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# 14 Forecasting in age-structural time

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## Introduction

Originally the product of research in the US National Intelligence Council, age-structural modeling was intended to serve as a quantitative, exploratory, long-range forecasting tool for foreign affairs, defense and intelligence analysts, a tool that could operate alongside a number of social science theories. Designed to run on publicly available data and rely on any off-the-shelf statistical package, it can graphically display conclusions in ways readily understood by analysts and policymakers.

Age-structural modeling is about timing. Each of these models' predictive curves operates in *age-structural time*, which measures progress along the path of the *age-structural transition* – the long-term shift from a youthful set of population distributions, to distributions that encompass much larger proportions of adults who are middle-aged or seniors. The goal has been to provide analysts with an expectation of *when* a social, economic or political shift is likely to occur, not to indicate *how* it happens or explain *why*. Rather than endeavor to unravel the Gordian knot of latent effects and feedbacks, within which demography plays a part, the intent of generating age-structural functions is to inform analysts of probabilistic shifts that are associated with the movement of states across the age-structural transition.

Essentially, age-structural models transform data representing a categorical segment of a social, economic or political transition, from their positions in the *chronological time domain*, **T**, into positions in the *age-structural domain*, **M**, an axis, measured in years of median age, ***m***, that represents the continuous path of the age-structural transition. Rather than being concerned about how states perform during a specific year in chronological time, analyses in

age-structural time predict their likely performance (or behavior), described in broad categories, at specific median ages – generally from 15.0 to 55.0 years – as their age structures mature and, thus, as they advance through the age-structural domain (Cincotta 2017).

There are advantages to working in this alternative time scale. Whereas in chronological time, analysts are frequently blindsided by the apparent abruptness of political transitions, or unexpected stalling/backtracking of indicators of political or development progress, these discontinuities largely disappear in age-structural time. And, unlike chronological time, age-structural time need not stop at the present. Once probability curves (called *age-structural functions*) are generated in age-structural time, they can then be applied several decades into the chronological future using the UN Population Division's (UNPD) biennially revised set of demographic projections.

This chapter is devoted to applying the age-structural modeling technique to forecast the timing of transitions in social, economic and political development. The objectives are threefold: (1) to review accepted theory concerning the dynamics of social, economic and political behavior of states during the course of the age-structural transition and to identify the most significant gaps in this pursuit; (2) to review age-structural modeling's most striking findings and forecasts; and (3) to discuss the relevance of these findings and current forecasts in light of ongoing and expected global trends.

## The Global Trends four-phase schema

To facilitate testing, standardize maps and other graphic means of communicating results and forecasts, and clarify narratives and discussions among analysts and policymakers, age-structural modeling divides the age-structural domain into four discrete phases. Developed within the National Intelligence Council (NIC) Global Trends program (NIC 2012, 2017) from schemas published by Leahy et al. (2007) and Malmberg and Lindh (2006, p. 68), each of the four phases is defined in terms of the country-level median age, $\boldsymbol{m}$ (the age of the person for whom precisely half of the population is younger), a scalar measure used to crudely characterize and compare the age distributions of populations. These four phases (with standard three-letter abbreviations) are:

- youthful phase [YTH], $\boldsymbol{m} \leq 25.5$ years;
- intermediate phase [INT], $25.6 \leq \boldsymbol{m} \leq 35.5$ years;
- mature phase [MAT], $35.6 \leq \boldsymbol{m} \leq 45.5$ years; and
- post-mature phase [PMT], $\boldsymbol{m} \geq 45.6$ years.

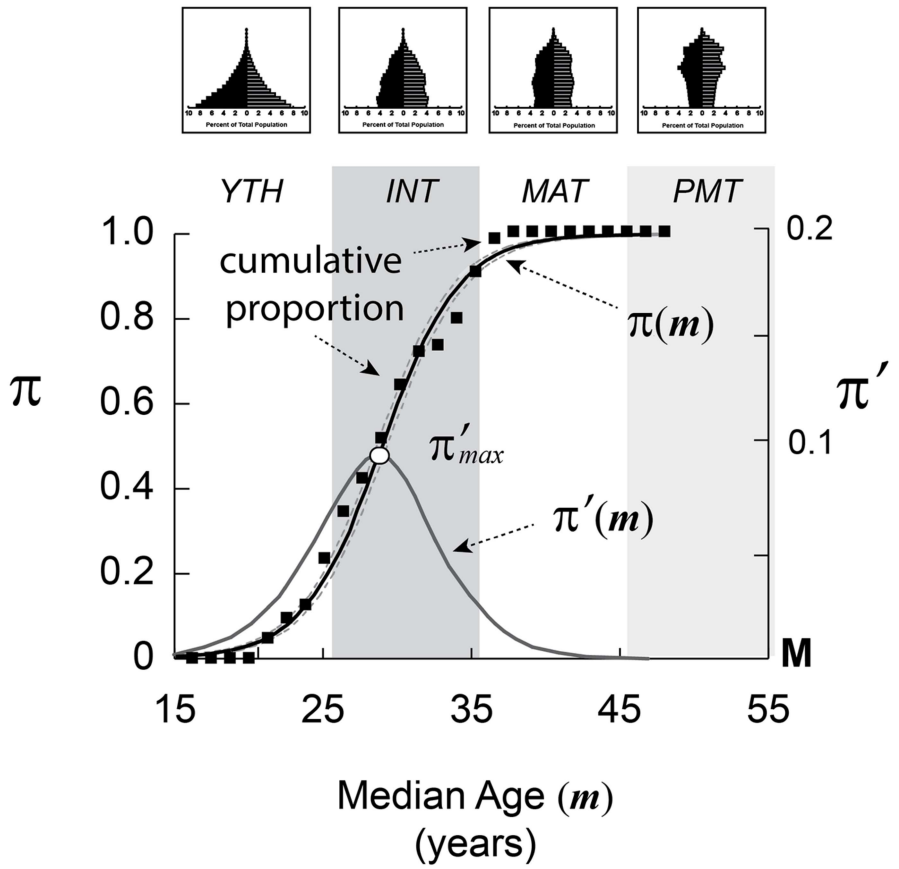
The use of single decimal digit precision (tenths) is clearly more precise than the concept warrants, and the categorical boundaries are unrealistically abrupt. Moreover, the representations of population profiles using horizontal bar graphs (see Figure 14.1, profiles aligned at the top of the figure) miss the variation within phases. Nonetheless, the standardization of these categorical boundaries and their iconic representation help keep maps, graphics and discussions consistent among analysts and technicians who are, otherwise, unfamiliar with demography, and it facilitates analysis using simple bar graphs and non-parametric statistical tests.

