The impact of declining birth rates on future infrastructure maintenance costs per capita

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Abstract

Purpose – This paper focuses on one vital consequence which is that future infrastructure maintenance cost per capita will increase. Using a sample of 23 developed countries, this paper looks at rail line maintenance cost per capita in the year 2020 versus rail line maintenance cost per capita in the year 2100. This analysis can be applied to most other infrastructure maintenance costs in the future.

Design/methodology/approach – However, this paper focuses on one vital consequence which is that future infrastructure maintenance cost per capita will increase. Using a sample of 23 developed countries, this paper looks at rail line maintenance cost per capita in the year 2020 versus rail line maintenance cost per capita in the year 2100. This analysis can be applied to most other infrastructure maintenance costs in the future.

Findings – The findings show that trail line maintenance costs per capita in the year 2100 will increase significantly for most developed countries.

Research limitations/implications – This research shows the negative consequences of declining birth rates in a very vital and important area.

Practical implications – Despite declining birth rates and population decline in the future, many infrastructure systems still need to be maintained.

Social implications – Maintaining the infrastructure will extract increasing amounts of vital national resources away from other societal concerns.

Originality/value – From an extensive literature review, very little, if any, has been written on this subject. Yet, this topic is highly important and will continue to get more focus in the future.

Keywords Birth rates, Infrastructure maintenance costs, Declining population, Fertility, Labor shortages, Economic impact, Network-type infrastructure

Paper type Research paper

Introduction

Since the 1970s, birth rates have been falling, particularly in developed economies throughout Europe and in wealthier Asian nations such as South Korea, Singapore, Japan, etc. More recently, birth rates in developing countries are also in decline (Clark *et al.*, 2010). The sustainable birth rate for any nation is 2.1 children per every woman of childbearing age. Currently, the world's population birth rate is at 2.4, slightly above the sustainable birth rate level. The birth rate in South Korea, Hong Kong and Singapore, however, is currently at 1.1, well below the sustainable birth rate. Japan's birth rate is 1.4. Italy and Spain both have birth rates of 1.3. Poland's birth rate is 1.4 and Germany's is 1.6 (International Strategic Analysis, 2019).

As the birth rate declines, these countries will have a higher percentage of elderly residents who require more resources, thus impacting the economy. This problem can be averted with increased labor immigration into countries with declining birth rates. Yet, in many countries, citizens may oppose immigration to offset population decline, as this could very well disrupt the unique culture and traditions of a country. Also, domestic laborers may oppose this solution and feel threatened by foreign labor entering the country and competing for jobs.

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Declining birth rates, barring any increase in immigration, will yield labor shortages. Therefore, other than nations having to devote more resources toward the elderly population, the labor shortages will increase wages, which in turn can lead to inflation. Furthermore, emerging economies that rely on exports to these developed economies will find their exports falling. On a positive note, declining birth rates can relieve stress on the environment.

This study examines another significant problem associated with declining birth rates, which is that infrastructure maintenance costs per capita will increase in the future due to declining populations. As a result, a higher proportion of taxes on a per capita basis will have to be allocated toward infrastructure maintenance, assuming immigration is kept at a constant rate.

Declining populations will have an impact on the infrastructure maintenance costs per capita. Yet, the impact will be different depending on the type of infrastructure. Uemura (2014) said that infrastructure can be classified into three broad areas. The first is point-type infrastructure, which can be thought of as government buildings, schools, etc. As the population declines, then point-type infrastructure can be merged or destroyed. In the same paper, the author referred to the second classification of infrastructure as point-network type infrastructure. An example of point-network type infrastructure is a water supply system, often financed through user fees. Uemura (2014) called the third classification of infrastructure, and the one referred to in this manuscript, as network-type infrastructure. Examples of network-type infrastructure are roads, rail lines, bridges, tunnels, etc., which are funded by government sources.

