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Human capital and demographic futures in Eastern Europe and the Caucasus: Challenges of population aging, depopulation, and brain drain

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Abstract

Any meaningful view of the future depends on accurate demographic outlooks. While many countries in Europe are at the forefront of global population aging and declines, the extent, speed, and consequences of these unfolding trends are subject to debate. This cumulative dissertation aims to further academic research on demographic complexities often acknowledged in theory but left unquantified. Furthermore, it continues efforts moving past the conventional sole consideration of age and sex structures to include human capital.

Multi-dimensional demographic approaches are used to develop and analyze population projections, in a range of scenarios, for five countries in and around Europe's East (Armenia, Georgia, North Macedonia, Romania, and Ukraine) as well as the macro-regions of the EU (East, South, and West). Different methods of quantifying future dependency burdens are then tested for the case studies of Armenia and Georgia.

Results show that 1) population aging is near-inevitable regardless of the migration or fertility scenario, 2) high-skilled human capital can expand (in relative and sometimes absolute terms) despite brain drain and depopulation, and 3) the metric used for determining dependency burdens holds decisive influence over the apparent severity of the problem. The findings also suggest some aspects of demographic change are more amenable to policy interventions than others. While long-term demographic stability is contingent upon a fertility recovery, this work highlights human capital and labor force participation as the critical factors for countering potential mid-term overgrowths in dependency burdens in aging, depopulating societies.

Kurzfassung

Für ein bedeutungsvolles Verständnis der Zukunft bedarf es eines akkuraten demographischen Ausblickes. Während viele europäische Länder Vorreiter der globalen Bevölkerungsalterung und des Bevölkerungsrückganges sind, stehen das Ausmaß, die Geschwindigkeit und die Folgen dieser sich entfaltenden Trends zur Debatte. Diese kumulative Dissertation zielt darauf ab, die akademische Forschung zu demographischen Komplexitäten zu fördern, die in der Theorie oft anerkannt sind, aber nicht quantifiziert werden. Sie baut auf den sich abzeichnenden Bemühungen auf, nicht nur die herkömmliche Berücksichtigung von Alters- und Geschlechtsstrukturen, sondern auch das Humankapital einzubeziehen.

Multi-dimensionale demographische Herangehensweisen wurden für die Erstellung und Analyse der Bevölkerungsprojektionen verwendet, in einer Vielzahl von Szenarien für die fünf Länder im und um den Osten Europas (Armenien, Georgien, Nord Mazedonien, Rumänien und die Ukraine) sowie für die Makroregionen der EU (Osten, Süden und Westen). Anschließend werden für die Fallstudien Armenien und Georgien verschiedene humankapitalorientierte Methoden zur Quantifizierung künftiger Abhängigkeitsbelastungen getestet.

Die Ergebnisse zeigen, dass 1) die Bevölkerungsalterung unabhängig vom Migrations- oder Fertilitätsszenario nahezu unvermeidlich ist, 2) das hochqualifizierte Humankapital trotz Abwanderung und Entvölkerung (relativ und manchmal auch absolut) zunehmen kann und 3) die zur Bestimmung der Abhängigkeitslast verwendete Metrik entscheidenden Einfluss auf die offensichtliche Ernsthaftigkeit des Problems hat. Während die langfristige demographische Stabilität von der Zunahme der Fertilität abhängig ist, werden in dieser Arbeit auch das Humankapital und die Erwerbsbeteiligung als die entscheidenden Faktoren hervorgehoben, um einem potenziellen mittelfristigen Anstieg der Abhängigkeitslast in alternden, entvölkerten Gesellschaften entgegenzuwirken.

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1. *Introduction*

1.1 Research Motivation

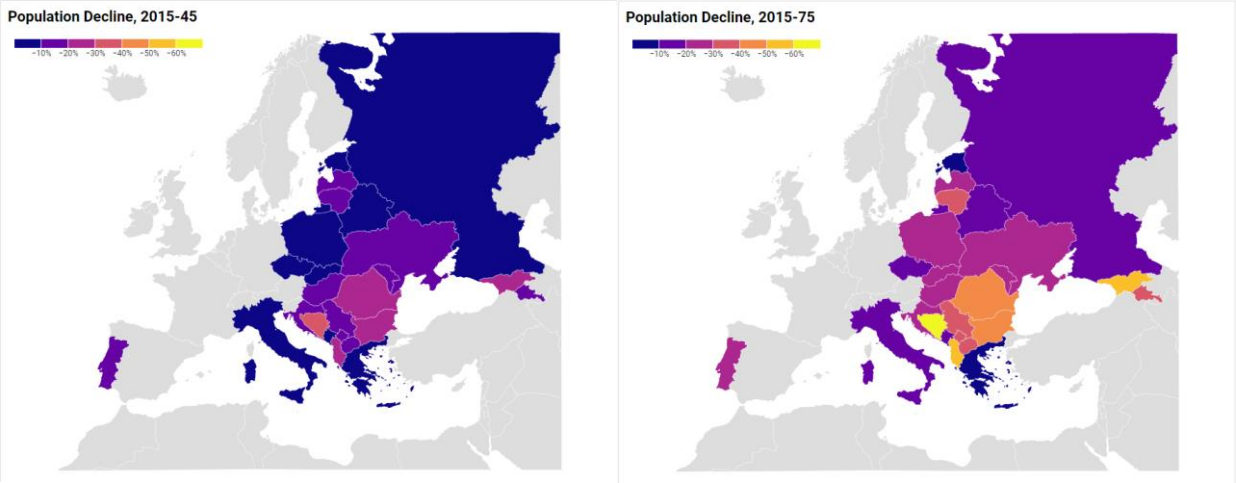
Population aging and depopulation are emerging dual realities for many countries in the late stages of the *Demographic Transition*, a near-universal pattern of development when high mortality, high fertility societies fundamentally transform into low mortality, low fertility societies. This has been characterized as largely irreversible (Lutz et al. 2006) and its consequences labeled as a "global mega-trend" (UN 2020). The demographic challenges ahead are increasingly recognized at the highest levels in Europe, evidenced by the European Commission's creation of the Vice Presidency portfolio on Democracy and Demography (EC 2019; EPC 2020) and the official adoption of a report on the impact of demographic change (EC 2020). National governments across the continent have expressed similar sentiments on the demographic outlook, attempting to mitigate the negative consequences of the trends by raising pension ages or encouraging work through other means (FCP 2021), as well as hoping to counter the trends themselves through policies of supporting families (Sobotka et al. 2019), or in parts of Europe, increasing immigration (Naumann & Hess 2021).

In particular, the countries of Eastern Europe[1] (incl. the Balkans and Baltic) and the South Caucasus have some of the fastest aging and shrinking populations (shown in Fig. 1) in the world. The broad region has moderately-low fertility (population weighted average TFR of 1.44), resembling other late-*Demographic Transition* societies, above Southern Europe's 1.24, and on par with the EU average of 1.50 (VID 2022). Besides the contemporary moderately-low fertility and the delayed effects of even lower fertility in the 1990s, the region faces the additional challenge of high emigration, which speeds the aging and population declines already in motion (Lutz et al. 2019; Jakovljevic et al. 2018; Kashnitsky et al. 2017). This same group of countries hold the distinction of being those least able to retain talent (WEF 2018), a type of emigration often referred to as 'brain drain'. The combination of ease of movement between European states, economic disparities, skill shortages in the west, and a cultural frame of reference that sets expectations for economic well-being according to

[1] The region has a wide variety of definitions, with the UN using the broadest definition that classifies the following states as Eastern European: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Estonia, Georgia, Hungary, Latvia, Lithuania, Montenegro, North Macedonia, Poland, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, and Ukraine (UN 2023).

Western European standards all unsurprisingly facilitate such East-to-West migration. Disruptions from COVID-19 had reversed some of the persistent outflows from the region (Economist 2021), but the phenomenon is likely to return in the long-run if the same basic preconditions remain in place.

Figure 1: Projected population decline in and around Europe, 2015-2045 and 2015-2075



Source: Lutz et al. 2018; Generated with Datawrapper

The future of human capital flight in Eastern Europe is relevant for the sending countries both in terms of the quantity of workers and the quality of their skills since emigrants tend to be disproportionally highly educated compared to the societies they leave behind (Atoyan et al. 2016). Differing political responses to the competition for talent in Europe reveal contending visions for what international community means in practice – as countless political and economic decisions inevitably influence brain drain – should it be encouraged or discouraged? The ambivalent dynamic between European states on this and other questions is characteristic of being caught between the *solidarist* and *pluralist* approaches to relations, as laid out by the English School in international relations theory. The solidarist view emphasizes commitment to mutual good over self-interest (Murray 2013), expressed by the EU's cohesion policy and core goal of achieving convergence in living standards. On the other hand, the pluralist view suggests a more limited understanding of responsibilities and narrower terms for cooperation (Stivachtis 2018), demonstrated for example by Germany's recruitment of scarce health care professionals in the Balkans to fill its own labor shortages. The still unsettled future of solidarity in Europe means that brain drain is likely to continue to feature among the demographic challenges for Eastern Europe.

This doctoral work aims to both bring up-to-date and include overlooked demographic variables in the larger academic effort to provide policy-oriented population projections. These projections focus on the outcomes of population aging, depopulation, and human capital flight. Any meaningful understanding of the future in the region depends on assessing the demographic outlook – answering how many, and who, will make up future society is critical for planning. At stake in Europe's migrant-sending countries is not only the sustainable functioning of pension systems, but productivity and competitiveness of firms, economic growth potential, taxation rates, maintenance of infrastructure and services, and more generally the wider resilience of society (Petrakis 2020; Batog et al. 2019; Atoyan et al. 2016). Aside from the list of possible unfavorable outcomes due to high emigration, the literature shows remittances to have ambiguous overall effects on Eastern European societies, depending on whether looking at a mixture of effects: boosts to consumption and investment, disincentives for recipients to participate in the local job market and a growth of young people not in education or work, as well as other secondary effects (Atoyan et al. 2016; Erdinç 2014; Federici 2009).

Across Europe, countries will deal with demographic change to differing degrees and in different forms over the coming decades. A range of policy decisions and demographic outcomes in both the migrant-sending and receiving countries have inevitable links to the EU's stated mission of socio-economic convergence between the regions. Ultimately, the scale and character of the anticipated problems, and what to do about them, depend heavily on the metrics used to evaluate population projections. By pushing forward emerging approaches to refine projections and evaluate the burdens of dependency in Eastern Europe, this work aims to get closer to identifying the true impact of the demographic trends in motion.

1.2 Research Context and Gaps

Population Projections

Demographic projections published by the United Nations and Eurostat provide an important overview of the future, capturing trends in fertility, mortality, and migration. On top of this, the Wittgenstein Centre for Demography and Global Human Capital (WIC) has added significant value by developing the additional dimension of education in its projections, a

measure of human capital (Lutz et al. 2018). In many cases however, across major institutions, naïve assumptions are made about migration. This is partially a necessity because migration is less predictable than fertility or mortality over time. However, the common treatment of certain elements of migration modeling leaves room for improvement. For example, migrants are often assumed to be proportionately distributed among the population by educational attainment, yet surveys and other studies indicate otherwise. In Eastern Europe, the education level of emigrants is often skewed at the higher, and to a lesser degree the lower, ends of the spectrum – an approximate 'U' shape (Atoyan et al. 2016), although this pattern varies by country. Therefore, it is worth expanding the existing capabilities of projection models to include observed education-specific (as well as updated age- and sex-specific) patterns of migration to better answer how the demographic and human capital future of the region looks in different scenarios.

Furthermore, until recently, the major population projection producers rely on base population estimates from national census data that can be almost two decades old for some countries – the case for Ukraine (2001) and North Macedonia (2002). Recent partial or full updates to the data landscape can be used to improve assumptions based on decades-old data points to better reflect the real demographic status quo. In terms of additional important country notes, the significant displacements associated with the 2022 escalation in armed conflict in Ukraine had pushed over 6.3 million Ukrainians (net border crossings) out of the country as of June 26, 2023 (UNHCR 2023). This shift both in terms of size and gender-skew is rendering existing population projections for the country increasingly obsolete.

Measures of Dependency and Human Capital

Secondly, and perhaps even more importantly, the interpreting and framing of population projection results is often done with rather misleading demographic indicators. The most feared consequence of population aging and decline is an overgrowth in dependency burdens. Typically, it is assumed that any individuals under the age of 15 (or 20) and those 65+ are unproductive dependents, while all people between the ages 15 (or 20) and 64 are considered as productive workers. The conventional age dependency measure does provide important information, but relying on age alone as a proxy for workers can only provide an incomplete sense of true dependency at best. Prominent studies acknowledge the changing reality of aging and the less dramatic burden it implies in the analysis and conclusions, such as a by the

Council of Europe (Athenosy & Revenco 2014). However, the study still relies on the solely age-based measures when it comes to quantifying dependency, which does not support or reinforce the overall point being made in the analysis. This doctoral work implements variations of emerging alternative measures of dependency, in a spirit similar to Skirbekk et al. (2022) or Marois et al. (2020), to reassess population projections for Eastern Europe and the South Caucasus.

Besides the widespread use of unsophisticated dependency measures, there is also a general research gap in the measuring of human capital and its flight. Most research on brain drain is limited to case studies of particular critical worker categories such as medical professionals or scientists. Attempts to construct a broad picture of the phenomenon across countries are undertaken by Docquier & Rapoport (2012) and Landesmann & Leitner (2015) looking at the economic determinates on the likelihood of emigration and the general push-/pull-factors of migration, and more recently, (Leitner 2021) estimated the skill composition of net migration in the Western Balkans. Similar estimates were produced by Brücker et al. (2013) in the IAB brain drain dataset, however the most recent year covered is 2010. The OECD also produces an important resource in this field, the DIOC database, which covers migration by education in the 35 OECD countries. A further joint effort by the OECD and World Bank created the DIOC-E database, expanding the estimates to include 55 non-OECD countries. These efforts to build standardized databases have focused on reconstructing the brain drain that has occurred, with the latest DIOC data from 2010-11 and DIOC-E from 2015-16. Where up-to-date, standardized data might be lacking, country-specific surveys of migrants from national governments or academic research can offer important snapshots of the trends. In this doctoral research such data was combined with population projections to quantify brain drain over time and present a range of paths it might take.

1.3 Objectives and Questions

Determining the demographic future (and its implications) is particularly timely in Eastern European countries, where aging and depopulation, driven by low birth rates and high emigration, are increasingly identified as problems. The specific research questions present to different degrees in each of the four components of this thesis can be summarized as**:**

RQ1: How do emigration, population aging, and depopulation in Eastern Europe and the South Caucasus impact the region's accumulation of human capital?

RQ2: To what extent would a range of future scenarios alter the course of human capital accumulation, aging, and depopulation compared to a *medium* scenario in which recent trends continue?

RQ3: What does this change imply in terms of potential unfavorable developments in dependency (those in need of financial or social support), particularly in relation to the productive population?

The larger goal of this research is to improve on the existing body of demographic research and projections to answer pressing policy-relevant questions and set realistic expectations for which demographic trends can and cannot be altered by possible interventions. One of the most widespread anxieties about current demographic trends is the feared decline in workers and the prospect of labor shortages. Such change is taking place in the context of improving automation and artificial intelligence, which are predicted to bring major disruption to the labor force (Prettner & Bloom 2020), even according to recent OECD revisions that downplay the previously anticipated likely impact; from 47% of all jobs to 'only' 14% (Nedelkoska & Quintini 2018). Considering the need for educational institutions to adapt accordingly to produce a sufficiently prepared labor force, the questions raised here about future human capital developments (in terms of number of workers and their skills) are all the more pertinent. In Europe, this need for understanding the future of human capital connects to the larger priority of socio-economic convergence between east and west that is often affirmed by the leadership of national governments and the European Union.

1.4 Research Approach: Theory and Methods

Theory

A society's level of human capital – adult educational attainment and skills – is a consequential determinant of economic success and wider social development (Bloom et al. 2021; Jones & Klenow 2016; Strulik et al. 2013; Lutz et al. 2008). For that reason, educational attainment is a common focus of research when social scientists attempt to

describe populations and societies. Furthermore, the formation of such resources requires years of training and cultivation. The concept of human resources, or human capital (as used in the English scientific literature in demography refers to the intangible and portable accumulated knowledge, training, and skills of a group. The term has its origins in the Latin "capus", meaning heads. Given the widespread implications and investments involved, it is worth understanding how the absolute and relative levels of a society's human capital might change over time, and under different conditions.

The first broad part of this doctoral work investigates the effects of current demographic trends on human capital through projections, which is hypothesis generating. The second broad part of this doctoral work is hypothesis driven: expecting that the consequences of population aging and depopulation on dependency burdens to appear less challenging when more complex measures of dependency are used. Aspects of the work involved synthesizing data, literature, and population projections in new ways, other aspects involved incorporating census and survey data into demographic projections, defining alternative scenarios, and analyzing the results. Defining alternative scenarios relative to a *medium* scenario is standard practice in demographic projections to illustrate divergent effects over time.

To analyze the phenomenon of population aging and depopulation requires the synthesis of literature and relying on theories like *Demographic Transition* and *Demographic Metabolism*, which hold predictive power and give the theoretical framework for thinking about how populations change over time (Lutz 2012). For post-*Demographic Transition* countries with low mortality and low fertility as those in Eastern Europe, Demographic Metabolism, is a particularly important concept to use in projecting how contemporary populations are changing, including in respect to education. As the younger generations replace the older ones, their different characteristics increasingly change the composition of the overall population for a given trait. Such data on education, by age and sex, is made available by many institutions, including Eurostat and the United Nations.

Methods

The different sections of this research required a variety of methods. Specifically, these include the use of modeling and analytic-synthetic methods. For the projection-based aspects of the research, this work involved calculating a set of assumptions and applying those to

baseline data. For the data sources and the more theory-based ideas covered in the previous section, the methods involve synthesizing literature and merging existing unrelated datasets to calculate results (on dependency outcomes) to answer research questions.

In the first projection-focused paper of this doctoral work, a new multi-dimensional population projection model was constructed for each of the five select countries in Eastern Europe and the South Caucasus. This approach considered age, sex, and education and used updated baseline population compositions and assumptions when applicable. The age dimension is divided into 20 five-yearly cohorts (*A:* aged 0-4, 5-9, …, 95-99) and a final open-ended age (100+). For each birth cohort (*C*), which is identified by the time of birth (*tob:* e.g. 2010-2015 birth cohort are aged 0-4 in 2015), sub-groups are defined by sex (*S:* male and female) and educational attainment *(E)*, which includes the following categories: e1: Lower secondary and less, e2: Upper secondary, e3: Vocational (VET), e4: Bachelor, and e5: Master and PhD). In the end, any individual in a country at a given time is in one of the 210 states (21 *A*ge-groups x 2 *S*exes x 5 *E*ducation categories) for the three dimensions (ASE). Over time, individuals can change their state either deterministically (aging) or stochastically (education transitions). Alternative scenarios to the baseline were constructed according to surveys on migration intentions among young people (ages 15-29), reduced emigration according to peer country performances (upper- and middle-income country averages), and country-specific reported desired fertility.

To compare demographic outlooks in Europe at the regional level, the CEPAM multi-dimensional demographic projection model (Lutz et al. 2018) was used in the second paper featured in this cumulative dissertation. The paper gave a particular emphasis to migration scenarios based on Eurostat migration data, which had the benefit of standardized definitions between the various EU member states' statistical agencies. The model used is a deterministic population projection model, which stratifies each EU-27+UK population by age (5-year age groups), sex, and educational attainment, computed using the "MSDem" package in R. The population by age and sex in 2015 (start of the projection) corresponds to Eurostat and educational compositions for the baseline year use the WIC dataset (Lutz et al. 2018). A baseline scenario is followed by the development of high and low non-EU immigration scenarios (in terms of the human capital and size of flows) using rates observed in Japan and Canada (prominent examples of high and low immigration systems among developed countries) as well as double or zero intra-EU migration scenarios. The country-weighted

assumptions for each macro-region are documented and model results are interpreted to provide an overview of the broad variations that emerge in the coming decades from different fertility, mortality, and migration regimes.

Next, population projections for Armenia and Georgia were analyzed according to well-established demographic methods for determining dependency burdens (based on age structure) and emerging methods that more explicitly consider human capital such as labor- and health-related factors. The analyses in papers three and four of this cumulative doctoral work made use of data on labor force participation, educational attainment, educational mismatch, disability rates, income, and other important sources of population heterogeneity to give more nuance to the process of distinguishing between dependents and those who are self-supporting or contribute to the wider economy and social systems. Different approaches to defining dependency were implemented to assess not only quantity of workers, but also quality. For example, a weighting system was used to quantify differences in productivity by education level (using country-specific studies on average earnings by education) and in the case of Georgia, tested skills by cohort (using OECD and World Bank data from international literacy testing programs PIAAC and STEP). In paper four, additional scenarios were explored for Armenia using peer country performances as policy goals in educational mismatches, brain drain, and labor force participation. The methods used for quantifying different types of dependency burdens makes possible a more nuanced analysis of population aging, depopulation, and human capital flight.

1.5 Thesis Structure

The following papers each contribute from different angles to the larger debate on the extent, speed, and consequences of population aging, depopulation, and brain drain.

Part 1: Human capital futures in Eastern Europe and the Caucasus amid aging, depopulation, and high skilled emigration

Education-selective migration is a key demographic reality missing from all major population projection efforts. To allow for the differentiation of migration by education, cohort-specific life expectancy, and other nuances of demographic change, this paper developed a population

model that differs from the period-based model used by Eurostat and the UN's Population Division. Various what-if scenarios were implemented, defined by age, period, or birth-cohort, for example: changing rates for a particular cohort (as implemented for Desired Fertility and Youth Exodus[2] scenarios). In total, four alternative scenarios and a baseline were explored for five countries (Armenia, Georgia, North Macedonia, Romania, and Ukraine) with output on change in population size, age structure, sex ratios, and education composition over the coming decades as well as the stock of human capital of the emigrants at the end of the projection period to quantify cumulative brain drain. Country-specific data and surveys were used for population and migration estimates (education and total flows) whenever possible to correct for incoherent or old data. The primary aim of this paper is to describe how a range of possible migration and fertility relates to the future human capital and demographic composition of countries. While the fate of emigration and fertility rates remain crucial for coping with or moderating demographic change, findings show that human capital is projected to nevertheless increase between 2015-2050 in the prominent migrant-sending countries studied.

Part 2: Migration and demographic disparities in macro-regions of the European Union, a view to 2060

Demographic futures in the macro-regions of the EU[3] (East, South, and West) are explored using different scenarios to see the extent population size, working-age population, education composition, and total age dependency can be influenced by alternate migration and fertility scenarios. We use a cohort-component projection model that incorporates improving levels of educational attainment in the population and explicit consideration of migration among EU Member States and migration between EU Member States and the rest of the world. Eight stylized 'what-if' scenarios were developed around a medium assumption projection. Although migration can have a large effect on total and working age population size, the EU population will continue to age and see a rise in age dependency regardless. Despite depopulation occurring in many eastern EU Member States, the region is and should remain in a better position than the south and on par with the west in terms of age dependency.

[2] Surveys of young people in many countries show very large proportions, in some cases outright majorities, considering leaving their country, especially for economic reasons.

[3] The grouping is based on the EUROVOC classification with Western and Northern Europe merged into a single entity due to similarity in demographic trends.

Part 3: Aging and depopulation in Georgia through the lens of human capital-focused dependency ratios

The gravity of the problems associated with population aging and depopulation depends on the measures used to describe dependency. By changing the complexity of the measure, the future of dependency in many countries can seem more, or less, daunting. This paper covers the aging and depopulating country of Georgia in the South Caucasus. The work contrasts the conventional age dependency (old age and total) against measures that account for human capital and health status. Such work involved calculating an education-weighted dependency ratio that links educational groups to corresponding income levels, a proxy for productivity. Similarly, another measure of dependency was developed to recognize the contributions of those at grandparent-ages as well as controlling for performance on internationally comparable literacy testing standards. Findings reveal a wide range of outcomes in dependency burdens between 2015-2050 (from +70% to -8% change), demonstrating how the definition of dependency shapes to a large degree apparent severity of the problem.

Part 4: The influence of education mismatches and human capital flight on dependency: A Case Study of Armenia

Armenia faces the dual challenges of low fertility and high emigration, as many of its peer countries. Human capital flight (brain drain), education mismatches (brain waste), and human capital activation (labor force participation) are three prominent phenomena that were investigated to determine the extent to which they represent opportunities for policy efforts to positively influence the future balance between non-workers and workers in society (dependency burdens). Population projections for Armenia by age, sex, and education were combined in a variety of conventional and emerging methods of calculating dependency burdens, including various 'ideal' and peer country performance-based scenarios. Findings suggest that achieving peer country performances is the most effective answer to lowering dependency burdens (-16.3%), followed by brain drain (-8.7%), and brain waste (-1.3%). Even in the baseline scenario dependency appears to slightly decline between 2015-2050 in Armenia, primarily due to change in educational attainment and its associated implications on labor force participation.

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2. Thesis Articles

2.1. Human capital futures in Eastern Europe and the Caucasus amid aging, depopulation, and high skilled emigration

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Working paper

Human capital futures in Eastern Europe and the Caucasus amid aging, depopulation, and high skilled emigration

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WP-23-003

Approved by:

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Abstract

Eastern Europe is a demographic frontrunner among late-stage *Demographic Transition* societies. The feared consequences of its aging, brain drain, and depopulation have drawn major political attention in the region. To assess the inevitability of such trends, a new multi-dimensional demographic model projects the populations of Armenia, Georgia, North Macedonia, Romania, and Ukraine. A range of futures beyond a baseline scenario were investigated, reflecting emigration intentions and desired fertility. Findings suggest that from 2020 to 2050 the five populations would decline by 5%-36% and the proportion aged 65+ would increase by 48%-99%, but concurrently see a 7%-49% relative rise in skilled human capital (vocational or tertiary education) among those aged 20-64. Depending on whether policy succeeds in helping people achieve their desired fertility or lowering brain drain pressures, these potential outcomes can become considerably more moderate or magnified.

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Human capital futures in Eastern Europe and the Caucasus amid aging, depopulation, and high skilled emigration

Introduction

Much of the broad Eastern European region is confronted with both the low fertility of high-income countries and the high emigration of medium-income countries since the socio-political upheavals of the early 1990s. This unique combination of trends has produced aging and shrinking populations. Governments of the region have acknowledged the situation with increasing urgency and dedicated resources to a variety of measures aimed at either coping with the consequences or attempting to reverse the trends. In 2020, Croatia's 6-month European Union presidency gave new prominence to the depopulation issue in Europe, with the Prime Minister labeling the prospect an "existential" risk (Fleming et al. 2019).

Such demographic change is – to some extent – natural or inevitable in industrialized societies where people live longer lives and have fewer children than in past centuries. Together with notable examples from East Asia like Japan and South Korea, many countries in Eastern Europe are at the forefront of new demographic frontiers in aging and depopulation currently emerging in late-stage *Demographic Transition* societies. However, these results of modern birth-death regimes are accelerated by, at times, large migrations westward. Perceptions of poor job prospects at home, inefficient labor markets and skills gaps in Western European countries, wage differences, and the ease of movement all facilitate high emigration rates. The Global Competitiveness Index shows that many countries of the region are among those least able to retain talent in the world (WEF 2017), while the IMF warns against broad declines in competitiveness and sinking GNI/capita despite remittances (Ruben et al. 2016). In recent years reporting has suggested that COVID-19-driven returns have reversed the longstanding net outflows from Eastern Europe (The Economist 2021), but it is too early to declare this as more than a temporary phenomenon since the basic pre-conditions for high emigration remain in place. In the case of Ukraine, the 2022 outbreak of conflict has already revived emigration on a massive scale (UNHCRa 2022).

The strengthening and activation of human capital have become even more critical as a realistic strategy for adapting to population aging and depopulation in Eastern Europe and the neighboring South Caucasus. For this reason, we consider how human capital will develop in a range of possible futures for five countries of the wider region: Armenia, Georgia, North Macedonia, Romania, and Ukraine. Human capital in this study is measured by educational attainment categories, broken down into lower secondary and less, upper secondary, technical training, and various levels of tertiary education to reflect the educational priorities and pathways in these five countries.

Comprehensive population projections are critical for national planning efforts, especially in countries with major demographic shifts in motion. Data limitations on migration and even large discrepancies in reported population size present additional challenges to establishing the current reality in many Eastern European countries. The results of this model – a Cohort-Based Multidimensional Demographic (CBMD) model –

represent new efforts to reconcile data discrepancies and include overlooked demographic variables to provide policy-oriented population projections for human capital in the region.

Demographic Scenarios:

The CBMD model is different from the period-based models, used by the Wittgenstein Centre (WIC), Eurostat, and the United Nations Population Division, which has the added advantage of being able to differentiate cohort-specific life expectancy, fertility, migration, and other variables as data become available. This is of interest to policy-makers because it is more user-friendly and allows for easy implementation of various what-if scenarios, defined by age, period, or birth-cohort; e.g., changing rates for a particular cohort (as implemented for Desired Fertility and Youth Exodus scenarios), for everyone during a period (COVID-19), or both during a specific period of time for a certain age-group(s) (e.g. new education reforms or a targeted fertility policy). In terms of output, we explore changes in population size, age structure, sex ratios, and education composition over the coming decades.

Middle-of-the-road assumptions on fertility, mortality, and migration were implemented in the baseline scenario to reflect recent trends. To establish or modify the base populations for Georgia and Ukraine, this paper uses estimates from their respective statistical offices, which both exclude disputed territories[1]. The projections begin in 2015 for Armenia, Georgia, and Romania, and 2020 for North Macedonia and Ukraine. A full account of the methods behind these projections can be found in the Supplementary Materials.

Special Case – Ukraine Baseline 1 and 2: Two different baseline scenarios were produced for Ukraine given important data discrepancies that complicate efforts to establish current demographic realities, especially on the country's population size and migration flows. An additional complication is how to treat the sizeable population of refugees, who may or may not return in large numbers over the coming years.

In Baseline 1 migration was taken from UN stock data and 80% of the ~4 million Ukrainian refugees (who left in the first 2-months of the 2022 war) are assumed to return by 2030. In Baseline 2 migration was taken from Ukrainian Border Crossings data and 25% of the ~4 million Ukrainian refugees (who left in the first 2-months of the 2022 war) are assumed to return by 2030. See Supplementary Materials for further details.

Using the CBMD model, three alternative scenarios (explained below) for each of the five countries studied were constructed to explore broadly different policy goals and the extent to which the baseline trajectories can in fact be altered.

Youth Exodus: In this scenario young people (ages 18-29) were projected to emigrate based on the desires they express in surveys [2]: Armenia (50.8%), Georgia (39.4%), North Macedonia (59.5%), Romania (68.4% / 65.5% / 52.7%, cohort specific), and Ukraine (60%). These extremely high rates capture a desire or plan,

[1] Projections in this study use population data from Georgia's GEOSTAT (which excludes Abkhazia and South Ossetia) and Ukraine's UKRSTAT (which excludes the Autonomous Republic of Crimea and city of Sevastopol).
[2] The implementation and the source of country-specific data is detailed in the Supplementary Materials.

which is very different from those who realize their emigration intentions. Nevertheless, if policies were to further facilitate the realization of even half of these potential movers, the demographic consequences would be severe. This scenario is meant to gauge the range of potential demographic implications if youth emigration accelerates. Other recent trends (fertility, mortality, education) were kept constant, and immigration is proportionally increased by 40% to account for returnees, using an estimated rate for Eastern EU countries between 2011-16 (Vercauteren 2019).

Outflows Reduced: In this scenario a mixture of less attractive opportunities in the typical destination countries and better prospects at home bring net migration in line with the global average for upper middle-income countries. This is done using a 75% reduction in emigration and then immigration was adjusted accordingly to fit with the UN's projected net migration five-year averages between 2015 and 2050, with the rate of -0.327 per 1000 people for 2020-2025 (UN 2019). The UN's projected rates for the lower middle-income country grouping were used for Ukraine, starting with -0.549 per 1000 people for 2020-2025 (2019).

The trigger for this new moderation in emigration could be the disruptions to economies and movement due to COVID-19. Sizable COVID-driven returns have reversed old East-to-West migration patterns across Eastern Europe, at least in the short-term. Many governments in the region hope such returns will be an opportunity to reintegrate these largely working age populations into the local labor force. Germany, one of the largest receivers of migrants from the region, also indicated reluctance to continue a large-scale recruiting program in the Balkans signaling a policy change from previously recruiting from the region in favor of reduced outflows from non-Schengen countries in Europe (Deutsche Welle 2018; 2020).

Desired Fertility: In this scenario, family support policies were implemented and succeed in helping people reach the family sizes they reportedly desire. The actual number of children had by couples in Armenia, Georgia, North Macedonia, Romania and Ukraine (and many other countries in the region) is consistently below what people express as their ideal in surveys due to a variety of competing interests and barriers, prominently economic worries. Such a change to the desired number of children would bring fertility near, or in some cases well above, replacement level (2.1 children per woman). Table 1 shows the desired fertility implemented in this alternative scenario, starting with the cohort aged 15-19 in 2015. For older cohorts, fertility rates for the remaining ages were adjusted accordingly.

Table 1. Desired vs. Baseline Fertility Estimates.

	Average Desired Number of Children[3]	WIC Estimated Fertility, 2015-20 (Lutz et al. 2018)
Armenia	2.4-2.8 (cohort-specific)	1.43
Georgia	2.8	1.78
North Macedonia	2.61	1.40
Romania	1.87-1.94 (cohort-specific)	1.48
Ukraine	2.0	1.38

[3] The implementation of country-specific data is detailed in the Supplementary Materials.

