Checking Up on the Engine of Social Change: a Cohort Decomposition and Counterfactual Approach across Global Societies

Leo Azzollini[1] and Francesco Billari[2]

[1] Department of Sociology and Social Research, University of Trento

[2] Department of Social and Political Sciences, Bocconi University

Extended Abstract

Cohorts have long been considered the 'vehicle' or engine of social change (Mannheim, 1928; Ryder, 1965; Elder, 1975), with cohort replacement (or newer cohorts joining society while older cohorts are leaving it) being one of the central avenues through which social change occurs (Alwin and McCammon, 2003). Recent evidence even suggests cohort replacement is crucial when it comes to divisive social issues (Restrepo-Ochoa and Vaisey, 2024). Yet, studies the role played by cohorts in social change leads to the chimæric Age-Period-Cohort problem (Ryder, 1965; Glenn, 1976; Luo 2013). In order to circumvent this problem, scholars rely on approaches such as Hierarchical Age-Period-Cohort models (Yang and Land, 2006, see applications: Smets and Neundorf, 2014; Grasso et al., 2017; Gorodzeisky and Semyonov, 2018; McLaren et al., 2020; Jeannet and Drazanova, 2023). However, results from these models are dependent on important assumptions and require theoretical insights to be fine-tuned (Bell and Jones, 2017; Ekstam, 2021). If cohorts are the engine of social change, understanding how they work requires 'opening up' the engine, which is a statistically costly process. An alternative is represented by decomposition approaches, such as the Firebaugh and Davis (1988) semi-parametric approach (see an application by Voas and Chaves, 2016), and the demographic decomposition by Das Gupta (1993,1999, as recently operationalised by Frese, Härkönen, and Hix, 2024).

In this paper, we reformulate and integrate these approaches into a **decomposition and counterfactuals approach**, which decomposes social change between two time points into the role of **cohort replacement (R)**, demographic compositional shifts **(C)**, changing attitudes (A), and a residual interaction term (I). The approach by Firebaugh and Davis (1988) identifies formally cohort replacement but is parametric (depends on a regression model) and does not focus on compositional demographic shifts, while Das Gupta (1993, 1999) focuses on demographic shifts but does not separate cohort replacement from the change in attitudes from existing cohorts. Thus, our approach combines the insights of both by being **fully non-parametric**, and by **identifying clearly the role of cohort replacement.** Its limitations are that it can't model dynamics across multiple periods (it works only between two time points), it does not model statistical uncertainty, and it cannot provide any explanations of social change beyond its cohort-based character.

Thus, we envisage this approach as a 'Check Engine' light: a descriptive, counterfactual, non-parametric approach which provides information at a glance on the role played by cohorts in social change, and is intended to precede and complement more sophisticated models such as HAPC.

Decomposition and Counterfactual Approach

Suppose we observe a society at two time points: an initial year t_0 (e.g., 2002) and a final year t_1 (e.g., 2022). We are interested in the average of an outcome variable $\bar{Y}_t$ (e.g., support for LGBT rights at

time t). Individuals are grouped into birth cohorts c, and their average attitudes can be expressed as $y_{c,t}$, while their weight in the population is $w_{c,t}$.

Let us consider the average outcome in the Population at time t, as the weighted average of the average outcome of each cohort.

$$\bar{Y}_t = \sum_c w_{c,t} y_{c,t} \text{ where } \sum_c w_{c,t} = 1$$

The actual change in the outcome between t_0 and t_1 is:

$$\Delta\bar{Y} = \bar{Y}_{t_1} - \bar{Y}_{t_0}$$

We can rewrite this actual change in terms of the cohorts: R+ $\Delta shared$. R represents the net change brought by the average outcome among cohorts present in t_1, but not in t_0 ("new"), minus the average outcome among cohorts present in t_0, but not in t_1 ("old"). $\Delta shared$ represents instead the change associated to cohorts present in both t_0 and t_1 ("shared"), whose weights w and average outcomes y are shifting at the same time.

