CONFERENCE OF CONSULTING ACTUARIES

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SESSION 506

Immigration Projection Practice and How to Improve It

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Speakers



Tom Terry, FSA, MAAA, FCA, EA
CEO, The Terry Group



Liaw Huang, FSA, MAAA, FCA, EA
Principal, The Terry Group



Richard Jackson, Ph.D.
President, Global Aging Institute

An Urgent Problem

- As birthrates have fallen in today's developed countries, immigration is increasingly replacing natural increase as the most important determinant of future population growth rates and age structures.
- As a consequence, immigration has also become an increasingly important determinant of the sustainability of social insurance systems, as well as the broader prospects for economic growth.
- Yet despite its growing importance, the immigration assumptions that national and multilateral agencies use in making their long-term population projections remain almost entirely ad hoc and judgmental.

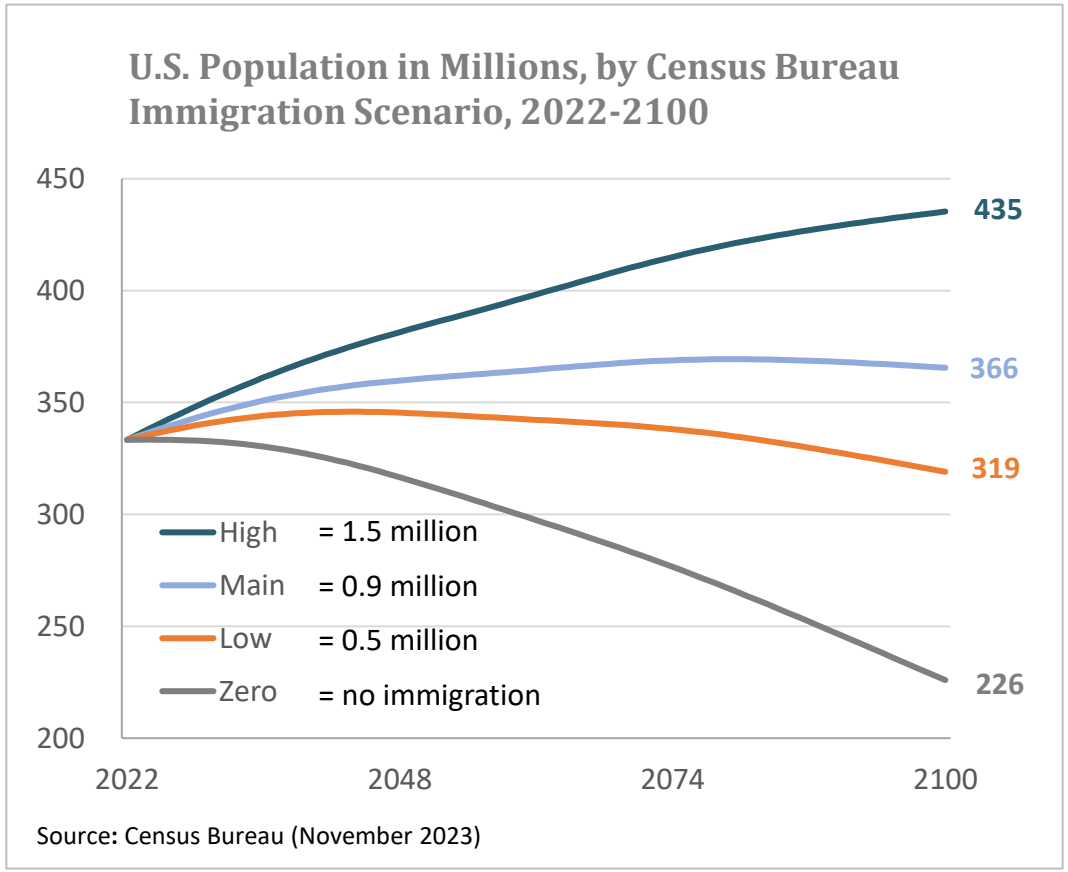
A Possible Solution

- Over the past few decades, a large theoretical and empirical literature has identified the push and pull factors that drive international migration.
- In this presentation, we explore how the insights this literature offers could be harnessed to develop a driver-based immigration projection model with the potential to improve long-term population projections.
- Actuaries have devoted considerable attention to developing more rigorous methodologies for projecting mortality and fertility. It is time that they paid similar attention to developing a more rigorous methodology for projecting immigration.