Results:

Depopulation and Aging

In this section the results explore a variety of possible demographic futures under different conditions in Armenia, Georgia, North Macedonia, Romania and Ukraine. By 2050, each of the five countries are expected to have smaller populations compared to 2020 in the baseline scenario, shown in Table 2. The declines over that course of time are as follows: Armenia(-5.2%), Georgia (-8.7%), North Macedonia (-35.6%), Romania (-19.9%), and Ukraine (-21.1% to -34.4%). Compared to the UN projections, the CBMD model results presented here demonstrate a similar-to-slightly more moderate outlook for change in population size in the Caucasus (Armenia and Georgia), while the declines in North Macedonia, Romania, and Ukraine appear to be deeper. Without considering updated current population estimates, updated emigration rates, or differentials in emigration by education, the UN projections estimate the following 2020-2050 decreases: Armenia (-5%), Georgia (-11.8%), North Macedonia (-10.8%), Romania (-15.5%), and Ukraine (-19.5%).

Table 2. Projected Population Size (millions) and Population Aging (% of population 65+), Baseline Scenario in 2020 and 2050.

	Population (mil), 2020	Population (mil), 2050	Prop. 65+ (%), 2020	Prop. 65+ (%), 2050
Armenia	2.9	2.8	12.5	24.8
Georgia	3.7	3.4	15.1	22.4
N. Macedonia	1.8	1.2	17.2	28.7
Romania	19.4	15.5	19.8	29.4
Ukraine-1	41.6	32.8	17.3	29.1
Ukraine-2	41.6	27.3	17.3	28.9

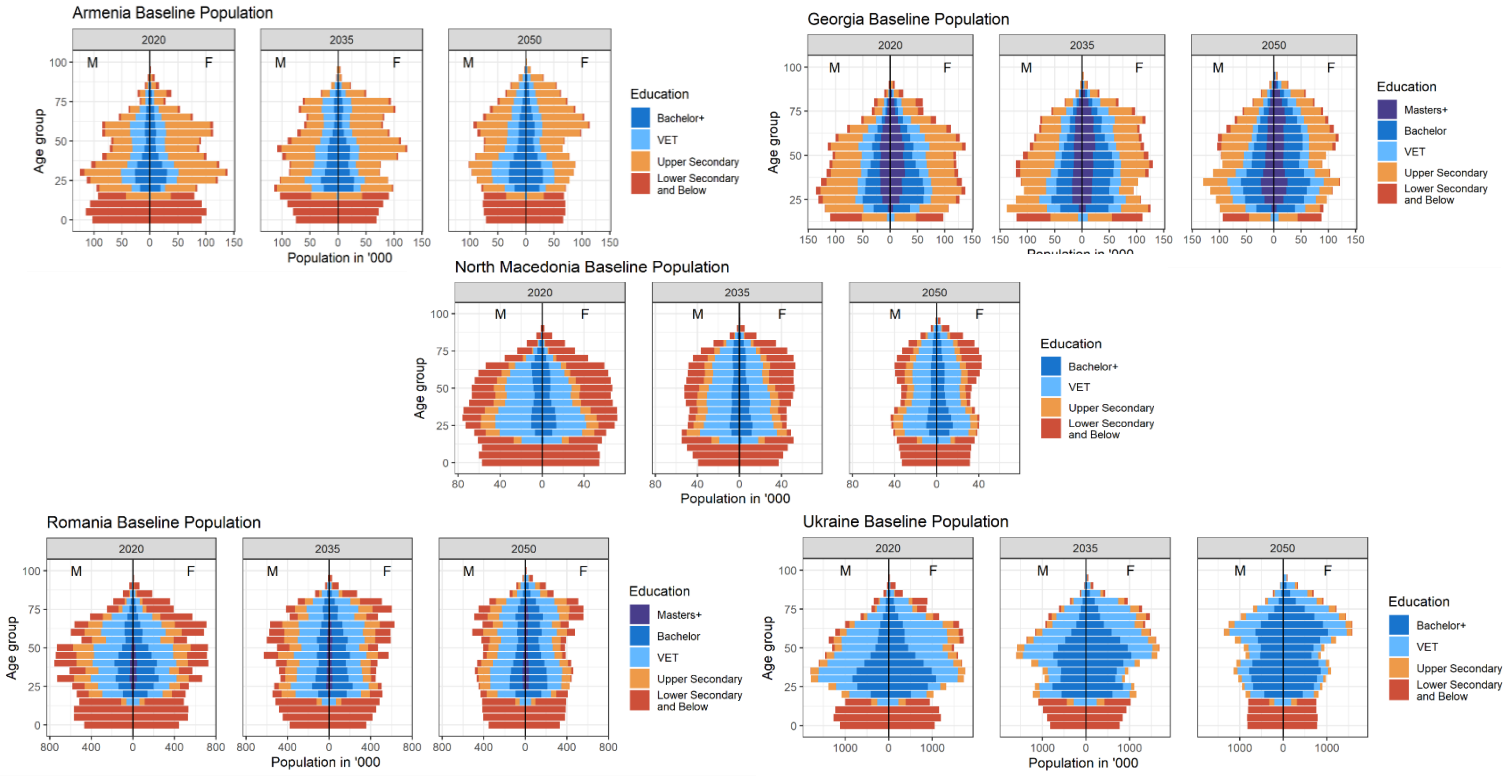
** The 2020 value for North Macedonia is projected based on 2021 Census results.*

Between the two alternative scenarios working against these depopulation trends – Outflows Reduced and Desired Fertility – the decline is more limited when fertility increases to desired levels for all of the countries, except North Macedonia, where a reduction in emigration makes a larger impact. Some of the strongest reversals by 2050 are seen in Georgia and Armenia, where populations are nearly stable (-4.3% and -3.8% with Outflows Reduced) or even growing (+20.6% and +13.3% with Desired Fertility) relative to 2020.
On the other hand, the scale of population loss would be unprecedented and extreme in a Youth Exodus scenario where emigration reaches levels of intentions expressed in surveys. The steep decline in which the young cohorts are nearly cut in half by the time they reach their early-30s would rapidly accelerate the demographic trends already in motion. Already by 2050 in such a scenario, the depopulation would range from a minimum of -25.1% in Armenia to a maximum of -46.3% in North Macedonia, with the others at: Georgia (28%), Romania (-40.4%), and Ukraine (-38.8% to -47.4%). The purpose of this scenario is not to present a likely scenario, but rather to demonstrate the extent of latent demographic downturns if policies further facilitate potential emigration.

The widespread phenomenon of populations getting older is also projected to carry on in the countries studied, as seen in Table 2. The following increases in the proportion of the population aged 65+ are projected in the baseline scenario from 2020 to 2050: Armenia (99%), Georgia (48%), North Macedonia (67.3%), Romania (48.6%), and Ukraine (67.2% to 68.3%). In spite of the relatively quick pace of aging, populations in the post-socialist countries of Eastern Europe and the Caucasus still remain younger than their counterparts in Western and Southern Europe. For comparison with the projection results shown in Table 2 – which show the proportions aged 65+ in the mid-to-upper 20s by 2050 – those same proportions are expected to reach 30% in Western Europe and 36% in Southern Europe by 2050, increases of 40.2% and 64.3% from 2020 respectively (Lutz et al. 2018). This is due in part to demographic momentum from higher birth rates in the decades preceding the 1990s as well as lower life expectancies, both gaps which have been reducing between the former East Bloc countries and the rest of Europe.

Below (Figure 1) is a set of population pyramids by age, sex, and educational attainment. The model used in this study implements the Wittgenstein Centre's assumptions for progression of educational attainment, which expects continuation of the present trend in the country, guided by regional and global pathways. For the countries covered in this study this means only modest growth past current high levels of educational attainment among the subsequent young cohorts. The baseline educational distributions and treatment of education transitions are detailed in the Supplementary Materials. Primarily due to the higher propensity of younger cohorts to attain tertiary education, and the gradual replacement of generations through a process referred to as Demographic Metabolism, the populations become more educated over time in each of the five countries.

Fig. 1. Populations by Age, Sex, and Education, 2020-2035-2050, Baseline Scenario.



** The VET category includes vocational and technical education, the majority of which is attained at the upper secondary level in the countries above.*

Refined Perspectives on Workers and 'Working Age Populations'

Population aging and depopulation has driven fears about a declining labor force, in particular a severe worsening of old-age dependency. However, the conventional measure of dependency relies on crude assumptions – everyone ages 20-64 are productive workers, and those 0-19 and 65+ are dependents. There is growing agreement among experts that this is a misleading demographic indicator for determining economic vitality. The solely age-based concept of dependency misses important changes in the nature of aging that are making age 65 an arbitrary and unsustainable cutoff for productive working life (Sanderson & Scherbov 2008; 2010). Using Sanderson and Scherbov's Prospective Aging measure (the proportion of population with a remaining life expectancy below 15 years), the future of aging in all five of the countries studied seems less dramatic compared to conventional, easy-to-misinterpret measures. In terms of the redefined aging measure, the results can be seen in Table 3. Critically, the refined perspective approximately cuts in half the level of potential burden that the equivalent 65+ metric otherwise indicates – a much more manageable prospect.

Table 3. Prospective Aging (Proportion of Pop with Remaining Life Expectancy of 15yrs or Less) vs. Proportion of Pop 65+

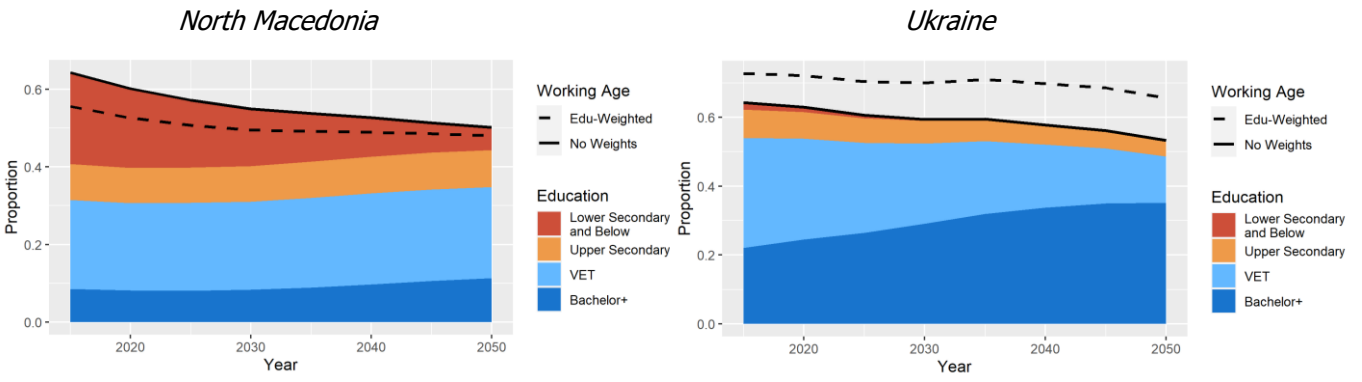
	Prospective Aging (%), 2020	Prospective Aging (%), 2050	Prop. of Pop 65+ (%), 2020	Prop. of Pop 65+ (%), 2050
Armenia	7.6	12.9	12.5	24.8
Georgia	11.1	12.2	15.1	22.4
N. Macedonia	11.9	16.9	17.2	28.7
Romania	12.3	17.3	19.8	29.4
Ukraine-1	13.2	16.4	17.3	29.1
Ukraine-2	13.2	16.7	17.3	28.9

Besides redefining when working life begins and ends, it is also important to recognize how accounting for human capital in the conventional working age population can alter outlooks on the future (Brunello & Rocco 2015). The share of the population aged 20-64 with VET or tertiary education is projected to grow (in proportion to those with lower educational attainment) between 2020 and 2050 by the following: Armenia (35.4%), Georgia (32%), North Macedonia (36%), Romania (49.2%), and Ukraine (6.9% to 12.6%). Such growth in VET and tertiary education suggests better future labor force outcomes and greater productivity (Lutz 2011). Critically, these human capital gains are also in absolute terms for Armenia, Georgia, and Romania, whereas North Macedonia and Ukraine see their total numbers of people with skilled human capital decline since the speed of educational attainment expansion fails to compensate for emigration and low fertility.

Figure 2 shows the conventionally-defined working age population by education attainment. The total working age population (solid black line) is meant to be contrasted with a productivity-weighted adjustment (dashed line), which assesses the working age population in terms of its component educational attainment groups. This is done by applying the observed average income by education, a proxy for productivity. The relative returns in the countries studied were calculated according to country-specific data (detailed in the

Supplementary Materials), which all follow a general pattern. When the average earnings of people with upper secondary education in the countries studied is set to 1 for reference, those with university education earn about 1.3 and those with lower secondary and below earn approximately 0.8 by comparison. In the countries studied the returns to VET are very similar to upper secondary earnings, similar to general findings by the OECD (Barişik & Budak 2020), although an employability benefit often exists for VET graduates.

Fig. 2. Working-Age Population (20-64) as a Proportion of the Total Population by Educational Attainment, Baseline Scenario, 2015-2050.



Relative returns to education can change over time and this productivity-adjusted measure does not incorporate other likely labor-relevant advancements such as technological, which could further aid in a population's overall productive and adaptive capacities. Furthermore, these figures are not meant for direct comparison with each other due to differing standards of productivity and wages.

The productivity-weighted measure indicates that North Macedonia's conventionally-defined working age population is underperforming (as the dashed line can be seen below the solid line), although the gap decreases over the decades. In spite of the falling proportion of working age people in the population, the overall productive capacity is seen to remain relatively stable over time. On the other hand, Ukraine's productivity-weighted working age population can be seen to already outperform its size at the start of the projection. The productive potential declines over time, but less steeply than the decline in the simple working age population. Similar patterns are seen in Georgia and Romania. Armenia's productivity-weighted working age populations closely follow the working age populations' trajectory due to a smaller jump in educational attainment from the current old and young generations.

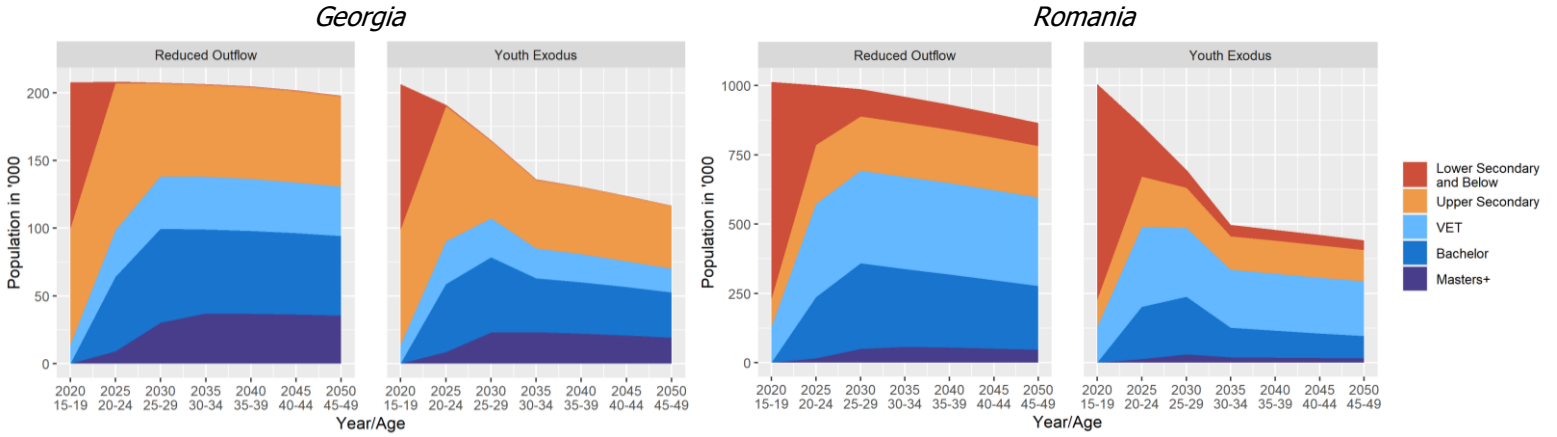
Scenarios of Human Capital Flight, 'Brain Drain'

The results below contrast the effects of emigration in the baseline (recent trends) scenario with those in the two alternative migration scenarios, which follow the extreme ends of contrasting policy goals. Emigration in the recent past has reshaped the region and created some of the largest proportional diasporas in the world, representing a critical undermining of human capital in the sending countries (Ruben et al. 2016). While brain drain can be defined more generally to encompass all those of working age or more narrowly to cover only critical professions, here we focus on the highly educated, conventional working-age population. In the baseline scenario projections, the accumulated (2020-2050) net migration of skilled human capital (VET and tertiary educated) among working-age (20-64) adults (expressed as a proportion of the equivalent working

age population in 2050) amount to the following losses: Armenia (-35.1%), Georgia (-14.3%), North Macedonia (-58.8%), Romania (-35.3%), and Ukraine (-4.9% to -33.7%). The large variation in Ukraine's brain drain values is due to the different migration rates implemented, UN vs State Migration Service, paired with contrasting assumptions about refugee return rates.

Figure 3 shows the evolution of the Georgian and Romanian age-cohorts born in 2000-2005, most of whom will still be in the process of completing their education into the late-2020s. The Outflows Reduced scenario presents a future where still more people are leaving than returning, but the rate reduces to the average levels of the upper middle-income countries. A scenario of moderate emigration would aid in the gradual accumulation of the countries' highly skilled human capital, where the expansion of educational attainment strongly overtakes the outflow of highly educated people. As indicated in the figure, the clear majority of the cohorts remain intact. Compared to the accumulated brain drain measure used in the paragraph above, this scenario only produces the following losses: Armenia (-8.1%), Georgia (-2.2%), North Macedonia (-4.4%), Romania (-7.8%), and Ukraine (-1.5% to -10.1%).

Fig. 3. Birth Cohorts 2000-05, Youth Exodus vs. Outflows Reduced Scenarios.



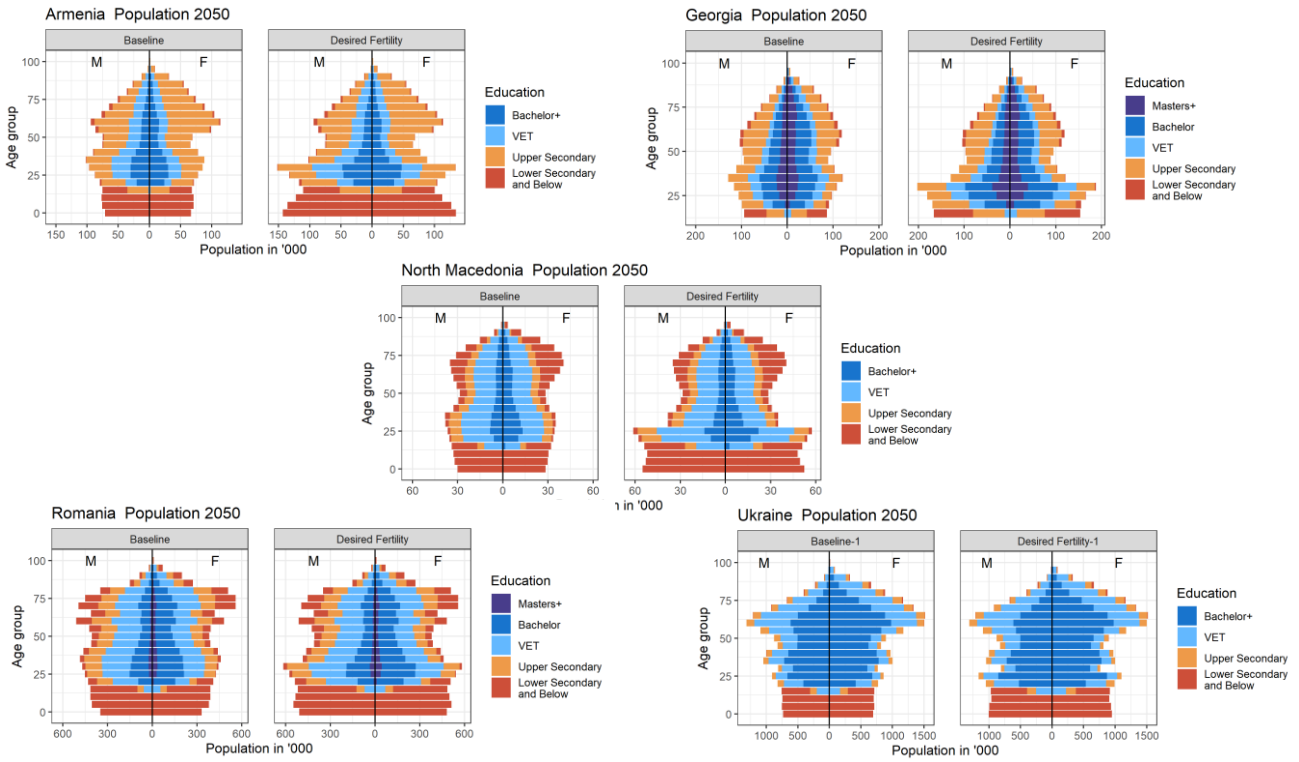
The Youth Exodus scenario – also in Figure 3 – shows a future where young people (18-29) leave their countries at the very high rates expressed in surveys and return according to estimated averages for the Eastern EU member states. If emigration was further facilitated by policies to actualize these potential movers, who express primarily economic motivations of employment and higher wages, there would be a severe drop in total human capital. Furthermore, the strength of the outflows would even reverse relative educational gains among the overall population in Romania. In terms of the conventionally-defined working age populations, this scenario would mean debilitating accumulated losses of those with VET or tertiary education over the period 2020-2050, relative to the 2050 population with the same educational attainment: Armenia (-105.5%), Georgia (-57.2%), North Macedonia (-95.4%), Romania (-112%), and Ukraine (-37.6% to -70.5%). The rapid shrinking of childbearing cohorts would also bring delayed impacts that become evident decades later in birth patterns, and eventually in levels of human capital.

Influence of Fertility on Young Populations

The most common policy response of governments to current demographic trends is the aim to restore birth rates to above replacement level. In keeping with the work of the Wittgenstein Centre, the baseline fertility is assumed to preserve differences by education, where more education is associated with later births and overall lower fertility. Low fertility and its delayed age structure effects of smaller cohorts (especially from the 1990s) are responsible for the declines in the baseline scenario youth population (0-29) from 2020-2050 to the following degrees: Armenia (64.4%), Georgia (94.8%), Romania (9.8%), North Macedonia (40.2%), and Ukraine (60.8% to 82.6%). The rest of the decline comes directly from emigration and indirectly from removing would-be mothers from the population. Due to its relatively young age structure, Armenia's fertility of 1.68-1.69 is still enough to very slightly grow the total population by 2050 in the absence of migration (the fertility-driven decline would show up in later decades). In Georgia, there appears to be a successful fertility rebound underway since the mid-2010s, suggesting rare potential for stabilizing around replacement level – which if maintained will reflect in the whole population in the long-run.

A scenario where an effective mix of policy support for parents is successful in helping couples achieve their desired fertility would bring a reversal of population declines in Armenia and Georgia, and the five countries studied would see significant absolute jumps (30%-101%) in their young populations compared to the 2050 baseline. As seen in Figure 4, the Desired Fertility scenario results in a return to the traditional pyramid shape from which the population pyramid takes its name. Nevertheless, the proportion of the population aged 65+ still rises in Armenia to 66.6%, Georgia (12%), North Macedonia (37.5%), Romania (35.6%), and Ukraine (53.6% to 55.2%) from 2020-2050, highlighting how population aging is essentially inevitable.

Fig. 4. Population Composition, Baseline vs. Desired Fertility Scenarios in 2050.



Policy Implications:

The baseline projections foresee smaller, older, and better educated future populations in the five countries studied. Such prospects are in line with the broad trends in most industrialized countries after decades of rapid growth in the earlier stages of the *Demographic Transition* (a near-universal pattern of development). Distinct to Eastern European and the Caucasus however – with the countries in this study as no exception – is the extra role that the outflows of people, especially to Western Europe, play in lowering population size and speeding population aging.

Within certain bounds, population aging and decline do not necessarily equate to general societal decline. To some extent these trends are even symptoms of medical and economic successes. Regardless of the causes and implications, population aging in particular is largely resistant to policy interventions (Lutz et al. 2019). The most serious of the commonly feared consequences of such demographic trends is an unfavorable breakdown in the balance between workers and dependents, a reality that may in fact not even materialize. In Europe, the near-equal advances in Life Expectancy at 60 and Healthy Life Expectancy at 60 (WHO 2020), and expansion of educational attainment, highlight how a population's composition is not constant and numbers alone are not a meaningful policy objective. If the goal is to maintain a balance of workers and dependents, efforts should be oriented toward cultivating the productive capacity of a population as well as limiting negative societal pressures that make it more difficult to establish working lives and families.

A Vision for Human Capital Management

For the countries covered by this study, a coherent human capital management strategy can be summarized by the following:

1) Ensure education is relevant and provides a clear pathway to working life
2) Incentivize greater labor force participation
3) Reduce barriers for people to achieve their desired fertility
4) Reach a consensus on migration and the competition for talent in Europe

Eastern European emigration is increasingly recognized as a force undermining prospects for development by various bodies, including the EU's European Committee of the Regions (Boc 2020). As explored by the Youth Exodus and Outflows Reduced scenarios, the number of people who will take their talents and human capital elsewhere between 2020 and 2050 is a vital question. This topic of growing concern warrants the attention not only of national politicians in the countries concerned, but neighboring states, especially amid continuing pull-factors in Western Europe and the stated long-term political goals of EU membership. Hopes of higher living standards elsewhere and better job prospects are consistently the main motivations to leave (Ruben et al. 2016; OECD 2019; Sandu et al. 2014). Young people in countries with underdeveloped work-based education routinely have a lower employment premium and face more difficulties in labor market integration (Cedefop 2013).

Lifting labor force participation rates has the power to completely overcome the potential worsening of the ratio between workers and dependents for many European countries. Work by the European Commission

(Lutz et al. 2019) confirms this reality using the labor participation of Sweden today as a standard of convergence over the coming decades, where around 65% of the 15+ population were active as of 2021 (ILO 2022). For the countries in this study, the equivalent rates stood at the following: Armenia (52%), Georgia (59%), North Macedonia (53%), Romania (52%), and Ukraine (55%)(2022). This range is roughly in line with the Balkan countries and France (56%), above Italy (48%), but below others including post-Communist eastern peers like the Visegrád countries (57-60%), Russia (61%), and the Baltic states (60-63%)(2022). Scandinavian countries have reached new highs in terms of labor participation in Europe due in part to earned income tax credits, pension reform, and other policies aimed at incentivizing work.

Central and Eastern European countries tend to perform relatively well when it comes to training their populations for the labor market compared to the South or West according to the EU's European Skills Index (Cedefop 2022). In spite of the favorable performances in the wider region, many studies find inadequate quality of education in Armenia, Georgia, North Macedonia, Romania, and Ukraine. In North Macedonia for example the European Training Foundation finds, "high and persistent mismatches" and "a relative deterioration in the position of tertiary-educated workers as a result of a large increase in the supply of such workers, an over-education phenomenon that is more prevalent than under-education" (ETF 2020). In terms of the situation by cohort, the mismatch problem appears to be somewhat better for younger workers between the ages of 20 and 29. To avoid further losses and offer individuals credible prospects of integrating into the labor market, the private sector would need to be formally included in shaping programs (vocational, tertiary, and lifelong learning) in the spirit of dual education systems.

Economy-education disconnects are especially notable in vocational training, an education type with which many of the current (and expected future) skill shortages could be remedied. Confirming this reality, an assessment by the European Commission found that VET in Romania, "remains a second-choice option and in most cases is not adapted to labour market needs'' (EC 2018). The longstanding tradition of apprenticeship learning (ucenicia lalocul de munca) nearly disappeared during the transition period of the 1990s, but more recent efforts have been made to revive a similar system (Cedefop 2019; 2016). More generally, greater cultural acceptance for VET would help countries to counteract skills obsolescence and adapt to the artificial intelligence disruptions (Cedefop 2018). Expanding the higher-tier post-secondary non-tertiary VET is seen as one way to raise the social status of applied education.

Besides doing more with fewer people – by improving education and labor participation – the barriers to starting new families should be limited if the goal is to maintain a stable and balanced population in the long-term. Many of the same quality of life concerns that motivate emigration also make it harder to realize desired fertility as it is connected to stability and confidence in the future. Scandinavia, the German-speaking countries, and more recently others in Central Europe have implemented a variety of pro-natal measures to this end: strengthened parental leave, kindergarten expansions for working parents, tax benefits and other approaches. In general, fertility measures focused on alleviating work-life pressures are more effective than direct cash transfers (Sobotka et al. 2019).

The countries of this study have seen strong growth in GDP over the last 10 years, but if Western Europe is used as the point of comparison, economic convergence is still seemingly far off. Amid economic hardship, decisions to leave a country or start a family both require a certain degree of confidence in the future. Many of these concerns are directly and inevitably linked to decisions within a national government's control,

however the countries studied do not exist in a vacuum as they are also heavily influenced by the most advanced economies of Europe and their migration incentivizing pull-factors. Even though solidarity is a guiding principle of contemporary intra-European relations, no coherent consensus has been reached on best practices when it comes to the ongoing competition for talent in Europe. Until key Western European countries successfully address their own skill shortages with educational reforms – particularly in critical fields like medicine and trades – they are set to continue passing on demographic and human capital externalities to their eastern neighborhood.

Supplementary Materials:

The methods used in this paper are explained in detail by first describing the model in general and then the specific treatment of various factors in particular.

We defined a multidimensional population projection model for each country. We consider three critical dimensions: age, sex, and education. The age dimension is divided into 20 five-yearly cohorts (***A:*** aged 0-4, 5-9, …, 95-99) and a final open-ended age 100 and older (100+). For each birth cohort (***C***), identified by the time of birth (***tob:*** e.g. 2010-2015 birth cohort are aged 0-4 in 2015), we further define sub-groups by sex (***S:*** male and female) and educational attainment (***E***: e1: <= Lower Secondary, e2: Upper Secondary, e3: Non-tertiary Post-Secondary, e4: Bachelor degree, and e5: Masters and PhDs). All together any individual in a country at a given time will be in one of the 210 states (21 ***A***ge-groups x 2 ***S***exes x 5 ***E***ducation categories) in the three dimensions (***ASE).*** Population distributions by age, sex, and educational attainment at the start of the projection period (2015) were extracted from the Wittgenstein Centre (WIC) projections (KC et al. 2018) that uses age and sex distribution for 2015 from the UN's World Population Prospects 2017 (UN 2017). These were then corrected according to newer data (when possible), with the country-specific modifications detailed in the subsequent sections of this Supplementary Materials section. WIC's assumptions of future demographic developments in age-, sex-, and education-specific fertility and mortality as well as the educational attainment transitions were implemented to produce the projections.

Steps of the Projection:

1. pop * sx
2. (pop * sx) * (edutran)
3. (pop * sx * edutran) * (1+imrate-emrate)
4. Births = pop_avg * asfr;
5. Popm_newcohort = births * sexr * sx

Over time individuals can change their state either deterministically (aging) or stochastically (education transitions), while other characteristics remain unchanged (sex). The model includes events both depleting (death and emigration; "sx" and "emrate") and increasing (immigration; "imrate") a cohort's size, and an event (birth) creating new cohorts according to age-specific fertility rates ("asfr"). Projection starts with July 1st, 2015 (besides Ukraine and North Macedonia, July 1st, 2020), and ends in 2050 in a five-year step, also called a time-step. The transitions for each event were defined in the following steps.

Baseline Population Size and Age/Sex Composition:

The base population size as well as age- and sex-structures for Armenia and Romania was taken from the UN's World Population Prospects 2019 (UN 2019). For countries with national statistics based on old census data and likely significant discrepancies between the official numbers and current number of people in the country, the model instead used alternative data to reflect the real situation as best as possible. Below is an overview of alterations made in this study to the Wittgenstein Centre's base population sizes and compositions (Lutz et al. 2018), with the purpose of better reflecting current demographic realities not captured by outdated or incomplete data.

Important Country Notes

Georgia: Geostat data (2022) was used to correct WIC's age-sex distribution for the 2015 population.

North Macedonia: The 2021 Census from North Macedonia's State Statistical Office (2022) was used to update the 2020 population size as well as age and sex distributions, since the previous estimates were outdated and showed large discrepancies as they relied on the last observed count in 2002.

Ukraine: State Statistics Service of Ukraine (2021; 2022) were used to update the population size, as well as the distribution by age and sex for mid-2020 (using 2020 and 2021 data).

Educational Attainment:

In this CMDM model five main education categories were covered. The lowest attainment categories used by WIC were merged into a category called e1 (at least lower secondary), followed then by e2 (upper secondary), e3 (post-secondary non-tertiary), e4 (bachelor), and e5 (master+). For only two countries (Georgia and Romania), the model uses WIC data covering all five of the outlined education categories. For Armenia, North Macedonia, and Ukraine we have WIC data for three education groups, with the highest education e3 grouping all levels of post-secondary tertiary education into "bachelor+".

Initial educational attainment distributions for the populations (besides Ukraine, explanation below) were interpolated from the Wittgenstein Centre (Lutz et al. 2018). For those countries, the additional step of splitting the commonly aggregated VET and secondary educational attainment categories in each of the countries, it was done according to the availability of age/sex-specific distributions. Profession-focused VET education was distinguished from other categories (upper secondary and post-secondary) because it

represents a path that many governments want to popularize and a qualitatively different approach to education.

Important Country Notes

Armenia: Four education categories from WIC, with the upper secondary category split into VET and regular according to DHS data from Armenia's National Statistics Service (2017).

Georgia: Five education categories from WIC, with the upper secondary category split into VET and regular after the projection according to the Geostat Labour Force Survey (2021).

North Macedonia: Four education categories from WIC, with the upper secondary category split into VET and regular after the projection according to estimates by the Vienna Institute for International Economic Studies (Leitner 2021).

Romania: Five education categories from WIC, with the upper secondary category split into VET and regular after the projection according to estimates by the European Commission (2018).