$$\Delta = \bar{Y}_{t_1} - \bar{Y}_{t_0} = \underbrace{\left(\sum_{c \in \text{shared}} w_{c,t_1} y_{c,t_1} - \sum_{c \in \text{shared}} w_{c,t_0} y_{c,t_0} \right)}_{\Delta_{\text{shared}}} + \underbrace{\left(\sum_{c \in \text{new}} w_{c,t_1} y_{c,t_1} - \sum_{c \in \text{old}} w_{c,t_0} y_{c,t_0} \right)}_{R}$$

To separate $\Delta shared$ into the **compositional** and **attitude adjustment** effects we are interested in, we engage in a **counterfactual step**, where we add and subtract **a counterfactual where the weights at t_0 are multiplied by the average outcomes at t_1.**

$$\Delta_{\text{shared}} = \left(\sum_{c \in \text{shared}} w_{c,t_1} y_{c,t_1} \underbrace{- \sum_{c \in \text{shared}} w_{c,t_0} y_{c,t_1}}_{-\text{CF Term}} \underbrace{+ \sum_{c \in \text{shared}} w_{c,t_0} y_{c,t_1}}_{+\text{CF Term}} - \sum_{c \in \text{shared}} w_{c,t_0} y_{c,t_0} \right)$$

Which can be rewritten as:

$$\Delta_{\text{shared}} \equiv \underbrace{\sum_{c \in \text{shared}} \left(w_{c,t_1} - w_{c,t_0}\right) y_{c,t_0}}_{C} + \underbrace{\sum_{c \in \text{shared}} w_{c,t_0} \left(y_{c,t_1} - y_{c,t_0}\right)}_{A} + \underbrace{\sum_{c \in \text{shared}} \left(w_{c,t_1} - w_{c,t_0}\right)\left(y_{c,t_1} - y_{c,t_0}\right)}_{I}$$

Where ***C*** represents the **compositional counterfactual** (what would have happened to social change had only demographic weights shifted), ***A*** represents the **attitude adjustment counterfactual** (what would have happened to social change had only average outcomes shifted), and ***I*** represents the **residual interaction term**, which captures **the simultaneous shifts in weights and averages** (the degree to which changes in weights and changes in averages tend to be correlated.) This is similar to the interaction term in Das Gupta (1993, 1999) and to the cross-product term in Kitagawa (1955) and Oaxaca-Blinder (1977) approaches.

Thus, the **full decomposition of social change** can be rewritten as:

$$\Delta = \underbrace{\left(\sum_{c\in\text{new}} w_{c,t_1}y_{c,t_1} - \sum_{c\in\text{old}} w_{c,t_0}y_{c,t_0}\right)}_{R} + \underbrace{\sum_{c\in\text{shared}} (w_{c,t_1} - w_{c,t_0})y_{c,t_0}}_{C} + \underbrace{\sum_{c\in\text{shared}} w_{c,t_0}(y_{c,t_1} - y_{c,t_0})}_{A} + \underbrace{\sum_{c\in\text{shared}} (w_{c,t_1} - w_{c,t_0})(y_{c,t_1} - y_{c,t_0})}_{I}$$

Or, for simplicity:

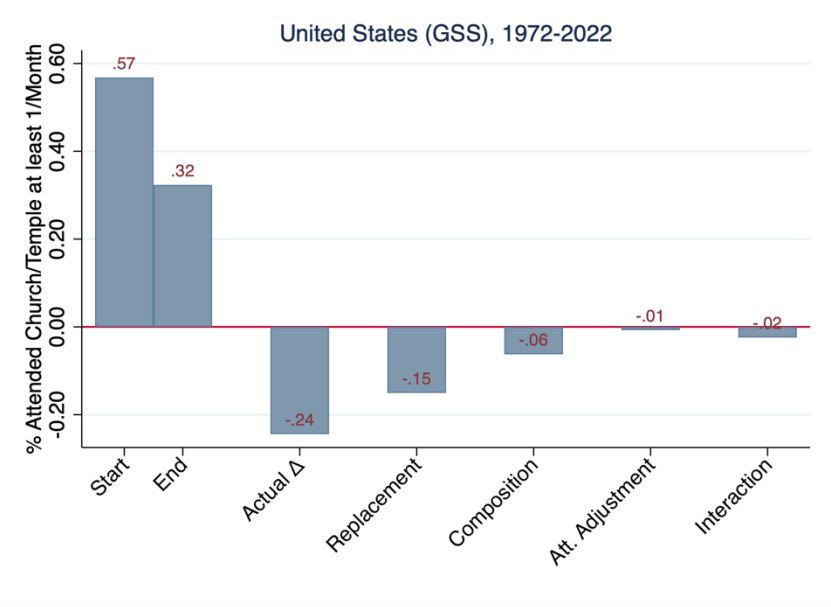
$$\Delta = R + C + A + I$$

Data and Preliminary Results

To employ our decomposition and counterfactual approach, we rely on the **US General Social Survey (1972),** the **Integrated Value Study (1981-2022, European Value Study + World Value Survey,** and the **European Social Survey (2002-2022).** This allows us to compare social change over time across societies in different continents. For purposes of simplicity and to retain statistical power, we use **ten-year birth cohorts (e.g., 1970-1979)**, but the approach is flexible to any definition of cohort.

Let us start with a *'sanity check'*, or from a social change phenomenon what is well-documented: **the extent of secularisation in the United States,** which is strongly characterised as cohort-driven (Voas and Chaves, 2016). The dependent variable we study is the proportion of individuals that declare they attend a religious place of worship at least once a month (GSS: *attend*). The graph below reports the results of our decomposition and counterfactuals approach.

Figure 1 – Cohorts and Secularisation in the United States (1972-2022)