This study specifically looks at the projected rail line maintenance costs per capita as populations either decrease or increase by the year 2100. Population projections are taken from the United Nations data bank on populations. The United Nations provides population estimates for 235 countries based on a country's current population, the age distribution of the population, the fertility rate, the birth rate, the mortality rate and net migration into and out of the country (PAHO, 2019). Roser (2017) wrote that the UN has a good track record in projecting the size of the global population.

It will be shown that as population decrease, mostly as a result of falling birth rates, then rail line maintenance costs per capita will increase, putting an additional strain on the economy.

Literature review

Declining birth rates and its underlying causes

Roser (2017) stated that population growth has already slowed from its peak in the late 1960s, and according to the United Nation's estimates, population growth will come to an end by the year 2100. Some regions in the world will continue to have population growth while other regions, mostly in developed economies, will see population declines. In developed economies with medical advancements, mortality rates are decreasing as people are living longer. At the same time, fertility rates in these countries are also declining.

Declining birth rates are not just a temporary phenomenon; rather, they are a long-term structural change (Clark *et al.*, 2010). In developed countries, where low birth rates are firmly established, populations are expected to decline by as much as 20% in the next 50 years, and the decline will be much greater further into the future. In Europe, the number of women of childbearing age will decline by 21.2%. Births in Europe are currently down by 40% from their high during the years 1955–1960. By the years 2045–2050, the rate will fall further, to 48%, with the potential to decrease to 63% if the fertility rates remain at the current levels of 1.4–1.45. In the United States, after discounting the immigrant population, the fertility rate is 1.85 which is below the replacement rate. Even in developing countries, the number of births is declining.

Japan and South Korea are at the forefront of countries experiencing declining populations. In these two Asian countries, the number of births is already 50% below their high. Japan's low birth rate is leading to an ever-aging society. Furthermore, Japan's declining population is magnified by the fact that the Japanese government places severe restrictions on immigration. Japan's decreasing labor force might eventually outstrip the increase in productivity resulting in a reduction of GDP and GDP per capita (Clark *et al.*, 2010).

Because of Japan's low fertility rate, it is projected that the Japanese labor force will decline from 67 million (as of 2008) to 42 million by 2050 (Clark *et al.*, 2010). In 2006 the Japanese labor force was less than its 1995 labor force. To offset this decline, Clark *et al.* (2010) asserted that the Japanese government needs to consider policies to encourage more labor force participation by women, elderly residents and youths.

Europe's fertility rate was 2.534 in 1970, and by 2019 it was 1.523 (The World Bank, 2019). In 1998, the European Union had its lowest fertility rate of 1.406, not far off from Japan's current fertility rate.

Declining populations in developed countries will create labor shortages. An obvious solution is to encourage labor immigration from developing countries. Although, these developing countries are also experiencing a decline in birth rates, and they too will soon have labor shortages. The resulting shortages will raise wage rates within developing countries, making the immigration of the labor force to developed countries less attractive. As a result, tax revenues generated by a smaller workforce in countries with low birth rates will be diverted from productive assets to more pressing social needs. This could cause a decline in living standards as well as the demand for goods and services and levels of investments, which will adversely affect economic growth (Clark *et al.*, 2010).

As stated in the introduction, due to decreasing birth rates, populations in many developed countries will decrease. Some factors impacting birth rates are the social structure within a country, religious beliefs, economic prosperity, education level and urbanization (Nargund, 2009). Birth rates in developed countries are lower because of economic affluence, lifestyle choices, higher education for women, and more job opportunities for women in the workplace. Within developing countries, children are needed to care for their parents in their old age. In developed countries with socialized pension systems, such as social security in America, children are not as necessary to help care for aging parents; as a result, children are looked at as an "economic drain" (Nargund, 2009, p. 191).

Consequences resulting from declining birth rates

Ivļevs (2012) wrote that falling fertility rates, aging populations and a corresponding unsustainable pension system are serious concerns for most developed countries. Ivļevs (2012) found that an economy with falling birth rates will be impacted in the future as there will be a shortage of labor to work in industries and to provide services. The shortage of labor will lead to low unemployment and higher wages, which will result in higher prices.