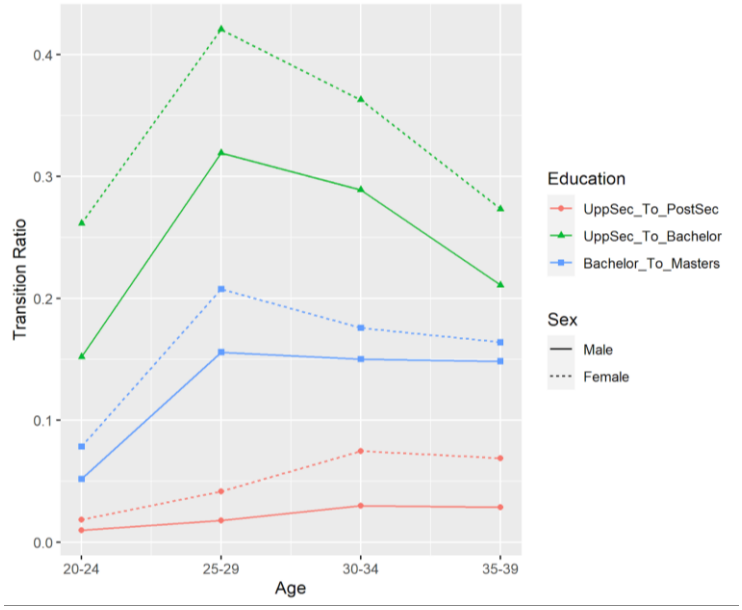
Ukraine: Four education categories; the Ukrainian population's educational attainment composition was synthesized based on WIC for older cohorts and Libanova et al. (2016) for the young and future population. This was done to account for the significant rise in tertiary education in the time since the last full census in 2001. For the VET category, upper secondary is split into VET and regular according to the same school-to-work transition surveys produced by the ILO (2016).

In terms of updating other demographic variables, the ultimately canceled Ukrainian electronic census conducted in 2019 showed a total population that was roughly in line with expectations, (37.29 million people as of December 1), excluding the Crimea and the Donbass regions. Experts argued the process was not reliable and represented a population count rather than a traditional census as it did not cover many of the usual demographic variables (Chukhnova 2020). Data remains inconsistent for those reasons, necessitating use of the multiple sources referenced.

Education Transitions:

Education-specific transition rates by age and sex determine the number of progressions to the next higher level of educational attainment during the time-step. We assume that the education transition stops after the cohort reaches age 30-34. The WIC database provides proportions (KC et al. 2018) and not transitions. Using the assumptions, we calculated the education progression ratios from each education group for each cohort starting at age 10-14 until age 30-34 for the projection period. Having transition ratios (example of Romania shown in Fig. S1) allows us to define alternative scenarios much easier than using proportions because education distribution is a result of the transitions and making changes at the root level (transitions) is more comprehensible and provides more concurrency to policy variables such as completion ratios, dropout rates, etc.

Fig. S1. Romania, Educational transitions as of 2011, by age group.



Source: (Lutz et al. 2018) WIC, based on data from the Romania Census 2011

Estimating education progression for each age-group: WIC projects education attainment for six levels of education categories (no education, some primary, primary, lower secondary, upper secondary, and post-secondary) at age 30-34 for each cohort that was used to calculate education progression ratio or the transition rates from each education level to the next one. Most of the education transitions occur during younger ages and were calculated by back-casting the cohort transitions using assumptions of progressions through ages. WIC assumes transitions to lower secondary are completed by age 20-24, for upper secondary and post-secondary it is 25-29 and 30-34 respectively. The assumptions are available as a proportional distribution of education by age and sex. For our purpose, using the proportion distribution, we computed transitions probabilities for each age. With the transition probabilities, we can easily define alternative scenarios. For a few countries [Georgia and Romania, here], WIC's post-secondary category was further divided into three categories: non-tertiary (which was combined into the larger VET category), first-level tertiary (bachelor), and second-level tertiary (master+). VET education, in terms of transition rates, was treated as upper secondary education. Examining WIC's data, the distribution of post-secondary (tertiary) into the two categories were held constant throughout the projection at the base-year (2015) level.

Mortality:

For the population aged 15 years and above, survival ratios for each group (by age, education and sex) determine the population surviving at the end of each 5-year time step and the survivors age an additional 5 years. For the population under 15 years old, survival ratios (in terms of the important education dimension) were defined by the mother's educational attainment. All mortality assumptions for the future (2015-2050) were extracted from the WIC database (KC et al. 2018).

Migration:

Emigration ratio for each group determines the number of people leaving the country during the time step, the denominator of which is the group size, including the emigrants, at the end of the time-step. The WIC's projections use migration flows that do not differentiate by education, a distinction which is being refined in our CBMD model. Hence, we estimated and defined a new set of assumptions in this report.

The migration rate used was adjusted according to UN stock data (UN 2022), which unlike UN migration flows data, is not tied to the after-the-fact balancing calculation for migration rates that is dependent on accurate fertility, mortality, and population size data to produce an accurate migration value.

Important Country Note

Ukraine: In the case of Ukraine two different migration rates were used given considerable discontinuities in migration data. The assumptions for the first baseline UA-1 (approximately net -110k over 5 years) come from changes in UN stock data (2015-20) which is not tied to the after the fact balancing calculation for migration rates that is dependent on accurate fertility, mortality, and population size data. The migration assumptions used for the second baseline, UA-2 are about 10x higher (approximately net -1,090,000 over 5 years), coming from State Border Guard Service of Ukraine data on border crossings of both Ukrainians and non-Ukrainians between 2013-17.

Both the baseline UA-1 and UA-2 scenarios modify the populations in the projection step of 2020-2025 to account for the significant refugee outflows following the outbreak of war in February 2022. Taking the outflows from the first two months (February 24 to April 24), 4,062,514 individuals were removed from the baseline population (UNHCR 2022a). Age and sex distributions were taken from estimates provided by the UN coving those entering Moldova (IOM/UN 2022), a major recipient and transit country for the refugees. Similar, less detailed data is documented about the flows to Poland (UNHCR 2022b). In terms of returnees, the UA-1 scenario assumes an 80% return rate by 2030 (3/4th return by 2025), based on polling responses (Razumkov Center 2022), while the UA-2 scenario assumes a much lower 25% return rate by 2030.

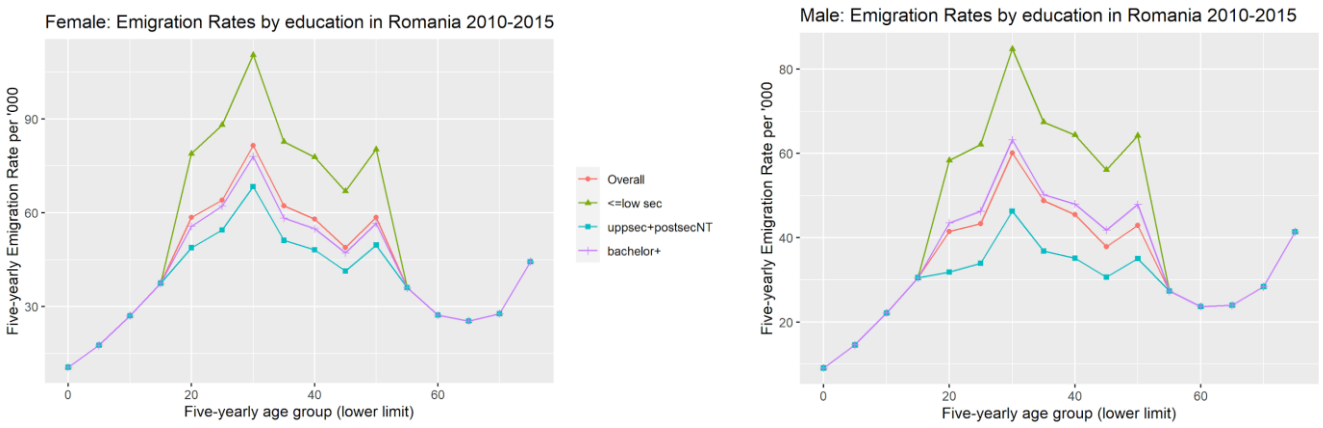
Education-, Age-, and Sex-specific Emigration

Age- and sex-specific migration rates were calculated using the age- and sex- specific migration flows from the work of Abel (2018), which uses UN migrant stock data (from the 2017 revision). Specifically, migration flows for the period 2010-2015 were divided by population from 2015 to calculate the rates. Only sex-specific total flows without age breakdown were reported in the 2018 paper, with the rest generated on request. These distributions reflect the general tendencies of migrants to be working-age in line with the standard Roger-Castro migration age-schedule (Rogers & Castro 1981).

These age- and sex-specific migration rates were then split by education – given the high prevalence (and therefore importance) of emigration in the region and variations in the self-selectivity of emigrants – using overall education-specific rates or proportions from the following studies: Armenia (Saavedra et al. 2019), Georgia (State Commission on Migration Issues 2017), Romania (OECD/WB 2022), and Ukraine (Luecke &

Saha 2019). North Macedonia is the only country in this study, which uses a distribution according to the general population's educational attainment structure. The resulting age-, sex-, and education-specific migration flow rates were further revised with the most recent revision of UN migration stock data (2020), such that the overall sex-specific flows during 2015-2020 matches with the difference in the change in stocks of foreigners in country X and citizens of X abroad. The obtained adjustment factors were then applied to all future periods (shown in Fig. S2).

Fig. S2. Emigration rates of 5-yearly age groups, by education, during 2010-2015.



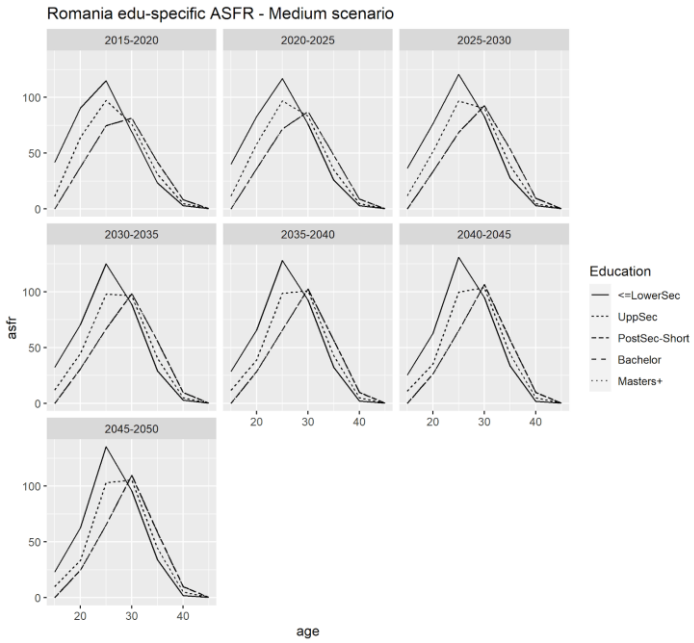
Immigration:

The immigration rate determines the number of people joining the group during the time step, the denominator of which is the group size at the end of the time-step. We use Abel's estimates (2018) for immigration by age and sex, which have converted stock data to flows. We then use the education distribution of the country (destination) due to limited data.

Fertility:

The model uses age-specific fertility rates by educational attainment for women in reproductive ages 15-49 years. The total number of births is then split into males and females using the UN's assumed sex-ratio at birth, males per female birth (UN 2017). Finally, sex-specific survival ratios by mother's education were applied and a new cohort aged 0-4 is created at the end of the time-step. All assumptions were extracted from the WIC database (KC et al. 2018). Higher education is associated with later birth. Figure S3 shows the age-specific fertility rates implemented for Romania by different educational attainment levels.

Fig. S3. Age-specific fertility rates (ASFRs) by education in Romania.



Assumptions behind each Demographic Scenario:

Baseline

We start with a baseline scenario building on the WIC's (Shared Socioeconomic Pathways) SSP2 "middle-of-the-road" projected future. In terms of inputs, the main advancements are in the differentiated migration inputs by age, sex, and education and the associated assumptions about the future.

We assume, based on a very extensive consultation with experts done with WIC, that the life expectancy will tend to converge to a higher value (front-runner country) in the long run. Assumption for fertility is country-specific, for countries with low fertility, a long-term convergence by 2150 to a value of 1.75 children per woman is assumed. Further information on the reasoning behind these decisions has been documented at length in Chapter 2 of a report by Lutz et al. (2018) published by the European Commission and International Institute for Applied Systems Analysis (IIASA). The education-specific propensities to out-migrate were assumed constant, but the average educational attainment levels for subsequent cohorts were expected to increase (and may stabilize) following the trend (country, regional, and global).

Youth Exodus

The rates implemented for the ages 18-29 in the projections (shown in Table S1) were based on the survey results in the following studies: Armenia (ETF 2013), Georgia (2013), North Macedonia (Galevski 2019), Romania (Roman & Vasilescu 2016), and Ukraine (Drobchak et al. 2019; Mostovaya & Rohmanin 2017). Immigration is proportionally increased by 40%, with returnees coming back according to the following patterns: 20% within the next five years (1st 5yr step), 30% in the next 5yr step, 40% in the next, and finally 10%. For consistency emigration intentions were extrapolated to apply to ages 18-29 in each country and applied with age-specific variation according to data availability.

Table S1. Average emigration intentions, assumptions for the Youth Exodus scenario.

	Intentions to Emigrate among Youth
Armenia	Ages 18-29: 50.8%
Georgia	Ages 20-29: 39.4%
North Macedonia	Ages 15-35: 59.5%
Romania	Ages 15-19: 68.4% / Ages 20-24: 65.5% / Ages 25-29: 52.7%
Ukraine	Ages 18-29: 60%

Note: The value for Ukraine is an average from the two sources given.

Outflows Reduced

The following rates shown in Table S2 were implemented for the Outflows Reduced scenario, with emigration being reduced by 75%, and then correspondingly immigration reduced to fit with the UN's projected global trends (UN 2019) in net migration for upper-middle income countries (Armenia, Georgia, North Macedonia, and Romania) and lower-middle income countries (Ukraine).

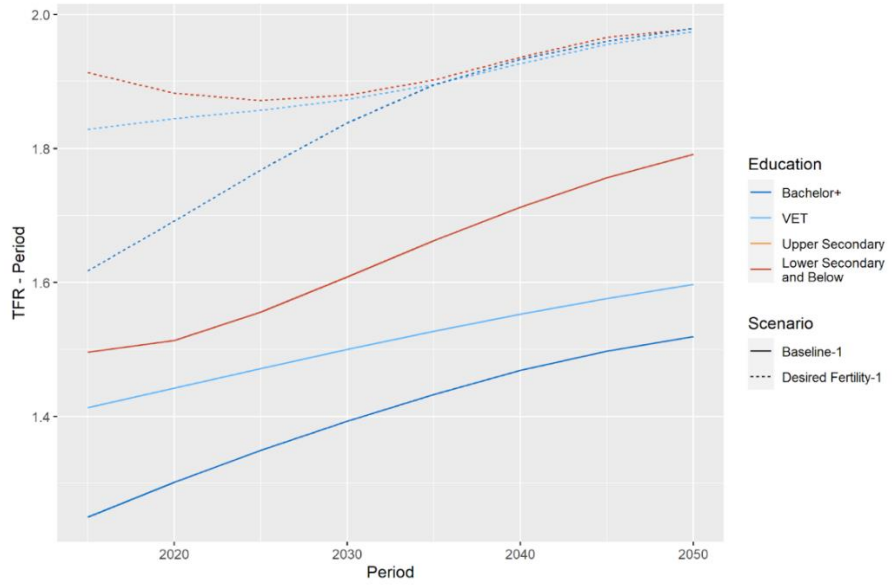
Table S2. Projected UN net migration rates for upper middle-income countries.

	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
Net migrants per 1000, Upper-middle income countries	-0.113	-0.327	-0.243	-0.169	-0.149	-0.146	-0.144
Net migrants per 1000, Lower-middle income countries	-0.687	-0.549	-0.479	-0.431	-0.409	-0.391	-0.376

Desired Fertility

Fertility rates for the Desired Fertility scenario were implemented using the following sources: Armenia (NSS-AR 2017), Georgia (Ketting & Lomia 2019), North Macedonia (Petreski 2021), Romania (Testa 2012), and Ukraine (UCSR 2008). Figure S4 shows how the TFR for Desired Fertility was gradually implemented compared to the baseline fertility, in this case for the projections of Ukraine.

Fig. S4. TFR by education in Ukraine, Baseline scenario vs. Desired Fertility scenario.



Productivity-Weighted Adjustment:

The relative returns in the countries studied, shown in Table S3, were calculated according to the following country-specific sources: Armenia (Hakobyan & Joulfaian 2016), Georgia (Keshelava 2017), North Macedonia (Mojsoska-Blazevski 2016), Romania (Varly et al. 2014), and Ukraine (Del Carpio et al. 2017).

Table S3. Productivity Weights Implemented by Educational Attainment.

	Primary	Secondary	VET	Tertiary
Armenia	0.833 (m) / 0.797 (f)	1 (m) / 1 (f)	0.992 (m) / 0.862 (f)	1.364 (m) / 1.029 (f)
Georgia	1	1	1.05	1.449
N. Macedonia	0.629	1	1	1.368
Romania	0.851	1	1	1.358
Ukraine	1	1	1.028	1.340

Note: Armenia, Georgia, and Ukraine have marginal populations with primary education or lower.

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2.2. Migration and demographic disparities in macro-regions of the European Union, a view to 2060

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This publication is part of the Special Collection on "Drivers and the potential impact of future migration in the European Union," organized by Guest Editors Alain Bélanger, Wolfgang Lutz, and Nicholas Gailey.

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Research Article

Migration and demographic disparities in macro-regions of the European Union, a view to 2060

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Abstract

BACKGROUND
Migration has become one of the most salient policy areas in the European Union. In response, the European Commission established a research team with the task of investigating a range of possible demographic futures.

OBJECTIVE
This paper explores the demographic effects of migration on eastern, southern, and western EU regions, using different scenarios to see the extent population size, working-age population, education composition, and total age dependency can be influenced.

METHODS
We use a deterministic cohort-component projection model that (a) incorporates improving levels of educational attainment in the population and (b) explicit consideration of migration between EU member states (MS) and migration between EU MS and the rest of the world. Eight stylised what-if scenarios are developed around a medium assumption projection.

RESULTS
Although migration can have a large effect on total and working-age population size, the EU population will continue to age and see a rise in age dependency regardless. Despite depopulation occurring in many eastern MS, the region is and should remain in a better position than the south and on par with the west in terms of age dependency.

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CONCLUSIONS
While both the south and east provide large demographic subsidies of working-age people to the EU's west, the south is less prepared to cope with the losses due to an already older population, lower labour force participation, and lower education levels.
CONTRIBUTION
We report demographic consequences of contrasting migration scenarios for the EU-28 (now EU+UK) based on multidimensional projections by age, sex, and educational attainment.

1. Introduction

Prior to the COVID-19 outbreak, migration both from outside the European Union and between member states (MS) was among the most pressing policy priorities in the European Union, a situation almost certain to return as soon as travel and economic activity rebound in the post-pandemic recovery (European Commission 2015; European Council 2019). The EU's progressing integration had created an unparalleled open internal migration regime within the Union, while EU MS had, to varying degrees, more restrictive stances on immigration from outside the EU (Comte 2017). Against the backdrop of differences in living standards, wages, and services, the right to free movement (in its latest form amended in the Treaty of Lisbon 2007) stimulates migration between the MS. Around 3% of EU citizens (19.9 million people) resided in an EU MS other than the one of which they were citizens at the end of 2017 (EUROSTAT 2018). Considering sizeable changes to migration in the EU-28 in recent years – the influx from the Middle East and North Africa countries during 2015–2016, and then the unprecedented downturn in migration during the global pandemic in 2020 – one can ask, how would different potential migration futures impact long-term demographic change in the major EU-28 macro-regions, given their variations in age structure and migration patterns?

This contribution to the special collection of *Demographic Research* uses deterministic multidimensional population projections and a range of stylised migration scenarios to model possible demographic futures in three major EU's macro-regions: east, south, and west[4]. The countries in these three macro-regions share migration

[4] The grouping is based on the EUROVOC classification with western and northern Europe merged into a single entity due to similarity in demographic trends. West (11 MS): Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, Sweden, and the United Kingdom. South (6 MS): Cyprus, Greece, Italy, Malta, Portugal, and Spain. East (11 MS): Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.

histories and contemporary patterns, with economic downturns, political changes, and country-specific regulations playing important roles in shaping migration in individual member states. Western European countries changed from historical net senders to net receivers of immigrants in the 1950s, attracting immigrants predominantly from southern Europe, Turkey, former colonies, and since the 1990s, from eastern Europe (Therborn 1987; van Mol and de Valk 2016). Germany has become the single largest receiving country with a flow of 2.7 million immigrants from outside the EU in 2013–2017, which represented 26% of all immigrants entering the EU in the same period.

Southern EU MS have been major emigration countries historically and since only the 1990s has immigration into the region gained momentum (King, Lazaridis, and Tsardanidis 1999; Castles 2000). Emigration from Spain and Greece increased again during the economic crisis and its aftermath in the early 2010s, but immigration increased as well with large inflows of asylum seekers in 2015–2016. Despite recent attempts to reform the Dublin system, the EU's asylum system still puts a large burden on southern MS at the external EU borders as migrants are meant to apply for asylum in the first EU MS reached rather than in locations in western Europe.

By contrast, eastern Europe had been largely closed to migration until the fall of the Iron Curtain. Emigration intensified with the accession of eastern European countries to the EU, although some of the intra-EU migration is of temporary or circulatory nature (Black et al. 2010). An estimated 1.8% of the population in the eastern member states that joined the EU in 2004 moved to the EU-15[5] between 2004 and 2009 and as much as 4.1% of population in case of Bulgaria and Romania between 2007 and 2009 (Fic et al. 2011). Populations of the EU-15 (old member states) grew by an estimated 0.4%, 0.3% of which was due to immigration from new members during the period (ibid). The migration was driven predominantly by large differences in conditions on the labour market of EU countries (e.g., Kahanec and Zimmermann 2010). So far, eastern MS tend to be net-sending countries and attract only a small fraction of non-EU immigrants into the EU (9% during 2013–2017 (EUROSTAT 2020)).[6] Today anti-immigration views, or preferences for immigration from culturally similar countries (Brunarska et al. 2016), are stronger in eastern Europe than in the western MS (Czaika and di Lillo 2018; Gorodzeisky and Semyonov 2016).

We distinguish in the projections between migration within the EU-28, which we label intra-EU migration, and between the EU-28 and the rest of the world, which we

[5] EU-15: Member countries in the European Union prior to the accession of ten candidate countries on 1 May 2004 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom).

[6] Czech Republic stands out as an exception, and recently immigration to some eastern countries increased as well (Eurostat 2019): for example, a stock of 222,000 Ukrainians with valid residence permits in Poland (UDSC 2020, https://migracje.gov.pl/en/)

label extra-EU migration.[7] We differentiate these two types of international migration because they are regulated differently and represent their own unique policy challenges. Intra-EU migration is subject to minimum regulation as the right to free movement is guaranteed to all EU citizens, which means that member states cannot introduce their own policies and regulations limiting such migration, apart from emergency measures, such as during the COVID-19 pandemic, or transitional restrictions with the accession of new countries.[8] Migration into the EU is more strictly regulated and is the prerogative of national governments, which have specific national policies and regulations concerning the granting of residence permits to non-EU nationals. Thus, for deeper policy insight it is useful to illustrate differentiated impacts of intra-EU and extra-EU migration. Important previous work in this direction includes subnational population projections by Rees et al. (2012) that evaluated possible impacts of successful or unsuccessful social cohesion policies using four scenarios with differentiated intra- and extra-EU migration trends using migration modelling for statistical analyses (MIMOSA) estimates (Raymer, de Beer, and van der Erf 2011). Further important efforts can be seen in the work of Kupiszewski and colleagues, who projected EU-27[9] populations and labour force (Kupiszewska and Kupiszewski 2013) using estimated flows between the EU-27 countries (Raymer 2008) and populations of European Economic Area countries at the Nomenclature of Territorial Units for Statistics (NUTS) level 2 (Kupiszewski and Kupiszeska 2011) using Demographic and Migratory Flows Affecting European Regions and Cities (DEMIFER) estimates (NIDI and Partners 2010). At the time of working on the projections presented in this paper, other projection exercises that cover EU countries did not project different types of migration separately but were using average net migration (UN 2019; Cafaro and Dérer 2019; EUROSTAT 2019). EUROSTAT projects immigration and emigration flows separately and differentiates between intra-EU and extra-EU flows starting from 2019 EUROPOP projections (EUROSTAT 2020) and formulates three scenarios with a baseline, higher, and lower migration that do not combine different assumptions for different types of flows. Projections presented here cover a broader range of scenarios.

In ageing low-fertility societies, migration is a consequential driver of demographic change. It causes population growth in many net-receiving, predominantly western and southern EU countries, and exacerbates population decline in net-sending countries, particularly in the east (Figure 1). Populations of six eastern MS shrunk by 10% to 26%

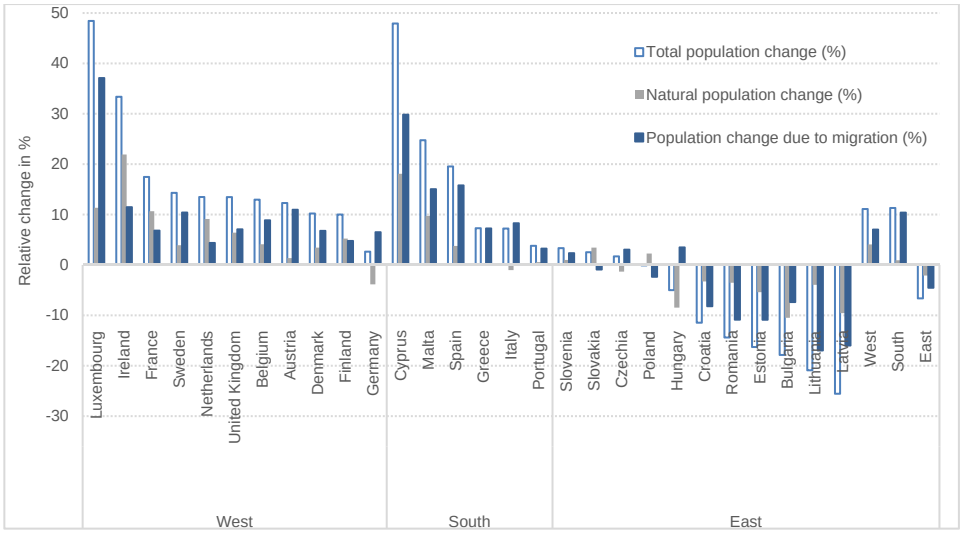
[7] To clarify our use of terms, intra-EU migration is a change of residence from one EU MS to another, that is, both origin and destination are EU-28 countries. By extra-EU migration, we refer to a change of residence from a non-EU-28 country to an EU-28 country or the other way around.

[8] These were lifted for most new member states in 2014 and 2015, Croatia being the last and only member state subjected to the restrictions until 2020. It is also the only country that has applied the principle of reciprocity and raised restrictions to the countries that introduced them towards Croatia.

[9] EU-27: the number of member countries in the European Union prior to the accession of Croatia in 2013.

between 1990 and 2015 due to combination of large emigration and low fertility. In the context of economic downturns and high unemployment in eastern MS during their economic transition to market economies, migration was mutually economically beneficial (Kahanec and Zimmermann 2010) and economic benefits of increased migration between the MS for the EU as a whole have been well documented (see for example D'Auria, McMorrow, and Pichelmann 2008). But large emigration has severe impacts (direct and indirect) on the sending member states: acceleration of already rapid population ageing, depopulation, decrease in the size and ageing of labour force, and reduction in number of births due to lower-reproductive potential because emigrants tend to be young workers at both productive and reproductive age. Not a single southern or western EU MS recorded population decline during 1990–2015, although Italy and Germany had a negative natural balance (births minus deaths). One can expect that natural change would turn (increasingly) negative in the near future in more countries as baby boomers age and smaller cohorts of women of reproductive age bear fewer overall births even if fertility rates were to increase. Excess mortality (Goldstein and Lee 2020), birth deficits (Luppi, Arpino, and Rosina 2020), and reduction in international migration due to COVID-19 might have spurred population declines in some EU-28 countries in 2020 and 2021.

Figure 1: Contribution of migration and natural change to population growth in EU-28 countries and macro-regions, 1990–2015



Source: European Demographic datasheet 2018 (WIC 2019) and EUROSTAT, authors' calculations.

The impact of migration goes beyond population growth or decline; therefore, we investigate how varying volumes and educational composition of migration flows influence composition of the working-age population and age dependency ratios. Educational attainment serves as a good proxy for human capital – the abilities and skills of workers – because education attainment is quantifiable, widely measured, and is strongly correlated with productivity in work and life. This human capital dimension is particularly vital for dealing with the effects of population ageing and the smaller anticipated working-age population in the future because it represents potential economic productivity and the ability of a society to meet the challenges ahead. Arntz, Gregory, and Zierahn (2016) estimate 9% of jobs in 21 OECD countries are at high risk of automation, while Nedelkoska and Quintini (2018) put the number at 14% for the OECD as a whole, with an additional 32% of jobs likely to be significantly altered. Those impacts are expected to hit the south and east of Europe much harder than the west given differences in the economy and how jobs are structured (Nedelkoska and Quintini 2018). Even though there is a relatively wide range of views in the literature about the extent to which artificial intelligence will revolutionise and disrupt the labour force with jobs lost and created, it is clear that human capital and the associated adaptability will be even more critical to success in the future. Educational attainment or skills need to be included in population and migration projections of modern societies, in which human capital is a major asset and source of competitive advantage.

2. Data and methods

Population and human capital projections presented in this paper use a widely accepted model of multidimensional population dynamics, which is an extension of standard cohort-component model that accounts for additional dimensions of population heterogeneity that influence demographic components (e.g., Keyfitz and Rogers 1982; KC et al. 2010; KC and Lutz 2014; Stonawski et al. 2015). Multidimensional models use the additional attributes to influence assumptions of the components and to generate model outputs (for differences to multistate models, see Rees 2019: 42). The Centre for Expertise on Population and Migration (CEPAM)[10] model used in this paper is a deterministic population projection which stratifies and projects each EU-28 country's population by age (in five-year age groups), sex, and educational attainment (Lutz et al.

[10] The CEPAM model was developed in the Centre for Expertise on Population and Migration (CEPAM), a joint research project between the International Institute for Applied Systems Analysis (IIASA) and the Joint Research Centre (JRC) of the European Commission. CEPAM's modelling work was directed to provide scientific evidence to the European Commission's bodies and support policymakers within the Commission.

2018; Lutz et al. 2019).[11] Population projection was computed in R using MSDem package.

The starting population by age and sex in 2015 corresponds to EUROSTAT,[12] and educational compositions for the baseline year come from the Wittgenstein Centre dataset (Lutz et al. 2018). All CEPAM scenarios are developed using SSP2[13] medium scenario assumptions on future fertility, mortality, and educational attainment for the EU-28 countries, which are documented in Lutz et al. (2018), while modifying the SSP2 medium migration assumptions, which are explained in the following section.

Mid- and long-term fertility assumptions maintain the target values of overall TFR for 2030–2035 and 2050–2055, which were derived from meta-expert meetings as described in Basten, Sobotka, and Zeman (2014), and short-term values assure a smooth transition from the 2010–2015 levels (UN 2017). The total fertility is set to converge to 1.75 children per woman in 2200. In the west of Europe TFR is 1.78 at the baseline and oscillates around this level during the whole projection, while in the east and south, where initial levels are at 1.46 and 1.43 children per women, respectively, the assumptions assume an increase to 1.6 children per woman. Educational differentials were updated with additional information from the Cohort Fertility and Education database[14] (Zeman et al. 2017) for the baseline, and over time these differentials are assumed to converge to ratios (relative to TFR of lower secondary) of 1.42 for up to primary educated women, 1.35 for lower secondary, 1.14 for upper secondary, and 1 for post-secondary (Lutz et al. 2018: 19–27). Education-specific TFRs for the three regions are presented in Table 1.

Table 1: Projection assumptions for education-specific total fertility rates for the three macro-regions and selected periods

	West				East				South			
	e1-e3	e4	e5	e6	e1-e3	e4	e5	e6	e1-e3	e4	e5	e6
2015–2019	1.90	1.94	1.75	1.68	1.54	1.61	1.44	1.30	1.85	1.76	1.48	1.27
2035–2039	2.09	2.13	1.88	1.73	1.88	1.89	1.64	1.48	1.99	2.00	1.68	1.44
2055–2059	2.11	2.17	1.90	1.72	2.06	2.05	1.73	1.56	2.15	2.11	1.77	1.51

Notes: e1-e3 = primary or lower; e4 = lower secondary; e5 = upper secondary; e6 = post-secondary. Values are weighted average of country-specific assumptions. Fertility assumptions for all years and countries can be found with the supplementary materials.

[11] The model uses the following categories based on ISCED 2011 classification: lower secondary and below (no education, ISCED 1–2), upper secondary (ISCED 3), and post-secondary (ISCED 4–8).
[12] Eurostat database, table demo_pjan [last accessed 10.6.2018]
[13] The Shared Socioeconomic Pathways (SSP) scenarios describe plausible future societal changes in demographics, human development, economy, institutions, technology, and environment in the context of sustainable development; SSP2 is a middle-of-the-road scenario (O'Neill et al. 2014). KC and Lutz (2014) detail the demographic components of SSPs.
[14] See http://www.eurrep.org/database/ for more details.

Long-term mortality assumptions for the end of the century foresee improvement in life expectancy and were formulated for female life expectancy at birth using the meta-expert survey (Caselli et al. 2014). The gender gap is assumed to narrow to three years by the end of the 21st century, resulting in higher increases for male life expectancy. These long-term mortality assumptions are linearly interpolated to correspond to the new baseline levels in 2015 (UN 2017). While these assumptions had been defined before the outbreak of the COVID-19 pandemic, they seem to be still meaningful since at this stage it is still very unclear what could be the longer-term impacts of the pandemic on future life expectancy. There could both be possible positive effects due to those not affected having on average better health (also called 'harvesting') and possible new investments in the health systems as well as possible negative effects due to possible long-term health impacts of those surviving infections. It is not yet clear what will be the balance of these opposing effects.

Table 2 shows average life expectancy at birth for men and women in the three macro-regions used in the CEPAM model. Southern EU has highest life expectancy at the baseline and also at the end of the projection. Western EU catches up to these levels and has highest assumed gain of 8.6 years for both men and women between 2015–2019 and 2055–2059. The improvements are smaller for east (8.3 years for women, 7.6 for men). A fixed six-year differential is assumed for the life expectancy of those with lowest versus highest educational attainment.