The Impact of Immigration on Population Outcomes

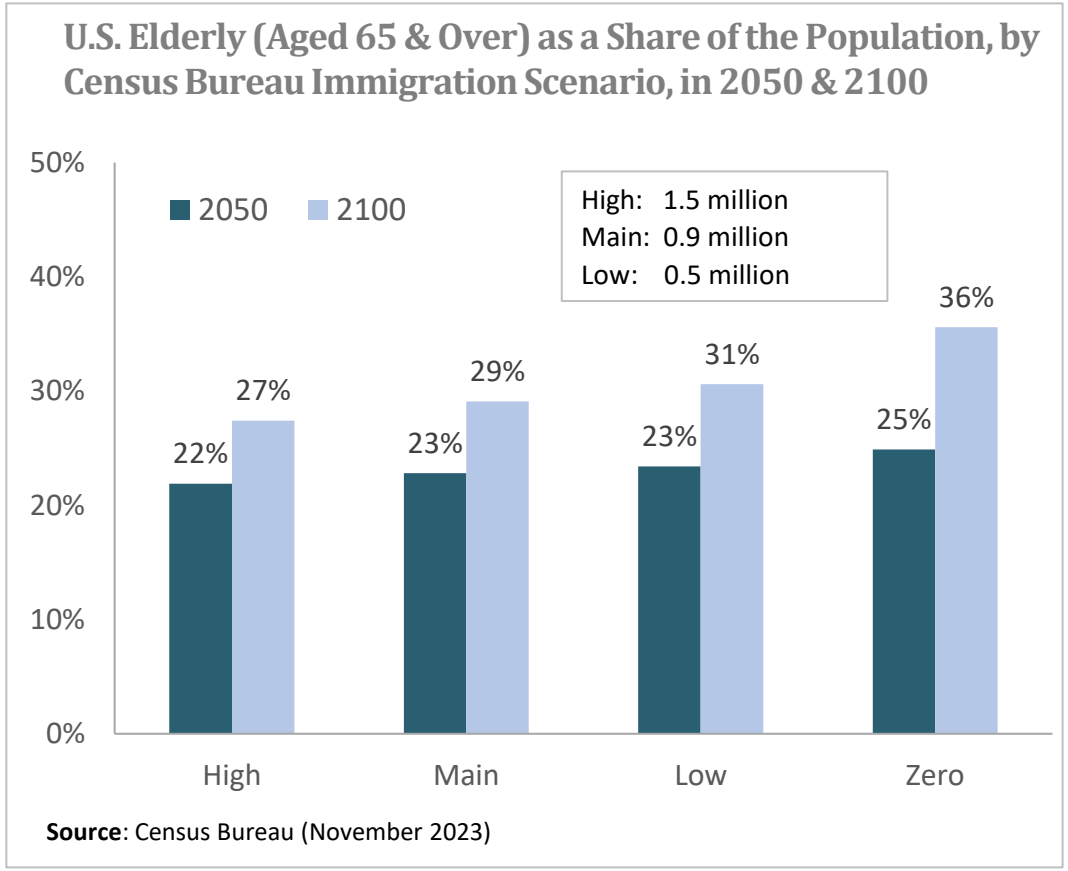
Size of the Total Population

- Sustained differences in net immigration can have an enormous impact on projected population size.
- In a country with below-replacement fertility, the level of net immigration will in the long run also determine whether the population increases or declines.



