Agents will be allowed to consume these, but in doing so, their energy will be reduced, ultimately lowering the agent population.

Individual solution attempts will be implemented by introducing a new kind of food and other resources. All policies have the intention of increasing birth rates and will only be introduced at a single point in time. To ensure the positive effect created by new policies is consistent over time, a dummy agent will consume food that represents policies intended to increase the birth rate and only produces "good waste". The existence of "good waste" reflects the effect of incentives, either monetary or of some other form, that leads to a boost in fertility. Other agents will be able to consume this good waste and they will have more energy to reproduce. Immigration will be introduced through an additional agent ("Immigrants") that will have a higher breeding chance than locals, reflecting the fertility rates of the top nationalities of newcomers to the country of interest, e.g. Morocco for Italy (OECD, 2023). Lastly, solution attempts can also be introduced through zones, by creating subregions in the rural and urban areas with increased resources and more suitable settings for agent reproduction, these will represent regions that receive enhanced health- and childcare through new policies.

Initially, the model will be run for a baseline scenario, i.e. a model without any policies or solution attempts. This will allow the causes and consequences to affect the agent population and we expect to observe a decline in the agent population. After a certain amount of time, the simulation will be stopped and new policies and solution attempts will be introduced. At first, policies will be implemented one at a time to measure their effect independently. At a later stage, cumulative effects may be studied by implementing the individual policy effects measured

earlier in a Randomized-Control Trial (RCT) setting all at once to justify their joint effectiveness, but an external model may be required for this.

If the population and fertility rates remain stable or increase, a solution will be deemed effective under the initial conditions. Otherwise, if the population continues to decrease or even if it reaches complete extinction, it will be deemed ineffective. Finally, to assess the result of the solution, the population graphs and log counts will be analyzed after a significant period has transpired following the implementation of a solution, to account for the possibility of unanticipated side effects.

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Glossary

1. Childcare provision: Care and supervision of children whose parents are working, provided by a childminder or local authority
2. Dependency ratio: the ratio between fifteen to sixty-four year olds, and people aged sixty-five and over.
3. Fertility rate: The average number of children that are born to a woman over her lifetime
4. Patriarchal society: A social system in which positions of dominance and privilege are primarily held by men
5. Quantum effects: Having more children than initially planned
6. Randomized controlled trials (RCT) are a form of scientific experiment used to control factors not under direct experimental control
7. Tempo effects: Having children earlier
8. Work-family gain: It represents benefits gained when individuals can perform the role of employees at work and the role of family members at home with equal involvement.