Table 2: Projection assumptions for life expectancy at birth, by sex and three macro-regions for selected periods

		2015–2019	2035–2039	2055–2059	Change from 2015–2019 to 2055–2059
West	Female	84.1	88.4	92.7	8.6
	Male	79.6	82.8	88.2	8.6
East	Female	80.6	84.8	88.9	8.3
	Male	71.7	75.2	79.3	7.6
South	Female	85.4	89.6	93.9	8.5
	Male	80.5	84.7	88.9	8.4

Notes: Values were calculated as weighted average of country-specific assumptions. An expanded set of assumptions for all years and countries can be found with the supplementary materials.

Future changes in educational attainment follow the Global Education Trend scenario (Barakat and Durham 2014). Multidimensional projections do not require transition rates and instead use modelled future shares of educational attainment at ages 15 to 19, 20 to 24, and 25 to 29 conditional on the presumed final attainment level reached

at ages 30 to 34.[15] These presumed final attainment levels at ages 30 to 34 in 2015, 2035, and 2055 are presented in Table 3 for the three macro-regions.

Table 3: Projection assumptions for education attainment at ages 30 to 34 by sex for the three macro-regions for selected periods

	Education	East	West	South		Education	East	West	South
2015 Female	e1-e3	1%	3%	4%	2015 Male	e1-e3	2%	3%	7%
	e4	8%	11%	18%		e4	10%	12%	25%
	e5	45%	36%	35%		e5	57%	41%	36%
	e6	46%	50%	43%		e6	31%	44%	32%
2035 Female	e1-e3	0%	1%	0%	2035 Male	e1-e3	1%	1%	1%
	e4	2%	4%	7%		e4	4%	6%	12%
	e5	42%	32%	36%		e5	56%	38%	44%
	e6	56%	63%	57%		e6	39%	55%	43%
2055 Female	e1-e3	0%	0%	0%	2055 Male	e1-e3	0%	0%	0%
	e4	1%	2%	1%		e4	2%	3%	4%
	e5	32%	23%	29%		e5	53%	33%	44%
	e6	67%	75%	70%		e6	45%	64%	52%

3. CEPAM migration scenarios

In order to understand how populations of countries and macro-regions would develop under different migration situations, we develop multiple what-if scenarios that combine different volumes of intra-EU and extra-EU migration with different educational compositions. The scenarios do not aim at forecasting migration and should not be understood as predictions but rather represent stylised migration situations that can also be viewed from the perspective of diverging policy options and thus allow policymakers to assess the long-term demographic outcomes of these contrasting migration futures. The scenarios presented in this paper replace the migration assumptions of the SSP2 scenario presented in Lutz et al. (2018), which use the long-term average of immigration and emigration rates derived from the global flows (Abel 2017).

Different approaches were employed to set assumptions for intra- and extra-EU migration. For the latter, the starting point was broad scenario narratives which describe in qualitative terms possible future volume and composition of migration flows in various socioeconomic and political circumstances. These broadly different futures can be benchmarked against a scenario of recent trends continued (which we model as the Medium scenario, described later in this section).

[15] For the reasoning of this solution to modelling of educational distributions rather than transition rates, see Goujon et al. 2016: 322.

The conceptual foundation for the development of migration scenario narratives was a survey prepared by the CEPAM team, which asked experts inside the European Commission (EC) and its agencies about possible future migration trajectories in the EU. The survey included a structured questionnaire in which experts evaluated different aspects of migration trends, drivers, and policies. The experts also answered an open question at the end of the survey, which prompted them to formulate one or several migration futures they would find useful to explore through demographic projections. The themes that emerged could be organised into several broad narratives that envisage future intra- and extra-EU migration trajectories within the context of economic stability and continuing integration inside the EU versus economic instability and more restrictive and selective policies regulating immigration into the EU. Although some respondents developed situations for intra-EU migration, most focused on the aspects concerning immigration from outside the EU, which is not surprising given that asylum migration had been a major focus of the EC in 2018. The survey was followed up with a workshop involving migration experts from the EC and scientific community that was held in April 2018. Invited experts were prompted to discuss in moderated groups and further develop the scenarios. This input was consolidated by a smaller expert group, which included the CEPAM team at the Joint Research Centre (JRC) and International Institute for Applied Systems Analysis (IIASA). The main themes raised by the experts were organised within the context of existing examples of policy responses and actions in migration management seen in other countries around the world. This process produced a set of four scenario narratives of extra-EU migration presented below.[16]

3.1 Scenario narrative 1: Low volume – High education (Lv-He) of immigration

Responding to historical changes as Europe becomes a continent increasingly defined by immigration, EU member states adopt more selective migration policies to both emphasise skills and substantially reduce overall volume. Immigrants are admitted primarily based on their potential for economic contributions, using a point system targeting highly specialised and needed skills. This highly selective system promotes short-term permits, restricts long-term migration towards the EU, and reduces the inflows to a fraction of what the EU has seen in the recent past. Economic integration is facilitated by their high skills profile and being screened by language and other criteria. Member states maintain integrity of the system by enforcing existing requirements for legal employment status and penalising businesses for unlawful hiring practices. Coming to terms with the reality of an ageing workforce, member states address associated

[16] An additional high-emigration scenario that emerged from the discussions is not analysed in this paper but is included in Lutz et al. (2019)

challenges by making investments in automation and mechanisation as in East Asia. The new policy focus intends to use emerging technologies to improve production efficiency and reduce the dependence of various sectors (agriculture, heavy industry) on repetitive, low-skilled, and automation-candidate labour.

3.2 Scenario narrative 2: Low volume – Low education (Lv-Le) of immigration

A major renewal of the education system benefits EU member states by successfully linking university and technical programmes with economic needs. With such developments and investments in automation, member states do not try supplementing their workforce by recruiting large numbers of workers from around the world. The primary focus of immigration policy shifts to providing for refugees and filling remaining low-skilled jobs. A new immigration system is implemented with an emphasis on work permits of a temporary and seasonal nature. Such changes to labour migration promote circular migration, resulting in much lower immigration into the EU than in the recent past. Member states also adhere to the new asylum policies to affirm they help designated groups at designated levels. Accordingly, asylum seekers are accepted as refugees in acute cases and for limited amounts of time. Despite some difficulty in economically integrating refugees, the general orderly management and low volume does not overload relevant support resources. At the same time, the spots for low-skilled migrants and temporary workers are calibrated to match with unfilled jobs, facilitating their relatively easy entry into the European workforce. The system depends on regular diagnoses of the economy, efficient administration of set migration levels, and ensuring employers of migrants and temporary workers fulfil legal work requirements as protection against fraud.

3.3 Scenario narrative 3: High volume – High education (Hv-He) of immigration

EU member states begin recruiting increasing numbers of high-skilled workers from countries around the world to address economic concerns. The introduction of a new high-volume, high-skilled immigration system brings approximately double immigrants into the European Union. Maintaining its selective nature, the system relies on strict enforcement of work permits and borders as the EU becomes an increasingly prominent immigration destination. Most of the new migrants originate from middle-income countries with relatively strong education systems, but the immigration system also attracts highly educated elites from low-income countries. Sending countries in turn struggle with the losses of their most talented and educated citizens as the appetite for

skilled workers in the EU continues. Integration into the economic system comes without significant barriers, since the admission of migrants is a function of scoring highly on measures of education, skills, language ability and work experience. A large proportion of the migrants pursue opportunities in the urban economic hubs of western and northern Europe, given the greater demand for high-skilled workers as well as their own personal preferences and existing migrant networks.

3.4 Scenario narrative 4: High volume – Low education (Hv-Le) of immigration

In the face of persistent conflict, instability, and poverty in the Middle East and Africa, and increasing costs and tensions from securing the external borders, EU member states decide to expand their intake of low-skilled labour and adopt more generous asylum policies (in terms of the determinations of safe countries, allocation of resources, and acceptance rates). Many member states aim for the highest migration-granting rates of recent years, focused less on skill-selection or border enforcement. Intensifying push factors create conditions for a constant supply of migrants as tens of millions of the developing world's impoverished look abroad to make their livelihoods. Furthermore, the EU is seen as an ever more viable destination by prospective migrants, encouraging a sustained and self-reinforcing exodus. Overall migrant flows to the EU as a whole double and are characterised by greater proportions of low-skilled workers, as well as refugees and family reunification cases. Economic integration becomes an important topic in public discourse as record numbers of migrants are given permission to live and work in Europe. Most arriving migrants tend to have a lower skills profile in comparison to the European average, presenting barriers to their potential labour market participation. Due to more plentiful economic opportunities, personal preferences, historical links, and existing communities, the majority of the migrants choose to live in western, northern, and a few southern European member states.

These four narratives – focused on migration between the EU and the rest of the world – are complemented by the Zero Extra-EU Migration (ZEM) scenario. It serves the purpose of a counterfactual against which the demographic effects of the other migration situations can be understood as an example of an extremely strict 'closed EU borders' situation. In the ZEM scenario the intra-EU migration trends continue as in the recent past because the demand for labour and economic attractiveness of the more affluent, yet ageing, EU MS would not cease.

In the Medium scenario, intra-EU and extra-EU trends continue as in the recent past. It serves as a benchmark for evaluating the impact of alternative intra-EU flows projected in the Zero Intra-EU Migration (ZIM) scenario and the Double Intra-EU migration scenario.

The last scenario used in the analysis explores what would happen if the EU sealed its borders (ZEM) and if investments into family-friendly policies resulted in increased fertility closer to desired fertility in the EU starting in 2020. ZEM+25% fertility scenario allows us to contrast the effect of immigration on long-term demographic outcomes against the effect of sustained higher fertility in the EU. Such comparisons explore the two commonly proposed paradigms for addressing potential population declines and population ageing: increased migration versus increased fertility. We label this scenario ZEM+25% fertility as we assume 25% higher fertility rates compared to the levels from the Medium scenario, resulting in overall EU TFR slightly above the replacement level by 2060.[17]

Table 4 shows an overview of migration assumptions in all scenarios. Fertility assumptions presented in Table 1 are the same in all scenarios except ZEM +25% fertility, which uses rates boosted by a factor of 1.25.

Table 4: Matrix with migration assumptions for intra-EU migration and extra-EU migration

Scenario	Immigration volume from outside EU-28	Education of immigrants from outside EU-28	Intra-EU migration volume
Medium scenario	Medium	Medium	Medium
Lv-He	Low	High	Medium
Hv-He	High	High	Medium
Hv-Le	High	High	Medium
Lv-Le	Low	Low	Medium
Zero Intra-EU Migration	Medium	Medium	Zero
Double Intra-EU Migration	Medium	Medium	Double
Zero Extra-EU Migration (ZEM)	Zero	Zero	Medium
ZEM+25% fertility	Zero	Zero	Medium

4. Translation of migration narratives into projection scenarios

4.1 Assumptions for extra-EU migration

The four storylines of extra-EU migration presented above were translated into numeric assumptions on volume and educational composition of the immigration flows following an associative process of identifying the closest possible empirical example of an existing

[17] Country-specific levels differ due to initial levels and Medium scenario assumptions reflecting country-specific trends. Projected TFRs in 2060 range between 1.88 in Romania to 2.48 in Finland.

migration system or migration policies that resemble the real-world situation and experiences of developed countries.

Numerical foundation of scenario 1 Low volume – High education (Lv-He) can be found in Japan in terms of volume and in the Canadian system in terms of educational selectivity. Japan has been selected as an example of an industrialised country with very restrictive immigration. We apply an average immigration rate of 0.235% per year derived from the 2010–2014 average[18] applied to the EU-28 (approximately 1.2 million every five years, which would mean immigration flows reduced to about 10% of the volume EU experienced during 2015–2019, according to EUROSTAT), and educational composition of immigrants arriving to Canada between 2011 and 2016. According to the Canadian 2016 census, 73% of immigrants in the age groups 25 to 44 had post-secondary education (seen in Table 5),[19] reflecting the established human capital point system of migration set up to attract young immigrants with high levels of education.

Table 5: Educational compositions of immigrants from outside the EU used in the projection scenarios

	e1–e4	e5	e6
Medium	39%	27%	34%
High	7%	20%	73%
Low	53%	35%	12%

In scenario 2 Low volume – Low education (Lv-Le) we use immigration rate as in Japan (scenario 1) and combine it with the educational composition of immigrants in Italy (taking recent stock of persons born outside the EU in the EU-LFS 2011–2016) seen in Table 5, an EU country that had the highest share of low-educated immigrants (52%) among the EU countries with available data.

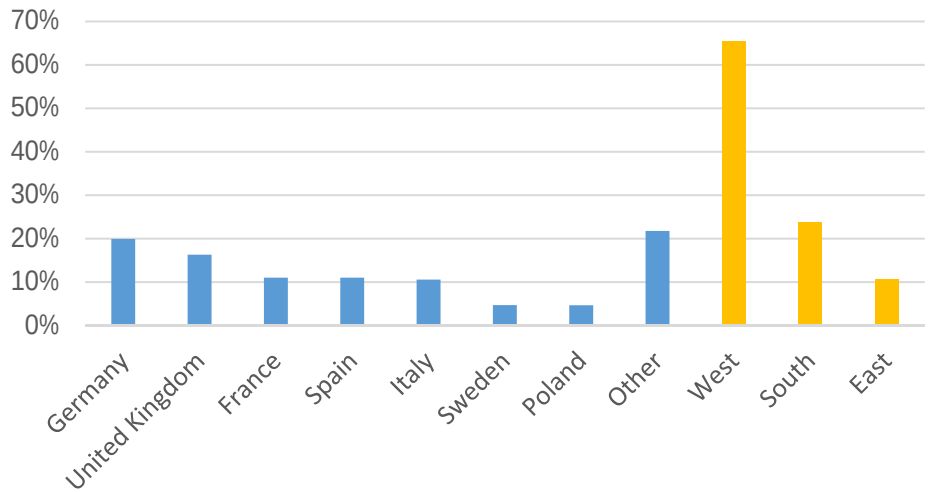
Scenario 3 High volume – High education (Hv-He) is based on the Canadian migration system applied to the EU. In terms of flows, such a situation would correspond to double volume of immigration into the EU compared to quinquennial equivalent of the EU's 2013–2016 inflows (Medium scenario). The educational composition of immigrants in this scenario takes from Canada (2011–2016).

Scenario 4 High volume – Low education (Hv-Le) covers a future of intensive immigration, predominantly made up of immigrants with low education. It uses again the low-educational composition of immigrants as in Italy (2011–2016) and combines it with double migration into the EU compared to quinquennial equivalent of 2013–2016 immigration flows.

[18] Taking inflows of foreign population to Japan in 2010–2014 as reported in International Migration Database (OECD) divided by total population of Japan in those years (OECD 2021).
[19] Canadian Census – Data tables: 2016 Census, immigration and ethnocultural diversity.

The assumption of medium migration volume for extra-EU immigration (used in the Medium, Zero Intra-EU, and Double Intra-EU migration scenarios) was derived as a quinquennial equivalent of 2013–2016 immigration flows of persons born outside the EU as reported by EUROSTAT.[20] This corresponds to 10 million for the whole EU-28 (extremely high flows for Germany 2015, Austria 2015, and Greece 2016 were replaced with average values for other years in order to correct for extremely high inflows that resulted from the refugee crisis). Figure 2 illustrates the distribution of this flow across the receiving countries. The same country distribution is used for the low and high immigration volume assumptions. Immigration flows by age were derived by applying the Rogers–Castro schedule (Rogers and Castro 1981).

Figure 2: Distribution of the modelled extra-EU immigrant flows across major receiving countries and macro-regions at each projection step 2015–2055



The assumptions for medium educational composition of extra-EU immigrants (used in Medium, Zero Intra-EU, and Double Intra-EU migration scenarios) was derived from the available 2011 census data. We use country-specific educational compositions of the stock of persons born outside the EU who arrived between 2000 and 2011. This country-specific educational composition is applied to the flow of immigrants at each projection step.

[20] Table migr_imm3ctb.

Emigration from the EU to the rest of the world is modelled in the same manner in all scenarios using country-specific emigration rates by age and sex derived from the EUROSTAT data for years 2013–2016, taking the average number of emigrants by sex multiplied by the proportion of emigrants leaving the EU,[21] divided by average population aged 20 to 34 during the same period. These rates were applied to the baseline, and this expected number of emigrants was then redistributed using the Rogers–Castro schedule (Rogers and Castro 1981). Age-specific rates were calculated using these expected numbers of emigrants by age to the baseline population by age and sex. An average emigration rate is applied to all education levels due to lack of empirical data, at all projection steps.

Table 6 summarises the resulting extra-EU immigration and emigration flows for the three macro-regions and all scenarios and selected periods.

Table 6: Projected extra-EU migration flows (in thousands) towards and from the macro-regions, by scenario and for selected periods

			Hv-He	Lv-He	Hv-Le	Lv-Le	Medium	Zero Intra-EU	Double Intra-EU
East	2015–2019	emigrants	638	638	638	638	638	638	638
		immigrants	2,159	130	2,159	130	1,079	1,079	1,079
	2035–2040	emigrants	528	449	528	449	486	516	461
		immigrants	2,159	130	2,159	130	1,079	1,079	1,079
	2055–2059	emigrants	496	353	494	353	420	462	392
		immigrants	2,159	130	2,159	130	1,079	1,079	1,079
South	2015–2019	emigrants	1,721	1,721	1,721	1,721	1,721	1,721	1,721
		immigrants	4,763	286	4,763	286	2,380	2,380	2,380
	2035–2039	emigrants	1,576	1,212	1,574	1,211	1,381	1,422	1,343
		immigrants	4,763	286	4,763	286	2,380	2,380	2,380
	2055–2059	emigrants	1,525	887	1,516	887	1,183	1,233	1,138
		immigrants	4,763	286	4,763	286	2,380	2,380	2,380
West	2015–2019	emigrants	3,771	3,771	3,771	3,771	3,771	3,771	3,771
		immigrants	13,079	785	13,079	785	6,535	6,535	6,535
	2035–2039	emigrants	4,280	3,281	4,265	3,280	3,744	3,653	3,823
		immigrants	13,079	785	13,079	785	6,535	6,535	6,535
	2055–2059	emigrants	4,769	2,949	4,712	2,946	3,784	3,658	3,879
		immigrants	13,079	785	13,079	785	6,535	6,535	6,535

Note: Country-specific values are provided in the supplementary materials.

[21] Tables migr_emi2 for emigrants by sex and migr_emi3nxt to estimate the share of emigrants leaving the EU which were not available by sex for all countries.

4.2 Intra-EU migration assumptions

For intra-EU migration we use a set of three basic, non-narrative (naïve) scenarios: Medium, Zero, and Double Intra-EU migration. The Medium scenario is based on recent trends of migration flows between the EU countries (2008–2016). These were estimated by applying the methodology for estimating and harmonising the migration flows between countries of the European Union developed in the Integrated Modelling of European Migration (IMEM) project (Raymer et al. 2013) on the EUROSTAT data by country of birth, age, and sex. The Bayesian methodology employed for this estimation was previously used to estimate the flows from 2002 to 2008 taking into account the various data collection systems, their accuracy, and the undercount or overcount of migration flows. IMEM calculations for 2002–2008 were extended to the period 2009–2016.[22]

More recent data capture the situation after the 2007–2009 economic crisis and for the new EU countries reflect the situation after the transitional restriction period on migration, at least for the later years of the period (with the exception of Croatia). We employ the exact same methodology, but update certain auxiliary data, for example the population size, gross national income, migrant stock, and trade flows between countries. The estimation was done in two steps: First, a measurement error model was used to estimate parameters of the data collection systems, and then a regression model estimated the flows after adjusting for the measurement error and harmonising the two reported flows. Using these numbers, we calculated destination-, age-, and sex-specific emigration rates for each EU member state. We assume average in and out rates for all educational levels. The rates in the Medium scenario are kept constant for the entire projection period. In the Zero Intra-EU Migration scenario, we assume no migration between countries, and in the Double Intra-EU Migration scenario the emigration rates are doubled and held constant during the whole projection period. With respect to the possible impacts of the COVID-19 pandemic on future migration trends it is too early to draw any conclusions. While during the period of the lockdown in 2020 there seems to be evidence that sizeable numbers of migrants returned to their home countries, it is still very uncertain what this implies for longer-term migration trends. In any case, the very wide range of alternative migration assumptions seems to cover very different possible future impacts of the pandemic on migration patterns.

[22] We would like to acknowledge Erofili Grapsa for preparing these estimates.

5. Demographic outcomes of alternative migration scenarios

5.1 Population size

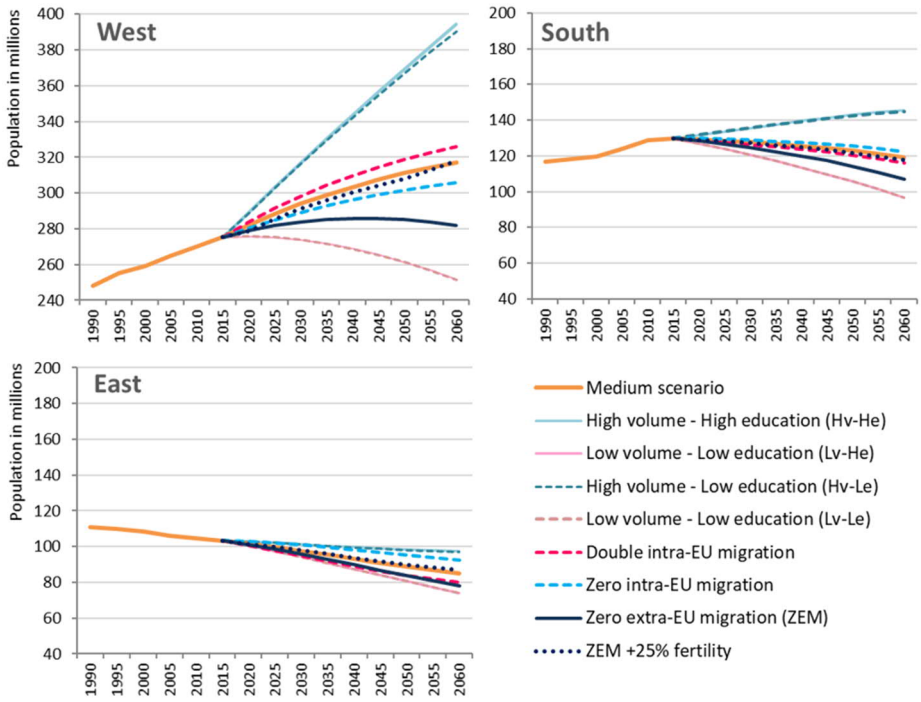
The EU-28 population has been steadily increasing from 475 million in 1990 to 508 million in 2018, with migration driving the 0.24% average annual increase. Population growth would continue under the assumptions of six out of the nine presented scenarios in this paper. The Medium scenario leads to a slightly increasing EU population to 521 million in 2060 (+2.5%). Doubled immigration of non-EU country nationals (Hv-He and Hv-Le scenarios) compared to the recent past trends would lead to rapid growth, a 25% higher EU population by 2060 (635 million) compared to 2015. In the case of Zero Extra-EU Migration (ZEM), the EU total population could expect about 8% decline to 466 million in 2060, back to the EU's population size in the 1980s. However, in the absence of extra-EU migration combined with a 25% increase in TFR to slightly above the replacement level, a 2.8% higher population of 522 million can be expected, very similar level to the Medium scenario.

These overall values conceal distinct demographic regimes and sharply contrasting demographic prospects between the west, south, and east EU macro-regions, as illustrated by Figure 3. The divide between west and south/east (presented in Figure 1) is a legacy of the diverging past demographic trends and their momentum. In the western MS below replacement, moderately low fertility combined with net migration gains overtake the potential natural decrease, driving population growth. This population growth is projected to continue in most western countries (Appendix Figure A-1) in all but the low-migration (Lv-Le and Lv-He) scenarios. The Medium scenario results in continued population growth with a projected population of 317 million by 2060, 15% larger compared to 2015 when it stood at 275 million. In the same period, the population of southern and eastern MS is projected to drop to 88% of its 2015 size (233 million in 2015 to 204 million in 2060).

A regime of sustained low fertility but sizeable immigration that reduces, and in some cases overtakes, population decreases due to negative natural change, is typical for contemporary southern Europe (Italy, Spain, see Appendix Figure A-1). Overall, population size in the southern EU most likely peaked between 2010 and 2015, following increased growth due to intensified immigration from outside the EU between 2000 and 2010, in particular to Spain and Italy. Only if immigration from outside the EU intensified again to similarly high levels in future (Hv-He and Hv-Le scenarios) would the south of Europe further grow its population. Both increased fertility (+25%) in the absence of extra-EU migration and doubled intra-EU migration would lead to smaller total population sizes in the southern EU MS.

Continuing population decreases seem certain in the eastern MS where only the degree differs across scenarios, ranging from 6% between 2015–2060 in high immigration scenarios (Hv-He and Hv-Le) to 24% in the theoretical Double Intra-EU Migration scenario. The past population declines emerged with the change of demographic regime in these countries after the fall of the Iron Curtain, when fertility fell and since then remained (with the exception of the Baltic states) at low levels, combined with sizeable emigration and low immigration. For instance, Latvia, Lithuania, and Bulgaria had lost between 26% to 16% of their 1991 population by 2017. Should intra-EU migration trends continue as in the recent past, the countries would lose a sizeable share of their 2015 population by 2060 (see Appendix Figure A-1).

Figure 3: Past and projected population in EU-28 macro-regions by scenario, 1990–2060



Sources: 1990–2015 EUROSTAT, 2020–2060 authors' calculations.

The volume of international migration clearly matters more for the projected population size than the educational composition of immigrants. In the population projections, lower-educated people are assumed to have somewhat higher fertility but also higher mortality. Therefore, adding more people with low education through migration will add to the number of births but also to the number of deaths. Evidently the second effect (more deaths) slightly outweighs the first effect for the given time horizon, and the net result is a slightly lower population size for the Hv-Le scenario as compared to the Hv-He.

In a situation of strictly limited extra-EU migration, we assume that intra-EU migration would continue due to pull factors in the economically more advanced MS, leading to the projected population declines in the south and east (ZEM scenario). Low-migration scenarios (Lv-Le and Lv-He) result in the sharpest population declines in all EU macro-regions because emigration according to our assumptions surpasses immigration.

This leads to questioning what would happen if intra-EU migration reduced to near zero, for example, with fast economic convergence among EU countries, represented by the Zero Intra-EU Migration scenario. This assumption reduces population decreases in eastern MS from 18% in the Medium scenario to 10% by 2060 (compared to the 2015 population). The effect is smaller in southern Europe, with 8% versus 6% loss by 2060 in the two scenarios. As expected, intra-EU migration further expands the western MS population size – doubled intra-EU migration rates would result in 3% higher population in 2060 compared to the Medium scenario. Whereas, stopped intra-EU migration (but persisting extra-EU migration) would reduce the projected 2060 population in the western MS by 4%.

Policies supporting families and stimulating higher fertility are often juxtaposed to increased immigration as contrasting policy paths for mitigating adverse effects of population decline or ageing. Figure 3 shows that if TFR increased by 25% (ZEM+25% fertility scenario) in the absence of extra-EU migration (but with continued intra-EU migration), the resulting population size in all macro-regions would remain very similar to the Medium scenario. Thus, successfully boosting fertility by 25% to above replacement level in the west and to about two children per woman in the south and east leads to sustained population growth in the west and relative stability in the south and east even in absence of extra-EU migration.

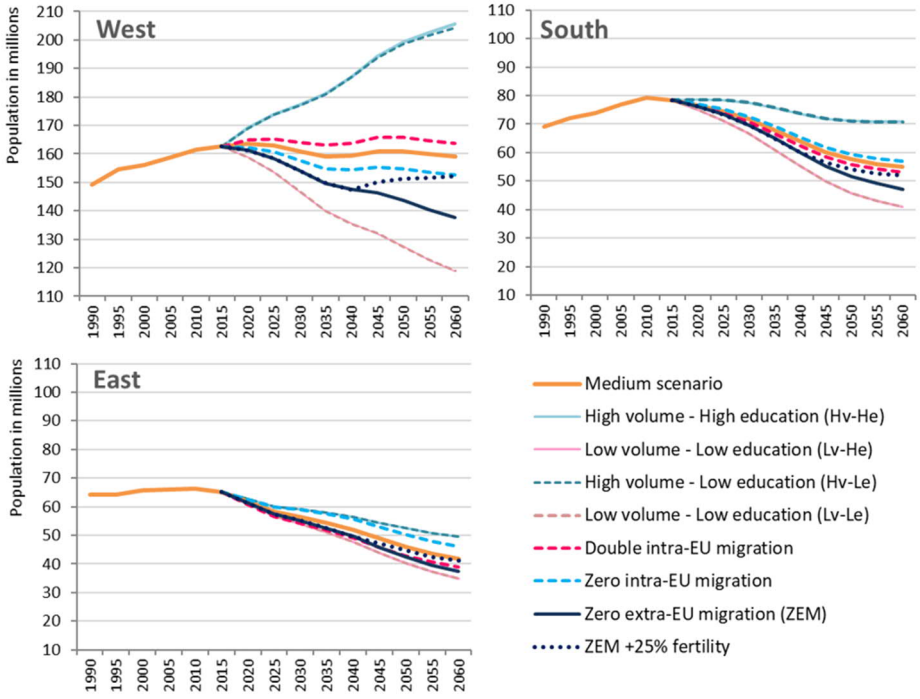
5.2 Did working-age population peak in the EU?

Mildly increased fertility boosts total population size; however, it would not prevent drops in the total working-age population (age 20 to 64) in any macro-region over the time horizon considered (Figure 4). Again, we see diverging past and projected trends in the size of the potential labour force between the regions. While working-age population most likely peaked in southern and eastern MS around the year 2010, it may not be the case in the western EU where the Medium scenario projects a rather stable working-age population, peaking between 2020–2025 at 164 million and oscillating around 160 million through 2060. In the southern EU, the Medium scenario results in 30% smaller working-age population by 2060 compared to 2015. In the eastern MS, partially due to the migration to western MS, the drop would be even more pronounced with a 36% smaller working-age population in 2060 compared to 2015.

In the west, Zero Extra-EU Migration (ZEM) would result in a smaller working-age population,[23] 138 million by 2060. This is the equivalent to 30 million fewer workers during the projection period than if both intra-EU and extra-EU migration continued as in recent past (Medium scenario). The 25% rise in fertility from 2020 onwards would result in lesser decline than in the ZEM scenario, but the benefits of increased fertility on the working-age population are most visible in the long run. In the 25% higher fertility scenario, the working-age population would drop to a minimum of 147 million in 2040 and would subsequently increase to 152 million by 2060. As expected, Doubled Intra-EU Migration would benefit western MS but adds in the long run only fewer than 5 million potential workers by 2060 to the region compared to the number projected with current levels of intra-EU migration.

[23] Working-age population (20 to 64) shrinks in ZIM scenario in all EU countries with the exception of Luxembourg (see Appendix Table A-2).

Figure 4: Past and projected working-age population (20 to 64) in EU macro-regions and by scenario, 1990–2060



Sources: 1990–2015 EUROSTAT, 2020–2060 authors' calculations.

Zero Extra-EU Migration (ZEM) has a less significant impact on working-age population in eastern MS (10% smaller in 2060 compared to Medium scenario) than in southern and western (14% smaller than in the Medium scenario). Country-specific results show that the impact of ZEM is smaller in eastern member states with fewer non-EU immigrants compared to southern member states (mainly Italy and Spain, see Appendix Figure A-2). In countries with net migration losses to outside the EU (such as Greece), ZEM scenario results in smaller decline and larger working-age population compared to the Medium scenario.

For eastern MS, the Double Intra-EU Migration scenario decreases the projected working-age population in 2060 by 7% compared to the Medium scenario and the Zero Intra-EU Migration scenario returns a nearly 10% larger working-age population in 2060 compared to the projected value in the Medium scenario. The impact of Zero Intra-EU

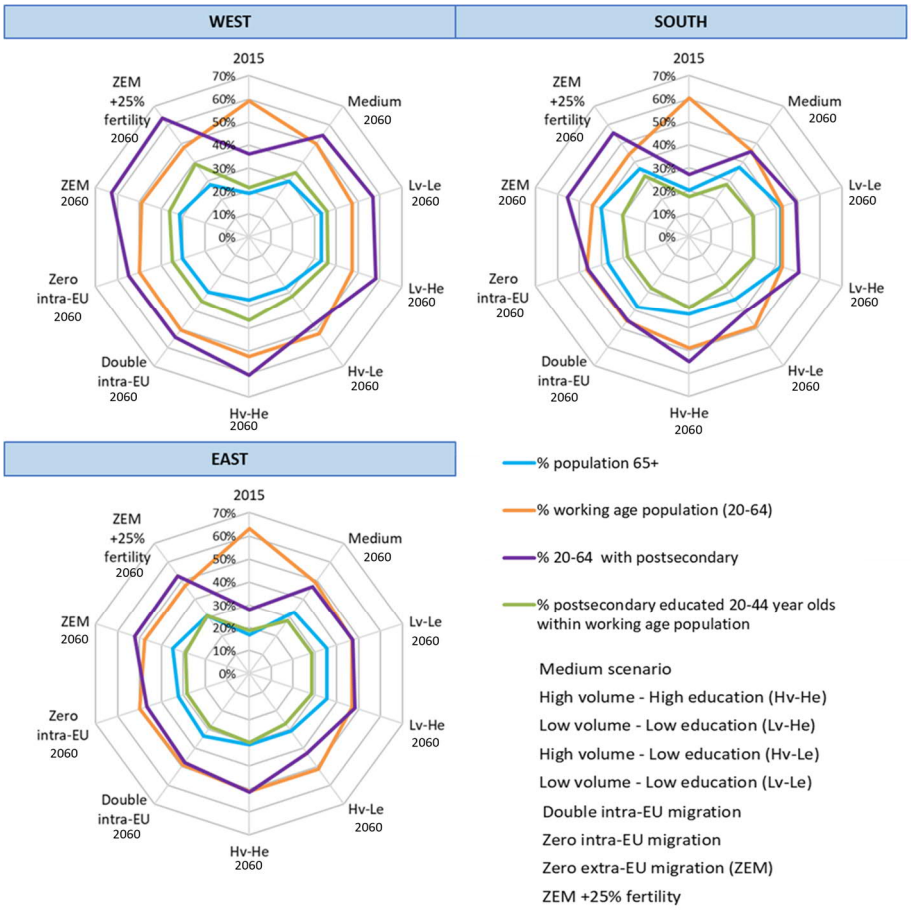
Migration is less pronounced in the southern EU, with a 4% reduction in 2060, while there is a 4% larger potential workforce in the Double Intra-EU Migration scenario compared to the Medium. Naturally, both high migration variants (Hv-He and Hv-Le) show the largest working-age population size.