## What we know, and don't know

Today, country-level age structures are more diverse than ever. According to the UNPD, they range in median age (the age of the person for whom one-half of the population is younger) from just above 15 years in Niger, the most youthful country, to more than 48 years in Japan, the world's most mature. Because the most mature country-level age structures have evolved over the course of fertility decline from very youthful age structures, demographers have a detailed record of their performance and behavior along this transition. Thus, researchers generally understand more about the youthful and intermediate phases of the age-structural transition, less about the mature phase and very little about the post-mature phase – a phase that, as of the year 2020, only four countries have entered (Japan, Germany, Italy and Portugal).

Empirically, demographers understand a great deal about what to expect of states in the early phases of the age-structural transition, the youthful phase – a portion of the transition through which roughly two-thirds of the world's states have passed. They may know even more about the transition's intermediate phase. The site of an unusual amount of economic, social and political change, considerable research has been focused on it. However, demographers understand less about the adaptive evolution of states in the mature phase, which lately has been yielding more of its secrets, and they know almost nothing about how states will adapt to advanced population aging in the post-mature phase.

Demographers are aware that in the *youthful phase*, where populations are numerically dominated by children, adolescents and young adults, countries typically experience very high rates of workforce growth, rapid growth of cohorts entering the school-age population, low per-capita levels of human capital and low levels of financial support for childhood dependents (Lee and Mason 2011). These conditions have presented obstacles to attaining high levels of educational attainment, child survival, per-capita income (Cincotta




**Notes:** The plotted cumulative proportion (points) and smoothed cumulative distribution function are shown for under-age-five mortality rate of less than 25.0 deaths per 1000 live births, 1970 to 2010, across the age-structural transition (measured in median age). The curve, $\pi(\boldsymbol{m})$, was generated using logistic regression. Its first derivative, $\pi'(\boldsymbol{m})$, is expected to peak where $\pi(\boldsymbol{m})$ equals 0.50, shown as $\pi'_{max}$. The age-structural transition is divided into four phases (shown at top of graph with iconic population profiles): youthful (YTH), intermediate (INT), mature (MAT) and post-mature (PMT).

**Figure 14.1** Phases of population profiles

2017), human capital spending (Lee and Mason 2011) and youth employment (Easterlin 1968). Youthful populations typically feature locally powerful extended families, clans and patronage networks (Wusu and Isiugo-Abanihe 2006). They rarely reach high levels of democracy (i.e., liberal democracy) (Cincotta 2008/09; Dyson 2013; Weber 2012; see also Chapter 13 of this volume), and when they do, they typically lose those levels within a decade

(Cincotta 2008/09; Weber 2012). Moreover, due to the general instability of their regimes, states with youthful populations are substantially more likely to abrogate a military alliance than those that are age-structurally more mature (Kim and Sciubba 2014).

Following a decline in the total fertility rate (TFR), generally below 2.8 children per woman (Cincotta 2017), the subsequent shift into the transition's *intermediate phase*, considered the most advantageous of the four phases, initiates a surge in the proportion of adults in the youngest portion of the prime working ages. This surge boosts the effective producers per dependent consumer, augments the number of producers and adult consumers and vastly increases the number of potential taxpayers (Lee and Mason 2011). Coincident with low fertility and high levels of support for children, this phase – sometimes referred to as the *demographic window* – typically heralds the rapid rise of educational attainment, human capital spending, per-capita income and, among some states, the accumulation of assets and/or savings among a broad public (Lee and Mason 2011). It also has been the most likely place for the rise of a stable liberal democracy (Cincotta 2008/09).

Economic growth rates tend to slow as states leave the demographic window and enter the transition's *mature phase*. Despite an aging workforce and a growing group of retirees in age-structurally mature states, favorable economic and stable political conditions typically prevail – conditions that make these states ultimate destinations for migrants fleeing a lack of opportunity and criminal and political violence. There has been an expectation that states that amassed considerable human capital and infrastructure during their intermediate phase will continue to facilitate savings and asset accumulation broadly among their citizens. However, recent research identifies a tendency toward rising income and asset inequality among most mature states (Fine et al. 2019) and a notable shift toward political nationalism and democratic back-sliding.