According to Demeny and McNicoll (2006), low fertility rates in developed countries will result in a much older population which will require more costly medical care. To help offset the cost of providing for the elderly, Demeny and McNicoll (2006) wrote that economies could rely on the immigration of labor to account for labor shortages. Yet this is a temporary fix, as these migrants will also age and, therefore will require care and support from the government. In addition, migrants might not be able to assimilate into their new surroundings, making them feel isolated and displaced. Relying on immigration to solve this demographic challenge will result in the native population looking to end any government support programs for newly arriving migrants. In response to the labor shortage it might be best to offset the shortage of labor with technology and also eliminate some low-wage labor jobs (Demeny and McNicoll, 2006).

Coleman and Rowthorn (2011) wrote that investors and entrepreneurs might be discouraged if they only foresee decreasing consumer and labor markets. Manufactured products with high development costs can be achieved more easily if there is a growing "capital market" (p. 226). A larger population can achieve economies of scale through division of labor which will yield higher productivity. Population decline reverses these advantages.

Further, Coleman and Rowthorn (2011) wrote that with "population decline, assuming static productivity improvements, GDP will decline" (p. 226); (but not necessarily GDP per capita), and economies of scale might diminish. A smaller labor force means higher wage rates. The combination of higher wage rates and a smaller consumer market will result in decreased profitability. As a result, investments will decrease. Manufacturing plants and factory infrastructure will not get updated and eventually become obsolete and uncompetitive. Cheaper imports will overtake more expensive domestically produced goods, and manufacturing infrastructure will get "hollowed" out.

Also, a declining population base will require higher taxes (on a per capita basis) to maintain existing infrastructure**.** Eventually, some infrastructure will have to be abandoned. A contracting housing market and reduced investments in public infrastructure will reduce demand for building materials and construction work. Smaller communities could become "unviable" (Coleman and Rowthorn, 2011, p. 227). A declining population will generate fewer "geniuses" which would then mean less innovation. Labor shortages will most likely be offset with capital substitution (as cited in Coleman and Rowthorn, 2011, p. 229).

Declining birth rates and increased future infrastructure maintenance costs per capita

Despite declining future populations, countries will still need to maintain much of their existing network-types of infrastructure (i.e. roads, rail systems, bridges, etc.). Palei (2015) found that a nation's investment in infrastructure improves its industrial base and economic competitiveness, which in turn, raises national income. Albala-Bertrand and Mamatzakis (2004) stated that national infrastructure increases productivity by decreasing production costs.

Stupak (2018) wrote that infrastructure "allows private businesses and individuals to produce goods and services more efficiently" (p. 1) which increases economic output in the long run by increasing overall productivity. Therefore, infrastructure investment reduces unemployment. Furthermore, Stupak (2018) said that during economic expansions and strong labor markets, infrastructure investments can have a sustained impact on the unemployment rate. Zachariadis (2018) found that infrastructure investment has a wide range of positive impacts on an economy via various channels of social and economic benefits in both the short run and the long run. First and foremost, the spending on infrastructure involves human capital, which will generate employment opportunities. The increase in employment multiplies the demand for general goods and services which, in turn, increases the size of an economy via increased market demand.

Uemura (2014) found that as populations decline, there will also be a decline in tax revenue. To maintain the existing network-type of infrastructure (i.e. roads, rail systems, etc.), then taxes imposed for maintenance by the central government will have to increase. On the other hand, point-network type of infrastructure such as water supply systems is financed by user fees. As populations decline, user fees will need to increase.

Uemura (2014) wrote that if the infrastructure is not properly maintained, then "human lives might be threatened by deterioration of the infrastructure" (p. 321). According to Uemura (2014), point-type infrastructure located in urban areas will be affected more by population decline than point-network infrastructure or network-type infrastructure, but as the population decline continues, then point-type infrastructure (for example, government buildings and schools) will suffer more than other types of infrastructures. Merging this type of infrastructure or demolishing it will become commonplace in the future. Population decline

will result in a reduction in the number of users, which will yield deterioration of the infrastructure. Uemura (2014) further stated that with respect to a decline in the number of users, the service provided by the infrastructure could be "abolished," which would help solve some economic issues. Although if the physical unit of the infrastructure is left intact after the services have been removed, then many environmental and safety issues can arise.