5.3 Smaller but better-educated working-age population

While projected population dynamics will result in a smaller potential workforce (Figure 4), increases in educational attainment can potentially offset some of the feared adverse effects of smaller working-age population. Educational attainment is positively associated with labour force participation and productivity (Marois, Bélanger, and Lutz 2020; Loichinger and Fürnkranz-Prskawetz 2017; Loichinger 2015; Stonawski 2009). Continued educational expansion and cohort replacement will result in a better-educated working-age population in the EU in 2060. Figure 5 shows selected indicators of population and working-age population composition for the three EU macro-regions in all scenarios. The southern EU may find itself in the least favourable situation due to the highest share of population 65 and over and reciprocally the least favourable composition of the working-age population. In 2015, 36% of the working-age population in the west had post-secondary education[24] compared to south (27%) and east (28%). This difference is projected to persist under current trends with the Medium scenario projecting 55% of the working-age population in western MS, 47% in eastern MS, and 46% in southern MS holding a post-secondary degree by 2060.

[24] Completed university (bachelor, master, or higher) or non-university degree. Post-secondary category covers ISCED 2011 levels 4 to 8.

Figure 5: Population composition in macro-regions in 2015 and projected 2060 by scenario



Sources: 1990–2015 EUROSTAT, 2020–2060 authors' calculations.

Western MS, under the Medium scenario, and in fact in most other scenarios, find themselves in a more advantageous situation when the stable working-age population is coupled with a highly educated population composition and slower pace of ageing than in other macro-regions. The share of young (20 to 44 years) and highly educated working-age population within the overall working-age population may best capture the simultaneous trends of ageing of the workforce and educational expansion. The share of

the highly educated young working-age population within the overall population ages 20 to 64 has been increasing and is projected to increase further: in the west to 35% in 2060 according to Medium scenario, up from 22% in 2015 and 16% in 1990.[25] In the east and south an increase to 28% is projected, coming from lower levels. Only 17% of the working-age population in southern Europe was young and had post-secondary education in 2015 (a mere 9% in 1990), compared to 19% in eastern MS in 2015. What education composition would be most advantageous is difficult to foresee as future labour demands depend on a large number of factors and often contradicting tendencies. However, a highly educated workforce is potentially more adaptable to the upcoming changes in nature of work due to upcoming technological progress related to robotisation and advances in artificial intelligence (e.g., Craglia et al. 2018).

Selective migration policies can alter the size and, to a smaller extent, the relative share and educational composition of the working-age population by stimulating migration of either low-skilled or high-skilled workers. The impact of immigration sizes and compositions is the most pronounced in southern MS. A doubling of international migration, but with higher selectivity of immigrants (Hv-He), such as in Canada (72% of highly educated among 25- to 44-year-olds) would add 16 million to the working-age population compared to the Medium scenario, and the share of highly educated 20- to 44-year-olds within the potential workforce would be 31% in 2060, only 3 percentage points (pp) higher than in the Medium scenario. High immigration flows with a low-educational profile (53% holding less than completed upper secondary education and only 12% post-secondary educated, as flows in Italy in the recent decades, Hv-Le) would result in similarly large working-age population, with 41% of post-secondary educated in 2060 – 5pp less than in Medium scenario. In this scenario the share of highly educated 20- to 44-year-olds would be the lowest of all the scenarios – only 26%. The impact on the highly educated population is the same, but at a lesser magnitude in the eastern EU compared to the west, as can be seen from Figure 5. Which of these situations would be more adaptable and advantageous in the future depends on the future labour market demands and structure of economies in individual MS.

Considering only the age selectivity of intra-EU migration, whether it doubled or ended, would make at most 1pp of difference to the educational composition of the working-age population in any macro-region by 2060. However, recent data find evidence for increased emigration rates of highly educated (D'Aiglepierre et al. 2019). This particularly holds for emigrants from the eastern EU and southern EU MS, with the exception of Spain (ibid). In the case of selective emigration, not modelled in these results, one would see more pronounced effects of intra-EU migration on educational composition of the potential workforce.

[25] 1990 values are taken from the Wittgenstein Centre Human Capital Data Explorer Version 2.0(beta), available at http://www.wittgensteincentre.org/dataexplorer.

Increased or stopped intra-EU migration does not alter the projected share of population 65 and over in the predominantly receiving western countries. In the predominantly sending eastern and southern countries the Zero Intra-EU Migration scenario would reduce the projected share of ages 65 and over from 36% to 35% in 2060 – a rather small effect. Increased fertility could reduce the share to 34% (ZEM+25% fertility) and increase extra-EU migration to 33% (Hv-He, Hv-Le), all indicating that the momentum of population ageing is essentially unchangeable. Despite pronounced variations in the scenarios explored, there is no meaningful prospect of changing the course of ageing. Country-specific results are shown in Appendix Figure A-3.

The most favourable educational composition and the highest share of highly educated 20- to 44-year-olds within the workforce results from the no international migration scenario (ZEM) and its variant with 25% higher fertility (ZEM+25% fertility). This is true in the long run with the fertility effect starting to influence the working-age population beginning in 2040, when the children start entering working age. In the western EU, ZEM+25% fertility increases the share of highly educated 20- to 44-year-olds within the working-age population to 39% by 2060 as compared to 35% in Medium scenario (i.e., adds 4pp). In the southern EU this variant adds 4pp and in the eastern EU 3pp.

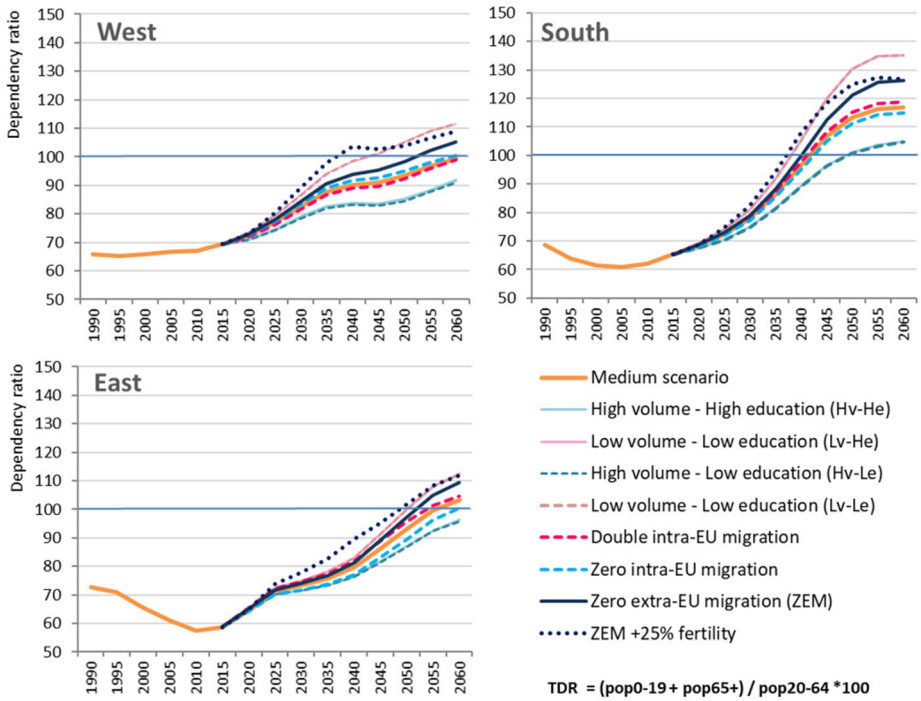
5.4 Population ageing and age dependency

Currently, the eastern EU has a younger population composition than the rest of the EU. In 2015 the share of the working-age population was highest in the east (63%), compared to the south (60%) and west (59%), while the opposite was the case for the share of population aged 65 and over (17% versus 20% versus 19%) (Figure 5). Population ageing will progress in all EU macro-regions but at different speeds, with eastern MS ageing fastest, surpassing the western MS in terms of population aged 65 and over by 2060. Under the Medium scenario, the eastern EU's share of population aged 65 and over nearly doubles to 33% by 2060. In southern Europe the pace of ageing will be slightly slower (85% increase in population 65 and over by 2060), but the projected share of 37% is still higher than in the east (33%) or west (30%). All scenarios show that population ageing is unavoidable and the share of population 65 and over is bound to increase in all macro-regions. High immigration, or increased fertility in the absence of extra-EU migration, can reduce this significant expected increase by at most 3pp.

Although sustained higher fertility decreases the share of population 65 and over, it leads to a higher overall total age dependency ratio (TADR) than the Medium scenario by 2060 (Figure 6) and increases the size and share of the working-age population only the long run (Figures 4 and 5). This is a particularly valid finding for southern MS, which

will face higher age dependency than western or eastern MS. For southern MS, the TADRs exceed 100 in all scenarios after the year 2050, including two scenarios with doubled extra-EU migration (Hv-He and Hv-Le). In the west, TADR exceeds 100 dependents per 100 working-age population only in the Zero Extra-EU Migration (ZEM) scenario and in the low-migration scenarios (Lv-Le and Lv-He) because of a negative net migration balance when keeping current emigration rates constant. Past data show that only in the coming decade will eastern and southern European countries see higher TADRs than in 1990. As expected, a scenario of zero intra-EU migration worsens TADR in the west but improves TADR in the east all else equal, and the inverse is true for a scenario of double intra-EU migration.

Figure 6: Past and projected total age dependency ratios by EU-28 macro-regions, 1990–2060



Sources: 1990–2015 EUROSTAT, 2020–2060 authors' calculations.

The results point to the fact that neither increased fertility nor increased migration are viable means to slow down population ageing and age dependency. Policy options that would aim at accommodating rather than at affecting demographic trends can focus on improving economic activity and productivity (Rees at al. 2012; Loichinger and Prskawetz 2017; Marois, Bélanger, and Lutz 2020). We showed that the future working-age population will have higher human capital, and it is important to emphasise that the same holds for 65 and over population. According to the Medium scenario, 45% of population 65 and over will be highly educated in 2060 in the western EU (19% in 2015), 39% in the east (16% in 2015), and 35% in the south (9% in 2015). Higher educational attainment is associated with better health (Raghupathi and Raghupathi 2020), a foundation for extending working lives among the future 65 and over population. This can be encouraged by policies that set floating retirement ages and promote gradual transition to retirement and the sustainability of social systems including pensions. Cohort replacement may also play an important role in halting the deterioration in the balance between workers and non-workers, as younger cohorts of women tend to have higher labour force activity rates.

6. Conclusions

The EU's macro-regions (west, south, and east) will have distinct demographic futures in the decades ahead. While the west is positioned for continued population growth and stabilised total working-age population, it nevertheless will not escape population ageing and rises in age dependency as in the south and east of Europe. The projections covered in this paper explore the extent to which future migration scenarios (both of internal EU migration and inflows from outside the EU) can or cannot influence various demographic indicators in the EU.

Contrasting scenarios for extra-EU migration, inspired by some of the existing approaches to migration management in terms of the size and human capital of immigrants, lead to substantial differences in total population size for the EU as a whole in only a few decades. Taking a high-volume approach, doubling the inflows of recent years to be among the world's highest rates, would result in about 630 million people living in the EU by 2060, adding over 100 million more than today. By contrast, with a low-volume approach roughly based on Japan, the EU would return to its population levels of the 1980s over the next 30 years. When considering relative measures of population heterogeneity such as age structure, however, the influence of migration is far more modest. Irrespective of which migration scenario, the results presented above illustrate that declines in potential labour force and population ageing are clearly unavoidable in all macro-regions. Importantly, the focus of interventions should not be

to change largely unmovable age compositions or to boost the total labour force size as such policies would have short-term effects and would not significantly alter the pace of population ageing in the long run. Successful adaptations to the challenges of an ageing society depend on policies that foster and encourage labour participation and productivity (Rees et al. 2012; Lutz et al. 2019; Marois, Bélanger, and Lutz 2020).

The south of the EU stands out as the region with the greatest challenges ahead due to notably high age dependency compared to both the east and west. Prospects of the south adapting to ageing are further complicated by its comparatively low average education levels, although younger cohorts are much more educated than their country averages. The EU as a whole is expected to be better educated in the decades ahead, a positive indicator for overall productivity and adaptability amid population ageing, but different demographic scenarios can exacerbate regional disparities.

In spite of the examples of depopulation occurring in some eastern MS, the region is and should remain younger than the south, and only on par with the west in terms of age dependency by about 2050. In the presented scenarios, the pace of ageing in eastern MS will be quicker, and the share of their population 65 and over would exceed the projected values for the western EU in the Medium scenario for the decades after 2040. Doubled intra-EU migration would increase the share by 1pp, with the east and west on par slightly earlier, by 2040. Considering solely the age selectivity of EU migration, whether doubled or ended, would make at most 1pp of difference to the educational composition of the working-age population in any macro-region by 2060. Evidence indicates, however, that intra-EU migration also disproportionately select for high education and therefore is likely to redistribute human capital from the south and east to a greater extent than is modelled in this paper due to lack of migration data by level of education.

The response of many eastern European countries to reductions in size and older population structures is to introduce family-friendly policies in the hope that this would help to increase fertility, an approach which if successful is most relevant for combating age dependency in the long term. However, in a situation of continued high-volume migration towards the western MS, such investments in family support as well as investments in human capital more broadly will still in effect 'demographically subsidise' the MS that have not borne the related cost in education, family support, and other social services. In the spirit of EU cohesion policy, MS can work to moderate the consequential pull factors in the more advanced MS by closing educational gaps and meeting domestic demand for critical professions. Similarly, the push factors can be better addressed in the sending MS by continuing to improve wages, structuring education to better coordinate with local economic opportunities, and strengthening governance and public services. Besides generally improving quality of life, these reforms would help the sending MS to

attract human and financial capital from their diasporas, stimulate return migration, and further decouple the necessity to uproot from achieving satisfying lives.

Within the EU, both the east and south deal with consistent losses of their relatively young, educated citizens to western MS. Pull factors in the advanced EU economies are unlikely to cease with pressure for workers from the EU's less developed members. Currently none of the eastern MS have reached income levels of the western MS.[26] Moreover, the International Monetary Fund (Batog et al. 2019) estimates that the pace of economic convergence may slow down by 2050. If EU migration continues at the recent level, more economically affluent MS could be significantly benefiting from transfers of younger workers at the expense of the worsening demographic situation in the sending – predominantly eastern and southern EU countries. Such developments can contribute to increased vulnerability and lower capacity of the sending MS to deal with the challenges of population ageing and decreasing potential labour force. According to the IMF, in the absence of rapid population ageing, eastern countries could reach 74% of western income levels by 2050 instead of the estimated 60% under current conditions (Batog et al. 2019). Conversely, for the western countries, positive demographic consequences from continued EU migration at the intensity of the recent past would benefit the age and educational composition of their working-age populations.

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[26] IMF estimates that per capita income in eastern Europe (including non-EU countries) would increase from current 52% of western level to 60% in 2060, with most economically advanced eastern MS (Estonia, Slovenia) nearing 95% of the western levels, but the economically weaker and rapidly ageing Romania and Bulgaria could remain below 60% of the western average (Batog et al. 2019).

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Appendix: Country-specific results from selected scenarios

Figure A-1: Relative change in projected population size 2060/2015 by scenario (1 indicates population in 2015 = population in 2060)

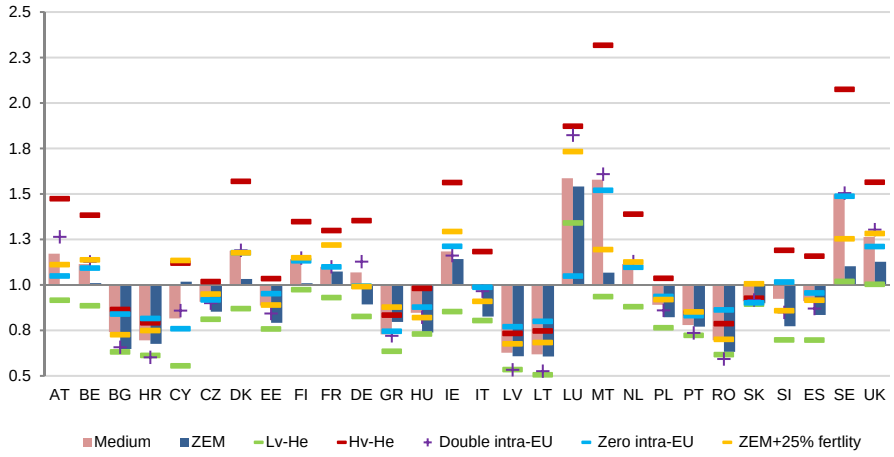


Figure A-2: Relative change in projected working-age population (20 to 64) 2060/2015 by scenario (1 indicates population in 2015 = population in 2060)

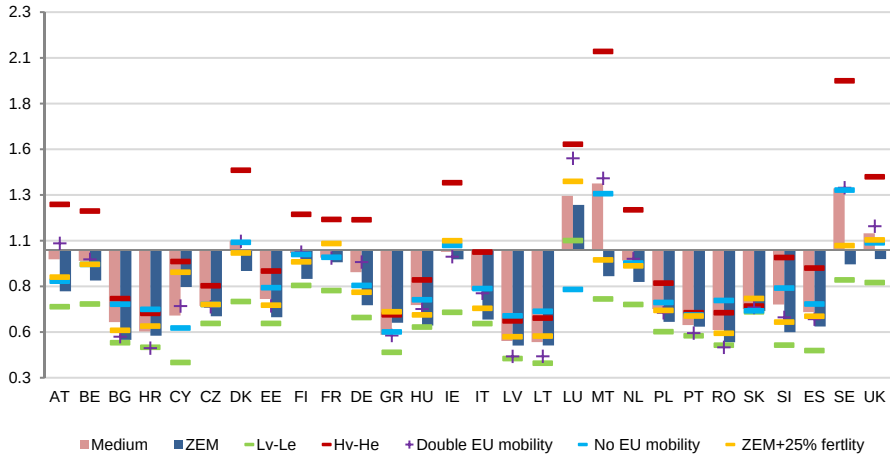
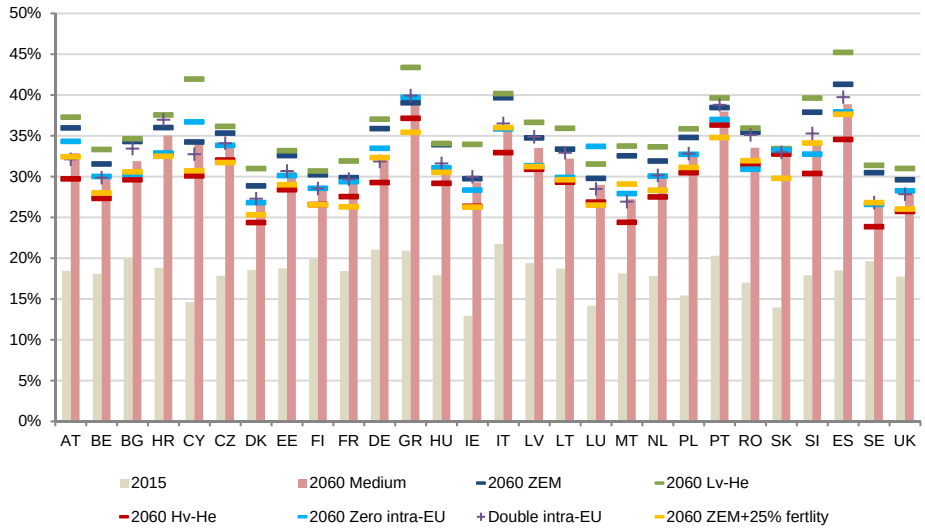


Figure A-3: Share of population age 65 and over in 2015 (green bar) and projected in 2060 in Medium scenario (pink bar) and selected other scenarios



Source: Lutz et al. 2019

2.3. Aging and depopulation in Georgia through the lens of human capital-focused dependency ratios

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Abstract:

The core policy concern of population aging and decline in post-*Demographic Transition* countries is a feared unsustainable growth in dependents relative to workers. This study challenges the still widespread age-based narrative by considering other factors of consequence for dependency burdens in the South Caucasian country of Georgia. Data on labour force participation, health status, tested literacy skills, and income as proxies for productivity were used together with population projections by age, sex, and educational attainment to explore a series of conventional and alternative dependency ratios. The findings suggest that human capital-oriented dependency burdens slightly decline between 2015-2050 in spite of population aging and decline. Quality and activation of human capital are shown to hold the power to completely avoid a sharp rise in dependency burdens, while also largely maintaining absolute levels of potential productivity unlike the declining population aged 15-64. The results underscore the importance of including more sophisticated methods when measuring dependency in populations, and more broadly, the policy-relevance of human capital in strategies for coping with population aging and depopulation.

Key Words: dependency, labour force, human capital, skills, productivity, South Caucasus

Introduction:

The South Caucasian country of Georgia is in a unique demographic position. On one hand, it shares a future of depopulation and population aging with many of its former Soviet peers in Eastern Europe and the Caucasus. But unlike most of the others, Georgia has managed to rebound its fertility to relatively high levels (2.01 in 2019), which will moderate potential changes in age structure to some degree if maintained (World Bank 2022a). Still, the Georgian population (3.73 million in 2021, down

from a peak of either 5.41 in 1989 or 4.91 in 1993 depending on the source[1]) has clearly been under downward pressure due to past low fertility, and high levels of working-aged emigrants destined for Russia, and increasingly Europe, facilitated by the EU's Eastern Partnership agreement and the associated visa liberalization regime in 2017.

The necessity to emigrate for financial reasons is a consequential challenge (SCMI 2019), which connects to broader questions about economic vitality and burdens of dependency. In 2016, Georgia was a reclassified as an upper middle-income country (World Bank 2019), having worked to overcome the turmoil of the 1990s following the dissolution of the Soviet Union. Economic activity grew by about 5% per year in the decade before COVID-19-driven disruptions. Still, the country grapples with very high unemployment, 17.3% in 2022, as well as absolute poverty, which stood at 17.5% in 2021 (Geostat 2023a;b). The problem is even more concentrated among young people, who had unemployment rates of 38% (women) and 40% (men) in 2020, the highest among the EU Eastern Partner countries (Eurostat 2022). In the context of this economic hardship, it is important to assess how demographic changes might influence the prospects for future development in Georgia. Select demographic outcomes from the past and projections are shown in Table 1, highlighting population aging, population decline, and rise in educational attainment in Georgia over time.

Table 1: Select Demographic Characteristics in Georgia

	1990	2005	2020	2035	2050
Population size	5.41m	4.21m	3.69m	3.54m	3.37m
Proportion of pop. aged 65+	9.3%	14.5%	17.8%	24.2%	27.9%
Proportion of pop. with tertiary edu.	21.2%	28.8%	33.2%	41.8%	51.7%

Sources: 1990-2005 Pop. Size and Prop. 65+ (UN 2019); 1990-2005 Prop. Tertiary (Lutz et al. 2018); 2020-2035-2050 Pop. Size, Prop. 65+, and Prop. Tertiary (KC & Gailey 2023).

While there is a wide consensus among demographers that the trend of population aging will continue in almost all countries of the world, the implications for the most aged, developed countries remain unclear. By the end of the century the average age in the EU-27 is expected to climb from 43.7 years in 2019 to 48.8 years by 2100 (Eurostat 2020). Comparing the major regions of Europe, the Wittgenstein Centre projects median ages to reach 49.7 in the East, 51.7 in the West, and 54.0 in the South by the end of the century (Lutz et. al 2018). For Georgia, those same projections put the average age at 39.5 in 2020 and 55.8 by 2100. Besides the median age, another common way to gauge aging is to look at the proportion of the population aged 65 and above. In this respect, Georgia's

[1] Estimates of the timing of Georgia's population peak differ between the UN 2019 Revision and the World Bank. The assessments for the year 2021 also vary between the UN (2019) and GEOSTAT (2023), 3.9m vs 3.7m. The UN adjusts the Georgian Census results to include disputed territories Abkhazia and South Ossetia outside the area of enumeration.

proportion aged 65+ jumps 56.7% between 2020 and 2050, to reach 27.9% of the population (KC & Gailey 2023). The European Commission finds a future of roughly equivalent increases and absolute levels in the EU and UK (Lutz et al. 2019a). The same study explores various fertility and migration scenarios, all of which do not result in meaningfully divergent futures of aging. Such inevitable momentum in age structure change is leading to an inversion of the traditional population pyramid seen in pre- and mid-*Demographic Transition* societies, where the young cohorts substantially outnumber the old cohorts. The shift can be understood as a natural consequence of lower fertility and gains in life expectancy due to medical improvements and healthier lifestyles.

The conventional analyses on aging heavily rely on the use of the Total Age Dependency Ratio (TADR), or its variant the Old-Age Dependency Ratio (OADR). A particular weakness of this dependency measure is that it relies on crude and increasingly outdated assumptions about work. Specifically, the assumptions that 1) workers can be defined by a 'working-age population' where everyone between ages 15-64 are productive workers and those younger and older are unproductive dependents and 2) that all workers produce the same value. As pointed out by Lutz (2021), Spijker & MacInnes (2013), Turner (2009), and others, this approach obscures important nuances that reveal the true state of dependency, with a clear risk exists in overstating the problem given that consequential decisions about state resources are made based on these calculations. By this old age-based measure, the Georgian TADR had declined from 58.6% (in 1959) to 49% (in 2014), but research indicates that the trajectory has reversed since 2010-15 (Eelens 2017; Lutz et al. 2018).

However, amid this drift to older ages brought on during the late stages of the *Demographic Transition*, the essence of chronological age has similarly failed to remain static. Work by Ryder (1975) first proposed using life expectancy rather than chronological age for the purpose of defining old age. Although the rate of increases in life expectancy has slowed somewhat recently in Europe, the change has amounted to about 2.5 extra years of life per decade, reaching 81 years of life on average by 2018 (OECD/EU 2020). The largest gains being made in the EU are in Eastern Europe, notably the Baltic countries, where life expectancy has been lower than in the south and west of Europe, around the mid-70s on average. According to the 2014 Census, Georgian life expectancy at birth was estimated at 67.7 years (males) and 76.5 (females) from 2010-14, which had revealed an overestimation of the population size and therefore overstated life expectancy given how the metric is calculated (Bruijn & Chitanava 2017; Hakkert 2017). The Wittgenstein Centre estimates life expectancy at birth in Georgia to continue its ascent to 77 (males) and 84.2 (females) by 2045-50 (Lutz et al. 2018). When thinking about dependency, it is important to capture the meaningful changes to aging and move away from solely chronological age-based measures.

Depopulation is a second demographic phenomenon connected to concerns about dependency in many countries. Together with East Asia, this trend is being led by Eastern Europe[2], where fertility declined well below replacement level and out-migration grew rapidly in the 1990s with the end of the Communist order. Many of these countries are today among those least able to retain talent in the world according to the Global Competitiveness Index (WEF 2018). The broad effects of depopulation are diminished economies of scale, reduced availability of social and cultural services, poorer transportation infrastructure, and fewer educational or job opportunities (Kiss 2021; Galjaard 2012; Gløersen et al. 2006). In Georgia, the population size stood at 3.73 million in 2021 (Geostat 2023), with net emigration and delayed age structure effects (from when fertility was below replacement in the 90s and 00s) projected to lead to depletion of the country of approximately 320,000 people between 2020 and 2050 (KC & Gailey 2023). The UN projections expect slightly higher losses at 472,000 over the same time period (UN 2019)

Aside from national-level population losses, rural depopulation is even more pronounced in Georgia, similar to parts of Europe. For the purposes of determining state aid eligibility, the European Commission defines a 'depopulated' territory as NUTS2 geographic regions having less than 8 inhabitants per km2 and NUTS3 regions with less than 12.5 inhabitants per km2 (Bisaschi et al. 2021). Not only is depopulation occurring in rural areas at almost double the rate in Eastern EU countries compared to those in the west (approx. 60% vs 35% of rural areas), but remote and rural populations in Eastern Europe are already particularly vulnerable according to a report by the European Parliament (Kiss 2021), which do not benefit from the efficiencies of denser settlements and the critical masses to maintain services. Georgia's renewed urbanization since the mid-2000s has increased the proportion living in cities, even though the shrinking of the population has taken from both rural and urban areas (Salukvadze 2019). Rural areas of Georgia in particular face challenges in terms of offering job opportunities, services, and infrastructure – for example, central water supply is available to only 41% of rural population and 32% in mountainous areas (UNDP 2018). An official rural development program was only established as state policy in 2017 (Gov. of Georgia 2019).

A third demographic challenge is 'brain drain', with Georgian emigrants disproportionately highly educated (SCMI 2017). The accumulated net human capital outflows (2020-2050) are projected to account for 14.3% of the vocational and tertiary educated 2050 working-age population (KC & Gailey 2023). This represents a significant loss of talent heading elsewhere, as well as lost state investments in terms of educational costs – even though the economic harms are mitigated to some degree through private remittances (Mekvabishvili & Atanelishvili 2017). Gerber & Torosyan (2013) find that

[2] This includes countries the post-Communist countries of Europe, both members and non-members of the European Union.

remittances in Georgia support household wellbeing and social capital while avoiding most of the associated negative consequences seen in other countries. However, an analysis by Brownbridge & Canagarajah (2020) find a more negatives, including a weak effect on spending that is overtaken by other factors and a loss of external price competitiveness.

Already Georgia spends a smaller proportion of its limited resources on education (3.52% of GDP in 2018) than the equivalent average of 4.68% in Europe and Central Asia (World Bank 2022b). The fact that the funding structure of higher education relies heavily on student tuition has given financial incentives for institutions to expand their enrolment, in some cases at the expense of educational quality (Andguladze & Mindadze 2018). While the problem of worsening educational outcomes with higher enrolment is not unique, it is said to be particularly pronounced in Georgia. The country has held the unenviable position as one of the countries with the highest proportion of unemployed persons with a tertiary education – making up 40.3% of unemployed vs. 31.6% of the employed (Labadze & Tukhashvili 2013). This situation naturally encourages brain drain by distracting from a focus on student outcomes and failing to incentivize labour market relevance. Quality of education and restructuring is an ongoing topic of political discussion in Georgia, evidenced by the Government's reforms promising to dedicate more resources to education. Specifically, there is a goal of increased spending – reaching 25% of the state budget by 2022 – with the expectation it will accomplish higher standards and lead to better outcomes after graduation (Bochorishvili & Peranidze 2020).

More broadly, amid population aging and depopulation, it is important to quantify the effects on dependency of future change in human capital. The fact that development heavily relies on human capital (Diebolt & Hippe 2019; Pelinescu 2015; Schultz 1961) is often qualitatively acknowledged alongside prominent usage of the simple OADR, as for example in Athenosy & Revenco (2014). Rarely, however, is human capital or its relationship with productivity quantified in a dependency measure. For the purposes of this study, special focus is given to educational attainment considering that it is strongly correlated with productivity (Psacharopoulos & Patrinos 2018; Chevalier 2004) and that it can be projected with relative confidence. Even though education cannot be blindly assumed to correlate with productivity as there are potentially important signalling and selection effects (Little 1980), it is still commonly seen as a predictor of individual success. Given that education systems are meant to prepare the future labour force and they determines the competitiveness of firms (Maran et al. 2009), the fate of students and accumulation of human capital is clearly relevant to considerations of future dependency in the country.

Researchers have proposed a variety of valuable methods for calculating dependency as done comprehensively by Harasty and Ostermeier (2020), who focus on the employment and work-related

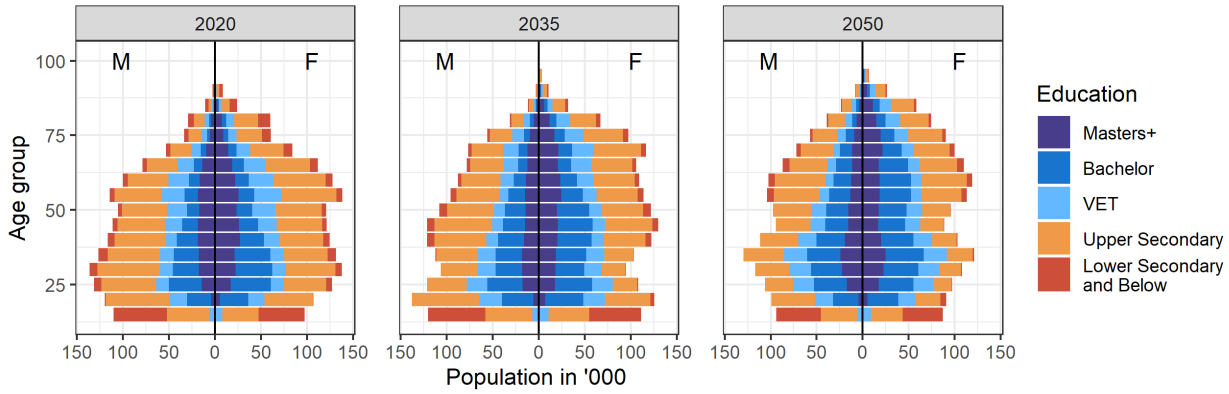
distinctions (including part-time work, underemployment, etc.). While these measures are well suited for answering the current state of real dependency, they are less suited for applying to projections because they rely on economic inputs which are less stable and predictable over time than age, sex, and educational attainment. An overview of dependency measures by Spijker (2015) summarizes attempts to more accurately capture the effects of aging, describing five broad categories of such indicators: 1) purely demographic, 2) purely economic, 3) demographic and economic, 4) health and disability, and 5) human capital. The findings of the literature review suggest that the relative usefulness of alternatives depends on the goal, which in the case of this study is to assess the change in the broad human resources of Georgia. According to Spijker's framework, the approaches used in this study can be characterized as encompassing dependency types 3, 4, and 5 since the methods combine demographic projections with labour force participation, income by educational attainment, literacy skills, and health-related data.