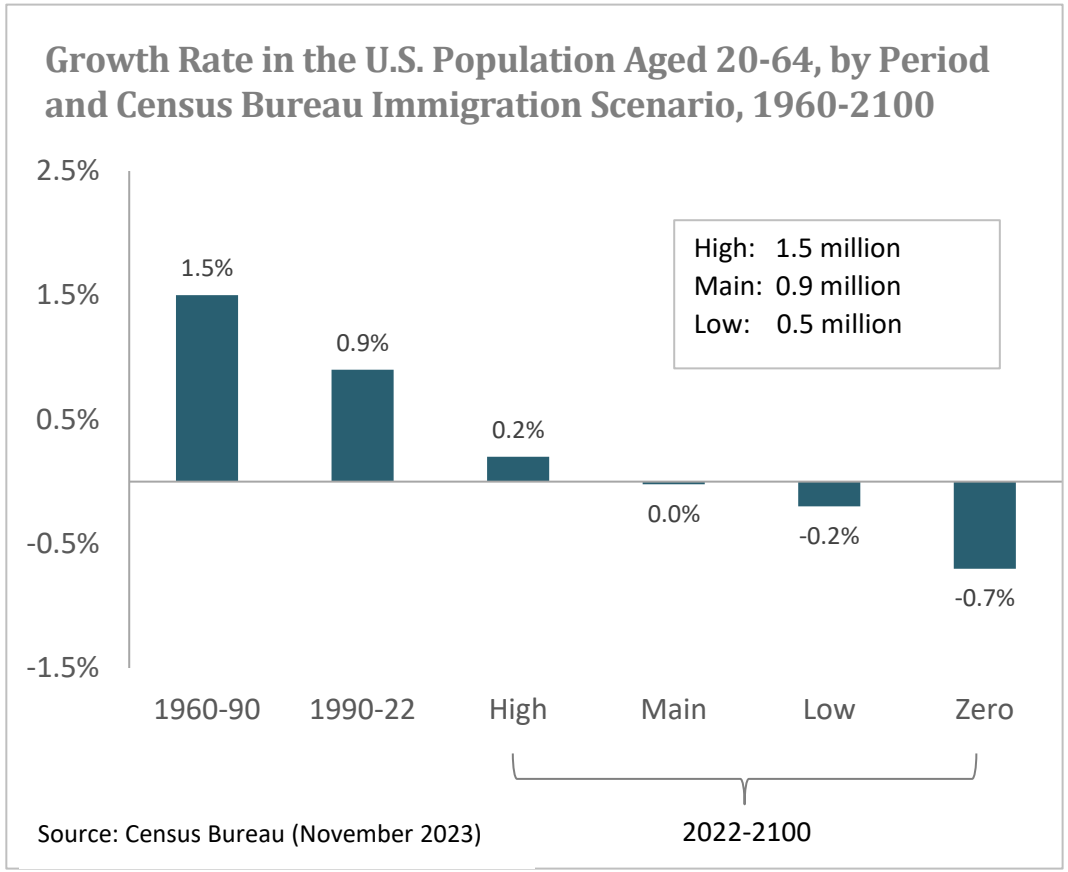
Degree of Population Aging

- Since immigrants tend to be younger on average than the native-born population, the level of net immigration can have a large impact on the degree of population aging that a country experiences.
- Net immigration is thus a critical determinant of the sustainability of PAYGO social insurance systems.



Growth in the Workforce

- The level of net immigration can also have a large impact on the rate of growth in a country's working-age population.
- All other things being equal, a higher or lower rate of growth in a country's working-age population will in turn translate into a higher or lower rate of growth in employment and a higher or lower rate of growth in GDP.



What Drives Immigration

Theoretical Frameworks (1)

- Neoclassical Framework

  A "pure economics" perspective: International migration is driven by the forces of supply and demand in the global labor market.

- World Systems Framework

  A sociocultural perspective: International migration is driven by the disruptive historical forces set in motion by development and globalization.

- Social Network Framework

  A social capital perspective: International migration is driven by path-dependent community networks in origin and destination countries.

Theoretical Frameworks (2)

- New Economics Framework

  A microeconomic perspective: International migration is driven by the complex economic choices that families make to overcome market failures in origin countries.

- Dual Labor Market Framework

  A demand-side perspective: International migration is driven by the two-tiered demand for immigrant labor in destination countries.

- Policy Framework

  International migration may be driven by all of the above, but legislative and enforcement choices made in the face of "immigration pressure" can play a decisive role in determining its magnitude and composition.

A Rich Empirical Literature

- Over the past few decades, demographers and economists have devoted considerable attention to statistically testing immigration theory against evidence.
- Most of this rich empirical literature focuses on trends in international migration since the 1950s, when data become more readily available. But some of it also examines migration in earlier eras, including the "Great Migration" of the 19th and early 20th centuries.
- Bottom Line: Social scientists now broadly agree on both the direction and rough magnitude of a significant number of causative migration drivers.

