Measuring Intergenerational Justice

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*A*bstract: *Concern with intergenerational justice has long been a focus of economics. This essay considers the effort, over the last three decades, to quantify generational fiscal burdens using label-free fiscal gap and generational accounting. It also points out that government debt – the conventional metric for assessing generational fiscal justice – has no grounding in economic theory. Instead, official debt is the result of economically arbitrary government labelling decisions: whether to call receipts "taxes" rather than "borrowing" and whether to call payments "transfer payments" rather than "debt service". Via their choice of words, governments decide which obligations to put on, and which to keep off, the books. The essay also looks to the future of generational fiscal-justice analysis. Rapid computational advances are permitting economists to understand not just direct government intergenerational redistribution, but also how such policies impact the economy that future generations will inherit.*

Keywords: *Generational Accounting, Fiscal Gap, Deficit Delusion*

Intergenerational justice and its measurement

Justice, the saying goes, is in the eyes of the beholders. But when it comes to intergenerational justice, future generations aren't here to assess, let alone contest their treatment. Consequently, it falls to current generations to consider the welfare of their descendants. This is exceedingly and conveniently difficult. No one can foretell the future. Unfortunately, this provides a ready excuse for many to ignore not just central tendencies, but worst-case outcomes.

Yet the generationally myopic, wilfully ignorant and self-interested are in the minority. Most of us care for our progeny. And since our offspring's fates are co-determined with those of our contemporaries, most of us recognise the collective skin, if not potentially comingled DNA, we have in the intergenerational game. This limits our capacity to look the other way as the climate changes, nuclear weapons proliferate, fiscal obligations grow, infrastructure is degraded, education is diminished, inequality rises… In short, our common maternal and paternal instincts lead most of us to ask and try to answer the question "What are we doing for sure or for maybe to our children?"

This natural concern for our descendants has been inscribed through the ages in covenants, compacts, constitutions and case law, all of which were written to extend *from generation to generation*. Indeed, generational commitments covering the infinite horizon show up in Genesis 9:12, which states, "This is the sign of the covenant which I am making between Me and you and every living creature that is with you, for all successive generations."

Generational responsibility is a common civic as well as religious theme. In his Farewell Address, President Washington admonished us to "not ungenerously [throw] upon posterity the burden [of debts] which we ourselves ought to bear." President Jefferson wrote, "It is incumbent on every generation to pay its own debts as it goes." President Lincoln proclaimed, "The fiery trial through which we pass will light us down in honor or dishonor, to the latest generation." And President Kennedy stated, "We… shall be remembered either as part of the generation that turned this planet into a flaming funeral pyre or the generation that met its vow 'to save succeeding generations from the scourge of war'."

Unfortunately, the distance between generational rhetoric and generational action seems to be growing, particularly in heterogeneous societies whose inhabitants don't view other people's children as their own, let alone their responsibility. The tug of genetics, the dictates of morality, and the economics of collective benefit are, it seems, in constant conflict with each generation's craven instinct to *take as you go* – the habit of each generation to extract the maximum possible from the next.

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Intergenerational versus intragenerational justice

The focus of this short essay on the measurement of intergenerational justice does not in any way negate the importance of measuring intragenerational justice. Intergenerational justice looks across those born at different dates. Intragenerational justice looks across members of a given cohort. A climate policy that permits sea levels to rise 100 feet over the next two centuries and drown a major share of the earth's population, if not destroy all human life, represents generational injustice. A healthcare policy that leaves the poorest members of each cohort with either no healthcare coverage or minimal healthcare coverage represents intragenerational injustice. Both forms of injustice demand proper measurement. The focus of this essay on intergenerational, not intragenerational, justice does not elevate the former over the later as an ethical imperative.[1]

Assessing intergenerational justice from the current, not the original position

Generational justice seems best examined in terms of the distribution at a given point in time in the expected lifetime wellbeing (utility) of current and future generations. For current generations, expected lifetime utility incorporates their realised past utility as well as their uncertain future utility.