Grover (2015) stated that America's infrastructure is in desperate need of maintenance. The lack of maintenance only gets attention when "catastrophe" (p. 50); strikes, such as a bridge collapsing or an oil pipeline bursting. In general, no one wants to pay for infrastructure maintenance and upkeep. Over the past few decades, America has devoted a smaller share of its GDP to infrastructure investment and infrastructure maintenance compared to other industrialized countries, such as Japan and Germany. As a result, America has experienced low productivity growth as compared to other industrialized countries (Aschauer, 1989).

Zhao *et al.* (2019), reporting on a study by the Volcker Alliance (2018) entitled "Truth and Integrity in State Budgeting: Preventing the Next Fiscal Crisis" found that only a few American states reveal the cost of deferred maintenance in their budgets. Furthermore, any unfunded infrastructure maintenance liabilities will grow every year when funds are not set aside for maintenance. Properly maintained and functioning infrastructure is necessary for the "functioning and growth of a nation's economy" (as cited in Zhao *et al.*, 2019, p. 1).

Based on a report from the American Society of Civil Engineers (1998–2017), Zhao *et al.* (2019) found that America's infrastructure is in poor condition and will need continued maintenance. The American Society of Civil Engineers stated that "new and innovative techniques, materials, technologies, and delivery methods are needed to improve the infrastructure" (as cited in Zhao *et al.*, 2019, p. 11).

In addition to higher labor costs which will increase future infrastructure maintenance costs, Chinowsky *et al.* (2013) found that future climate change will add additional pressures on increasing maintenance costs. Their analysis showed that climate change will increase the annual costs of keeping paved and unpaved roads in service by $785 million in present value terms by 2050. Furthermore, Underwood *et al.* (2017) found that climate change has resulted in more frequent infrastructure failure and increased maintenance costs.

Increased public spending on infrastructure has a long-term impact on an economy, which is brought on by supply-side benefits. As large amounts of capital are injected into an economy through infrastructure spending, the productivity of all factors of production rises; thereby broadening productivity in every sector of the economy. For instance, investment in public transportation provides a better reach to capital as well as human resources, which had been previously cut off from economic centers within a country (Zachariadis, 2018).

The huge investment needed to fund the construction phase of infrastructure projects often results in negative cash flow situations (Cifuentes and Espinoza, 2016). The construction phase can generally last for several years, depending on the type and scale of the project; one example is a hydropower project. Even though infrastructure projects often generate a huge negative balance on the books of a government, they generally yield a wider positive impact for the common good of the people. In the long term, these projects will have a positive impact on the economy (Zachariadis, 2018).

Wagenvoort *et al.* (2010) found that roughly 40% of infrastructure needs to be funded by the public sector within the EU. Whether it is funded by the central government or local government depends on the specific country (Athenosy, 2017).

To fund infrastructure projects, typical financial instruments employed by governments are taxes and borrowings from either national or international investors. On the other hand, private sector sources typically fund infrastructure projects through loans, bonds, and equity. On average, about 80% of a private sector project is funded by loans, 6% by bonds and 14% by equity in the EU (Wagenvoort *et al.*, 2010).

Data analysis

Assuming that immigration rates are less than the decline in birth rates, then as birth rates decline, so will populations. As a result, the labor force will decline, which will increase wage rates. The combination of higher wage rates and a reduction in the population tax base will cause infrastructure maintenance costs per capita to increase in the future.

In Table 1 (see below), the first column lists the countries that were included in this sample. The countries in the sample are all considered developed or newly developed countries. Declining birth rates are primarily considered a phenomenon in developed countries, but as Coleman and Rowthorn (2011) stated, within the next few decades, birth rates will begin to decline in developing countries as well.