Some Potentially Modelable Drivers

- Age structure of origin countries
- Differences in wage and education levels between origin countries and destination country
- Level of economic/social development in origin countries
- Size of foreign-born stock in destination country
- Common border/language or colonial connection between origin and destination countries

An Impoverished Methodology

- Despite everything we now know about what drives international migration, current immigration projection practice at the national and multilateral agencies responsible for making long-term population projections remains largely ad hoc and judgmental.
- Most of these agencies base their assumptions about future immigration on some combination of recent historical experience and current law.
- With only a few partial exceptions, they make no attempt to incorporate migration drivers into their projections or to ground their assumptions in any explicit theory of why immigration happens.

Long-Term Population Projections Examined

National Projection Agencies

Canada:	Statistics Canada
France:	INSEE
Germany:	Federal Statistical Office
Italy:	National Institute of Statistics
Japan:	IPSS
UK:	Office for National Statistics
United States:	Census Bureau, CBO, and SSA

Multilaterals & Academic Institutes

Eurostat
Institute for Health Metrics and Evaluation
International Institute for Applied Systems Analysis
United Nations Population Division

Toward a Driver-Based Model

Recent Developments in Immigration Modeling (1)

Model / Typical Functional Form	Basic Approach / Advantages	Ideal Time Frame / Data Needs	Research Examples
TIME SERIES $y_t = c + \Sigma\, \varphi_k y_{t-k} + \varepsilon_t$ (Basic AR model; variants include ARIMA)	Immigration is projected by extrapolating historical migration patterns. Allows for the quantification of predictive uncertainty.	Near Term (1 to 5 years) Requires long and consistent quarterly or annual historical data series on migration flows. Modeling is complicated by historical breaks in migration data or expected shifts in migration flows.	Bijak et al. (2019) compare alternative time-series approaches to projecting immigration to the UK and assess model performance over different time periods.
MACHINE LEARNING (e.g., boosted trees, neural nets)	Projections incorporate relationships between predictor variables and historical migration patterns. Allows for nonlinear relationships and the use of nontraditional data.	Near Term (1 to 5 years) Requires large labeled datasets that include historical migration flows and covariates. Typically used for now-casting or early warning.	OECD (2026) surveys the state of predictive and anticipatory immigration projection tools.
BAYESIAN HIERARCHICAL $r^c_t - \mu^c = \varphi^c(r^c_{t-1} - \mu^c) + \varepsilon^c_t$ $\varepsilon^c_t \sim N(0, \sigma^{c2})$ $\mu^c \sim N(\lambda, \tau^2)$ (Example of country-dependent parameters from Azose & Raftery)	Country-level differences can be reflected in the structure of model parameters. Projections capture heterogeneity and allow for the incorporation of expert opinion.	Near to Medium Term (1 to 10 years) Requires historical data on migration flows and covariates, as well as expert input on future migration trends.	Azose & Raftery (2015) project global migration flows using hierarchical AR(1).

Recent Developments in Immigration Modeling (2)

Model / Typical Functional Form	Basic Approach / Advantages	Ideal Time Frame / Data Needs	Research Examples
GRAVITY / SPATIAL INTERACTION $M_{ij} = \exp(\alpha + \beta_1 \ln P_i + \beta_2 \ln P_j - \beta_3 \ln d_{ij} + \gamma X_{ij})$	Bilateral migration flows between multiple "origin-destination pairs" are analyzed to determine the role of such factors as geographic proximity, population size, migrant networks, and economic performance in driving migration.	Near to Medium Term (1 to 10 years) Requires historical data on migration flows and stocks, as well as data on the other model inputs. Analysis can be used to make projections, but is primarily used to understand historical migration trends.	World Bank (2018) uses a gravity approach to explain bilateral migration flows; Cottier (2024) and Cutuli et al. (2024 preprint) combine a gravity approach and a Bayesian hierarchical approach to explain bilateral migration flows.
ECONOMETRIC / STRUCTURAL $M_{ijt} = f(\Delta w_{ijt}$, jobs, housing, policy; $\theta) + u_{ijt}$	Migration flows are analyzed to determine how behavioral responses to wage differentials, unemployment rates, housing affordability, government immigration policy, and other factors affect migration.	Near to Medium Term (1 to 10 years) Requires historical data on migration flows, as well as data on the other model inputs. Analysis can be used to make projections, but is primarily used to understand historical migration trends.	Saks (2005) studies the impact of housing supply constraints and labor mobility on immigration; Molloy, Smith & Wozniak (2011, 2014) examine the causes of the decline in U.S. interstate migration.
DRIVER-BASED MODEL (See slides 23 & 24)	Projections are based on a comprehensive set of demographic, socioeconomic, and policy drivers. Enables the construction of internally consistent, long-term immigration scenarios.	Primarily Long Term (10+ years) Requires historical data on migration, as well as historical data on model drivers and projections of model drivers.	Howe and Jackson (2006) describe a driver-based model for projecting immigration to a destination country from multiple origin countries.