Considering generational justice from our current (initial) condition rather than from some Rawlsian original position is practically minded. The past can't be changed. Bygone policy and economic shocks may have left current and future generations in dire straits, and those actions and outcomes may be viewed as both extremely unfair and unfortunate. But such assessments are irrelevant for forming today's and tomorrow's generational policy, which are the only things we can control when it comes to generational justice. Stated differently, generational justice is not a metaphysical but a practical question. It concerns how we

are going to act from this point forward, and what we can expect will happen based on those actions to current and future generations. This said, the set of initial conditions includes the realised past welfare of current generations. How well current generations fared in the past may matter for assessing the justice of current generation policy.

This does not suggest that the treatment of currently deceased generations is irrelevant to the bigger question of whether a country, over the course of time, has been unjust in its treatment of deceased versus living and future generations. But such analyses are philosophical in nature. The practical economic question is the distribution of lifetime welfare among those whose welfare can still be changed, namely those now alive and those yet to be born. The role of the economist is not to declare particular generational policies just or unjust. Economists are not ethicists and their social judgements are personal, not scientific. Instead, the role of economists is to analyse the implications of different generational policies on the distribution of generational welfare.

This said, knowing the levels and distribution of economic well-being of past generations is a proper focus of economic analysis, and such findings will, presumably, inform policy judgements concerning the treatment of current and future generations. For example, a finding that past generations had much higher welfare than the current and future generations will be able to sustain, and that the reason reflects systematic redistribution to past generations from current and future generations, may lead policy-makers to decide to end ongoing policies that will continue to immiserate future generations at the benefit to current generations.

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Economic theory and the measurement of generational justice
Economic theory is an indispensable guide for assessing generational justice in terms of the need to take policy actions given the current position or, as economists put it, the state of the world. There are two major strands of theory that go to the heart of generational justice. One is the intergenerational altruism model, clarified by Barro (1974), in which each generation's welfare includes the welfare of its children. The other is the pure life-cycle model, which traces to the work of Fisher (1930), in which each generation is solely concerned with itself.

The intergenerational altruism model
Barro's interlinkage of utility functions collapses (is isomorphic) to the Ramsey (1928) model of a single, infinitely-lived agent, where the agents' future selves reference or represent their descendants. As Barro pointed out, this possibility – that each generation cares about the next, effectively making today's generation care about all future generations – was originally suggested by David Ricardo in 1820 in his "Essay on the Funding System". Ricardo's suggestion, which Barro elegantly exposited and elaborated, was that if today's generations cared sufficiently for tomorrow's, they would

privately provide them the means to offset government intergenerational redistribution arising, for example, from the issuance of government debt.

Such operative intergenerational altruism lessens, if not fully eliminates, collective concern over intergenerational justice. The reason is that, given intergenerational altruism, current generations will automatically internalise the welfare of future generations and take actions to protect those generations. This is particularly the case in the presence of marriage. As Bernheim and Bagwell (1988) and Kotlikoff (1989) have independently showed, the marriage between two members of two altruistic clans will effectively altruistically link those clans. Bernheim and Bagwell make the further point that – given the extent of intermarriage across religious, national, ethnic, and racial lines – the probability of altruistic linkages across essentially all inhabitants on the planet rapidly approaches One. Since such global altruism would rule out wars, among other things, these papers represent a telling critique of the intergenerational altruism proposition.

Interestingly, Ricardo was himself dubious about the efficacy of intergenerational altruism. Although he raised such altruism as a theoretical possibility, he rejected its empirical relevance (in literally the next sentence)[2]. Specifically, he questioned the ability of current generations to correctly assess and appropriately offset government redistribution to them at the expense of their descendants.

Kotlikoff et al. (2009) question a critical, implicit assumption underlying Barro's (1974) so-called "debt neutrality" result (i.e. that the government's intergenerational redistribution will be neutralised by private, intra-family transfers). They point out that it hinges critically on the assumption that agents within the extended family take each other's transfers to them as given; i.e., there is no hold-up behaviour in which one family member says, for example, "I'm rejecting your gift if that's all you are giving me." In this context, in which extended family members differ on how much they weigh each other's utility, Barro's Nash equilibrium collapses with the resulting bargaining between family members depending on their threat points. Since intergenerational redistribution by the government will change these threat points, such redistribution will have real impacts and alter the degree of intergenerational justice, no matter how measured. Stated differently, Barro's model requires both intergenerational altruism and particular game-theoretic behaviour. Without the latter, his proposition of debt neutrality no longer holds.