Because of the novelty of the transition's *post-mature phase*, scant empirical evidence – or even observational anecdote – can yet be applied to understand how state institutions might be mobilized to mitigate these risks. Demographic projections indicate that states in this phase will be faced with larger-than-ever proportions of retirees and dependent elderly, and declines in the proportion of those in the prime working ages. Such conditions risk fiscal imbalances which could be addressed by higher levels of taxation, higher rates of immigration and higher levels of debt (Eberstadt and Groth 2010). Some analysts speculate that, in the future, these states will find their capacity to extend military power far beyond their borders substantially weakened and their participation in the international system constrained (Brooks et al. 2018/19; Haas 2007),

while other analysts find the same pressures can induce adaptive responses that favor bilateral alliances and greater participation in regional economic and defense organizations (Sciubba 2016).

## Modeling

Age-structural modeling's standardized protocol (discussed in more detail in Cincotta 2017) is structured to generate logistic curves in the age-structural domain. It requires that:

- cases include only those for independent states with populations over 500,000;
- the development transition under analysis is divided into a meaningful sequential series of dichotomous *outcome categories* (WHO and World Bank development maps are useful sources for categories), or an available standard series of outcome categories (e.g., the World Bank's income classes, or Freedom House's freedom scores from Freedom in the World reports);
- each outcome category, except the least advanced category, is individually modeled;
- each observation in the outcome category being studied is coded as either a zero (0), indicating a value less advanced than those encompassed by the outcome category; or as a one (1), representing a value *within the outcome category* or *within a more developmentally advanced category*;
- age-structural modeling's domain variable, country-level median age (the age of the individual, in years, for whom precisely half of the population is younger), appears as the only *continuous* independent variable in the logit equation; and
- all other independent variables, including standard controls – e.g., resource reliant states (oil and mineral rents greater than 15 percent of GDP), and non-resource reliant states with a small population (less than 5.0 million) – and optional experimental variables are coded dichotomously (0,1).

When graphed in the age-structural domain, the resultant probability function (known as an age-structural function) that is generated by the logistic regression algorithm is described by a simple logistic curve – an S-shaped curve (shown in Figure 14. 1) with its inflection point, $\pi'_{max}$ (the maximum of its first derivative), at a probability, $\pi$, of 0.50 – or by a partial segment of a simple logistic curve where the inflection point is not visually apparent. Where the inflection point is apparent, it serves as a useful guide for forecasters, who should expect a large proportion of states to advance into this category in the vicinity of this point.

## Forecasting models: results and conclusions

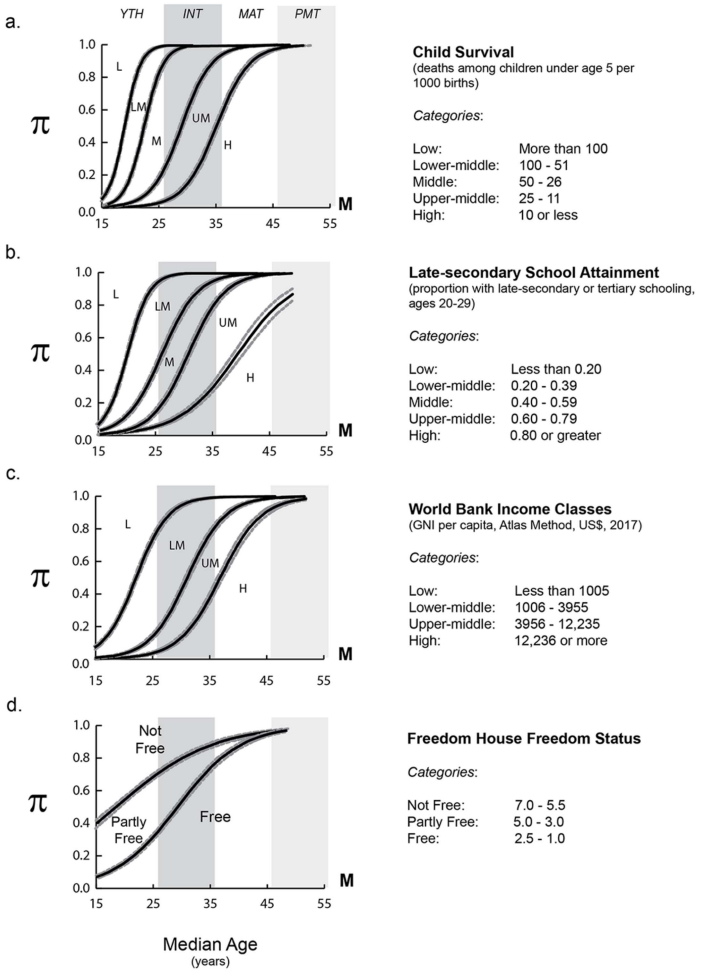
Age-structural forecasting begins with statistical expectations generated by age-structural functions. Age-structural research has yielded six sets of age-structural functions that predict the timing of the following six categorical transitions, three socioeconomic and three political:

- *child survival transition* (from high to low levels of under-age-five mortality);
- *late-secondary educational attainment transition* (from low to high levels of late-secondary attainment among 20- to 29-year-olds);
- *per-capita income transition* (from low to high levels of per-capita gross national income);
- *political liberalization transition* (from autocracy and partial democracy, to liberal democracy);
- *civil political stability transition* (from high to low prevalence of non-territorial armed conflict, including revolutions and other non-separatist warfare); and
- *ethnic stability transition* (from high to low prevalence of territorial armed conflict, which is primarily composed of ethnoreligious separatist rebellion).