When does a driver-based model make sense?

- **When the goal is to improve long-term population projections**

  Different models serve different purposes. In making near-term population projections, time series, Bayesian, and machine-learning models may be appropriate. But these models are less useful in making long-term projections. If the goal is to improve long-term population projections, a model that incorporates future trends in the key drivers of international migration has considerable advantages.

- **When the necessary data series exist or can be developed**

  Building a driver-based model not only requires testing drivers on detailed historical data, but also requires making projections of independent demographic, macroeconomic, and socioeconomic variables. Only countries with the necessary data will be able to develop a driver-based model.

- **When there is an institutional interest in scenario-building**

  In addition to improving long-term population projections, a driver-based model could also serve as a powerful tool for modeling how different economic, social, and political developments affect migration.

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Critical Issue: Migration Categories

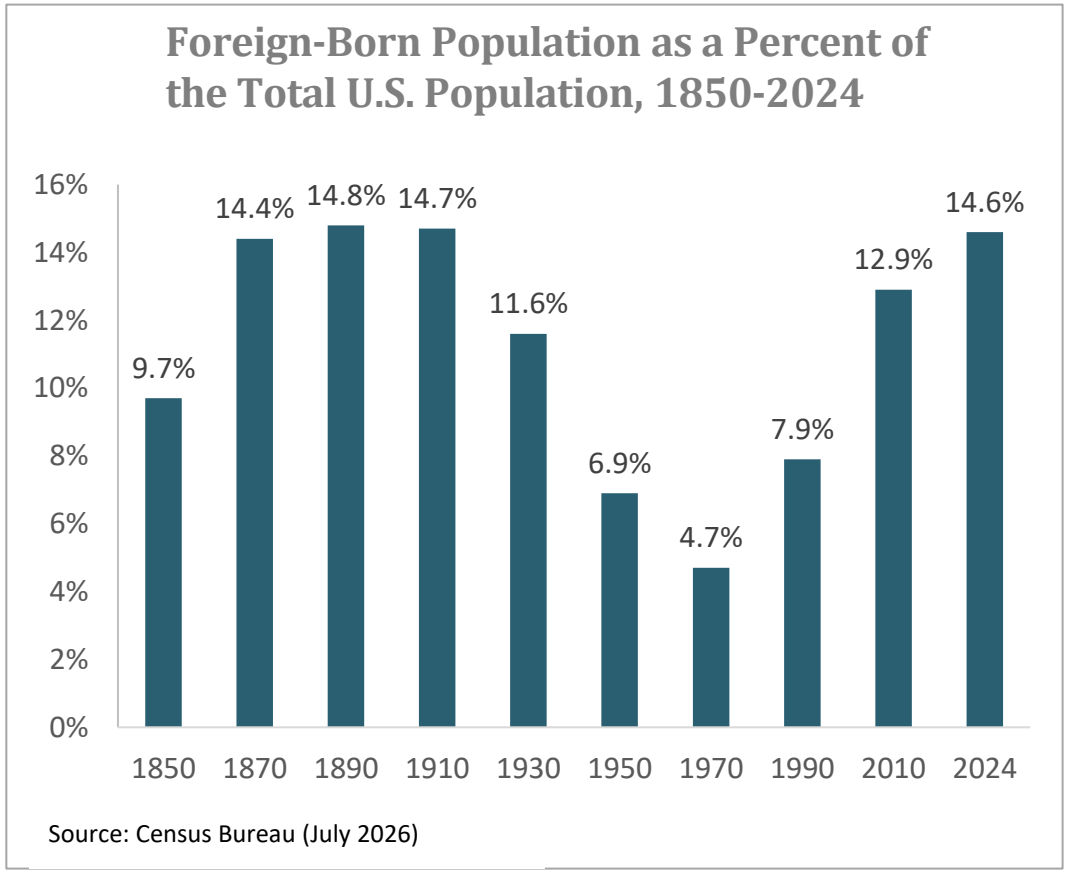
- People migrate for many different reasons. For projection purposes, migration into a destination country can be separated into two broad categories:
  - Involuntary (or forced) migration, which includes refugees and asylum-seekers
  - Voluntary migration, which includes labor migrants, "family reunification" migrants, and students
- Any projection must also take into account emigration—the reverse flow of people (usually much smaller) leaving the destination country. Some models project immigration in net terms, while others project in-migration and out-migration separately.
- Depending on its purpose, a projection may or may not distinguish between legal and illegal immigration.