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Yet another critique of debt neutrality in the context of generational altruism is that raised by Laitner (1992). This and Laitner's subsequent papers point out that if extended family members don't perfectly share preferences, altruistic dynasties can be at corners with respect to making transfers to their members in the context of their facing earnings shocks, longevity risk, and other forms of risk. An example of preference differences is one-side

altruism in which parents care for the utility of their children, but children do not care about, or care less about, the utility of their parents. In this case, if children, for example, have sufficiently high earnings relative to their parents, the parents may be at a corner and make no transfers to their children notwithstanding government redistribution from children to parents, provided it isn't large enough to move them away from their corner.

The life-cycle model
Fisher's (1930) life-cycle consumption choice model rejects intergenerational altruism outright in so far as it posits agents who care only for their own welfare. Although Fisher laid out the microeconomics of intertemporal consumption choice, it took economists decades to begin examining how those micro decisions, coupled with generational policy, impacted macro outcomes and the distribution of welfare across current and future generations.

The first dynamic overlapping generation (OLG) model was developed in 1947 by Maurice Allais (1947). Samuelson (1958), who focused on the efficiency of overlapping economies, is the next major theoretical contribution to the OLG model. The third seminal OLG study is that of Diamond (1964). Diamond examined how government redistribution from young and future generations to current older generations (characterised in his study as "deficit policy") would impact current and future generations, both directly in terms of their levels of taxation, and also indirectly in terms of the wages and asset returns they would receive. In highlighting the intergenerational redistribution inherent in intergenerational fiscal policy, Diamond made intergenerational justice a major topic of economic analysis.

These early studies relied on simple two-period (youth and old age) models whose dynamics could be described in terms of a first-order, non-linear difference equation in the economy's relative supply of capital to labour. The two-period OLG model became a workhorse in economics because of its ease of use and exposition. But it also stimulated interest in developing and solving more realistic models in which agents lived for periods corresponding to years. The goal was to understand the timing of annual economic responses to changes in policy as well as technology. The timing of those responses would also govern how particular policies impacted particular generations, i.e. how they would matter to the measurement of intergenerational justice.

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But solving such models posed a major problem. Adding extra periods transformed the transition equation from first order to very high order. For example, a model in which adults live for up to 80 periods, from 20 to 100, produces a 160th order non-linear difference equation. Since mathematics offers nothing beyond approximate solutions to such problems, economists were stumped. The OLG model was, and arguably is, the core dynamic model of the profession, but no one could determine how it actually worked in real time. In the absence of a way to solve for realistic OLG transition paths, many economists, e.g. Tobin (1967), simply ignored the economy's transition path and focused on the long

run, i.e. on the steady states of realistic OLG models. Others, e.g. Summers (1981), "solved" the transition problem by assuming agents formed irrational expectations – specifically myopic expectations under which agents always assume the economy to be in a steady state (i.e. that all future product and factor prices will equal prevailing values), even though they learn from one year to the next that the opposite is true.

In 1981, 34 years after Allais had produced the first OLG model, Auerbach and Kotlikoff (1981) showed how the transition path of realistic OLG models could be solved on a computer using a Gauss-Seidel-type algorithm, with inner and outer loops, that iterated over the economy's entire transition path. Auerbach and Kotlikoff (1987) used their simulation method to study the wide variety of means by which governments redistribute across generations. They showed that, regardless of how governments characterise policies that take from the young and give to the old, such policies can affect major welfare losses on successive generations, both through their direct fiscal and indirect general-equilibrium feedback effects. The Auerbach and Kotlikoff OLG simulation method was quickly adopted by researchers around the world. In the ensuing years, economists have developed computable OLG models that incorporate heterogeneous agents, realistic age-specific rates of fertility and mortality, multiple regions encompassing the global economy, multiple traded and non-traded goods, international specialisation, capital adjustment costs, region- and cohort-specific rates of technological change, immigration, labour supply as well as consumption decisions, unintended and intended bequests, informality, educational choice, borrowing constraints, idiosyncratic wage rate uncertainty, robots, climate change, all manner of fiscal policies, and many other economic factors and issues.