### Socioeconomic development transitions

The *child survival transition* has been categorized using the World Health Organization's (WHO) global maps of country under-age-five mortality (U5M) levels (WHO 2015). This transition is measured in deaths of children under age five per 1,000 live births, drawn from the UN Population Division's most current revision (UNPD 2019): low child survival (≥ 100.0), lower-middle (50.0 to 99.9), middle (25.0 to 49.9), upper-middle (10.0 to 24.9) and high (< 10.0). The child survival transition (Figure 14.2a) is largely an irreversible transition that typically commences and makes substantial progress prior to significant fertility decline. However, the achievement of the upper-middle category appears constrained to the intermediate phase of the age-structural transition. While reversals in child survival are relatively infrequent, setbacks have been associated with the AIDS epidemic (mortality associated with mother-to-child HIV transmission), high-intensity warfare (principally in sub-Saharan Africa and Asia) and punctuated catastrophic conditions.

The *late-secondary educational attainment transition* follows the proportion of young adults, aged 20 to 29 years, who have attained late-secondary educational level or higher (Figure 14.2b). The five proportional, late-secondary




**Notes:** Categorical age-structural functions comprising four fundamental transitions: (a) child survival; (b) late-secondary educational attainment; (c) per-capita income; and (d) political liberalization. Each graph shows the categories within each transition, and their stacked probabilities (and 0.95 confidence intervals) across four age-structural phases: youthful (YTH), intermediate (INT), mature (MAT) and post-mature (PMT).

**Figure 14.2** Categorical age-structural functions

educational attainment categories, expressed as percentages, are: low (< 20.0), lower-middle (20.0 to 39.9), middle (40.0 to 59.9), upper-middle (60.0 to 79.9) and high late-secondary attainment (≥ 80.0). Data are drawn from the Wittgenstein Center Data Explorer (WCDGHC, 2015; an annual average of about 10 percent of cases are unavailable). This transition is largely irreversible,

yet more susceptible to stalling than the child survival transition. Educational systems vary in terms of quality and length, and some European programs encourage early transfers to apprenticeships and employment.

The *per-capita income transition* follows the inflation-adjusted estimates of gross national income (GNI) per capita (Atlas Method) in current US$, using the World Bank's FY2018 revised schema: low ( $12,055). For most states, advances in per-capita GNI appear largely irreversible. While there is evidence of periodic regional and global economic setbacks (e.g., 1998–2000; 2008–09), they are less observable in the categorical representation of the transition. Moreover, control variables that identify oil- and mineral-reliant economies isolate the effects of state income derived from rents and sovereign wealth funds, as well as separating the effects of commodity price fluctuations from other more human-capital dependent economies (Figure 14.2c).

Each transitional series of age-structural functions can be put to work to help analysts make a first approximation of a country's expected progress along any of these transitions. For a country that is over 5 million population and not a GCC or other highly resource-dependent state, analysts can individually assess countries – now and in the future – by extending a vertical line on the graph, perpendicular to the country's median age. Such a line cuts across the probabilistic regions associated with each of the transition's categories, giving analysts a visual indication of which categories in the transitional set are most likely to be realized at a given median age. If a calculated statement of these probabilities is needed, these can be generated mathematically (as follows).

For example, according to the UN Population Division's 2019 estimates, the 2018 median age of Bangladesh is 26.8 years. Extending a line perpendicular to 26.8 years, through the transitional series associated with the World Bank's income classes (Figure 14.2c), we find the three categorical age-structural models divide that line into four segments (the full line equaling 1.0). Measuring those segments, mathematically, indicates that Bangladesh's probability of being in the low-income class in 2018 is 0.14, in the lower-middle income class is 0.62, in the upper-middle income class is 0.19 and in the high-income class is 0.06. As it turns out, the World Bank reported that, in 2018, Bangladesh was in its lower-middle income class.

Likewise, one can perform this exercise for 2030, when the UNPD's medium fertility variant projects Bangladesh will have a median age of 31.6 years. For this age structure, the income transition's age-structural models yield the following set of probabilities: low income, 0.03; lower-middle income, 0.39; upper-middle income, 0.38; and high income, 0.20. Thus, looking

ahead a decade, there appears to be an almost equal probability that, in 2030, Bangladesh will still be in the World Bank's lower-middle income class, or have shifted to its upper-middle income class.

## Political development transitions

To model the *political liberalization transition* (see Chapter 12 this volume), a liberal democratic regime is assumed to be indicated by an assessment of "free" status in Freedom House's annual survey of political rights and civil liberties (see FH 2020).