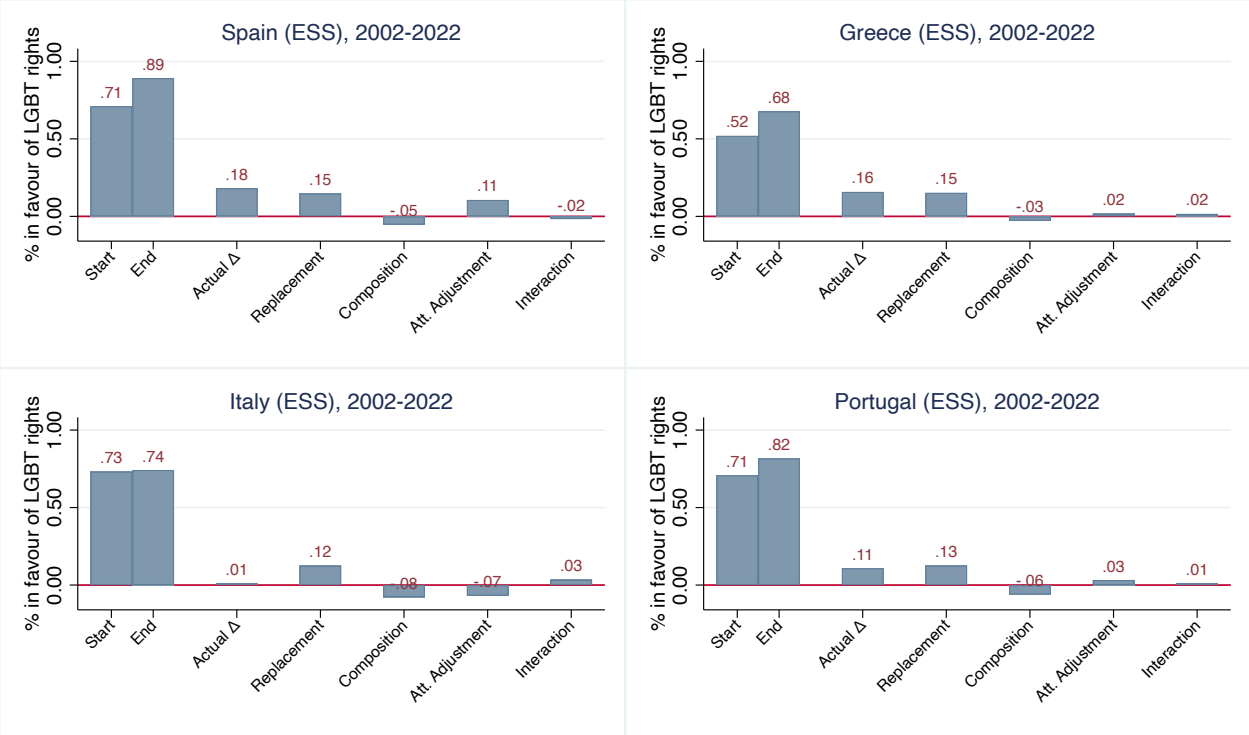


The proportion of individuals that declare they attend at least monthly decreases from 57% in 1972 to 32% in 2022, with a net change of around **-24 p.p.**. Through our approach, this change can be decomposed into **Replacement** (the net effect of cohort replacement), **Composition** (the demographic shifts of cohorts present in both time points), **Att. Adjustment** (cohorts existing in both time points changing their attendance), and **Interaction** (a residual term for the interaction between C and A). We can interpret these results by assessing how much of the actual change is driven by each component. In this case, **Cohort Replacement** constitutes almost

60% of the actual change in religious attendance, with an additional 25% coming from **Compositional** demographic changes. In substantive terms, these results highlight how secularisation is being **primarily driven by newer less religious cohorts replacing more religious cohorts,** and secondarily within the cohorts existing in both time points, the **shrinking of more religious cohorts** (such as 1940 and 1950). In contrast, there is **very scarce role** for cohorts present in both time points **changing their behaviour**. (The Interaction residual is similarly small). The conclusions are aligned with well-known secularisation patterns in the US: they are primarily driven by cohort replacement (Voas and Chaves, 2016), reassuring us that this 'check engine' approach captures similar results as more sophisticated approaches. After this sanity check, let us **broaden the geographic and substantive scope** to other phenomena.

Consider, for instance, the proportion of individuals in Southern European countries that agree and agree strongly with the statement that '*gays and lesbians should be to free to live as they wish*' in the (*freehms*).

Figure 2 – Cohorts and favourability towards LGBT+ Rights in Southern Europe (2002-2022)