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Thanks to the work of Marcet (1988) and Judd, Maliar and Maliar (2009), economists can also now simulate large-scale OLG models with aggregate shocks. Hasanhodzic and Kotikoff (2013), which includes 80 periods and major shocks to the economy's productivity growth and capital deprecation rates, is the first such model. While their model is highly stylised, it provides a blueprint for the production of more realistic stochastic OLG models. Such models can be used to show how particular policies impact the distribution of welfare changes of current and future generations. The Hasanhodzic and Kotlikoff study is also important in so far as it indicates that even large shocks to the economy do not materially affect the intergenerational redistribution arising from policy changes. Stated differently, their study shows that OLG models without shocks – which are easier to simulate and can more readily handle complex economic factors – can provide good estimates for the generational redistribution arising in models with shocks, even large ones. The intuition is that each generation lives for many years. Hence even large, serially correlated annual shocks tend to cancel out over time. Moreover, contemporaneous generations can share these risks with one another via bond and other financial markets.

Assessing the two intergenerational frameworks

The two intergenerational frameworks, briefly reviewed above, continue to compete for economists' consideration and use. The single-agent, infinitely lived, implicitly intergenerationally altruistic model has become the mainstay of the real business cycle literature in macroeconomics. This literature focuses on the economy's response to shocks, which are computationally much easier to handle with the assumption of a single representative agent. The life-cycle model has, for its part, primarily been used in deterministic settings to study dynamic feedback effects of policy changes as well as the interconnected impacts of changes in demographics.

The ability of the life-cycle model to handle economic as well as policy shocks, as demonstrated in Hasanhodzic and Kotlikoff (2013), will likely lead more macro economists to work on the life-cycle model. The reason is the strong evidence, accumulated over the years, against operative intergenerational altruism. Micro studies by Altonji, Hayashi and Kotlikoff (1992, 1997) and Hayashi, Altonji and Kotlikoff (1996) show that extended families share neither their resources nor shocks to their resources when it comes to determining how much each extended family member should consume. Rather than acting like a unitary family, parents and their adult children consume, in the main, as if they were unrelated.

Altruism has also been strongly rejected in cohort data in a study by Abel and Kotlikoff (1994). And Gokhale, Kotlikoff, and Sabelhaus (1996) and Lee and Mason (2011) show remarkable shifts through time in favour of the elderly in the US profile of average consumption – shifts which coincide with major and ongoing redistribution from younger to older generations.[3] In the early 1960s, the US age-consumption profile was hump-shaped, peaking at roughly age 50. Today it is an upward sloping line. These robust findings against operational intergenerational altruism are complemented by strong findings by Browning et al. (2011) and others against operational altruism between spouses within marriages.

Direct measurement of intergenerational justice

There are many aspects of intergenerational justice which economics is just beginning to examine in computable general equilibrium simulation models. An example is the impact of climate change on the welfare of future generations. When this research is completed, it will provide qualitative and quantitative assessments of the range of impacts that current climate policy may have on future generations.

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To date, most of the direct measurement of intergenerational justice has centred around the fiscal treatment of current versus future generations. This has taken the form of fiscal gap and generational accounting.[4] Fiscal gap accounting focuses on the government's intertemporal budget constraint, which requires that the present value of a government's expenditures, no matter how labelled, equals the present value of its receipts, no matter how they too are labelled. The fiscal gap measures the extent to which expenditures exceed taxation valued in the present.[5]

To illustrate fiscal gap accounting, consider the current US federal government's fiscal gap. It is massive, totalling roughly $200 trillion.[6] Since US GDP is close to $20 trillion, the US fiscal gap represents 10 years of current US GDP or 10.5% of GDP through the infinite horizon.[7] Eliminating the US fiscal gap via tax hikes would require an immediate and permanent 53% increase in all federal taxes or, alternatively, a 33% immediate and permanent cut in all federal expenditures, including those the US government labels as "official debt service".