Further analyses (Cincotta 2017) indicate that:

- stable "free" status is most often achieved in the vicinity (±2 years) of a median age of 29 to 30 years;
- at any time, a relatively small proportion of age-structurally youthful states (from 15 to 20 percent) are assessed as "free", but generally are unable to sustain this status for more than a decade if they remain in the youthful phase;
- the least populous states (less than 5 million residents) have been able to attain "free" in their youthful phase and remain remarkably stable, unlike more populous states;
- single-party authoritarian regimes (identified by the Authoritarian Regime Database 2015; see also Hadenius and Teorell 2007) are generally autocratic political monopolies that have been consolidated using an exclusive ideology, and can be expected to advance through the intermediate and mature phases without attaining "free"; and
- military regimes (identified by the Authoritarian Regime Database) are vulnerable to the advancement of age-structural time; they are stable while the population is youthful, but typically yield to more liberal regimes as the population moves through the transition's intermediate phase.

With inequality and migration looming as larger political issues for countries in the age-structural transition's mature phase, democratic backsliding could be on the way – particularly in post-communist states. In 2018, Hungary and Serbia declined from "free" to "partly free". Moreover, in 2018, Poland, while still assessed as "free", lost a full point on Freedom House's scoring system. Declines from "free" among youthful democracies represent the most common form of categorical democratic backsliding (Figure 14.2d). Nonetheless, since 1972, three states in the transition's intermediate or mature phase have dropped from "free" to "partly free" without yet recovering their "free" status: Thailand in 2005; Ukraine in 2010; and Indonesia in 2013.

The *civil political stability transition* hypothesizes an age-structurally timed decline of non-territorial intra-state conflict (revolutions and other non-separatist intra-state conflicts) – i.e., the transition toward less frequent incidents of non-territorial conflict. Drawn from the Uppsala/PRIO Conflict Data Set (UCDP/PRIO 2017), this type of armed intra-state conflict is defined as a "contested incompatibility resulting in at least 25 battle-related deaths in a calendar year" (UCDP/PRIO 2017, p. 1), in which the opposition actor intends to change or modify the political system or regime (rather than a territorial conflict, also known as a separatist conflict, where the opposition actor intends to change or modify the status of a territory).

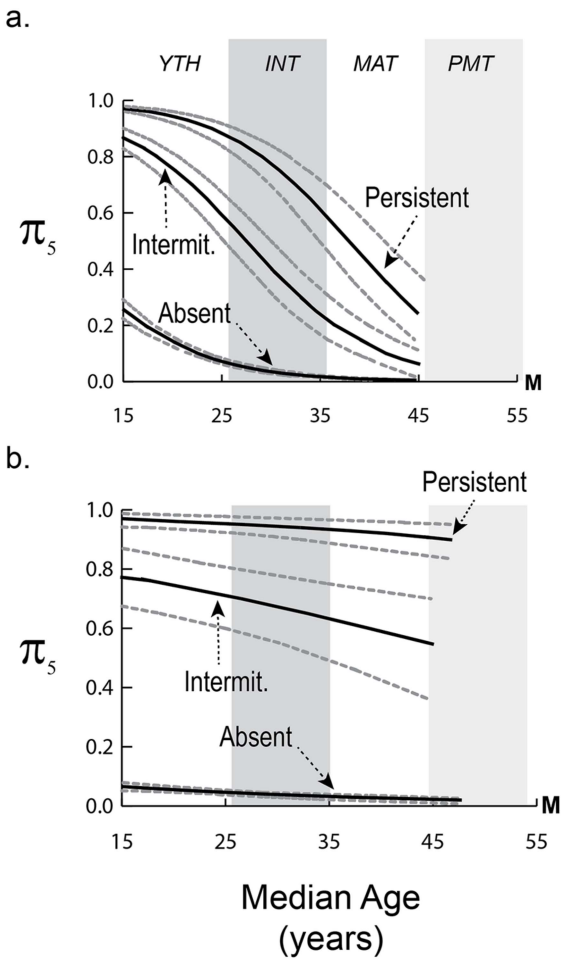
The analysis by Cincotta and Weber (forthcoming) employs a single outcome variable: the occurrence (1), or absence (0), of at least one conflict-year of revolutionary conflict during the next five years. Three age-structural models, each differentiated by conflict history – i.e., by the number of revolutionary conflicts that a state has experienced during the prior four years, include:

- conflict absence (0 conflicts in the past 4 years);
- intermittent conflict (1 or 2 conflicts in the past 4 years); and
- persistent conflict (3 or 4 conflicts in the past 4 years).

Where revolutionary conflict has been absent, the annual probability of an onset of revolutionary conflict is relatively low (Figure 14.3a), yet still most elevated among the very youthful states – those with a median age of less than 20 years. Youthful countries with a recent history of revolutionary conflict run very high risks of another incident of conflict during the next five years. However, progress into the intermediate phase of the age-structural transition tends to dramatically reduce that risk. Together, these three conflict-history models suggest that:

- countries in the youthful phase of the transition are more likely to be engaged in a non-territorial conflict (see Cincotta and Weber forthcoming); and
- the risk of intermittent non-territorial (revolutionary) conflict declines precipitously during the age-structural transition's intermittent phase.

*The ethnic political stability transition* hypothesizes an age-structurally timed decline of intra-state territorial conflict (separatist conflict) – i.e., the transition toward less frequent incidents of territorial conflict, defined as a conflict where the opposition actor intends to change or modify the status of a territory (UCDP/PRIO 2017). This analysis (Cincotta and Weber forthcoming) employs the same categories as the civil political stability transition. However, the trends appear weaker and less certain (Figure 14.3b).