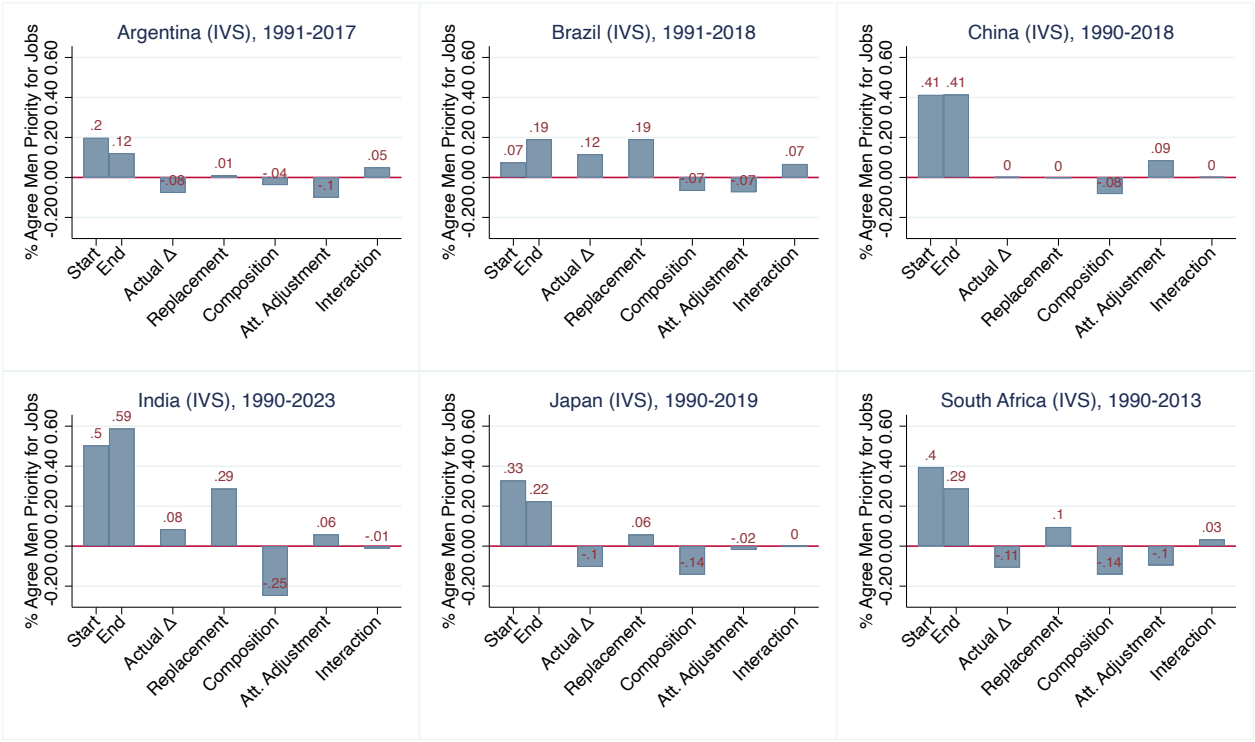


In all countries but Italy, there were considerable increases in the favourability towards LGBT+ rights. **Was cohort replacement the engine of social change?** Across all four countries, in the absence of any other change, **cohort replacement would have improved the favourability by at least 10 p.p..** In Greece and Portugal, the increase in favourability is indeed only attributable to cohort replacement. In **Italy**, the **apparent social stasis** reflects **polarisation on the matter:** while cohort replacement brought an increase, this was counterbalanced not only by compositional effects, but **also by cohorts present in both 2002 and 2022 becoming, on average, *less* favourable towards LGBT+ rights.** This pattern contrasts starkly with Spain (whose starting point was almost identical to Italy): the cohort replacement effect was **reinforced** by cohorts present in both 2002 and 2022 becoming, on average, ***more* favourable** towards LGBT+ rights. This comparison reflects the advantage of our approach: with a quick glance, we are able to say that cohort replacement is pushing towards pro-

LGBT+ societies in Southern Europe, but this either **unaffected** (Greece and Portugal), **counterbalanced** (Italy), or **reinforced** (Spain) by cohorts present in both 2002 and 2022 **changing their minds on average** (or not!).

Another important pattern of social change is the **spread of gender equality in the labour market** (Goldin, 2002). But is cohort replacement moving in the same directions outside North America and Europe? Figure 3 highlights patterns in six large countries (for which we have enough data) **across South America, Africa, and Asia**. Across these countries, we see that cohort replacement, on its own, would have led to ***greater*** agreement with male-preference for jobs when the latter are scarce (*C001* in IVS) in all countries besides Argentina and China, with particularly strong counterfactual increases in Brazil and India. In some cases, the main thrust of progress towards gender equality was a change in attitudes in the shared cohorts (Argentina, Brazil, South Africa), or by the pattern that more gender-conservative cohorts are shrinking in size (India, Japan, South Africa). Notably, newer cohorts are not more progressive by default – possibly reflecting greater competition upon labour market entry.

Figure 3 – Cohorts and prevalence of male preference for jobs during scarcity, across six countries (Integrated Value Survey, World Value Study).



Preliminary Conclusions

Are new cohorts truly the engine of social change? While more sophisticated models can tell us if so, and why, at the expense of important assumptions, our 'check engine light' approach can provide insights at a glance, through its non-parametric decomposition and counterfactuals features. It allows scientists to assess quickly whether social change (or apparent stasis) can be decomposed in terms of cohort replacement, demographic shifts, or individuals changing their minds, providing a descriptive basis which may be complemented with evidence from more sophisticated models.