In the following section, the various dependency measures calculated in this study are described in detail. The refined measures aim to better reflect the state of labour and potential social contributions, and how they are influenced by the level of human capital.

Data and Methods:

Multi-dimensional population projections for Georgia were used as the basis for this study on dependency. The baseline comes from an updated version of the Georgia projections from the Wittgenstein Centre for Demography and Global Human Capital (WIC), which break down populations by age, sex, and education for 201 countries. The updated projections, by KC & Gailey (2023), use country-specific data to update assumptions for Georgia's SSP2 scenario, in addition to accounted for commonly overlooked variables such as emigration by education. Some of the key underlying assumptions for 2015-2050 are as follows: the net migration rate ranges from -9 to -8 per 1000, life expectancy increases from 69.30 years for males and 77.7 years for females to 77 years (m) and 84.2 years (f), and the transition rate from secondary to tertiary among 20-49-year-olds expands from 47% to 67.4% by the end of the projection. A detailed summary of the methods and inputs behind the WIC projection database can be found in KC et al. (2018), and the Georgia-specific improvements to the WIC assumptions in KC & Gailey (2023), with resulting population pyramid visualized in Figure 1.

Fig 1: Georgia Population Pyramids by Age, Sex, and Education, 2020-2035-2050



Source: (KC & Gailey 2023)

Geostat data was used for the baseline population size and composition, which excludes the populations of Abkhazia and South Ossetia. The two territories are notable however in terms of Georgia's recent migration history, with separatist political movements and wars that led to over 300,000 internally displaced persons – mostly ethnic Georgians – relocating to undisputed parts of Georgia in the 1990s (UNHCR 2009). Following a period of major displacements, Abkhazia was estimated to have had 215,972 people remaining by 2003 (Beacháin 2012) and South Ossetian authorities counted[3] their population at 53,532 in 2015 (Dobrushina et al. 2020).

To test the implications for future dependency, the following measures were calculated:

1) Total Age Dependency Ratio (TADR)
2) Old Age Dependency Ratio (OADR)
3) Labour Force Dependency Ratio (LFDR)
4) Productivity Weighted – Labour Force Dependency Ratio (PW-LFDR)
5) Potential Contribution Dependency Ratio (PCDR)
6) Skills Weighted – Potential Contribution Dependency Ratio (SW-PCDR)

Conventional Dependency

First, conventional demographic methodology was used to calculate dependency with the Total Age Dependency Ratio, and its variant, the Old-Age Dependency Ratio. These simple age-based measures routinely support the common narrative on population aging, clearly demonstrating how an increasing proportion of the population will fall into the category of 'old age' (65+). The TADR and OADR serve as a basis for comparison with more refined indicators.

$$Total\ Age\ Dependency\ Ratio = \frac{(population\ aged\ 0\ to\ 14) + (population\ aged\ 65\ and\ older)}{population\ aged\ 15\ to\ 64} \times 100$$

[3] Georgia was not able to hold its 2002 Georgian Census in South Ossetia.

$$Old\ Age\ Dependency\ Ratio = \frac{population\ aged\ 65\ and\ above}{population\ aged\ 15\ to\ 64} \times 100$$

Labour Force Dependency

Next, to generate a 'Labour Force Dependency Ratio' (LFDR), this study uses the 2020 Labour Force Survey from Georgia's National Statistics Office Geostat (2020). From this survey age-, sex-, and education-specific labour participation rates were extracted and then applied to the respective sub-groups at each of the 5-year steps over the projection period (2015-2050). As shown in Table 2, the 2020 Geostat survey reveals that, for a given age and education level, men are roughly twice as likely to participate in the labour force than women.

$$Labor\ Force\ Dependency\ Ratio = \frac{population\ not\ in\ the\ labor\ force}{population\ in\ the\ labor\ force} \times 100$$

Labour participation rates for Georgian men and women aged 50+ with a bachelor's degree had to be computed due to lack of observed data. This was done by averaging the participation rates of those with VET/professional education and those with a master's degree or higher for the respective age and sex group. For the purposes of applying the rates to the projections, the observed age-, sex-, and education-specific participation rates were held constant to focus specifically on the effect of changing educational composition rather than make predictions about how inclinations to participate may or may not change over time.

Table 2: Proportion of Georgians Participating in the Labour Force

Observed Proportion of Workers										
	Men					Women				
Age	e1	e2	e3	e4	e5	e1	e2	e3	e4	e5
0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
15	3.7	21.0	64.3	0	0	9.3	37.4	54.5	0	0
20	18.3	34.4	57.7	74.8	54.2	61.7	63.4	74.7	83.9	93.8
25	19.9	32.0	53.1	68.8	82.2	64.9	78.7	87.0	89.2	92.4
30	20.9	36.0	51.6	66.6	79.0	61.8	77.6	85.6	92.1	91.9
35	31.4	44.0	59.1	70.7	73.0	65.3	76.1	83.8	85.6	89.5
40	38.3	51.2	62.0	76.2	77.7	60.1	73.1	81.4	87.9	86.6
45	32.6	50.4	65.0	75.0	86.0	45.5	71.8	78.8	95.5	83.7
50	30.8	47.1	55.5	67.5	79.5	42.4	69.6	75.3	79.3	83.4
55	35.6	41.4	49.7	61.4	73.2	52.8	63.9	70.3	74.4	78.6
60	16.1	27.5	36.3	45.5	54.7	40.2	56.8	59.0	64.6	70.2
65	15.7	21.8	29.2	36.4	43.5	28.3	38.1	42.7	49.6	56.4
70	8.3	11.2	18.0	21.3	24.6	16.8	27.5	28.9	32.5	36.1
75	5.4	4.5	6.2	6.7	7.3	16.1	17.8	18.7	21.6	24.6
80	2.3	2.3	2.6	4.0	5.4	6.7	6.1	6.6	8.9	11.3
85	0	0	0	0.5	1.0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0

Source: (Geostat 2020)

** Educational Categories: E1 = Lower Secondary and Below, E2 = Upper Secondary, E3 = Vocational (VET), E4 = Bachelors, E5 = Masters+*

** Highlighted sections = Computed values, averaged from corresponding e3 and e5 age groups.*

Productivity Weighted Labour Force Dependency

Building on the LFDR, this study then calculated a 'Productivity-Weighted Labour Force Dependency Ratio' (PW-LFDR), applying an income-based weight to the projections tied to educational attainment. The purpose of this is to account for changes in the potential productivity of the labour force by using the observed difference in income according to educational attainment. A comprehensive overview of the education-earnings relationship can be found in the work of Montenegro & Patrinos (2014), which confirms previous findings of positive private returns to more schooling, but also that returns have only slightly declined over time, which suggests global demand for skilled workers has more or less kept pace with the increase in supply.

$$Productivity\ Weighted\ Labor\ Force\ Dependency\ Ratio = \frac{population\ not\ in\ the\ labor\ force}{population\ in\ the\ labor\ force\ (age-, sex-, and\ education-\ specific\ productivity\ weights)} \times 100$$

This study uses a review of the Georgian labour force and relative earnings by the International School of Economics at Tbilisi State University (Keshelava 2017). Where 'Secondary' education is set to 1, 'Professional/VET' is equal to 1.05, and 'Higher' education (1.45). Less than secondary educational attainment describes only a minor subset of the population in Georgia, most of whom are youths who are not yet working. This weighting pattern generally resembles the wage-income relationship observed in neighbouring Armenia (Hakobyan and Joulfaian 2016), as well as in Europe (Marois et al. 2020).

Potential Contributions Dependency

Next, a 'Potential Contributions Dependency Ratio' (PCDR) was calculated for another refined perspective on how to view contributions to productive society. This involves both accounting for the social value of 'work' – including unpaid work – performed by those in retirement ages and the increase in years spent in schooling by young adults.

$$Potential\ Contributions\ Dependency\ Ratio = \frac{(population\ aged\ 0\ to\ 19) + (disabled\ population\ 60\ and\ above)}{(population\ aged\ 20\ to\ 60) + (nondisabled\ population\ 60\ and\ above)} \times 100$$

In contrast to the traditional age-based dependency measures, the denominator of the dependency equation is expanded to recognize the invaluable work often provided by individuals aged 60+, particularly in their role as grandparents. Arguments in evolutionary biology, such as by Garay et al. (2018), credit the purpose of humans living past reproductive years in part for the benefits it brings to the survival of next generations, with the 'grandmother hypothesis' suggesting that grandmothers in particular are the most effective and motivated among those in the community to help share burdens

and ultimately improve the reproductive success of the parents (Coall & Hertwig 2010; Coall et al. 2018). The cultural context in Georgia is no exception to this rule as Andguladze et al. (2020) explain there is relatively low participation of fathers in activities or time spent with children, compensated for by high engagement of other members of the family, especially grandparents. To quantify this societally useful service, the conventional dependency assumption is reversed in the PCDR so that individuals 60+ are counted in the 'productive' category as long as they are in good health (60+ was used as a threshold because disability rates become important at that age). This splitting of the 60+ ages was implemented based on rounded proportions of disability prevalence from a study by Bruijn & Chitanava (2017), which shows an approximate 5% increase in disability with each subsequent 5-year step in age, starting with those aged 60-64 (about 8% of whom were disabled according to the 2014 Census). These rates were applied consistently at each 5-year step of the projection results. The European Health Expectancy Monitoring Unit and the United Nations have set the precedent for using disability data for more accurately defining dependency, often labelled ADDRs or Adult Disability Dependency Ratios (Sanderson & Scherbov 2010).

An additional adjustment was made, narrowing the conventionally defined 'productive' ages to start at age 20 instead of 15. This was done to reflect the increasing reality of schooling taking up more years of youth. The mean years of schooling for those 20-24 in Georgia stood at 12.73 in 2015, which having risen from 11.67 in 2000, is assumed by the Wittgenstein Centre to further increase in the future (Lutz et al. 2018). Most Georgians in the 15-19 category still live as dependents having not yet entered the labour force or finished education.

Skills Weighted – Potential Social Contributions Dependency

Lastly, a measure of dependency was created to account for the overall level of skills in the population, which has implications for not only the labour force, but the functioning of society more broadly. This new measure builds on the PCDR to make a 'Skills-Weighted Potential Contributions Dependency Ratio' (SW-PCDR).

$$Skills\ Weighted - Potential\ Contributions\ Dependency\ Ratio = \frac{(population\ aged\ 0\ to\ 19) + (disabled\ population\ 60\ and\ above)}{(population\ aged\ 20\ to\ 60 + nondisabled\ population\ 60\ and\ above)(age\ and\ sex\ specific\ skill\ weights)} \times 100$$

The work of Lutz et al. (2021) and Reiter et al. (2020) has developed SLAMYS, Skills in Literacy Adjusted Mean Years of Schooling, to assess the quality of education because it is important to distinguish between years of schooling (quantity) and skills (quality). By the SLAMYS measure, Georgia is essentially at the average performance for the post-socialist Eastern Europe and Caucasus region, which is above the performance of Southern Europe and about 10% lower than the Western

European average. This study uses the skills adjustment concept to apply it to dependency measures, done by calculating a skills standard to compare against Georgia. Age- and sex-specific average skill-levels for Europe[4] were calculated based on available data from adult literacy skill performances in the OECD's Programme for the International Assessment of Adult Competencies (PIAAC).

Georgia's age- and sex-specific scores were taken from the World Bank's STEP Skills Measurement Program, which was explicitly designed for comparability with PIAAC and conducted in Georgia between 2012-14 (World Bank 2014). Depending on the age and sex sub-groups, the Georgian performance was between 3.6% and 14.2% below (9.5% lower overall) the averaged European standard, shown in Table 3. By comparison, age- and sex-specific scores in Georgia are closely aligned with its immediate neighbours for which there is data (Armenia, Russia, and Turkey).

As with the PCDR, the productive age for the SW-PCDR starts at 20, where the skills-adjustment was applied. The skills weighted values for 60-year-olds in 2015 are applied to the larger 60+ category for lack of data. The same disability adjustment was made for those 60+ to determine which side of the dependency ratio they fall under, after the 20+ population was weighted downwards for the lower skills level by age and sex. Ultimately, the SW-PCDR was intended to both redefine socially valuable contributions as well as to capture consequential gaps in literacy performance compared to international standards, a proxy of social development.

Table 3: Skills Adjustment Factor

Age	Men	Women
0	0	0
5	0	0
10	0	0
15	0.93665	0.96446
20	0.91528	0.92552
25	0.88563	0.87838
30	0.85996	0.87437
35	0.85775	0.91206
40	0.89451	0.91555
45	0.87703	0.92516
50	0.86631	0.92169
55	0.89344	0.92906
60+	0.91843	0.94273

Source: Own Calculations, World Bank 2014

[4] PIAAC adult literacy scores included were taken from points between the years 2011-2018. The following countries were included in the Europe average: Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Russia, Slovakia, Slovenia, Spain, Sweden, Ukraine, and United Kingdom.

In the next section, the results of the application of these dependency measures to the population projections are shown with a focus on how divergent lessons come from implementing these various methods in dependency ratios.

Results and Discussion:

Concerns about dependency can be thought about in two broad categories. Namely, 1) the expected worsening of dependency burdens (relative terms) and 2) the understanding of current levels of dependency (absolute terms).

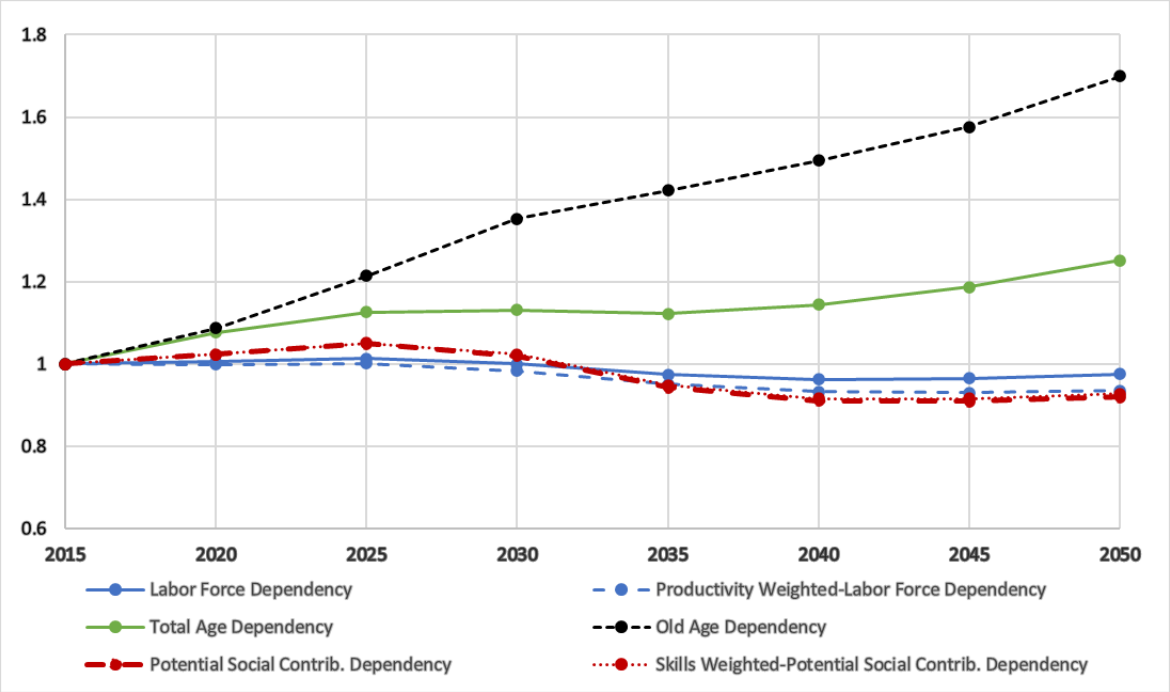
Relative Change in Dependency Measures

Change in the dependency burden status quo is perhaps what commonly receives the most attention. In Georgia, the projected values of two conventional demographic measures – TADR and OADR – are expected to increase substantially, shown in Figure 2. In only the course of a few decades, by 2050, the Total Age Dependency burden grows by a quarter (25.2%) and the old-age burden is up nearly three quarters (70%). These results in the age-based TADR and OADR measures are unsurprising considering population aging in Georgia is broadly in line with a shift to older ages seen in Post-*Demographic Transition* countries of the world, where advancements in medical interventions and improved nutrition have been extending life expectancies and driving the average age higher. Prior to the updated projections for Georgia by KC & Gailey (2023), the Wittgenstein Centre's population projections showed an even greater jump in the TADR, more resembling the other former East-bloc countries and the EU.

Different from the age-based measures, the change in Georgia's LFDR is not only less extreme, but in fact there is even a slightly decrease by 2050 (-2.4% relative to 2015), suggesting a fundamentally different story on the future burden of dependency. This is the result of implementing the age, sex, and education specific rates to more accurately define who is a worker or not in Georgia. The improving (lowering) LFDR over time is due to the changing education composition of the Georgian population and the greater propensity of individuals with higher education levels to participate in the labour force. Marois et al. (2020) projected various dependency ratios for the EU, finding that the projected LFDRs for Eastern European EU member states show only a modest increase over the next decades (moderate relative to the age-based measures). Specifically, looking at 2050 for comparison, the authors' LFDR projections showed the following change for some relevant aging and depopulating countries: Bulgaria (+21% relative to 2015), Croatia (+21%), Estonia (+16%), Hungary (+5%), Latvia (+19%), Lithuania (+28%), Poland (+15%), and Romania (+16%). By comparison, the results for Georgia in this study show an even more dramatic revision of the conventional narrative, with a minor decline. The productivity weighting modification of the LFDR, the PW-LFDR, produces a negligible difference with the LFDR (in terms of the rate of change) due in part to the assumed

differentials in income by education and the educational attainment of the population over the projection, which has already been at high levels from the Soviet educational system legacy.

Fig 2: Change in Projected Dependency Ratios in Georgia, 2015 = 1



Source: Own Calculations

The PCDR and SW-PCDR also show relative stability in dependency, with a modest decline over time. An improving dependency situation in these two cases means that is due to the proportions of healthy older individuals (classified as contributors) will grow faster than the proportion of unhealthy older individuals and youth aged 0-19 (classified as non-contributors). The skills-weighted rates by age and sex were held constant to focus on the age-composition effect and not to make assumptions about how the skills gap might develop in the future. Therefore, the relative change in SW-PCDR follows closely the PCDR. While the LFDR, PW-LFDR, PCDR, and SW-PCDR all largely overlap in Figure 2, the difference becomes apparent when looking at dependency in absolute terms.

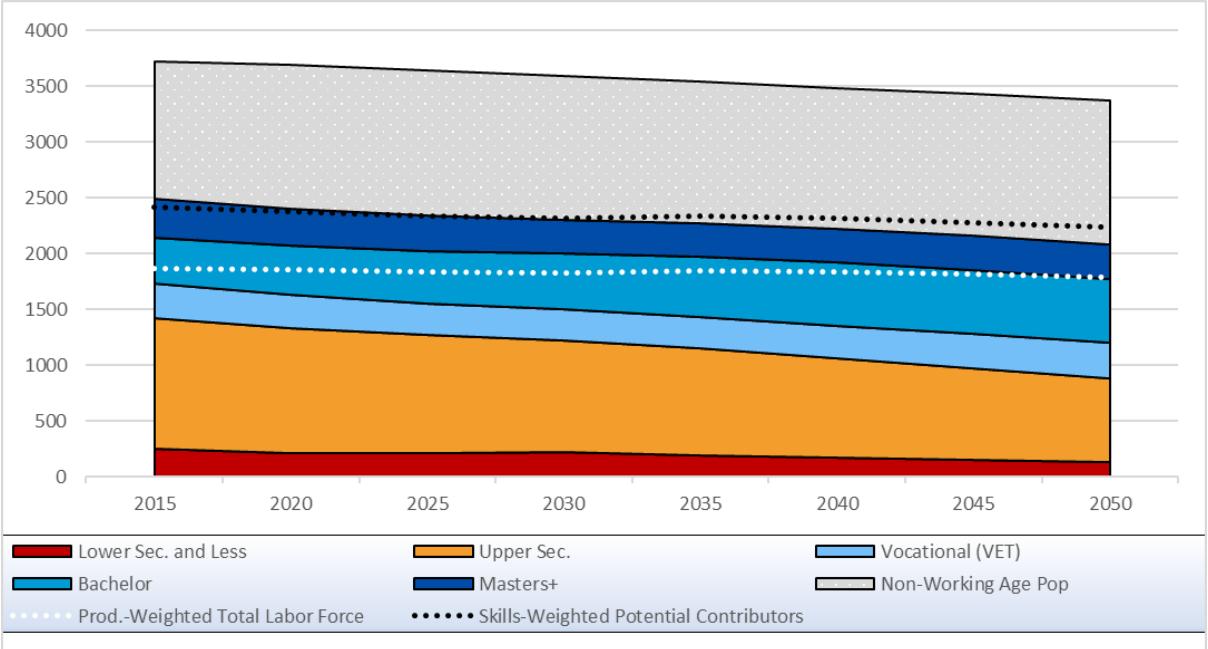
Absolute Levels of Dependency and Workers

A second way to view dependency – rather than the change – is the absolute level or the dependent-to-independent balance itself. The concept of *Demographic Dividend* is closely tied to this consideration, as a lower dependency burden is argued to spur productive work and investments into the fewer dependents that exist, putting a country of the fast track to development. According to the UN's Population Division (2004), this 'window of opportunity' is said to have opened when the proportion of youth sinks below 30% and those aged 65+ are still below 15%. A further sub-divided

characterization of the window by Crombacha & Smits (2020) would place Georgia in the 'late-window' group in 2015, as it still had a relatively high proportion at ages 0-14 (18%) and ages 65+ remained below the 15% threshold (14%). By 2050, Georgia will have long since passed into the 'post-window' phase, however it still exhibits a relatively consistent proportion of young in line with its current late-window values, which is dissimilar to most other post-window countries in Europe or elsewhere.

The absolute values for the Georgian working age population (ages 15-64), by education, can be seen in Figure 3. It is clear the projected size of the conventionally-defined working age population declines from 2015-2050. For comparison, the size of the total labour force, weighted for productivity, remains below the working-age population over the same period. On the other hand, the size of the skills-weighted potential contributor population, exceeds the working-age population by 2030. The sum of labour force participants and potential contributors in the two alternative measures both maintain a near-stability, seeing relative moderation compared to the total population in working ages.

Fig 3: Projected Working Age Population (15-64) by education vs. Productivity-Weighted Total Labour Force and Skills-Weighed Potential Contributors

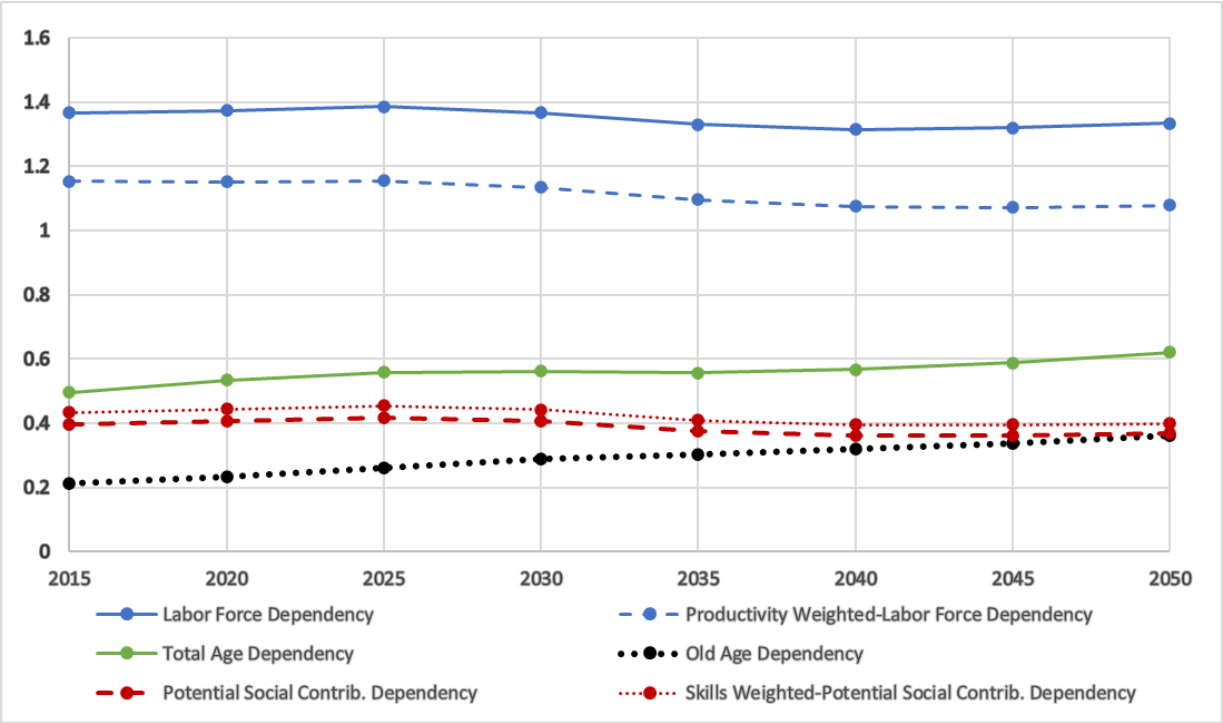


Source: Own Calculations

Age-based measures, TADR and OADR, suggest that Georgia will see its absolute dependency level move away from the Eastern and Western European averages. Georgia's burden worsens, but it is noticeably less than the norm in Europe by 2050. In terms of TADR, about 0.5 dependents in Georgia needed to be supported by each non-dependent in 2015, seen in Figure 4. This puts Georgia between

the EU average (0.53) and the Eastern European average (0.44). By the end of the projection period, Georgia has a more favourable age structure (by the age-based dependency metrics), than every EU country besides Malta (Lutz et al. 2018). This amounts to a 23% lower overall dependency burden than the EU average. The 2050 TADR in Georgia of 0.62 has more in common with those in neighbouring Armenia (0.68), Azerbaijan (0.54), Russia (0.64), and Turkey (0.57) (Lutz et al. 2018). The OADR tells a similar story, where Georgia's dependency burden, while still growing, remains at more moderate levels (0.36 in 2050) than in Eastern Europe (0.45) or Western Europe (0.53).

Fig 4: Projected Dependency Ratios in Georgia, 2015-2050



Source: Own Calculations

The labour force-oriented measures, LFDR and PW-LFDR, both show a significantly higher dependency burden because they define productivity in a stricter sense, individuals who are working or looking for work. This results in the highest dependency of the ratios generated. Using this definition, the non-workers outnumber the workers. There were 1.37 non-working Georgians for every working Georgian in 2015. This dependency ratio is higher than in most European countries, where labour force participation is higher and in 2015 the EU+UK average stood at 1.07 non-workers per worker (Marois et al. 2020). The LFDR values are higher than the conventional measures of dependency due to the crude assumptions that everyone in the 'working ages' between the ages of 15 and 64 are working, which fails to account for students, homemakers, those unable to work, and various other life situations that do not lead to participation in the labour force. For an international comparison of absolute levels of LFDRs, by 2050, Marois et al. (2020) find: Bulgaria (1.41), Croatia

(1.50), Estonia (1.10), Hungary (1.23), Latvia (1.17), Lithuania (1.28), Poland (1.26), and Romania (1.22). Further refining the LFDR measure, when distinctions are made by productivity among workers based on income levels as a proxy (PW-LFDR), the overall level of dependency is significantly lower than the LFDR, ranging from about 21-26% depending on the year.

Finally, the measures redefining social contributions and the overall skills of the population paints a picture of much lower dependency burdens. These perspectives find about two contributors for every dependent. The PCDR, produces a more favourable balance due to the reclassification of healthy 65+ individuals as contributors and the growing proportion of the population at older ages. Similarly, the skills adjustment implemented in the SW-PCDR quantifies weaker performance on literacy skills tests relative to the European average, which pushes higher the burden by 9.7% in 2015, incrementally declining to 8.8% higher in 2050. While the World Bank's STEP test results for the adult population were used for this indicator, the recent performance of students in Georgia confirms the justification for a downward adjustment factor. Georgia's 2018 PISA performance, although improving since first measured in 2010, corroborates lower skill levels in young cohorts, with scores in Reading (380), Math (398), and Science (383) compared to the OECD average of around 490-500 depending on the subject (Avvisati et al. 2019).

Conclusions:

The complexity of the dependency measures matters greatly when determining the level of concern that aging and depopulation should warrant in Eastern Europe and the Caucasus. Focusing on Georgia, age-based measures show the country is clearly facing a coming rise in dependency burdens, although much less severe than in former east-bloc countries or Western Europe. More sophisticated labour-based measures indicate that Georgia may have less to worry about in terms of a deterioration in the non-worker-to-worker balance than other countries, potentially even seeing a slight improvement over the coming decades. Similar to the labour-based perspective, when the productive population is redefined by broader social contributions according to a mixture of age and health status, dependency burdens appear to lessen over time. This holds true even after a correction for the lower skill levels in Georgia relative to European averages. By holding constant the assumptions behind each dependency measure (rates of labour participation, disability, productivity weighting proxies), the results isolate the effect of the population's changing age structure and its educational attainment breakdown.

This study explored the bounds within which dependency can be said to develop. Not only dependency, but also the broader success of a nation, is contingent on the functioning of the economy and labour market, health of the population, and its average level of skills (human capital). These three interrelated domains and their corresponding dependency ratios calculated were designed to

consider major relevant factors that are obscured by the often-simplistic age-based measures. Still, there are certainly more nuances that could be addressed. Data willing, there will be more accurate ways to estimate the true burden of dependency. Such is particularly relevant for questions of health status and work-oriented human capital, but also other factors like seasonal workers who are only in the country part of the year, all of which influence a society's dependency burden in the end. The focus on the national level is another limitation, which leaves the possibility for significant geographic variations in urban vs. rural dependency that impacts on local administration as well as economic and social dynamism.

Concerning labour force dependency, the status quo in Georgia is a relatively high burden by the standards of Europe, 1.36 in 2015. The equivalent LFDRs for the EU as a whole and the subgroup of Eastern EU members both stood at 1.07 (Marois et al 2020). However, a convergence is projected over the coming decades as the ratio of workers to non-workers in Georgia slightly improves, in contrast to most of Europe, where it worsens. A logical extension of the motivation behind calculating the LFDR would prefer an employment-based dependency ratio, which captures more precisely who actually works and does not work. Georgia's unemployment rate of 19% in the fourth quarter of 2021 was high even compared to those seen in Southeast Europe, justifying the elevation of the problem to be among the highest priorities for the Georgian political leadership (Geostat 2022a). However, an employment-based dependency measure is less compatible with population projections because economic forecasting of the economy and employment rates is far less predictable or possible in the long-run compared to factors such as labour force participation.

In a wider sense, social contributions are at the core of dependency concerns. While difficult to quantify, the PCDR featured in this study redefined 'contributors' in keeping with the spirit of recent demographic literature suggesting the 65+ population is far from a burden. Many individuals not in the formal labour force offer work of great social value, as argued with the invaluable perspective and practical help offered by grandparents. At the same time, young people increasingly spend more years in educational systems, so the productive age was moved up to 20 instead of the traditional age 15. The PCDR as a health-modified age-based measure could certainly be refined further to incorporate other Georgia-specific sources. Results from this study suggest Georgia has 0.4 to 0.36 non-contributors for every contributor over the projection period, a much more optimistic outlook on dependency than the measures focused solely on age or formal labour participation.

Lastly, this study made weighting adjustments to dependency measures based on proxies for human capital, using incomes by education and tested literacy scores. In one case, the dependency burden in Georgia is revised downward due its high educational attainment and education-specific income levels. This is based on a standard that upper secondary wages are the norm. On the other hand,

internationally comparable scores in literacy performance – based on the standard of a European average – point to lower skill levels on average and therefore imply an unfavourable revision of the overall dependency burden upwards. Such weighting systems build on ongoing efforts to meaningfully describe the quantity and quality of human capital in a country.

How dependency is defined matters greatly when drawing policy lessons. As implied by the PCDR, the activities of individuals who are not working or looking for work in the formal job market can nevertheless produce much value in society. Defining dependency broadly and without context can run into important trade-offs. For instance, Georgia's near-replacement level fertility rate might not be maintainable if policy incentives attempt to increase female labour force participation – although it is difficult to establish a definitive relationship between labour force participation and motherhood as it is not necessarily a 1-to-1 trade-off as seen in the contrasting examples of Scandinavia and Southern Europe. Furthermore, children – dependents in the clearest sense – are a necessary investment in the future of a country. Therefore, the ideal policy framework would aim to minimize dependency only in a stricter, more targeted sense because 'dependency' – especially as characterized by the crude solely age-based measures – is not uniformly undesirable or otherwise against the interests of society. This study uses a lower total fertility rate than the World Bank (2022a) estimation, starting with the period 2015-2020 (1.78), a result of implementing the WIC age-, sex-, and education-specific fertility rate assumptions (Lutz et al. 2018) together with a correction to the Georgian population composition, particularly education structure. If Georgia does in fact avoid converging with the Eastern European fertility norm however, the country has even further reason to expect more moderate changes in age structure and dependency in the long run.

From the perspective of the refined dependency measures explored in this study, Georgia's future burden appears far more manageable than implied by less sophisticated, solely age-based measures. Potentially nearing its peak in terms of labour force dependency burden, Georgia may have less dramatic changes to the status quo ahead compared to most countries in Eastern and Western Europe (Marois et al. 2020). Such a prospect holds true under the conditions where the Georgian population transitions within broad expectations and maintains its age-, sex-, education-specific performances at current levels (in terms of labour, health, and human capital). Potential improvements on such factors would further secure a manageable state of future dependency. On the other hand, depending on labour agreements with destination countries and future migration dynamics, a return to large-scale brain drain could undercut Georgia's human capital accumulation and reverse some of these brighter prospects.