**Notes:** Trends in the five-year probability, $\pi_5$, of experiencing a (a) non-territorial conflict (revolutions and other non-separatist attempts to violently destabilize the central government) and experiencing a (b) territorial conflict (separatist conflict) as states traverse the age-structural transition, measured in median age. Curves (solid lines) and their 0.95 confidence limits (dashed lines) are read as probabilities for three different conflict histories: absent conflict (0 conflict years during the past 4 years); intermittent conflict (1 or 2 conflict years during past 4 years); and persistent conflict (3 or 4 conflict years during past 4 years).

**Figure 14.3** Probability of conflict

These functions impart several lessons. Their trajectories suggest that the risk of a new emergence of a territorial conflict among states that have not experienced them recently (absence) is low, even for youthful states, and very

gradually declines as countries move through the age-structural transition, never reaching zero. The trajectories also imply that, once territorial conflicts become intermittent or persistent, the risk that the state will experience another conflict incident over the next five-year period is very high, even at advanced phases of the age-structural transition.

The emergence of a territorial intra-state conflict is rare, and nearly non-existent in the least populous countries (population less than 5 million) (Cincotta and Weber forthcoming). However, the persistence and re-emergence of separatist conflict is common. Apparently, intermittent and persistent separatist conflicts are difficult to settle (Denny and Walter 2014). Moreover, separatist conflicts tend to persist through age-structural time.

The method used to generate probabilities for the three categories in the political liberalization transition (Figure 14.2d) is identical to the vertical-line method previously described for the development transitions (Figures 14.2a, b, c). However, unlike the prior transitional sets of curves (shown in Figure 14.2), each conflict-history curve (Figures 14.3a, b) is, itself, a transition. In other words, erecting a vertical line, perpendicular to a median age, cuts through only two conflict categories. Above each curve (from the curve upward to 1.0), the length of the line segment represents the probability that a country will be engaged in a similar type of conflict during the next five years. Below the curve (from the curve downward to 0.0), the distance represents the probability that this country will not be engaged in a similar type of conflict during the next five years.

## Key Findings

*Development and political stability accompany the age-structural transition*

The pattern of the three development transitions – child survival, late-secondary educational attainment and per-capita income – are strikingly similar. Youthful age-structures, and the high levels of fertility that maintain them, consistently appear as powerful constraints to reaching moderately high levels of development. With the exception of some of the least populous states and those with high levels of oil and mineral endowments (discussed in the following section), youthful states are confined almost exclusively to the low and lower-middle categories of these development transitions. In contrast, the upper-middle categories of socioeconomic development are consistently properties of states that have attained the age-structural transition's intermediate phase, passing a median age of 26 years. Crossing that threshold typically involves states declining to a total fertility rate below 2.8 children per woman (Cincotta

2017), plus additional years for the bulge of adolescents in the age-structure to mature.

The political advantages inherent in attaining this demographic window are made graphically obvious by the intersection of upper-middle categories and the clustering of their inflection points near a median age of 30 years. Notably, the inflection point on the political liberalization transition's "free" function (Figure 14.2d), and the civic political stability transition's intermittent conflict function (Figure 14.3a) also appear within this cluster. Given the coincidence of these trends, it seems obvious why state capacity appears to coalesce in the intermediate phase, and why countries are able to build their infrastructure and institutions during this demographic window.

*Territorial intra-state conflicts have a weak relationship with the age-structural transition*

Among youthful countries, non-territorial conflicts – particularly an insurgency that seriously contests the legitimacy of the central government – is increasingly likely to be settled, to fade to very low levels of intensity or to emerge only briefly as states enter the intermediate phase and traverse the age-structural transition (Cincotta and Weber forthcoming). The exceptions among non-territorial conflicts are principally comprised of intermittent attacks occurring in the stable economies of age-structurally mature states – including the al-Qaeda-organized 9/11 attacks in 2001, the 2004 Madrid train and 2005 London Underground bombings that may have been assisted by al-Qaeda operatives and the Oklahoma City bombing by members of a US-based neo-Nazi militia. These have typically entailed terror against largely symbolic state targets or against civilians in capital cities or commercial hubs. This difficult-to-classify set of conflicts, which often features foreign actors, social media, international travelers and resident discontents, harbors no serious potential of overturning the central regime, but has had significant economic and social impacts.

On the other hand, territorial intra-state conflicts – which generally involve ethnic separatist insurgents – tend to be highly persistent or intermittent across the age-structural transition. Separatist conflicts rarely begin where they have previously been absent, and they are nearly non-existent in small-population states (fewer than 5 million inhabitants). However, among more populous states, once they begin, it is difficult to completely eradicate a separatist conflict at any time in the transition (e.g., the separatist conflicts composing the Yugoslav Civil War, 1991–2001). Thus, it is little wonder that some multi-ethnic states with mature populations and distinct regional enclaves

have opted for peacefully dismembering their union (e.g., the dissolution of Czechoslovakia, 1993; and the Soviet Union, 1991). In some states, wide and sustained gaps in fertility and age-structure signal prolonged tensions between majority and minority groups – particularly when the minority represents a large proportion of the provincial or state population – and when they are politically organized (Blomquist 2016). Thus, median age at the country level is generally *not* indicative of these conflicts (Cincotta and Weber forthcoming; Yair and Miodownik 2016).