The countries with the largest population declines are listed first in column one, and those countries that will experience population increases are listed last in column one. The country that is projected to have the largest population increase is last (i.e. Australia). The second and fourth columns in Table 1 list each country's population under the age of 75 according to the United Nations (https://population.un.org/wpp/Download/Probabilistic/Population/). Column two lists the populations of those under the age of 75 during the year 2020. Column four lists the projected populations of those under the age of 75 for the year 2100. For the year 2100, the UN estimated these populations. These estimates are based on projected fertility rates, birth rates, death rates, mortality levels and net migration for each country in the year 2100. Roser (2017) stated that the United Nation's estimates are very accurate.

Table 1.
Data regarding the future expected change in rail line maintenance costs per capita

Country	Year 2020 population under the age of 75 per UN	Year 2020 rail line maintenance costs per KM per capita for those under 75	Year 2100 population under the age of 75 per UN * projected	Year 2100 rail line maintenance costs per KM per capita for those under 75	Percent change in population	Percent change in rail line maintenance costs per KM per capita
S. Korea	48,361,940	0.00411	21,762,809	0.00914	−0.5500	1.2871
Japan	107,426,566	0.15264	55,538,003	0.29525	−0.4830	0.93429
Greece	9,525,951	0.00517	4,984,544	0.0098	−0.4767	0.89555
Italy	52,475,829	0.00843	30,123,443	0.01468	−0.4260	0.7414
Portugal	9,063,000	0.0043	5,423,000	0.00718	−0.4016	0.6697
Spain	42,617,003	0.0099	25,246,152	0.0166	−0.4076	0.6767
Netherlands	15,931,636	0.02929	12,558,377	0.03716	−0.2117	0.268692
Germany	73,653,376	0.01484	59,845,992	0.01826	−1875	0.23072
Hungary	8,967,585	0.00981	7,437,549	0.01183	−0.1706	0.205912
Finland	4,988,888	0.00681	4,155,719	0.00818	−0.1670	0.201175
Poland	35,142,227	0.00051	29,097,942	0.00061	−0.1720	0.196078
Austria	8,029,720	0.01002	6,954,034	0.01157	−0.1340	0.154691
France	58,955,487	0.0023	51,669,001	0.00262	−0.1236	0.13913
Czech R	9,836,715	0.00499	8,715,055	0.00563	−0.1140	0.128257
Belgium	10,460,778	0.00944	10,076,228	0.0098	−0.0368	0.038136
UK	60,904,044	0.00373	63,304,198	0.00359	0.0394	−0.03753
Denmark	5,317,527	0.01039	5,678,251	0.00973	0.0678	−0.06352
Sweden	9,365,413	0.00569	10,580,818	0.00504	0.1298	−0.11424
Switzerland	7,724,311	0.02572	8,875,262	0.0228	0.1490	−0.11355
USA	305,364,607	0.0007237	359,709,955	0.000614	0.1780	−0.15158
Norway	4,959,173	0.03136	6,510,142	0.02389	0.3127	−0.2382
Canada	35,142,227	0.00041	46,583,368	0.00031	0.3256	−0.2439
Australia	23,547,303	0.00105	35,192,642	0.00070	0.4946	−0.3309

Column three in Table 1 provides each country's rail line maintenance costs per kilometer per resident under the age of 75. The age of 75 was used as a cutoff because in almost all cases, residents over the age of 75 have stopped working and therefore would not be contributing to the upkeep of infrastructure by way of taxes. Column five uses the same information as column three except it is for the estimated population in the year 2100.

Column six in Table 1 shows the percent change in population for each country from the year 2020 to the year 2100. Column seven shows the percentage change in rail line maintenance costs per kilometer per capita between the years 2020 and 2100.

The country with the largest projected population decline is South Korea. Its population is expected to decline by 55%. This is followed by Japan with a projected decline of 48.3%, and then Greece with a projected decline of 47.67%. Conversely, Australia is projected to have a population gain of 49.46%.

