Intellectual Merit: The effects of the migration of low-skill Eastern Europeans into the UK and EU have been political debated, although empirical work suggests that low-skill immigration has a small negative effect on average British wages. However, individual-level migration data suggests that Eastern European migrants tend to be highly educated and highly skilled **[1]**, motivating my proposed investigation of the effects of the emigration of high-human capital individuals from Eastern Europe following the collapse of communism in the nineties. In particular, what are the macroeconomic impacts of a shock to the distribution of human capital as a result of immigration?

Empirical work suggests that there are large differences in output per worker across countries **[2],** and that differences in total factor productivity (TFP) account for the bulk of these differences in output **[3].** The mass emigration of high human capital workers decreases aggregate productivity directly through the decrease in labor productivity. Research on the emigration of academic Jewish scientists in Nazi Germany **[4, 5]** shows that there are persistent negative impacts on emigrants' departments' performances because the replacements are of lower intellectual caliber and positive effects on receiving departments' patenting. This micro work validates macro-theoretical research on shocks to human capital.

One aspect of Schumpeterian growth theory is that innovations are the result of firms' investment decisions based on expectations of future profits. Previous work has made the connection between national knowledge stock and innovation at the scientific frontier. My work bridges the connection between negative shocks to population and aggregate human capital with innovation in a technology-follower setting. I incorporate the firm's trade-off between investment in R&D and production as a function of the distributional shift in human capital, specifically firms' decisions to invest in R&D as a result of Eastern European emigration in the 1990s.

Methods: I will construct a general equilibrium overlapping generations (OLG) model of a small open economy populated by heterogeneous agents that vary in their stock of human capital and age, and then apply this framework to estimate the impact of the migration-induced productivity shock on Bulgaria's economic growth. Using the structural model, I am able to analyze the welfare effects on heterogeneous individuals through equilibrium values of the model.

Human capital accumulation is an endogenous process, meaning that agents choose their optimal level of human capital. The agents allocate their time between labor, leisure, and human capital accumulation in each period. Firms split labor and capital inputs into production and research, where the research production function is governed by a Poisson process. Intuitively, investment in research yields innovations or tangible improvements in technology at random and fairly rare points in time, and this understanding of knowledge production closely fits within a Poisson process. The parameter that governs this Poisson process is endogenously determined by the stock of human capital in the labor force available to the firm and the existing stock of knowledge. In other words, within a discrete period of the model, the discovery of one innovation does not have any bearing on the discovery of a second innovation (memoryless property of the Poisson distribution), but between periods the total innovations impact the rate of knowledge production. The firm faces a tradeoff between production for profit in a given period and investment in research for a potential payoff in a future period. This decision involves risk. Firms also consider distortionary taxes and expectations about economic conditions in their decision.

One metric of innovation is patent applications. Applications are a reasonable proxy for immigration because patent applications are not dependent on a government agency's determination of the worthiness of an innovation for being patented. In a revealed preference framework, applying for a patent indicates that the firm believes it has produced innovation worthy of patenting. This belief informs their decision to invest in research and development. The preparation of a patent application is not without effort; therefore, applying for a patent represents the firm beliefs I am interested in capturing.

I will calibrate my structural OLG model to Bulgarian data to conduct a policy experiment on emigration. Using individual-level data, the Mincerian earnings function for the returns to schooling and experience can be calculated **[6]**, which gives direct estimates of the parameters governing the human capital accumulation decision by the agent. The weight of consumption in utility is adjusted to capture aggregate hours worked in the data (available from OECD), and this parameter characterizes the labor-leisure decision of the agents. The parameters governing the relationship between the rate of knowledge

production and human capital are estimated in the literature. These parameters combined with the first-order conditions of the structural model determine the firm's behavior. Because I can fluently read and speak Bulgarian and my personal experiences, I am uniquely able to obtain the necessary innovation data to calibrate the rest of model. Otherwise, standard data and computational resources are sufficient.

Because the migration decision depends on a number of unobservable characteristics, it is implausible to include this decision in a structural model. Information about the types of people who migrate, include their ages, educational levels, and work experience are observable in individual-level surveys conducted in Bulgaria. Accordingly, emigration is captured by changes in the relative sizes of human capital and age cohorts as well as level changes in population. Additionally, as a result of bottlenecks related to work visas, documentation, and language barriers, this mass migration does not happen immediately after the collapse of communism. This delay in the timing of the migration shock allows for a few years post-collapse to establish the baseline macroeconomic trends.

Thus, there are two balanced growth paths of interest. One growth path is the case where no migration occurs, and the model is calibrated to match the known pre-shock periods. The other growth path includes the migration shock, and data on immigrants is used to adjust the measures of ages and human capital types. The comparison between the second balanced growth path and the data measures the performance and predictive capacity of the model, while the comparison between the second growth path and the first (the simulated counterfactual) represents the effect of the migration shock. A successful model will replicate targeted moments of the data.

Broader Impacts: Understanding the effects of high-skilled emigration is crucial to reconciling why the economies of Eastern and Western Europe have not converged since the 1990s and designing policies that encourage talent to remain in Eastern Europe. The model I propose captures another dynamic of migration through shifts in the age distribution. Empirical work indicates that migrants tend to be younger, and a large migration event such as in Eastern Europe following 1991 may shift the age distribution upward. Previous work has analyzed the macroeconomic implications of an aging population as well as changes to human capital separately, but the interaction between the two remains an open question. My model and associated calibration would partially fill this gap in the literature.

Furthermore, the mass migration of young people negatively shocks the population growth rate. Because the growth rate of the population is determined by the proportion of young people, the one-period shock to the population growth rate propagates through R generations, where R is the cutoff between young and old. Combining this with the level decline in population as a result of the shock, my model also captures the absolute population declines observed in some Eastern European countries. Because population declines independent of wars, pandemics, and the like are rarely observed, there is little empirical work on the macroeconomic implications of declining populations. My model and computational approach incorporates these effects and could isolate them via simulating an age-biased, human capital-neutral migration event, where migrants are young but equally skilled as the population. Several countries in Asia, Western Europe, and Latin America are expected to experience population decline in the near future, and the mass-migration events of the nineties started this process earlier in Eastern Europe than the rest of the world. Accordingly, my findings on the effects of population decline are of significant interest and would contribute to an open and deeply relevant question.

Moreover, the relationship between high-skilled emigration and innovation is not limited to Eastern Europe. There are several US states, including my home state, Kansas, with net high school and college graduates leaving, resulting in a negative shock to human capital. During the Covid-19 pandemic, several Midwestern cities, including Topeka, Kansas, adopted policies that gave workers a lump-sum transfer of money in exchange for moving and living in the city for at least a year. A natural extension of my work is to evaluate the prevalence and demographics of uptakers of such policies, and then analyze my model with shocks to the human capital distribution as observed in the data.

References: **[1]** IMF report "Emigration and its Economic Impact on Eastern Europe" **[2]** McGrattan and Schmitz, (1998) Federal Reserve Bank of Minneapolis **[3]** Hall and Jones (1999) QJE **[4]** Moesa et al (2014) American Economic Review **[5]** Waldinger (2016) Review of Economics and Statistics **[6]** Patrinos (2016) IZA World of Labor