*Beware of exceptional conditions*

Among the most useful features of age-structural modeling has been its ability to identify exceptional conditions, and states experiencing those conditions. Exceptional conditions are those that permit or constrain states to *not* fit age-structural modeling's most basic assumption – that development progress is associated with advancement across the age-structural domain. Once exceptional conditions have been observed or suspected, they can be deductively tested as dichotomous explanatory variables. Those that have repeatedly deviated from the larger pack of countries, across several development transitions, are now used in age-structural modeling's logit equations as standard dichotomous controls. These include: (a) substantial levels of oil and mineral rents (when greater than 15 percent of GDP), and (b) the least populous states (fewer than 5.0 million residents).

Most small-population states are age-structurally precocious performers in that they have regularly achieved the upper-middle levels of the development transitions before the rest of the pack, and a significant portion have both achieved "free" in the youthful phase and held on to it (e.g., Costa Rica, Jamaica, Botswana and Namibia). Moreover, fewer of these least-populous states are in non-territorial conflict as youthful states, and none have been in conflict since the 1970s while in the intermediate or mature phases. Oil- and mineral-reliant states are also precocious development performers. However, they generally lag in their political transitions – fewer than expected have achieved "free" and their risk of non-territorial and territorial conflict is generally greater.

Four additional conditions appear to deviate from expectations. However, none of these have been added to age-structural models because they are represented by relatively few cases or they arise and decline erratically. Nonetheless, encountering any of these conditions in a focus country or its regional neigh-

borhood should prompt forecasters to temper the certainty of their statistical predictions or adjust its predicted outcome. These are:

- *the presence of a single-party political regime or theocracy* (identified by the Authoritarian Regime Data Set 2015) deters political liberalization, and may impede other transitions. The most implacable of these regimes (e.g., China, North Korea and Iran) maintain elite means to smoothly accomplish leadership transitions capable of sustaining the regime's political monopoly. States with these types of regimes have traversed the demographic window (the intermediate phase) without regime change or dramatic reforms and have successfully suppressed all challenges.
- *Ongoing high-intensity territorial (separatist) or non-territorial conflicts (revolutionary and other non-separatist conflicts)* appear to deter progress in some political and development transitions, particularly if conflicts are intense and not territorially contained.
- *The influence of powerful neighboring states or their within-state proxies* can deter political transitions. Examples include chilling effects of the Soviet Union on the neighboring Eastern European states during the Cold War, and Iran's financial and material support of Hezbollah in Lebanon.
- *Disparate rates of majority and minority demographic change – from gaps in fertility or migration – can undermine political transitions* (Blomquist 2016). Conditions appear to be most exceptional when that minority becomes sufficiently populous, and when that minority is politically organized.

## Relevance to ongoing and future trends

By its nature, age-structural modeling is only capable of describing the timing of recognized political and development transitions that (a) are paced by the age-structural transition and (b) are, or can be, broken down into a meaningful series of discrete categories for which time-series data are abundantly available. Because age-structural modeling reaches into past data to build models that can be used to guide analysts' perspectives on the future, its categorical models should be expected to most accurately theorize the timing of state behaviors during the early, data-rich phases of the age-structural transition, and be less knowledgeable about when categories of behavior arise, are reached, or retreated from, during the transition's latter stages. Thus, the statistical characterizations of trends and their timing that are produced by age-structural modeling will be most relevant to the future of states that will remain in the youthful, intermediate or mature phases, and those that traverse between these phases.

To 2050, roughly three-quarters of all states are projected to remain in these three phases. By identifying clusters of youthful states, analysts should have an idea where non-territorial conflicts will most likely break out, and where all types of ongoing intra-state conflict will likely persist or frequently recur. The most persistently youthful clusters are likely to become crisis hotspots, generating warfare that spills across borders, pockets of severe food insecurity and significant out-migration. In contrast, among the handful of states that are projected to leave the youthful phase and pass deeply into the intermediate phase, analysts should look for newly emerging economies and hints of political liberalization.

The remaining quarter of the world's states are heading into an unchartered age-structural future. According to the UNPD's medium fertility variant, more than two-thirds of all European states and nearly half of East Asia's (including China) could reside in the post-mature phase in 2050 – about 40 states; up from only four, today. As a means to discern state behavior and performance under such novel demographic conditions, age-structural modeling is, admittedly, unfit.

Until a larger, more varied set of countries affords a proper statistical view of post-maturity, our perceptions of this future will continue to be influenced by some combination of narrative theories, mechanistic models, comparative analyses, case studies and ideologically tinged personal opinion. States may, indeed, find institutional means to adapt smoothly to advanced population aging. Some may not. Whatever future unfolds in post-maturity, only the most disciplinary and ideologically constrained analysts can continue to remain oblivious to age structure's influence on the evolution of modern states.

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## References

Authoritarian Regime Data Set (2015), 'Authoritarian Regime Data Set, 1972–2014', Retrieved May 20, 2017 from https://sites.google.com/site/authoritarianregimedataset/.

Blomquist, R. (2016), 'Ethno-Demographic Dynamics of the Rohingya-Buddhist Conflict', *Georgetown Journal of Asian Affairs*, 3 (1), 94–117.

Brooks, D. J., Brooks, S. G., Greenhill, B. D. & Haas, M. L. (2018/19), 'The Demographic Transition Theory of War: Why Young Societies Are Conflict Prone and Old Societies Are the Most Peaceful', *International Security*, 43 (3), 53–95.