Waiting to make fiscal adjustments makes the size of the requisite adjustments even larger. And the longer the government waits to address its generational problem, the larger will be the number of older generations allowed to consume through the end of their lives without having to pay more in taxes or receive less in benefits. This, in turn, means a larger fiscal burden that will be imposed on today's young and future generations over the course of their lifetimes.

Generational accounting is an extension of fiscal gap accounting. It was introduced by Auerbach, Gokhale, and Kotlikoff (1991) to measure the burden on future generations of balancing the government's intertemporal budget (eliminating the fiscal gap) assuming current generations are entirely exempted from helping eliminate a country's fiscal gap. Based on current US fiscal policy, future generations face lifetime net tax rates (the present value of lifetime net taxes divided by the present value of lifetime labour earnings) that are some 70% higher than those today's young generations would face under maintenance of current law.[8]

The huge US fiscal gap and generational bill being foisted on unborn Americans reflects the country's demographics, its postwar expansion of pension and healthcare benefits provided to the elderly, and successive rounds of federal tax cuts not matched by reductions in defence and other discretionary federal spending.

American economists have strongly endorsed fiscal gap and generational accounting, as may be seen at www.theinformact.org. The Inform Act is a bipartisan bill that would compel three US government agencies – the Congressional Budget Office, the Office of Management and Budget, and the General Accountability Office – to do fiscal gap and generational accounting on a routine basis. The bill, which has received limited support in Congress and has not, therefore, been enacted, has been endorsed by 20 American Nobel Laureates in Economics and over 1,300 American economists, primarily from academia.

Fortunately, other countries are taking the measurement of intergenerational fiscal imbalances seriously. The creation of Norway's Petroleum Fund (now called The Pension Fund Global) appears to have been strongly influenced by Auerbach, Gokhale, Kotlikoff and Steigum (1993) as well as Steigum et al. (1999). Both are generational accounting studies, which asked whether Norway was overconsuming its petroleum wealth.

The European Union is now producing fiscal gap measures for its member countries every three years. It references this measure as the S2 indicator. European Commission (2015) reports fiscal gaps for 10 of 26 member countries in excess of 3% of GDP on an ongoing basis. While far smaller than the 10.5% figure for the US, even 3% of GDP per year represents a very major fiscal

imbalance.[9] And, given the zero-sum nature of generational accounting, the longer adjustment is delayed to eliminate these fiscal gaps, the larger the fiscal burden that will be left for today's young as well as future generations.

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Fiscal gap accounting, generational accounting or both have been done over the years by the IMF, the World Bank, Her Majesty's Treasury, the Bundes Bank, the New Zealand Treasury and many other institutions and government entities around the world, including, as mentioned, the European Commission. The list of countries that have engaged in fiscal gap or generational accounting, or an equivalent calculation, whether on a one-time or routine basis includes not just most members of the European Union, but also Australia, New Zealand, Mexico, Russia, China, Japan, South Korea, Canada, Thailand, Chile, Brazil, El Salvador, the UK and the US.

A number of these studies are included in *Generational Accounting Around the World*, a 1999 National Bureau of Economic Research (NBER) volume edited by Alan Auerbach, Laurence Kotlikoff and Willi Leibfritz. This volume also includes a study entitled "Generational Accounting in General Equilibrium" by Hans Fehr and Laurence Kotlikoff, which shows that general equilibrium effects can materially impact, but not fundamentally alter, the picture of generational equity produced by standard partial equilibrium generational accounting.

The critique of deficit accounting

The strong global interest in fiscal gap and generational accounting reflects, in large part, the realisation that convention deficit and debt accounting do not constitute meaningful measurements of the fiscal burdens being foisted on young and future generations. Feldstein's (1974) introduction of the concept of Social Security wealth made clear that the US government was keeping liabilities of various kinds off its books, i.e. liabilities that weren't being recorded as US official debt.

But the problem Feldstein discovered ran and runs far deeper than the well-known fact that governments don't disclose everything they owe. As Kotlikoff (1986, 1988, 1993, 2002, Auerbach and Kotlikoff (1987), and Green and Kotlikoff (2009) show, government debt is not theoretically well-defined. Instead, the debt and its change through time, the deficit, reflect economically arbitrary choices of how to label government receipts and payments.