Migration Categories in a Driver-Based Model

- A driver-based projection model would focus on voluntary migration, which both responds to incentives and is typically the largest migration category.
- Involuntary migration is volatile and event-dependent. A driver-based model would project it separately, perhaps based on expert opinion or a data-driven analysis of recent and emerging trends.
- A driver-based model would project in-migration and out-migration separately, since the drivers are different. Emigration is typically projected as a share of the foreign-born stock in the destination country.
- A driver-based model would not ordinarily distinguish between legal and illegal migrants, since both categories respond similarly to the same drivers.

Critical Issue: Policy Regimes

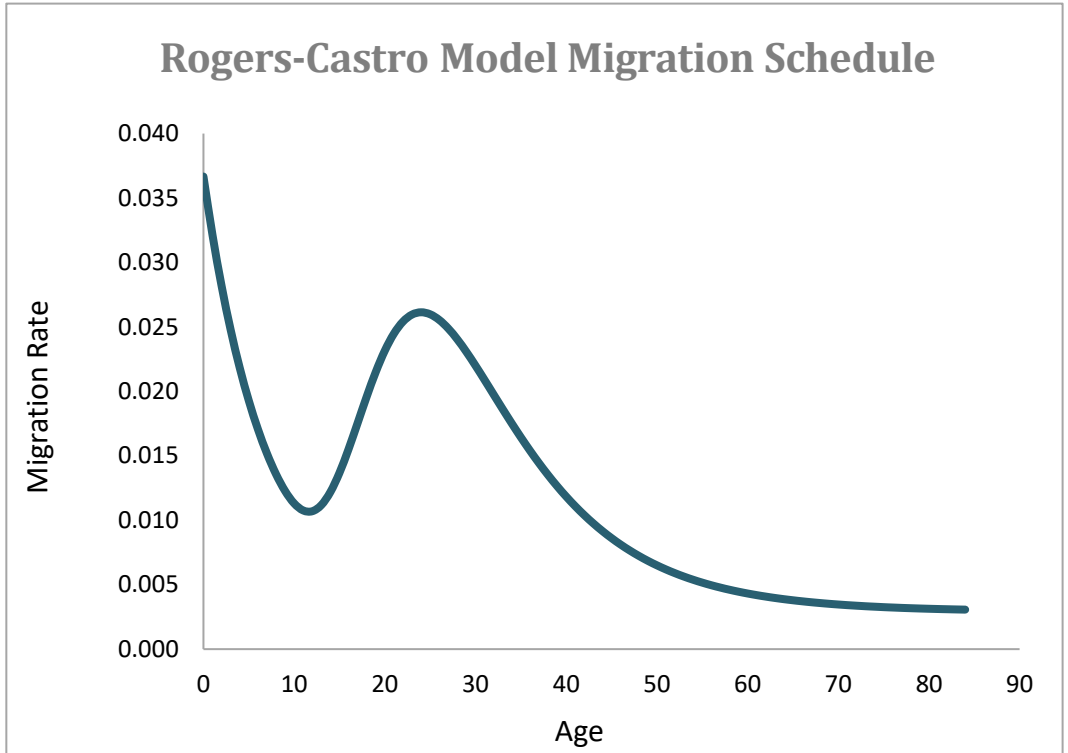
- A driver-based model projects changes in migration flows as a function of the conditions in origin countries and the differences in conditions between origin countries and the destination country.
- In a basic driver-based model, it might be assumed that current immigration policy remains unchanged.
- Yet policy regimes do change, alternating between more accommodating and more restrictive. Historically, such changes have often been associated with large changes in migrant flows and stocks.
- Some research suggests that policy regimes change in response to immigration, rather than the other way around. This in turn suggests that it may be possible to include an endogenous policy driver in the model.