Cincotta, R. (2008/09), 'Half a Chance: Youth Bulges and Transitions to Liberal Democracy', *Environmental Change and Security Program Report*, 13, 10–18.

Cincotta, R. (2017), 'The Age-structural Theory of State Behavior', in W. Thompson (ed.), *Oxford Research Encyclopedia of Politics*. Oxford: Oxford University Press.

Cincotta, R. & Weber, H. (forthcoming), 'Youthful Age Structures and the Risk of Revolutionary and Separatist Conflict', in Goerres, A. & Vanhuysse, P. (eds), *Global Political Demography*. London: Palgrave Macmillan.

Denny, E. K. & Walter, B. F. (2014), 'Ethnicity and Civil War', *Journal of Peace Research*, 51 (2), 199–212.

Dyson, T. (2013), 'On the Democratic and Demographic Transitions', *Population and Development Review*, 38 (suppl.), 83–102.

Easterlin, R. A. (1968), *Population, Labor Force, and Long Swings in Economic Growth: The American Experience*. New York: National Bureau of Economic Research & Columbia University.

Eberstadt, N. & Groth, H. (2010), 'Demography and Public Debt: Time for a "Demographic Stress Test" for the Western Economies. What Does It Mean for Switzerland?' *WDA-HSG Letters on Demographic Issues*, No. 2010/1. St. Gallen, Switzerland: University of St. Gallen.

Fine, D., Manyika, J., Sjatil, P. E., Tacke, T., Tadjeddine, K. & Desmond, M. (2019), 'Inequality: A Persisting Challenge and Its Implications', *Discussion Paper*. New York: McKinsey Global Institute.

[FH] Freedom House (2020), *Freedom in the World, 2020: A Leaderless Struggle for Democracy*. Washington, DC: Freedom House.

Haas, M. L. (2007), 'A Geriatric Peace? The Future of U.S. Power in a World of Aging Populations', *International Security*, 32 (1), 112–47.

Hadenius, A. & Teorell, J. (2007), 'Pathways from Authoritarianism', *Journal of Democracy*, 18 (1), 143–56.

Kim, T. & Sciubba, J. D. (2014), 'The Effect of Age Structure on the Abrogation of Military Alliances', *International Interactions*, 41 (2), 279–308.

Leahy, E., Engelman, R., Vogel, C. G., Haddock, S. & Preston, T. (2007), *The Shape of Things to Come: Why Age Structure Matters to a Safer, More Equitable World*. Washington, DC: Population Action International.

Lee, R. & Mason, A. (eds) (2011), *Population Aging and the Generational Economy: A Global Perspective*. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Malmberg, B. & Lindh, T. (2006), 'Forecasting Global Income Growth Using Age-structural Projections', in Pool, I., Wong, L. R. & Vilquin, E. (eds), *Age-structural Transitions: Challenges for Development* (pp. 60–82). Paris: Committee for International Cooperation in National Research in Demography.

[NIC] National Intelligence Council (2012), *Global Trends 2030: Alternative Worlds*. Washington, DC: Office of the Director of National Intelligence.

[NIC] National Intelligence Council (2017), *Global Trends: Paradox of Progress*. Washington, DC: Office of the Director of National Intelligence.

Sciubba, J. D. (2016), 'Willing and (Somewhat) Able: Japan's Defense Strategy in a Graying Asia', *Georgetown Journal of Asian Affairs*, (Fall), 50–56.

[UNPD] United Nations, Dept. of Economic and Social Affairs, Population Division (2019), 'World Population Prospects: The 2019 Revision', New York: United Nations, Dept. of Economic and Social Affairs.

[UCDP/PRIO] Uppsala Conflict Data Program, & Center for the Study of Civil Wars, Peace Research Institute at Oslo (2017), *UCDP/PRIO Armed Conflict Dataset Codebook: Version 4-2017*, Oslo: UCDP/PRIO.

Weber, H. (2012), 'Demography and Democracy: The Impact of Youth Cohort Size on Democratic Stability in the World', *Democratization, iFirst*, 1–23.

[WCDGHC] Wittgenstein Centre for Demography and Global Human Capital (2015), 'Wittgenstein Centre Data Explorer', Version 1.2, retrieved April 17, 2018 from http://www.wittgensteincentre.org/dataexplorer.

World Bank (2018), *World Development Indicators, Online*. Washington, DC: World Bank, retrieved September 20, 2018 from https://databank.worldbank.org/reports.aspx?source=world-development-indicators.

[WHO] World Health Organization (2015), *Map: Under-5 Mortality Rate, 2015*, retrieved April 17, 2018 from http://gamapserver.who.int/mapLibrary/Files/Maps/Global_UnderFiveMortality_2015.png.

Wusu, O. & Isiugo-Abanihe, U. C. (2006), 'Interconnections Among Changing Family Structure, Childrearing and Fertility Behaviour Among the Ogu, Southwestern Nigeria: A Qualitative Study', *Demographic Research*, 14 (8), 139–56.

Yair, O. & Miodownik, D. (2016), 'Youth Bulge and Civil War: Why a Country's Share of Young Adults Explains Only Non-ethnic Wars', *Conflict Management and Peace Science*, 33 (1), 25–44.