Indeed, Green and Kotlikoff (2009) provide a general proof that fiscal policy can be arbitrarily labelled to permit governments to report any time path of official debt (positive or negative) regardless of the government's underlying fiscal policy. Their proof holds for all neoclassical models with rational agents, i.e. agents who are not fooled and whose economic decisions are not influenced by the choice of language.

The Green and Kotlikoff study indicates that a country with a zero fiscal gap and a highly intergenerationally just fiscal policy could, via the choice of fiscal labels, nonetheless project a path of official debt that perpetually rises relative to the economy. Alternatively, the country could have a large and growing fiscal gap and state that it has a surplus (negative official debt), whose projected value is rising through time. Again, all that's needed to claim your country is fiscally responsible when the opposite is true is the adoption of the right, internally consistent labelling convention. Since the Green-Kotlikoff paper shows that *all* neoclassical models with rational agents can be relabelled, the indeterminacy of the debt and the deficit is unrelated to market imperfections, adverse selection, moral hazard, distortionary taxation, liquidity constraints, uncertainty, monopoly, and all other economic issues that have been studied using economic models with rational agents.

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In contrast to official debt and deficit numbers, the fiscal gap and lifetime net tax rate facing future generations that is needed to eliminate the fiscal gap, which generational accounting produces, are label-free measures; i.e. their values are the same regardless of the choice of fiscal-labelling convention.

The proposition that conventional debt measures are economically meaningless is a critically important finding when it comes to the measurement of intergenerational justice. Yes, economists largely understand the labelling problem; yes, fiscal gap and generational accounting are becoming standard methods of fiscal analysis in certain parts of the world; and yes, simulation studies of the fiscal/demographic transition in large scale OLG models are becoming more frequent. But official debt and deficit accounting remains the central measuring rod for governments' fiscal decision making as well as fiscal discourse. In the US, for example, the country's long-term fiscal imbalance is rarely mentioned by politicians, whereas the size of the debt and deficit are routinely discussed. Since those numbers are both figments of language, not true economic indicators, fiscal policy-making in the US and other countries is deeply irrational. International institutions, including the World Bank and the IMF, contribute to this problem by putting the debt and deficit front and centre in their discussions of fiscal sustainability.

This situation is akin to governments and international institutions basing decisions involving the physical world ignoring relativity's teaching that time and distance are effectively functions of language (one's frame of reference based on the direction and speed of travel). Just as the equations of physics do not pin down unique measures of time and distance, the equations of neoclassical economics do not pin down measures of the debt and the deficit or, for that matter, taxes and transfer payments. The "accounting" of such "concepts" is, unfortunately, content-free.

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Conclusion

The ongoing use of official debt to consider fiscal sustainability and, implicitly, to assess intergenerational justice is without scientific merit. The economics profession has the primary responsibility to make this clear to the general public, the press, and

the politicians. We cannot meaningfully discuss intergenerational justice by resorting to measures that purport to bear on this question but do nothing of the kind. Economists are aware of this problem but need to be much more vigorous in educating the general public and, ultimately, policy-makers to focus on fiscal reality not linguistics.

In discussing intergenerational justice, economists would do well to point to the lesson of Argentina, which, a century back, had one of the world's highest levels of per capita GDP. Today Argentina's per capital GDP is less than a quarter of that in the US. Argentina's long-term, *generational* decline in relative, if not absolute, living standards, doesn't reflect immutable productivity shocks, natural disasters, or sustained changes in its terms of trade. It reflects, from all appearances, a century of poor governance, which enriched politicians, internal power groups and current generations at the expense of long-term economic growth and the welfare of future Argentines. Any fair-minded observer of Argentina's history of fiscal, monetary, and other policies must conclude that its long–term economic decline represents a case study in intergenerational injustice.[10]

While the US has a far more stable democracy and far better adherence to the rule of law, its fiscal policy is slowly but surely taking future generations down the path of Argentina. A country's fiscal gap is measured in present value. As such, it is like a household's credit card bill, which grows with interest when left unpaid. America's fiscal gap is not being officially acknowledged, let alone being eliminated. Indeed, it is growing at roughly $6 trillion per year! But the US is not alone in leaving massive unpaid bills to the unborn. Other countries, including Japan, China, Russia, and at least 10 EU member countries, are engaged in a fierce, ongoing generational policy of *take as you go*.