Basic Demographic Drivers

- **Age structure of origin countries.** There is a strong empirical link between age structure and migration. Any driver-based model will require data on the current and projected age structure of all origin countries. Migration rates by age may be derivable from historical immigration data. If this is not available, a "model migration schedule" can be used.

- **Size of foreign-born stock in the destination country.** A driver-based model will need to track the foreign-born migrant stock in the destination country by country of origin, age, gender, and vintage. Tracking the foreign-born stock is critical for capturing network effects. It is also necessary for calculating emigration.



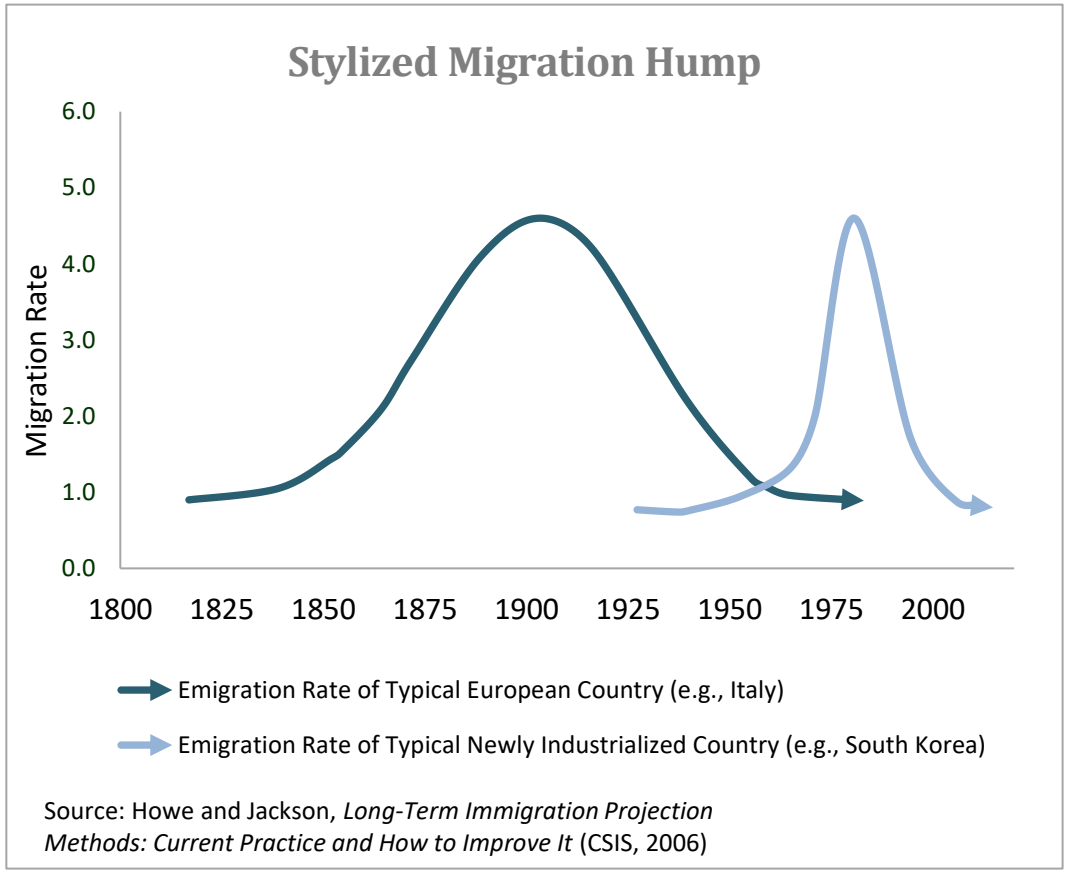
Source: Rogers, Castro, and Lea, "Model Migration Schedules: Three Alternative Linear Parameter Estimation Methods," *Mathematical Population Studies*, 12:1 (2005)