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2.4. The influence of education mismatches and human capital flight on dependency: A case study of Armenia

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Abstract: Mismatches between human capital and the job market reflect inefficiencies in the educational system, with direct and indirect consequences for dependency burdens. This study generates dependency ratios for the case of Armenia from 2015-2050, using population projections and age-, sex-, and education-specific data on labor force participation and income. A baseline where recent trends continue was tested against scenarios with zero educational mismatches and zero brain drain, as well as three policy-oriented scenarios modeled after top peer-country performances in human capital formation, activation, and retention. Findings show that with zero brain drain or brain waste, productivity-weighted labor force dependency in Armenia departs from the baseline (1.29 in 2050), ranging from 1.24 to 1.13. The same measure of dependency burdens reduces to a level between 1.27 and 1.08 if select policy interventions were to successfully achieve observed peer-country performances in education mismatch, emigration, or labor force participation by 2050.

Introduction

Inefficiencies in educational systems often fail to prepare graduates for the future, producing substantial mismatches between a population's human capital and the economy. The global trend of expanding educational attainment has not ushered in corresponding gains in labor market outcomes according to the International Labour Organization (ILO), with only half of workers globally holding jobs relevant to their education (Stoevska 2021). Such mismatches produce what is often referred to as "brain waste", the underutilized potential of workers given their qualifications or skills. Although some form of mismatch is inevitable, the larger the misalignment between human capital supply and demand, the greater the losses for both individuals and the state. Economic risks of brain waste can take the forms of lost

investments in training (public and private contributions to education), associated opportunity costs for individuals during the years spent in education, and upon graduation lower productivity in the labor force and higher unemployment levels. Such sub-optimal outcomes also come with wage penalties and reduced job satisfaction for individuals falling in these gaps, relative to well-matched peers (Lieberman 2022; Bischof 2021). The focus of this study – Armenia – exemplifies a country facing challenges from high levels of brain waste, and the connected phenomenon of brain drain.

Brain waste and brain drain are investigated to understand the extent to which they influence the state of current and future of dependency burdens. This dynamic has remained under-studied in the literature on the aging, depopulating countries of the world in spite of emerging efforts in the field of demography to quantify the implications of changes in human capital. This study uses survey data and population projections to generate more sophisticated dependency ratios that go beyond the still prevailing focus on age structure. The results offer a more realistic view of the contemporary levels of dependency and a much more manageable outlook for its future development than conventional measures otherwise predict. For the case of Armenia, dependency shows modest-to-substantial improvements by 2050 if different forms of brain waste or brain drain are reduced to levels observed in peer countries.

The concept of mismatched workers varies depending on the measure of human capital, and therefore, requires precise definitions. Mismatches can generally be sub-divided into two categories, qualification (educational) mismatch and skills mismatch. Often this distinction is made in the literature, including work by the International Labour Organization (ILO), reflecting the fact that formal degrees are not strictly equivalent to skillsets since schooling outcomes vary by quality as well as quantity (ILO 2020). The EU's European Statistical System on the other hand does not have a standardized definition (Gallelli 2019) and has used the term 'skills mismatch' interchangeably to describe what others call qualification or educational mismatches. In such a context, skills can be broadly understood as comprising job-specific technical skills, basic skills (literacy and numeracy), and generic soft skills, all of which pose challenges to consistent measurement and are not done by standard Labour Force Survey (LFS) efforts. Depending on the definition skills can encompass factors inherent to individuals (or at least not directly addressed by formal education) such as personality as well as work experience. Qualification or educational mismatch – referred to as simply "educational mismatch" from here on – is the focus of this study. Furthermore, a second axis

on which to conceptualize mismatches is horizontal (wrong type of education/skills) vs. vertical (over- or under-education/skills) mismatch. In line with LFS data detailed in the methods section, this study deals with vertical educational mismatch.

Highly developed economies produce a relatively wide range of outcomes on matching education with the job market. In fact, data from the OECD (2023) shows that the larger economies such as the English-speaking and western European countries have higher degrees of mismatches than those in Czechia, Slovakia, Hungary, Poland, Slovenia, and the non-OECD economies of Bulgaria and Romania included in the database. According to the Cedefop Skills Index – a composite measure covering skills and qualification matching in the European Union – Czechia leads in preparing its graduates for entering the labor force (Cedefop 2023). A fairly consistent annual rating pattern can be seen for the years covered (2020-2022), with the top performances broadly in the East and North, followed by West, and then South of Europe, findings corroborated for earlier time periods by Mcguinness et al. (2017). However, an OECD study finds different patterns and distinguishes between over-skilling and over-qualification (McGowan & Andrews 2015). These findings reflect differences both in the methods used and the different nature of education and skills mismatches. A study by Flisi et al. (2017) even finds an inverse relationship between the two types and the authors suggest that skill mismatches are less detrimental than education mismatches (common in Southern Europe). Regardless of the variations between high income countries, as a broad group, they have about 60% of workers holding jobs that match their education, while the average stands at 52% in upper-middle income countries (Stoevska 2021).

The South Caucasus region performs similar to Southern Europe in terms of education matching. Armenia struggles with very high unemployment by OECD-country standards, 12.7% in 2021 (WB 2023a), or even 15.5% according to the tentative 2021 estimate by Armstat (2023). In spite of the high levels, recent figures of unemployment are the lowest observed in at least two decades. Youth unemployment stood even higher at 24.8% in 2021, partial consequences of unsuitable training and human capital formation (WB 2023b). Insufficient training is a reality in Armenia (Baghdasaryan & Alaverdyan 2021), as well as neighboring Georgia (WB 2013), Azerbaijan (Amirova & Valiyev 2021), and Turkey (Dereli 2018). Specifically, the European Training Foundation (ETF) estimates that 30.6% of Armenian workers were overeducated and 7.6% undereducated in 2019, with overeducation

trending upward (2022). Furthermore, while not unique to Armenia, the IMF found an oversupply of graduates from humanities programs as the byproduct of incoherent higher education policies (2019), which do not plan for the collective interest of graduates. Although the country has lifted itself to upper-middle income status and overseen an average GDP per capita growth of 4.32% from 2017-2021 (reaching 4,670 USD in 2021), inefficiency in the form of education mismatches undermines the country's attempts to develop its economy more broadly (WB 2023c; 2023d). The education-labor force misalignment has been targeted by the Armenian Government, international organizations, and private firms, expressed by their joint initiatives in recent years, such as "Edu2work" and the "Education Improvement Project (EIP)" (Ghazanchyan 2022; Baldryan 2021; ETF 2021).

Besides the direct effect of educational mismatches on the efficient functioning of the labor force, its consequences also manifest as a secondary phenomenon in the form of emigration. The outflows of people, especially highly educated people, is often called "brain drain" as it represents unrealized potential for the home country as well as lost investments. While some losses might be recouped by family members and society more broadly through remittances, the net effect of such transfers on long-term GDP growth is disputed and varies by country, in addition to producing other concerns such as lack of economic independence and reduced incentives for non-migrants to work at home. For the post-socialist countries of Central and Eastern Europe, the IMF finds that the net economic effect of brain drain is negative for the sending countries, estimating a reduced competitiveness of firms and that 0.6% to 0.9% of GDP growth is lost annually to migration (Atoyan et al. 2016). Similarly, potential "brain gain" through the upskilling of migrants while abroad who then return to their country of origin (often labeled "brain circulation") characterizes a relatively modest fraction of emigrants in practice (2016). For example, Croatia's brain circulation-oriented Unity Through Knowledge Fund ended up dropping the return aspect of its work after low return rates, showing how the theoretical vision for programs encouraging such brain circulation can unintendedly further promote brain drain in the end (Bottcher 2014). The consequences of brain drain in these parts of Europe is reflected in the Global Competitiveness Index rankings, which put much of Central and Eastern Europe among the countries least able to retain talent in the world (WEF 2018).

Armenia has been no exception to the rule of brain drain in the broad post-Socialist Eastern Europe and Caucasus region. After the dissolution of the Soviet Union in 1990s, a large wave

left Armenia for Russia, further solidifying the status of Armenians as one of the most prominent diasporas in proportion to their home country population; 6 to 9 million (OHCDA 2023; Norkus et al. 2019) vs. 2.78 million in 2022 (UN 2022). Strong diasporas are widely acknowledged to facilitate further emigration by softening the social and financial costs of moving. A survey by the ETF (2012) found that 36% of Armenians between 18 and 50 were seriously considering leaving the country. The propensity to consider emigration shows important variation by sex, 42% men vs 30% women, while low educated men are the most likely to want to leave (slight majority), followed by high educated men, and then high educated women. However, among those in the pool of potential migrants seriously considering migration, the ETF data show that highly educated men have the highest proportion of individuals with the resources to do so and thereby most likely to realize their migration intentions. The net migration of Armenians (in absolute terms) consistently ranged between -25,000 and -30,000 from 2003 to 2019, after which it was slightly moderated to about -13,000 during the COVID-19 disruptions (WB 2023e) and turned positive with inflows from Russia in 2022, about half of which are estimated to come from the Armenian diaspora (ARKA 2022).

Amid the larger backdrop of economic hardships and demographic changes – particularly population aging and depopulation – the question of labor force dependency is essential for a meaningful understanding of Armenia's future. The population of non-workers relative to workers (labor force dependency) gages the productive capacity and resilience of a society. The primary aim of this study is to explore the degree to which human capital formation, activation, and retention hold influence over the trajectories for such dependency.

Methods

To quantify the potential human capital losses due to inefficiencies and emigration, this study uses a multi-dimensional demographic approach, considering variations in the population by age, sex, and education when possible. In addition to the conventional focus on age and sex, educational attainment is also covered in keeping with the work of the Wittgenstein Centre, which among other advantages, allows for the calculation of productivity-weighted perspectives on dependency. Specifically, the following labor force dependency ratios were generated:

Part 1: Conventional Measures

- Total Age Dependency Ratio (TADR)
- Old-Age Dependency Ratio (OADR)

Part II: Baseline

- Labor Force Dependency Ratio (LFDR)
- Productivity Weighted-Labor Force Dependency Ratio (PW-LFDR)

Part III: Perfect Formation and Retention of Human Capital

- PW-LFDR – Zero Mismatch (Supply)
- PW-LFDR – Zero Mismatch (Demand)
- PW-LFDR – Zero Brain Drain

Part IV: Policy Goal Role Models

- PW-LFDR – Reduced Educational Mismatch
- PW-LFDR – Moderate Emigration
- PW-LFDR – Higher Labor Force Participation

Part I: Conventional Measures

For comparison with the various human capital-focused LFDRs calculated in this study, the standard measures Old Age Dependency Ratio (OADR) and Total Age Dependency Ratio (TADR) were calculated according to widely used definitions:

$$Total\ Age\ Dependency\ Ratio = \frac{(population\ aged\ 0\ to\ 14) + (population\ aged\ 65\ and\ older)}{population\ aged\ 15\ to\ 64} \times 100$$

$$Old\ Age\ Dependency\ Ratio = \frac{population\ aged\ 65\ and\ above}{population\ aged\ 15\ to\ 64} \times 100$$

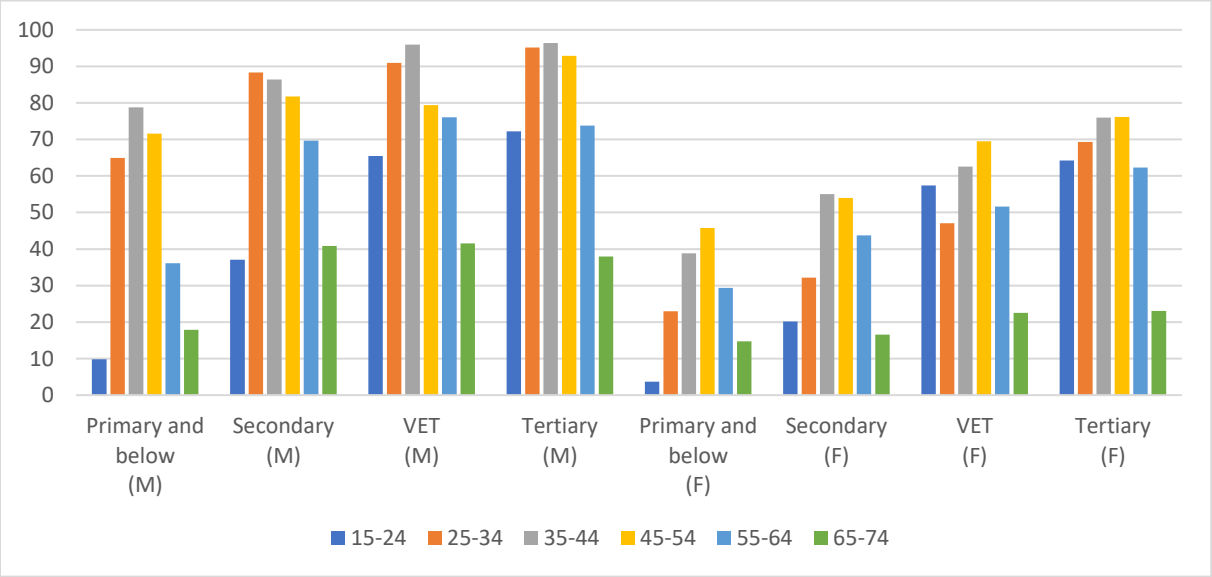
Part II: Baseline

To start, Armenia's 2021 Labour Force Survey data was used to define age-, sex-, and education-specific labor force participation rates. The age variable was compiled into 5-year groups by birth year and educational attainment categories were grouped into primary, secondary, vocational (VET), and higher education (bachelor+). The age-, sex-, and education-specific labor force participation rates, shown in Table 1, were combined with an updated version of population projections for Armenia from KC & Gailey (2023) for the purposes of generating a Labor Force Dependency Ratio (LFDR). This ratio showcases differentials by labor force participation – the first of two educational effects explored in this study.

$$LFDR = \frac{population\ not\ in\ the\ labor\ force}{population\ in\ the\ labor\ force} \times 100$$

The projection update uses the base population size and age-sex distributions from the UN's WPP22. As in KC & Gailey, the same educational categories were used from the Wittgenstein Centre and Armenia's National Statistics Service (2017) to distinguish the important VET educational category – which is associated with a higher likelihood to participate in the labor force and be employed compared to secondary education.

Figure 1: Labor force participation rates in Armenia (%), by age, sex, and education, 2021



Note: The rates are expressed in % of those participating in the labor force in their respective age/education categories; the columns refer to the age categories, with ages 75+ assumed to be out of the labor force. Data from the 2021 LFS (Armstat 2023)

A second type of LFDR was generated, with the addition of a weighting system to account for productivity differences among the labor force, shown below. This measure is meant to more accurately represent potential labor supply than indirect measures based on age alone. Specifically, the productivity weighting was set using income by educational attainment as a proxy for productivity to produce a Productivity Weighted-Labor Force Dependency Ratio (PW-LFDR). The PW-LFDR ratio is considered the most refined baseline measure of dependency in this study, building on the LFDR to account for the double effect of education differentials in labor force participation as well as productivity.

$$PWLFDR = \frac{population\ not\ in\ the\ labor\ force}{pop\ in\ the\ labor\ force\ (age-, sex-, and\ education-\ specific\ productivity\ weights)} \times 100$$

Even though the connection between education and earnings is not necessarily causal and can change over time it is important to acknowledge somehow to gage the quality, not only quantity, of the labor force. The income by educational attainment data comes from the 2021 LFS. The LFS values for nominal incomes by age, sex, and education are notably lower than other statistics from Armstat on overall average income, which is due to differences in methodologies and samples. The productivity weights were calibrated according to the benchmark of secondary earnings from the respective age- and sex-specific categories (set to the value of 1) to define the 'standard' productivity for each age and sex category. The resulting productivity weights are displayed in Table 1. For example, the productivity of a man aged 35-44 with secondary education = 1, while a 35-44 aged man with vocational education = 1.037 and a 35-44 aged man with tertiary education = 1.462. This approach to the productivity weighting of a population continues work by Lutz et al. (2019) and Marois et al. (2020; 2021), which fits available data on income by age, sex, and education together with population projections by age, sex, and education.

The secondary and vocational earnings are largely equivalent in Armenia, where vocational education is associated with a modest premium of 1.84% for men and 3.80% for women, while tertiary education earnings show an average premium of 37.7% (m) and 29.6% (f) relative to earnings for those with secondary education. The age-, sex-, and education-specific earning premiums (productivity weights) were assumed to follow their respective cohorts over time, where the differentials for the age cohort 15-24 in 2020 were applied to all younger cohorts over the projection period, once they enter the age category 15-24.

Table 1: Nominal Incomes by Age, Sex, and Education, relative to Secondary Educational Attainment.

	Male			Female		
	Secondary	Vocational	Tertiary	Secondary	Vocational	Tertiary
Total	1	1.018	1.352	1	1.038	1.249
15-24	1	1.078	1.56	1	0.872	1.399
25-34	1	0.965	1.29	1	1.211	1.231
35-44	1	1.037	1.462	1	1.028	1.178
45-54	1	1.022	1.657	1	0.94	1.368
55-64	1	1.033	1.181	1	1.044	1.123
65-74	1	1.111	1.121	1	1.179	1.017

Note: Earnings premiums of those with vocational and higher are shown relative to secondary education, where secondary education = 1. Data from the 2021 LFS (Armstat 2023)

The productivity weights shown in Table 1 were assumed to follow the respective cohorts as they age over the course of the projection. All cohorts younger than those aged 15-24 in 2020 were assigned the same productivity differentials as those seen in the 15-24 cohort in 2020 as they enter into the working ages during the projection.

Part III: Scenarios of Perfect Formation and Retention of Human Capital

Next is a set of theoretical scenarios, assumptions shown in Table 2, that were defined to examine the influence on dependency of different inefficiencies in human capital formation and retention. Specifically, these cover two types of brain waste (education mismatch on the supply-side of labor, and labor shortages on the demand-side of labor), as well as brain drain.

Table 2: Summary of Assumptions for the 'Perfect' Performance Scenarios

Scenario	**Implementation**	**Timeline**	**Source Used**
PW-LFDR Zero Mismatch (Supply)	Tertiary productivity weights were corrected upwards, proportionally increasing the income premiums by the rates of observed overqualification.	Complete correction made as of 2015, applied throughout the projection period.	Mismatch data from the 2021 LFS (Armstat 2023)
PW-LFDR Zero Mismatch (Demand)	The labor force size was corrected upwards, moving non-labor force participants into the population of participants at a rate equivalent to job vacancies in the population from 2019-2020, filling the labor shortages.	Complete correction made as of 2015, applied throughout the projection period.	Labor shortage data from Armstat (2020; 2021)
PW-LFDR Zero Brain Drain	Scenario was generated using population projections of Armenia with no migration (natural population change). Immigration was also set to zero since most immigrants to Armenia are returning emigrants.	Complete correction made as of 2015, applied throughout the projection period.	Natural Population Change projection, updated from KC & Gailey (2023).

PW-LFDRs for a Zero Mismatch (Supply) scenario were generated in a theoretical case without brain waste, where the total supply of human capital in the labor force is fully utilized, to express the gap between the 'expectations' of the educational system and the baseline reality.

Education mismatches were determined using Armenia's 2021 LFS, disaggregated by age, sex, and educational attainment. Various studies discuss how to quantify the somewhat difficult to measure concept of education mismatch and brain waste, with this study focusing on workers who self-report being overqualified for their current job. The Armenian LFS phrases the question as: "Do you think your education / qualification corresponds with your present job?". The rates of age-, sex-, and education-specific overqualification were taken from those who answered, "No, my education/qualification is higher". These rates, shown in Table 3, reveal a relatively consistent pattern across age groups and between men and women. Starting with 2025, the overqualification rates of the age groups proceeding those 15-19 are assumed to take on the values of the previous cohort. Once the proportion of the labor force with education mismatches were determined, a correction was made to proportionally increase the productivity premium (described earlier in the methods section), by the age and sex specific mismatch rates for vocational and tertiary education levels. This means overqualified individuals integrate well into the labor market and fully utilize their education, whereas previously they were bringing down the wage premium averages for their respective education groups by working jobs below their qualification level.

Table 3: Overqualification rates (%) among tertiary educated workers in Armenia

Over-qualification	Male	Female
	Tertiary	Tertiary
Total	23.4	17.9
15-24	30.1	16.7
25-34	24.8	19.3
35-44	20.8	24.1
45-54	25.0	15.1
55-64	19.8	15.4
65-74	30.3	5.4

Note: Over-qualification rates, expressed in %, captures the proportion of workers with tertiary education who report holding a position that does not require tertiary education. While the age groups covering 25-74 are statistically representative, ages 15-24 had fewer respondents than required to guarantee a representative sample. Data from the 2021 LFS (Armstat 2023).

Considering the brain waste phenomenon from the demand side, this study next generated a PW-LFDR Zero Mismatch (Demand), which looks at how dependency would change if Armenia's education system was able to more efficiently train the population and eliminate existing labor shortages to meet the demand. Data from Armstat (2021) was used to

determine the extent of labor shortages, taking the average of job vacancy rates from 2019 and 2020 (2.18%). This rate was combined with Armstat data, using the number of 1,077,400 employed persons in 2019 to estimate the absolute number of unfilled jobs, which was then tied to the population at the start of the projection to get a job shortage rate of 1.87% among the total population (Armstat 2020). The job shortages were then 'filled' by taking from the population outside of the labor force at a rate of 1.87% and correspondingly adding to the population in the labor force over the projection.

The consequential phenomenon of brain drain was also explored by generating a PW-LFDR Zero Brain Drain from projections with only natural population change, showing the results of a theoretical situation where Armenia achieved perfect retention of its human capital, also with no inflows, as most immigration is comprised of returning Armenians who had previously left.

In addition to the question of dependency, this scenario allows for calculating a measure of accumulated human capital losses in the form of Lost Working Years (LWYs) over the projection period, in line with literature concerned with labor force capacity and working life expectancy (Shiri et at. 2021). Specifically, working years in Armenia were calculated by summing the yearly productivity-weighted labor force sizes over the projection. The difference between the cumulative working years from the PW-LFDR Baseline and the PW-LFDR Zero Brain Drain scenario captures the emigration-induced LWYs.

Part IV: Scenarios for Policy Goal by Role Model Performances

Lastly, three policy-oriented scenarios were implemented to see how the outlook for productivity-weighted labor force dependency changes if Armenia would achieve improved levels of education matching, retention of would-be emigrants, or labor force participation. The assumptions behind each scenario are detailed in Table 4.

Table 4: Summary of Assumptions for Policy-Oriented Scenarios

Scenario	**Implementation**	**Timeline**	**Source(s) Used**
PW-LFDR Reduced Skills Mismatch	PW-LFDR was altered to fit with an average of the top performers in overqualification rates in the EU (Croatia, Czechia, Hungary) from 2020.	Change implemented over 10 years: starting in 2020, completing in 2030.	(Eurostat 2023)

PW-LFDR Reduced Brain Drain	PW-LFDR was generated with projections using the UN's projected 5-yearly net migration rate for upper-middle income countries.	The UN's projected net migration rates applied from 2020 to 2050.	(UN 2019); and Reduced Outflow scenario, updated from KC & Gailey (2023).
PW-LFDR Higher Labor Force Participation	Labor force size by age, sex, and education was uniformly raised by 10.7%, with a corresponding decrease in the respective populations outside of the labor force.	Change implemented over 10 years: starting in 2020, completing in 2030.	(WB 2023f)

For the purpose of testing the impacts on dependency of improved education matching, some of the best performers in the EU that are also post-Socialist countries, were taken as role models. An average of overqualification rates[5] for men and women from Croatia, Czechia, and Hungary were used, equaling 13.1% for men and 14.7% for women (Eurostat 2023). Only tertiary education mismatches, the most consequential education category for productivity weighting, were implemented due to available data. The equivalent rates of mismatch in Armenia stood at 30.1% (m) and 16.7% (f) in 2021 (Armstat 2023). These example countries have experienced emigration of highly skilled nationals in recent years, especially Croatia, which could act as a potential 'release valve' for education mismatched individuals. However, such emigration has been proportionally many times lower compared to Armenia and has somewhat moderated in recent years (CIA 2023), and yet Armenia still has twice the education mismatch. The changes in education mismatch were phased in starting with those ages (15-20) in 2025 and subsequent younger cohorts.

A second policy goal scenario was explored to test the effects on productivity-weighted dependency of role model performance in improved human capital retention. The Reduced Migration population projections in KC & Gailey (2023) were combined with the same labor force participation rates and income by education levels used to generate the baseline PW-LFDR described earlier in the methods section. The UN's upper-middle income projected average net migration rates were implemented, shown in Table 5, with a range over the projection period from a high of -0.113 net migrants per 1000 population from 2015-2020 and a low of -0.327 during 2020-2025.

[5] The 2020 percentages for men = Croatia (14.0), Czechia (12.2), and Hungary (13.1); for women = Croatia (13.2), Czechia (16.0), and Hungary (14.8).

Table 5: Projected net migrants per 1000 population, upper-middle income countries

2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050
-0.113	-0.327	-0.243	-0.169	-0.149	-0.146	-0.144

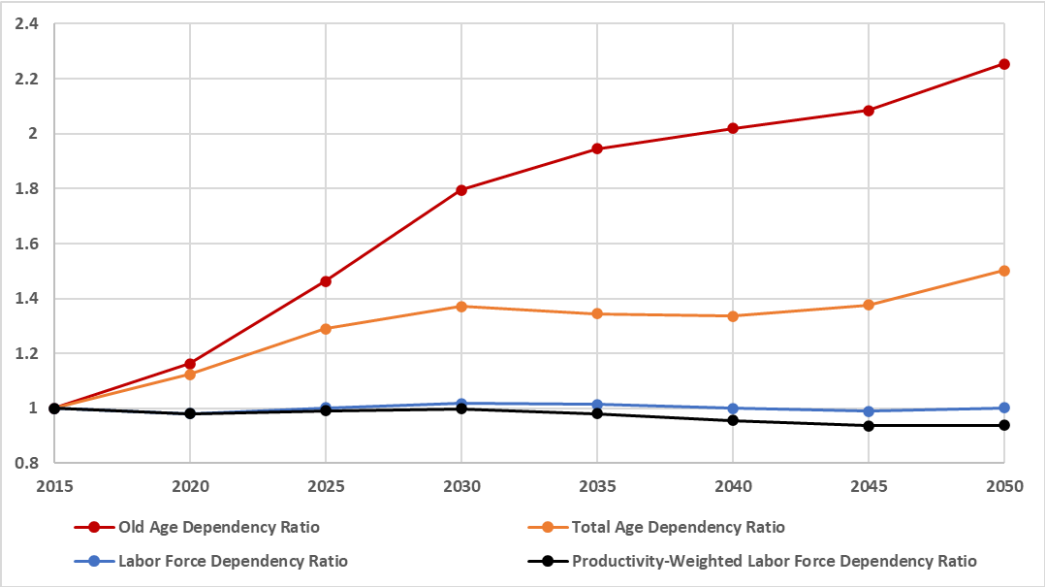
Source: UN (2019)

A third policy goal scenario focused on improved labor force participation and dependency. The baseline population projections for Armenia were combined with a higher standard, the 2021 upper-middle income country average (WB 2023f) – 64% of the aged 15+ population, which is roughly in line with values from other top performers in the post-Socialist countries of Central and Eastern Europe, including Belarus, Czechia, Estonia, Hungary, Lithuania, Latvia, Poland, Russia, and Slovakia. The 2021 LFS values provided by Armstat (2023) used for the baseline scenario (57.8%) was increased to the higher 64% level. The jump in participation by 10.7% was gradually phased in over the 5-year steps of the projection, starting with 2025 and completing the improvement by 2050.

Results and Discussion

The results of LFDR and PW-LFDR, show a more favorable picture than the conventional age-based measures in terms of change in the status quo. Figures 1 and 2 show the overall levels of dependency and the rate of change over time respectively. The overall level of labor dependency appears much higher than age-based measures, due to a stricter and more realistic definition of working individuals (those observed in the labor market). However, the rate of change is also much more stable over the projection period. Armenia is projected to experience a less than 1% increase in LFDR between 2015-2050, compared to the equivalent 125.3% explosive growth in the status quo shown by the OADR measure, which crudely defines productivity only in terms of being below age 65. The notable stability in LFDR is a function of the projected growth in educational attainment in the population, paired with the observed differences in the labor force participation rates by education in Armenia. The education expansion follows the Wittgenstein Centre's assumptions of a continuation of recent trends in Armenia, weighted by the global educational expansion average (KC et al. 2018).

Figure 2: Relative Change in OADR, TADR, LFDR and PW-LFDR.

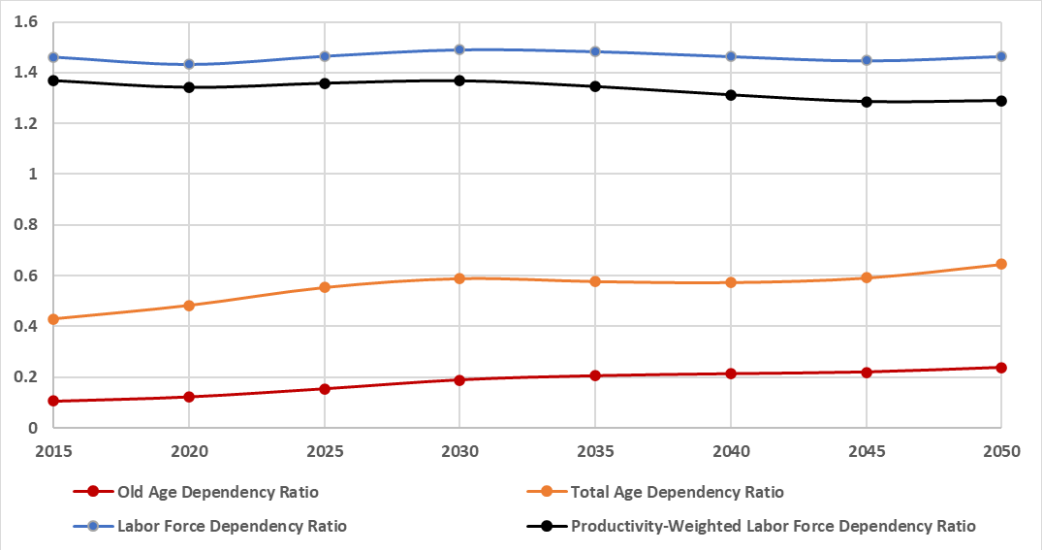


Note: The dependency ratios featured are made relative to the starting value; 2015 = 1

By comparison, Armenia's LFDR projections show a relatively healthier development over the coming decades compared to various EU member countries. Specifically, averaging the findings of Marois et al. (2020), Western EU members[6] oversee growth from 1.03 in 2015 to 1.35 in 2050. Similarly, the post-Socialist Eastern EU members[7] are found to have an average LFDR of 1.07 in 2015, and 1.30 in 2050. While unlike in Armenia there is a growth in labor force dependency projected, the pace in both Western and Eastern EU members is still much milder than their equivalent age-based dependency measures. In absolute terms, there is a convergence occurring between Armenia and EU member countries. While Armenia largely maintains its 2015 LFDR over the coming decades – with education gains and labor force participation differentials keeping potential increases in check in the proceeding decades – the EU members see growth in such burdens in the same time period. These divergent trends result in a meeting at roughly the same absolute levels of labor force dependency by 2050.

[6] Average shown for Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, Netherlands, Sweden, and United Kingdom.
[7] Average shown for Bulgaria, Croatia, Czechia, Estonia, Hungary, Lithuania, Latvia, Romania, Poland, Slovakia, and Slovenia.

Figure 3: Absolute Levels of OADR, TADR, LFDR and PW-LFDR.



Note: The dependency ratios shown contrast differing definitions of the 'unproductive' and 'productive' parts of the population.

Armenian workers have a less dramatic earnings premium by educational attainment than workers in many other countries, including those in Europe (Usanov & Chivot 2013), yet they fall between the premiums seen in Armenia's immediate neighborhood (Sargsyan 2020). This leads to a less pronounced effect of a productivity-correction for dependency measures. For comparison, calculations of PW-LFDRs for the EU27 countries and the United Kingdom by Marios et al. (2020) show the equivalent average absolute value rising from 1.0 in 2015 to approximately 1.10 by 2050. Similarly, in two different scenarios that represent upper and lower bounds of fertility, Marois et al. (2021) project the future of PW-LFDR in China to range from 0.92-0.95 in 2050. These lower levels of dependency than Armenia are not necessarily reflective of the differences in population structure however, since these studies about the EU27+UK and China both make larger distinctions between low and high education levels in the populations. Productivity differentials were assumed to follow the 5-year age cohorts over time in this study, except for the PW-LFDRs labelled "Constant Productivity" (only Fig 3), which instead tested the impact of holding constant the age, sex, and education-specific productivity differentials. In either of the two cases for how the productivity differentials develop over time, Armenia's PW-LFDR is still found to decrease, while the EU27+UK average sees a slightly increase and China remains quite stable.

Perfect Formation and Retention of Human Capital

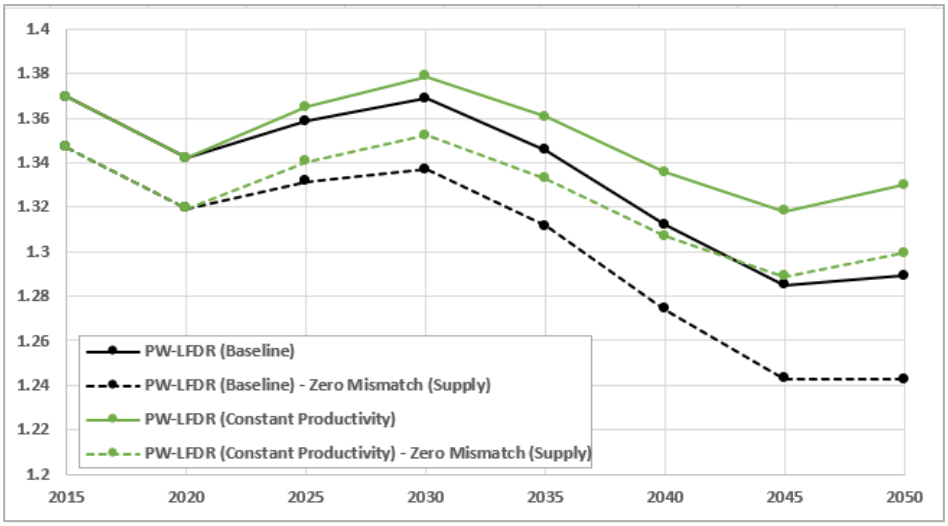
While the LFDR and PW-LFDR incorporate current brain waste/lower potential, three scenarios were explored to show the extent of improvements if losses could be mitigated completely in the formation and retention of human capital.