Bibliography

Alwin, D. F., & McCammon, R. J. (2003). Generations, cohorts, and social change. In J. T. Mortimer & M. J. Shanahan (Eds.), *Handbook of the Life Course* (pp. 23–49). Springer.

Bell, A., & Jones, K. (2017). The hierarchical age–period–cohort model: Why does it find the results that it finds? *Demographic Research, 37*, 473–512.

Das Gupta, P. (1993). *Standardization and decomposition of rates: A user's manual*. U.S. Bureau of the Census.

Das Gupta, P. (1999). Decomposition of the difference between two rates and its consistency when more than two populations are involved. *Mathematical Population Studies, 7*(1), 49–77.

Eckstam, C. (2021). Age–period–cohort analysis: A critical review and some new findings. *Sociological Methods & Research, 50*(4), 1723–1761.

Elder, G. H. (1975). *Age differentiation and the life course*. Annual Review of Sociology, 1, 165–190.

Firebaugh, G., & Davis, K. E. (1988). Trends in antiblack prejudice, 1972–1984: Region and cohort effects. *American Journal of Sociology, 94*(2), 251–272.

Frese, F., Härkönen, J., & Hix, S. (2024). Generational replacement and social change: A decomposition approach. *European Sociological Review*. Advance online publication.

Glenn, N. D. (1976). Cohort analysts' futile quest: Statistical attempts to separate age, period and cohort effects. *American Sociological Review, 41*(5), 900–904.

Goldin, C. (2002). A pollution theory of discrimination: Male and female differences in occupations and earnings. *Journal of Political Economy, 112*(S1), S141–S174.

Gorodzeisky, A., & Semyonov, M. (2018). Context and generational differences in opposition to immigration: Testing the cultural and economic impact hypotheses. *International Journal of Comparative Sociology, 59*(5–6), 311–334.

Grasso, M., Farrall, S., Gray, E., Hay, C., & Jennings, W. (2017). Thatcher's children, Blair's babies, political socialization and trickle-down value-change: An age, period and cohort analysis. *British Journal of Political Science, 49*(1), 17–36.

Jeannet, A. M., & Drazanova, L. (2023). Generational replacement and political attitudes: Evidence from Europe. *West European Politics, 46*(4), 889–915.

Kitagawa, E. M. (1955). Components of a difference between two rates. *Journal of the American Statistical Association, 50*(272), 1168–1194.

Luo, L. (2013). Assessing validity and application scope of the intrinsic estimator approach to the age–period–cohort problem. *Demography, 50*(6), 1945–1967.

Mannheim, K. (1928). Das Problem der Generationen. *Kölner Vierteljahrshefte für Soziologie, 7*(2), 157–185.

McLaren, L. M., Boomgaarden, H., & Vliegenthart, R. (2020). News coverage and public concern about immigration in Britain. *International Journal of Public Opinion Research, 32*(1), 56–76.

Oaxaca, R. (1973). Male-female wage differentials in urban labor markets. *International Economic Review, 14*(3), 693–709.

Restrepo-Ochoa, D., & Vaisey, S. (2024). Cohort replacement and the persistence of cultural divides. *Socius, 10*, 1–12.

Ryder, N. B. (1965). The cohort as a concept in the study of social change. *American Sociological Review, 30*(6), 843–861.

Smets, K., & Neundorf, A. (2014). The hierarchies of age–period–cohort research: Political context and the development of generational turnout patterns. *Electoral Studies, 33*, 41–51.

Voas, D., & Chaves, M. (2016). Is the United States a counterexample to the secularization thesis? *American Journal of Sociology, 121*(5), 1517–1556.

Yang, Y., & Land, K. C. (2006). A mixed models approach to the age–period–cohort analysis of repeated cross-section surveys: Trends in verbal test scores. *Sociological Methodology, 36*(1), 75–97.