Looking long-term, measurement of generational injustice will likely rely less on fiscal gap and generational accounting and more on the results of Monte Carlo simulations of large-scale, highly detailed life-cycle models, which feature uncertainty and incorporate not just intergenerational redistribution through fiscal policy but the truly mega issues of generational equity, namely climate change and nuclear proliferation.

As Weitzman (2009) points out, our posterior probability distributions of catastrophic events arising from such planetary life and death issues have fat tails because we have such limited information on their likelihood. Given this, the next generation of dynamic and, thus, intergenerational models will need to incorporate disaster distributions that feature, to the extent possible, not only our uncertainty about things we know but also our ignorance about things we don't know.

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Cai et al. (2013) is indicative of how quickly economics is moving to refine and expand its modelling in the area of climate change. Their model counts among the first to seriously incorporate both uncertainty about climate change damage and the potential for climate-change tipping points. They show, as Weitzman suggested, that uncertainty greatly strengthens the case for immediate and strong climate-change mitigation in the form of the imposition of far higher carbon taxes than have previously been suggested. This research makes clear that the future of measuring intergenerational justice and determining policies to achieve intergenerational justice lies in stochastic, dynamic modelling that simultaneously captures all major interacting factors.

Measuring intergenerational justice is, of course, only the first step in achieving generational justice. As described above, many countries have pursued and are pursing policies that pose tremendous risks – fiscal, environmental, and, arguably, existential risks – to our descendants. This is passing strange in a world where parents universally proclaim their children to be their most precious possession. The measurement of intergenerational justice is now moving at an accelerating pace. Whether it is matched with the rapid actions needed to protect the welfare of our collective progeny remains to be seen.

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Notes

1 Auerbach/Kotlikoff/Koehler (2016) provides a new method for measuring intragenerational inequality.

2 O'Driscoll (1977) provides a full description of Ricardo's assertion and immediate rejection of "Ricardian Equivalence".

3 In 1970, payments to Medicare, Social Security and Medicaid (70% of which goes to the poor elderly) per oldster (person 65 and older) equalled 37% of per capital GDP. Today the ratio is close to 70%.

4 Generational accounting references a specific framework developed by the author, Alan Auerbach and Jagadeesh Gokhale (see Auerbach, Gokhale and Kotlikoff (1991)), to calculate and characterise fiscal burdens being left to future generations assuming currently living generations do not contribute to eliminating the fiscal gap. Generational accounting, as formalised in Auerbach, Gokhale, and Kotlikoff (1991), does not capture other net burdens, such as climate degradation, that current generations impose on future generations. The generational accounting framework has been modified by other researchers to, for example, allocate, by generation, the benefits of public goods spending and to examine the fiscal treatment of future generations in all or some of the fiscal gap that is closed via additional net taxes levied on current generations (see, for example, Raffelhüschen and Walliser (1996) and Bonin (2013)).

5 Governments cannot escape satisfying their intertemporal budget constraints since doing so would imply that a country could consume more than its resources, where consumption and resources are both measured in present value. Hence, fiscal gap accounting is an inherently partial equilibrium analysis showing the need for fiscal adjustment, while leaving open the means of fiscal adjustment. Practically speaking, a government that attempted to maintain a positive fiscal gap indefinitely would find itself trying to extract more than 100% of the resources of the young to trans-

fer to the old or to the government. This produces "game over", which is illustrated in Evans, Kotlikoff and Phillips (2012).

6 Author's calculations based on projections of the Congressional Budget Office.

7 I.e. the present value of 10.5% of GDP projected over the infinite horizon equals roughly $200 trillion.

8 Estimate by author.

9 To get a sense of the size of 3% of GDP, note that 3% is roughly the ratio of US Social Security benefits (paid for, in part, by a 12.4% payroll tax) to US GDP.

10 See Cavallo and Runde (2017) for an outstanding review of 20th- and 21st-century economic history.

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