The last column in Table 1 shows the percentage change in rail line maintenance costs per capita for those under the age of 75 between the years 2020 and 2100. As expected, the countries predicted to have population declines will have a projected increase in rail line maintenance costs per capita (for those under the age of 75). The expected change in rail line maintenance costs per capita for South Korea is an increase of 122.38%. For Japan, it is an increase of 93.4% and for Greece it is an increase of 91.29%. For Australia, whose population is expected to grow, the anticipated percentage change is a decrease of 33.09%.

Different types of infrastructure will be handled differently due to population decline. For instance, Uemura (2014) wrote that point-type infrastructure (buildings, such as government buildings or school buildings, etc.) can be merged or demolished. However, in the case of network-type infrastructure (i.e. roads and railways), population decline means that taxes (on a per capita basis) used to maintain the infrastructure will need to be raised.

For most countries in the sample, rail line maintenance costs were taken from the Organization for Economic Co-operation and Development (OECD) Data Bank on Infrastructure Investment (https://data.oecd.org/transport/infrastructure-investment.htm). The OECD did not have the infrastructure maintenance costs for rail lines for the following countries: Australia, Denmark, Germany, Greece, Japan, Spain and the United States. Table 2 lists the sources where the data for these countries come from.

Australia	https://www.queenslandrail.com.au/business/acccess/Compliance%20and%20reporting%20%20archive/2018-19%20QCA%20Annual%20Performance%20Report.pdf
Denmark	https://ec.europa.eu/transport/sites/default/files/6th_rmms_report.pdf
Germany	https://ir.deutschebahn.com/en/bonds-and-rating/deutsche-bahn-finance-gmbh/reports and https://ir.deutschebahn.com/en/reports/archive
Greece	https://www.ergose.gr/the-company/financial-statements/?lang=en
Japan	JR-Central: https://global.jr-central.co.jp/en/company/ir/investor-meeting/ JR- East: https://www.jreast.co.jp/e/investor/index_year.html JR-West: https://www.westjr.co.jp/global/en/ir/library/annual-report/2019/
Spain	https://www.renfe.com/es/es/grupo-renfe/gobierno-corporativo-y-transparencia/transparencia/renfe-fabricacion-y-mantenimiento-sme-sa/funciones/cuentas-fabricacion-mantenimiento and https://www.renfe.com/es/en/renfe-group/corporate-governance-and-transparency/financial-and-activity-information/epe-financial-statements
The United States	https://infrastructurereportcard.org/cat-item/rail/

Table 2. Source listed for those countries that were not included in the OECD data bank on infrastructure maintenance costs for rail lines

Conclusion

Throughout the developed world, birth rates are declining. As a result, many countries will find that their populations will also decline, despite immigration. For example, according to the United Nations, by the year 2100 South Korea's population is expected to decrease by 55%, Japan by 48.3%, Greece by 47.67%, Italy by 42.6% and Spain by 40.76%.

A declining population will result in labor shortages. Wages should then rise, followed by inflation. Also, as populations decline, infrastructure maintenance costs on a per capita basis will increase, even if labor costs were to somehow remain stagnant, due to a shrinking population and tax base.

Infrastructure is important to an economy in that it makes the economy more productive and competitive. As a result, network-type infrastructure (i.e. roads, rail lines, bridges, etc.) will need to be maintained. If network-type infrastructure is not maintained, then it could deteriorate and become hazardous to those who continue to use the infrastructure. On the other hand, if it is removed, then those being served by network-type infrastructures will be cut off from other cities or towns.

The obvious solution is to increase the future tax base. In an effort to increase birth rates, governments could employ social planning by way of financial incentives such as child support, subsidized daycare, increased tax credits per child in each family, etc. Countries could also encourage immigration to increase the tax base. However, the downside to this is that the domestic population might feel threatened that their culture and their unique way of life is disappearing. In addition, domestic labor would likely feel threatened by foreign labor coming into the economy to compete for the same jobs.

One ideal situation is for countries to increase productivity within the infrastructure maintenance sector via automation or other technologies. If productivity improves significantly, it could offset the projected rise in the costs of infrastructure maintenance per capita.

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Further reading

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