Basic Economic Drivers

- **Relative wage level.** Expected lifetime economic gain is a fundamental migration driver. A driver-based model will require projections of wage levels in both origin and destination countries. If this is not feasible, projections of per-capita GDP can serve as a proxy.

- **Relative education level.** Some research suggests that changes in relative years of schooling are as important a driver as changes in relative wages. A driver-based model will require projections of educational attainment in both origin and destination countries.

- **Economic development.** The level of development in origin countries is a powerful independent driver. Many indicators can be used to measure it, including poverty rates, urbanization, size of the manufacturing sector, and various socioeconomic and human capital indices.



Source: Howe and Jackson, *Long-Term Immigration Projection Methods: Current Practice and How to Improve It* (CSIS, 2006)

Other Possible Drivers

Additional Possible Nonpolicy Drivers

- Relative income/wealth inequality
- Trade, technology, and globalization
- Political, social, and environmental stress

Country and/or Time-Specific Effects

- Geographic proximity/common border
- Common language or colonial connection
- Unique policy/regulatory regimes

Destination Country Policy Drivers

- Relative size of foreign-born stock
  (tracks noneconomic impact on public opinion)
- Foreign-born stock weighted by education gap between immigrants and native-born workers
  (tracks economic impact on wages)

Ilustrative Model (1)

Howe/Jackson Model: Overall Structure

$$M_{NET} = I_V - E_V + \sum_{i=1}^{n} M_{CATi}$$

where
M_{NET} = *total net immigration*
I_V = *voluntary immigration*
E_V = *voluntary emigration*
M_{CAT} = *net involuntary immigration*

Source: Howe and Jackson (CSIS, 2006)

Illustrative Model (2)

- The Howe/Jackson driver-based model is designed to project migration into a single destination country from multiple origin countries.
- Immigration and emigration are projected as rates, but are then translated into population counts by age and gender for incorporation into a cohort-component projection model.
- While the model is structured as a linear multivariate equation, other functional forms are possible.
- The model could be modified to allow for a transition from a near-term projection based on recent experience or policy to a long-term projection based on modeled migration drivers.

Howe/Jackson Model: Voluntary Immigration Equations

$$PN_{jt} = (PT_{jt})(AGE_{jt})(ADJ_{jt})$$

and

$$(Iv_{jt}/PN_{jt}) = \alpha + \sum_{i=1}^{d} \beta_i D_{ijt*} + \sum_{i=1}^{e} \gamma_i E_{ijt*} + \sum_{i=1}^{o} \delta_i O_{ijt*} + \sum_{i=1}^{p} \varepsilon_i P_{ijt*} + \sum_{i=1}^{x} \zeta_i X_{ijt*} + e_{jt*}$$

I_v	=	*voluntary immigration*
PT	=	*total population*
AGE	=	*age-weighted probability of migration per capita*
ADJ	=	*other population multipliers*
PN	=	*population normalized for likelihood of migration*
D	=	*demographic drivers*
E	=	*economic and development drivers*
O	=	*other nonpolicy drivers*
P	=	*destination country policy drivers*
X	=	*dummy variables for country and/or time-specific effects*

Source: Howe and Jackson (CSIS, 2006)

Conclusion

- Immigration is an increasingly important component of the population projection equation in most developed countries. Yet current immigration projection practice at the national and multilateral agencies responsible for making long-term population projections remains almost entirely ad hoc and judgmental.

- We have argued that it is possible to harness the rich theoretical and empirical literature on immigration to build a driver-based immigration projection model with the potential to improve the reliability of long-term population projections.

- Building a driver-based projection model is a major project that will require overcoming formidable data obstacles and resolving thorny methodological issues. However, the large potential payoffs make the effort worthwhile.