Firstly, the PW-LFDR Supply scenario explores the outcome of zero education mismatches, if the supply of workers being produced by the educational system in Armenia was perfectly absorbed by the labor market. Figure 3 shows if these corrections are applied from the start of the projection in 2015. Rates of education mismatch found in the 2021 LFS line up with other studies of Armenian education (ETF 2022) and surveys from employers (Rutkowski 2015). The overall effect of correcting for education mismatches is found to be modest, mostly due to relatively small wage premiums between education groups, particularly among women. The effect is a 2.3% decrease in dependency when assuming constant productivity distributions by age, sex, and education, or a 3.6% decrease in dependency in the baseline scenario where productivity for the younger generations follows the current age, sex, and education patterns among the young. While this study only concerns the labor force aspect of education mismatches, other relevant effects in such a scenario would likely include fewer lost investments by the state (and therefore returns to gains in productivity) and lower unemployment.

It is also important to note that the overqualification rates shown in Table 3 only reflect values for employed workers. This fails to capture individuals who were previously mismatched and then left employment or even the labor market all together – whether remaining in the population or emigrating out of the country. This correction implemented therefore represents a lower limit for the true extent of education mismatches in Armenian society. Such unsuccessful integration into the labor force is evident in the relatively high rate of individuals who are not in employment, education, or training (NEETs) at 26.1%, compared to a range of 11-13% in the European Union, Russia, and United States, but largely in line with neighboring countries in the region (WB 2023g; Varshavskaya 2016). This phenomenon is influenced by economic conditions and ability of individuals to successfully use their qualifications to integrate into, or return to, the labor market after time away. Mismatch concerns also shape expectations about working life, which along with security

concerns, dominate sentiments among Armenian emigrants (Lieberman 2022; Yeghiazaryan 2022).

Figure 3: PW-LFDR Zero Education Mismatch (Supply); Cohort Change vs. Stable Productivity

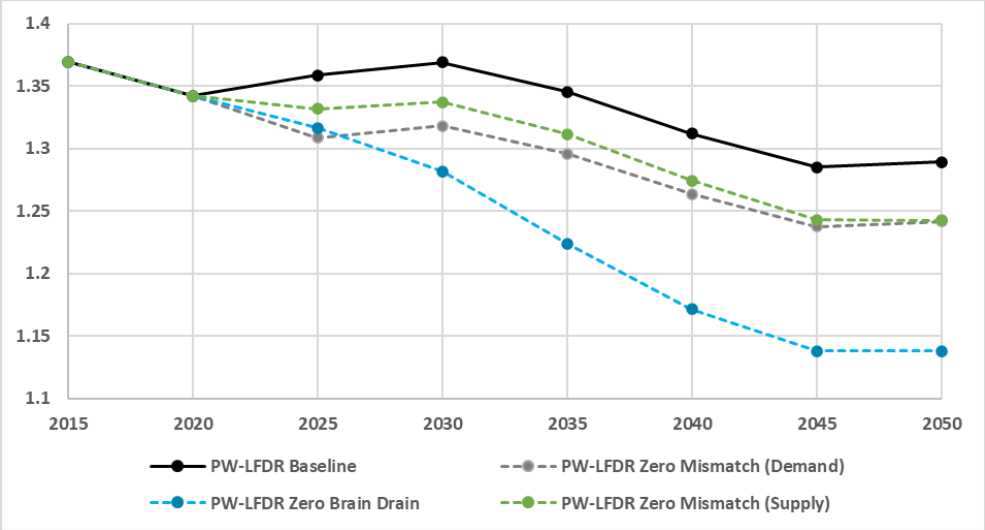


Note: This chart tests the differences when assuming constant productivity vs. cohort improvement, where productivity differentials by age, sex, and education stick with the respective cohorts and the differentials of the cohort aged 15-19 in 2020 are adopted by all younger cohorts. All other scenarios in this study assume education- and sex-specific productivity differentials follow 5yr age cohorts.

Another way to look at education mismatches is from the demand side of labor, specifically job shortages. Estimates by Armstat (2021) put the average unfilled job rate at about 2.18% of total jobs. The Minister of Economy has characterized the situation in quite serious terms, stating that "acute demand for labor in construction, agriculture, information technology, the manufacturing sector and even the taxi business" exists, suggesting that labor shortages are on the radar of Armenian policy-makers (Hayrapetian 2021). The presence of labor shortages, even if relatively minor, highlight inefficiencies in the education system. This is particularly noteworthy given the high unemployment rate in Armenia, an indicator of excess of supply of labor. To address this question, this study tested a Zero Mismatch (Demand) scenario where all job shortages are filled by those currently not in the labor force, in order to see how a perfectly operating educational system and allocation of human capital would impact dependency. Findings, shown in Figure 4, reveal a 9.3% decrease in PW-LFDR from 2015 and 2050 if labor shortages were solved, as opposed to the equivalent 5.9% decrease in the baseline scenario. However, this is a naive scenario that does not account for complex

spillover effects and the future of labor demand, which is outside the scope of this study and demographic research more broadly.

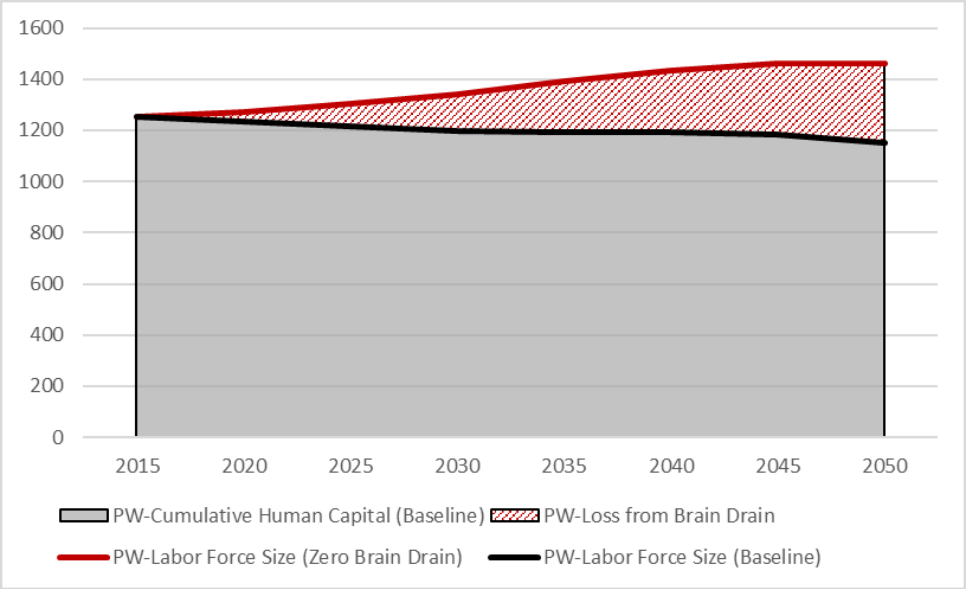
Figure 4: PW-LFDR Baseline vs. PW-LFDRs without Brain Waste and Brain Drain



Note: Baseline is contrasted with a scenario with no migration (Zero Brain Drain), a scenario where the population fills labor shortages (Zero Mismatch – Demand), and a scenario where the supply of workers (by qualification) matches their work (Zero Mismatch – Supply).

Of the PW-LFDR variations produced in this study about brain waste and brain drain, the Zero Brain Drain scenario shows the largest reductions in terms of dependency. At the end of the projection by 2050, in a scenario without migration, Armenia achieves the PW-LFDR value of 1.14, a 16.9% reduction from 2015. This highlights the significance of the role emigration plays in undermining the human capital of Armenia. Another way to conceptualize brain drain losses is through Lost Working Years (LWYs), which amounts to 5,718,379 LWYs over the projection period. These working year losses relative to the baseline scenario are visualized in Figure 5 by the area shaded in red, amounting to a cumulative 13.6% loss from 2015 to 2050, or a 25.4% loss relative to the baseline working years in the final step of the projection 2045-2050.

Figure 5: Productivity-Weighted Labor Force Size in Armenia, Baseline vs. Zero Brain Drain



Note: The area in red represents the cumulative lost human capital due to brain drain, while the area in grey represents the cumulative human capital remaining in Armenia over the period 2015-2050.

Armenia faces similar challenges to many countries in Eastern Europe and the Caucasus which see a significant proportion of their populations lost to emigration. A Zero Brain Drain scenario results in a drop in dependency of 18.2% due to emigrants skewing younger and spreads the inevitable aging over time. As one proxy for human capital abroad, remittances comprised an average of 11.6% of the Armenian economy from 2017-2021 and in the last decade peaked at nearly 20% in 2013 (WB 2023h). In terms of labor force size, the Zero Brain Drain scenario produces a nearly 100,000-person larger labor force (+8.5%) from 2015 to 2050, but naturally more non-workers as well. In the Zero Brain Drain scenario the same demographic processes of aging and decline continue (in a milder form) as long as fertility remains below replacement level and longevity continues to climb.

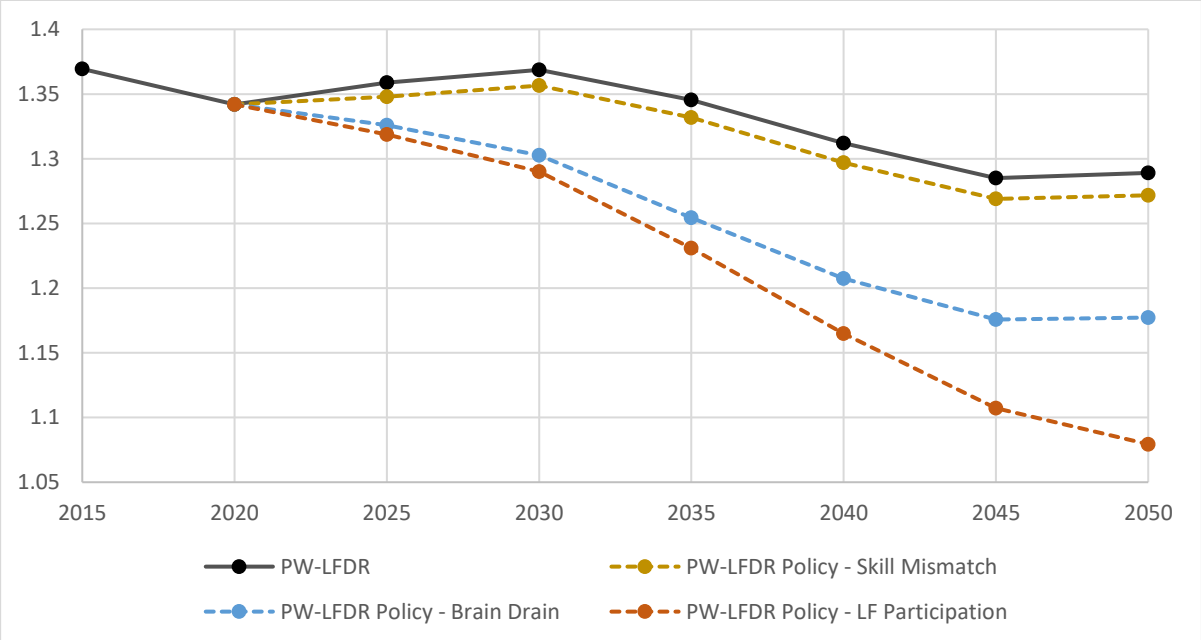
Policy Goal Role Models

A final set of dependency scenarios, seen in Figure 6, were explored based on observed performances in terms of human capital formation (brain waste), retention (brain drain), as well as activation (labor force participation). While the previous scenarios were meant to show the effect of the brain waste and brain drain phenomena, these are meant to rank the

relative importance of more realistic targets for policy-efforts taken from observed performances on different metrics.

In what is found to be the most influential policy intervention for dependency, Armenia is projected to achieve a PW-LFDR of 1.08 by 2050 when labor force participation rises. Specifically, this occurs if participation reaches the 2021 upper-middle income average of 64% by 2050, a rate equivalent to top performers in Central and Eastern Europe. Such a change would represent a 16.3% reduction in dependency relative to the baseline scenario in 2050, (or -21.2% from where it stood in 2015). Higher participation rates are generally made possible through flexible parental leave and active aging policies, among other economic and cultural factors. Such findings of the power of changes in labor force participation in Armenia align with the lessons from a European Commission study (Lutz et al. 2019), and Marois et al. (2020), which use Swedish labor force participation rates as the target for an improved participation scenario and find the top EU performers[8] to be Hungary (0.88), Slovakia (0.91), Cyprus (0.92), Estonia (0.94), and Poland (0.94).

Figure 6: PW-LFDR, Baseline vs. Policy Goal Scenarios for Brain Waste, Brain Drain, and Labor Force Participation



Note: By the end of the projection period (2050) the reduction in dependency relative to the 2050 baseline value in each policy goal scenario is as follows: Skills Mismatch (-1.3%), Brain Drain (-8.7%), and Labor Force Participation (-16.3%).

[8] Excluding countries with populations under 1 million.

The second most consequential policy achievement is the PW-LFDR Moderate Emigration scenario, where net migration reduces to the average observed in the peer group, upper-middle income countries. Specifically, the findings suggest an 8.7% reduction in dependency relative to the baseline in 2050, and 14% reduction in dependency relative to the 2015 projection start. Renewed policy interest in this direction has been underway in Armenia, signified by the restructuring of Government Ministries and the creation of an Office of the High Commissioner for Diaspora Affairs in June 2019. The Office is charged with cultivating cultural and economic ties between Armenia and the diaspora, and to create a centralized, easily navigable repatriation infrastructure making the prospect of returning more attractive (Gov. of Armenia 2023; Gregorian 2022). As many upper-middle income countries struggle with human capital flight, broader efforts to improve the economy will need to be successful before the economic push-factors are sufficiently moderated. Furthermore, pull-factors exist as an additional force in play. Although decisions in foreign countries are largely outside of the sending countries' control, formal agreements involving labor or educational exchanges that require mutual participation may inadvertently facilitate brain drain depending on their formulation.

Lastly, the scenario of an approximate 50% improved performance in education mismatch (PW-LFDR Reduced Educational Mismatch) appears the least consequential for dependency of the three goals tested, producing a 1.3% reduction in dependency from the baseline in 2050, and a 7.1% reduction compared to 2015. This result is a partial function of the proxy used for productivity differentials by education in Armenia, as well as the data on mismatches themselves, which represents a likely undercounting of its true prevalence in Armenian society both in magnitude and quality due to data availability. Mismatches create a false sense of economic well-being by giving the illusion of employment and stability, while having a negative correlation with productivity and in-effect imposing a hidden tax on employers (Puckett et al. 2020). In terms of the most pressing educational mismatch problems and resulting troubles finding a suitable job, unemployment rates of Armenian workers with vocational education are in fact slightly worse than those with general secondary education, unlike vocational benefits in other EU 'Eastern Partnership' countries, which typically leads to better employment outcomes for graduates (ETF 2022). The vocational employment rate 'benefit' comes out to -1.1% (-5.6% relative change), compared to an average of +1.7% (+43.2% relative change) in Belarus, Georgia, Moldova, and Ukraine

(2022). This suggests a need for relative improvements in the quality of vocational training, in addition to the overall lifting of standards by educational attainment to reach employment outcomes similar to peer countries.

Conclusions

Armenia faces demographic challenges in line with many post-*Demographic Transition* countries. In spite of the ongoing transformation of the population size and structure, the country appears to be in a less precarious position – in terms of dependency burdens – than conventional analysis would suggest. This paper contributes to research on emerging population trends in Armenia by calculating LFDRs and exploring what common policy responses might hope to achieve. A particular focus is given to human capital formation and retention given the growing prominence of such themes in adaptation strategies to the future effects of population aging and decline. While this study concerns the specific situation of Armenia, the general lessons for the coming decades hold relevance for many of the former Soviet republics.

In spite of the much higher absolute burden revealed by the use of more sophisticated, multi-dimensional measures to calculate dependency, the relative stability of PW-LFDR over time implies a much more manageable future burden. This underscores the need for demographic analyses to no longer rely on the conventional, solely age-based methods when investigating the effects of population aging and decline. While some trends (gains in labor force participation and educational attainment) are shown to help maintain the contemporary level of dependency in Armenia over the coming decades, other trends (brain drain and brain waste) undercut potential for reducing dependency burdens and improved socio-economic development more broadly. Muted economic growth encourages the outflows of Armenians and undercuts the accumulation of a critical mass of human capital, prolonging time spent at the high end of the bell-shaped emigration-development curve (Dao et al. 2017).

The future quality of an educational system has far-reaching implications for a country's human capital, as it is the primary formal institution for preparing citizens to establish their work lives. Objective educational outcomes such as low test scores or high educational mismatches by international standards, reflect in part the inefficiencies of an educational

system. While not unique, the Armenian higher education system is structured in a way that incentivizes institutions to increasing enrollment and graduation rates, even if it comes at the expense of quality of outcomes. Additionally, findings by Bils & Klenow (2000) suggest that quantity of schooling explains less than a third of economic growth. Aligning the interests of institutions with employment of graduates would be an important step in policy-efforts to reduce educational-labor market misalignment, which directly results in brain waste, and indirectly, brain drain. Further lost potential is evident in the form of 1) inefficient use of the limited state resources in Armenia with 9.3% of the total budget spent from 2017-2021 (WB 2023i); 2) direct costs to the individual for vocational education (775,000 AMD), bachelor (2,060,000 AMD), or master (3,090,000 AMD) over the course of the degree programs (Sargsyan 2020); and 3) indirect investments in the form of time. Besides the tangible outcomes of education, trust is important as most of those emigrating believe finding work is still heavily linked to connections, whereas those who stay tend to have faith in the emergence of merit and hard work-based hiring (Lieberman 2022).

Notwithstanding other demographic interventions by the state, such as family support policies, establishing conditions to curb brain waste and closely-related brain drain are shown to have 1.3% and 8.2% potential for additional reductions in dependency past the baseline decline respectively, based on observed international performances. The findings of this paper also reveal the relative importance of labor force participation as a consequential policy target to push dependency downwards (16.3% in 2050 relative to the baseline), a sentiment echoed by the World Bank in Armenia (Honorati et al. 2019). Educational mismatch, brain drain, and labor force participation are inter-dependent, self-reinforcing phenomena that hold influence over a country's development prospects. Ultimately, the ability of a population to capably respond not only to demographic (but also economic and technological) change with resilience, hangs on the quality of human capital and its integration into the labor force.

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3. Conclusions

3.1. Main Findings

The findings from this cumulative doctoral work broadly affirm expected ranges of population aging and depopulation in Eastern Europe, while also quantifying the extent of brain drain and overall growth in human capital and testing the malleability of such trends in different policy-oriented scenarios. New applications of dependency measures for select countries are also implemented, finding that the fundamental story about the consequences of demographic change is heavily influenced by the measure of dependency used. Below is a brief summary of the results.

Comparing the major regions of the EU between 2020 and 2060, Eastern Europe is shown to maintain a higher proportion of its population in the conventional working ages (20-64) in the baseline scenario, compared to Southern Europe. By 2060 however, Eastern Europe (currently the youngest region in Europe) is expected to age quicker and 'catch up' with Western Europe in terms of the proportion of the population aged 65+ and total age dependency burdens. Table 1 shows projected population aging according to the results of paper one, shown aside the equivalent projections on the pace of aging from the UN, Eurostat, and WIC. The differences in projected aging are primarily due to updated baseline populations and differing assumptions about migration.

Table 1: Change in the Proportion of the Population Aged 65+ from 2020 to 2050

	United Nations	Eurostat	WIC	Doctoral Work
Armenia	75.8%	--	108.3%	99%
Georgia	45.8%	--	86.5%	48%
North Macedonia	84.6%	--	99.8%	67.3%
Romania	47.4%	61.1%	69.7%	48.6%
Ukraine	75%	--	50.7%	67.2% to 68.3%

Sources: UN (2019); Eurostat (2021); WIC = Lutz et al. (2018); Doctoral Work = KC & Gailey (2023)

Parts of Europe now face depopulation following centuries of population growth, which began in the High Middle Ages and sustained a rapid pace through the industrial era (Lutz & Gailey 2020). Eastern Europe shares with the highly developed nations of East Asia the likely prospect of population decline over the coming decades. Western Europe would also manifest

declines in accordance with its natural growth rate, if not for immigration (both from Eastern Europe and outside of the EU). Table 2 makes a comparison of projected depopulation, with the differing results being a function of the updated base population data and/or migration data used as inputs.

Table 2: Change in Population Size from 2020 to 2050

	United Nations	Eurostat	WIC	Doctoral Work
Armenia	5%	--	15.9%	5.2%
Georgia	11.8%	--	29.4%	8.7%
North Macedonia	10.8%	--	15.6%	35.6%
Romania	15.5%	19.6%	24.3%	19.9%
Ukraine	19.5%	--	13.7%	21.1% to 34.4%

Sources: UN (2019); Eurostat (2021); WIC = Lutz et al. (2018); Doctoral Work = KC & Gailey (2023)

When quantifying the extent of brain drain for the five countries considered in KC & Gailey (2023), it was found that the accumulated (2020-2050) losses of skilled human capital (individuals with completed tertiary or vocational education) reach an average of 32.6% relative to the equivalently skilled population in 2050. Put another way, the gap between Armenia's productivity-weighted labor force in the 'Baseline' and 'Zero Brain Drain' scenarios amounts to an annual average of 13.6% over the period 2015-2050, or 25.4% in 2050. The scale of this lost potential over time is high by the standards of other measures of lost economic opportunity and underutilized capacity. Such is the case for the natural unemployment rate, which is considered acceptable at levels of 4% to 5% (Kagan 2021), or the consequential metric of labor force participation, which has a maximum variation of 26% between best and worst performing OECD countries (OECD 2022). These results on brain drain are to be understood as country-context specific rather than internationally comparable or an all-encompassing value for human capital. As cited in the Georgia-focused paper, work by Reiter et al. (2020) and Lutz et al. (2021) argues what many would instinctively suspect, which is that quality of educational outcomes is complex and human capital ideally should not be measured by quantity of school alone if additional relevant data on quality exists.

In spite of the aging and depopulation driven by low fertility and high emigration, human capital (as measured by educational attainment) is set to grow – at least as a relative share of the populations covered. This is true among the highly educated working age populations in both the projections for Eastern Europe as a whole (+67.9%) from 2015-2060 (Potancokova

et al. 2021), and for the select five countries in KC & Gailey (2023) an average of +32.5% from 2020-2050. Whether these potential gains also occur in absolute terms, the overall size of the highly skilled working age population, varies by country. Individual human capital improvements propel both economic productivity (Botev et al. 2019) as well as technological innovation due to better research and development (Prettner & Trimborn 2017; Bils & Klenow 2000), with a critical mass of human capital being a precondition for sustaining functioning industries, specialization of the economy, and even talent retention.

After establishing the baseline demographic outlook, another question concerns the extent to which these futures are inevitable, which was tested with alternative 'what-if' scenarios. Different migration scenarios (based loosely on the Canadian and Japanese models) result in significant variations in change of overall population size (and working age population sizes) across European macro regions between 2020-2060, yet the populations age and the age-based dependency burdens clearly grow irrespective of the starkly different migration scenarios. In terms of the five countries featured in paper one, the realizing 'desired fertility' as expressed in surveys would mean the return of a more traditional pyramid shaped population age structure over the course of a few decades. If policies would further facilitate youth intentions to emigrate, this would nearly double aging and depopulation and reverse human capital gains (absolute gains in all cases, and even relative gains in some cases) between 2020 and 2050. Conversely, if policies would help moderate emigration to be in keeping with the global average for low- and middle-income countries, demographic change would be moderated and dependency more favorable (e.g. -8.7% in Armenia's productivity-weighted labor force dependency in 2050 relative to the baseline). In these alternative migration and fertility scenarios, human capital (absolute levels) and brain drain vary widely, but in most cases, the future populations would still make relative gains due to *Demographic Metabolism,* the natural cycling of generations.

While educational growth is found to partially compensate for population declines (Prettner et al. 2013), the effect is less pronounced in the depopulating countries of Eastern Europe due in part to brain drain (Siskova et al. 2022). In this doctoral work, non-conventional measures of aging and dependency from a human capital perspective are explored, supporting a more optimistic picture than suggested by the prevailing methods. Findings for the five countries selected in paper one, which used an adjusted definition of 'old age' to 15 years of remaining life according to Sanderson & Scherbov's methodology (2008; 2010), show roughly a quarter

of the increase in aging (15.2%) compared to the conventional 65+ measure (66.1%) between 2020-2050. Tables 3 and 4 show a selection of results on Georgia and Armenia respectively, highlighting the widely different outcomes contingent on the definition of who counts as a dependency burden. In spite of the variation among sources on the extent of the change in age-based dependency burdens, there appears to be large growth in all cases. However, various alternative measures of dependency implemented in this doctoral work (highlighted in blue) account for education-based differentials in labor force participation and productivity and indicate near-stabilization or slight decreases in dependency.

Table 3: Change in select Dependency Ratios, Georgia, 2015-2050

Conventional Age-Based Dependency				Refined Dependency Measures		
Total Age Dep. Ratio (UN)	Total Age Dep. Ratio (Wittgenstein Centre)	Total Age Dep. Ratio*	Old-Age Dep. Ratio*	Labor Force Dep. Ratio (LFDR)*	Productivity Weighted-LFDR*	Potential Contributions Dep. Ratio*
+26.6%	+60%	+25.2%	+70%	-2.4%	-6.5%	-8%

Note 1: Percentages show the change relative to 2015.
Note 2: Total Age Dependency, where 'productive' ages = 15-64; Old-Age Dependency, where 'old age' = 65+
Note 3: Ratios calculated with data from (UN 2022), and for the Wittgenstein Centre (Lutz et al. 2018). Sources and definitions for those with an asterisk (*) are covered in Part 3 of this thesis.
Note 4: The difference in Total Age Dependency Ratios from the Wittgenstein Centre and the UN/doctoral work is largely due to the use of updated data for the starting population size and the implementation of different assumptions about future fertility and migration.

Table 4: Change in select Dependency Ratios, Armenia, 2015-2050

Conventional Age-Based Dependency			Refined Dependency Measures		Policy Scenarios		
Total Age Dep. Ratio (UN)	Total Age Dep. Ratio (Wittgenstein Centre)	Total Age Dep. Ratio*	Labor Force Dep. Ratio (LFDR)*	Productivity Weighted-LFDR (PW-LFDR)*	PW-LFDR: Reduced Educational Mismatch*	PW-LFDR: Reduced Brain Drain*	PW-LFDR: Improved Labor force participation*
+32.2%	+54.5%	+50.3%	+0.1%	-5.9%	-7.1%	-14%	-21.2%

Note 1: Percentages show change relative to 2015.
Note 2: Total Age Dependency, where 'productive' ages = 15-64
Note 3: Ratios calculated with data from (UN 2022), and for the Wittgenstein Centre (Lutz et al. 2018). Sources and definitions for those with an asterisk (*) are covered in Part 4 of this thesis.
Note 4: The difference in Total Age Dependency Ratios from the UN and Wittgenstein Centre/doctoral work is largely due to the implementation of different assumptions about future fertility and migration.

A review of population thought over time shows that population growth has been largely synonymous with power and success as it meant society had secured livable conditions for its people (Lutz & Gailey 2020). This was a relatively consistent view across time and place until the industrial revolution, with some exceptions such as Plato arguing for the existence of an ideal population, and the benefits of a large population size being subject to debate in ancient China. Conversely, population decline commonly struck justifiable fear as it was

associated with tragedy and hardships such as disease, war, and famine. The contemporary declines seen in East Asia and Eastern Europe, however, are due to voluntary, or semi-voluntary, conditions concerning lifestyle preferences and financial limitations. Further complexities involve the uneven effects of population decline in terms of the urban-rural divide, regional movements, and population sorting (often by age and education), all of which require attention for fully understanding the true impact of contemporary demographic trends.

More nuanced views on population size and structure lead to questions about the optimal priorities for population policies. The findings from this doctoral work support the idea that a realistic and effective population policy is concerned about the number of people only secondarily to the composition and abilities (human capital) of a population. While there are certainly limits after which population aging and decline becomes difficult to sustain, questions about the future populations in terms of who makes them up (on many dimensions, not just age) and their productive capacities are likely to be more consequential for the future resilience of societies.

3.2. Concluding Remarks

This doctoral work intends to advance research on demographic trends in and around Europe, where timely and far-reaching debates on post-*Demographic Transition* societies are taking place. Contributions of this work include refining population projections by making country-specific updates and accounting for previously overlooked variables. Furthermore, this work put the projected outcomes in context by applying emerging and new methods to answer open questions about dependency burdens in the region. This research connects a range of pressing, demographically-relevant decisions – both direct and indirect – made routinely and inevitably by governments and other relevant actors. The main goal is to identify evidence-based human capital strategies that can remove barriers for individuals in a population to achieve healthy and productive lives, which in turn either moderates demographic change or helps to manage its potential negative consequences.

Established migration regimes within Europe have consistently shifted demographic burdens onto the lesser developed states (Potancokova et al. 2021; Krastev 2020), part of the larger discussions about a vision for intra-European relations amid imbalances and expectations of ‘solidarity’. In a 2014 speech, the EU Commissioner for Employment, Social Affairs, and

Inclusion, László Andor, argued in favor of both the legal framework that allows individuals to migrate, as well as the economic benefits it brings the EU. He stated however that, "when the most talented people leave, achieving an economic recovery in the countries of origin can actually become more difficult", going on to also briefly recognize pull-factors in the receiving countries (EC 2014). When such topics are discussed by policy-makers in Europe, typically emphasis is placed on reducing push-factors, treating pull-factors as a given, which misses an important part of the dynamic and produces lopsided transfers of human capital (Carragher 2021; Armand 2020). Among the most prominent players, Germany has made recent moves to accelerate economic integration of Ukrainian refugees for filling its domestic labor gaps (Dahm & Kurmayer 2022) and previously looked to recruit professionals from the Balkans (DW 2020a/b; 2018), while the EU has similarly launched a series of "Skills and Talent" proposals intended to attract skilled migrants to satisfy the perceived needs of its economy, among other reasons (EC 2022). These policy actions suggest that explicit migration pull-factors from neighbors will likely be a persistent challenge for Eastern Europe and its efforts to build up human capital.

Indirect pressures from inefficient education-to-work transitions also contribute to accelerating the phenomenon of brain drain, a widespread worry on the minds of many Eastern (as well as Southern) Europeans (Krastev et al. 2019). As society's primary social institution for human capital formation, education systems are designed with different priorities across countries. The broad regional patterns among European education systems are characterized as universalistic (Scandinavia), liberal (UK/Ireland), employment-centered (Continental West Europe), sub-protective (Southern Europe), and post-socialist transitional (Eastern Europe) – which is the most heterogenous of the regional groups and has adopted a mix of the liberal and employment-centered approaches (Hadjivassiliou et al. 2016; Pastore & Zimmermann 2019). Cedefop's European Skills Index (2022), measuring skills matching, reveals that many countries in Europe's East show relatively strong performances compared to the rest of Europe. Although job outcomes are perhaps the single most important factor, additional factors such as years spent in education, dropout rates, and quality of education matter when judging the overall efficiency of a given system. On the larger point about labor supply however, a literature review by Brunello & Wruuck (2019) shows that labor shortages in Europe's East (estimated to impact 40% of businesses) are more than double as common than in the West/North (15%). While the authors point out that the company-reported labor shortages likely overstate the problem, the general trends show that domestic successes in

skills matching may not prevent labor shortages depending on pull-factors and the state of education-economy disconnects in neighboring countries.

Besides policies affecting migration, those that concern work-life balance hold influence over the ability of a population to establish and grow families. Greulich et al. (2016) find that in low fertility countries of Europe, the transition to a second child depends heavily on the ability to balance work responsibilities, with childcare being the most crucial of policies. Different from German-speaking and Mediterranean Europe, childlessness has been a relatively minor phenomenon in Eastern Europe, as first order children are overrepresented (2016). This reflects broadly popular determination to have kids rather than childbearing intentions being concentrated in a narrower contingent of prolific families. Furthermore, desired fertility in Europe is regularly shown to be at or above replacement level for most countries (Beaujouan & Berghammer 2019; OECD 2016; Testa 2012). While the valuation of children exists, at least in principle, making the jump to actualize intentions requires confidence in the future and depends on cultural sensibilities about being prepared for parenthood. The extent to which policies can reduce tradeoffs related to competing life goals, particularly with regards to work, the higher the chance of allowing conditions conducive to higher fertility. Attempts to reconcile competing attentions in modern life have mixed results, with those giving stability by guaranteeing childcare and ensuring returns to working life for mothers more successful than one-time payments (Lutz & Gailey 2020; Sobotka et al. 2019).

While some prospects such as population aging are largely inevitable and a product of development successes, others like brain drain and depopulation are somewhat more amenable to policy interventions. Even in the event of current trends continuing, the widely feared overgrowth in dependency burdens appears much milder than commonly assumed by solely age-based analyses. This is especially the case if strategies to adapt can reinforce current momentum for both greater labor force participation and expanding human capital. The fate of these two factors, along with the direction of fertility in the long run, will hold large influence over the future extent and manageability of dependency. While this doctoral work is based on the most common policy concerns (primarily economic) in Post-*Demographic Transition* societies, other domains of life including culture and geopolitical matters warrant further attention for a comprehensive view of Eastern Europe's unfolding, multi-faceted demographic change over the coming decades.

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