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Investigating the Effects of Migration on Economic Growth in Aging OECD

Countries from 1975-2015

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Abstract

This paper investigates whether open migration policies have alleviated any potentially negative effects that aging populations have on economic growth in 29 developed OECD countries from 1975-2015. From 1975 to 1995, aging slowed economic growth, while from 1995 to 2015, aging had little effect on growth. Further, migrants did not curb any negative effects associated with aging from 1975-2015. I also find that the popular Card (2001) migration instrument has little predictive power in an international context. Lastly, I find that contemporaneous economic growth does not affect the rate of aging in a country, which calls into question the use of aging instruments in other cross-country studies.

Introduction

Have open migration policies alleviated the potentially negative effects that aging populations have on economic growth in developed OECD countries? The share of 60+ year olds in developed countries has increased from 11% in 1950 to 20% in 2005, and by 2050, the share will increase to around 33% (United Nations 2009). While several factors associated with economic growth, like lower fertility rates and health care advances, have fueled population aging, a number of studies have projected that aging can slow economic growth potential (Preston 1975, National Research Council, 2012; Sheiner 2014). Specifically, population aging can shrink a country's labor supply, decrease the national savings rate, and strain national social security systems.

As developed countries begin to grapple with the negative effects of aging, migration has become a central political and human rights issue throughout the world. The Syrian refugee crisis and the rise of anti-immigration sentiment has brought significant attention to the social and economic implications of migration policies. To inform this important discussion, a proper understanding of the economic impact of migrants is critical.

Since much of the economic argument against immigration rests in the labor market, most economic literature has analyzed the effect of immigration on native labor. Several papers argue that migrants can crowd out native workers and bring down wages, while others suggest that migrants can complement the native workforce (Borjas 2003, Card 2005). Fewer studies have analyzed the effect of migration on GDP per capita. While some papers argue that an influx of migrants can dilute the amount of resources each individual has, migrants also tend to bring important skills to a host country, boosting labor productivity and economic growth (Boubtane and Dumont 2016; Alesina, Harnoss and Rapaport 2016).

Since most immigrants move to seek work, they also tend to increase the working age population of a country (Figure 6a and 6b). As I discussed earlier, many developed countries are grappling with the negative effects of aging. In this paper I ask: by increasing the working age population of a county, can migrants boost economic growth in aging countries? More specifically, I investigate how aging and migrant stock growth has affected the output growth rate in 29 OECD countries from 1975 to 2015.

This paper contributes to the existing literature in several ways. While many studies have projected the consequences of aging in the future, I only found 3 papers that estimate the realized negative effect on economic growth. Bloom, Canning and Finlay (2010) measured a significantly negative effect on Asian countries from 1960-2005; Bloom Canning, and Malaney (2000) measured an insignificantly negative effect on 70 developed and developing countries; and Maestas, Mullen and Powell (2016) found that a 10% increase in the share of 60+ year olds caused a 5.5% reduction in GDP Growth in the U.S from 1980-2015. Furthermore, I wasn't able to find a paper that measured the realized effect of aging across only developed countries. Further, there is no study based in the migration economics literature that investigates if migrants impact the economic growth of their host countries by changing their age structures. By controlling for migration and applying the model used by Maestas, Mullen, and Powell (2016) to the international context, I investigate the impact aging and migration have on 32 OECD countries from 1975 to 2015.

My econometric investigation suggests that from 1975 to 1995, aging slowed economic growth, while from 1995 to 2015, aging had little effect on growth. Further, migrants did not ameliorate any potentially negative effects associated with aging from 1975-2015. I also find that the popular Card (2001) migration instrument has little predictive power in an international context, though at least two cross country studies have used it (Boubtane and Dumont 2016; Dolado et al 1994). Further, I find that contemporaneous economic growth does not affect the rate of aging in a country. This

result calls into question the use of aging instruments in other cross country studies (Bloom Canning, and Malaney 2000; Bloom Canning, Finlay 2010).

I organize the paper in the following manner: I first provide more background literature on the effects of aging and migration on economic growth. I then derive an estimable specification, discuss the econometric strategy I take to insure valid estimates, and review my data sources. I then review my results and discuss the findings in relation to other studies.

Literature Review

To develop a better theoretical understanding of how migrants could ameliorate the potentially negative effects aging has on an economies, I review existing research on the effects aging and migration each have on economic growth.

The Effect of Aging on Economic Growth

Population aging can negatively affect economic growth through three related channels: it can shrink a country's labor supply, decrease the national savings rate, and strain national social security systems. Börsch-Supan (2003) argues that projected capital intensification alone cannot compensate the projected labor supply declines in Europe. Further, he concludes that only countries which invest heavily in human capital and increase the retirement age can alleviate pressure on the labor force.

Lee and Mason (2010) think aging countries will naturally invest more in human capital. Not only do low fertility rates lead to an aging population, they also cause parents

to invest more money into their children's education. Bloom, Canning, and Fink (2011) are skeptical that this natural increase in educational attainment will compensate the negative effects of aging though.

To increase the retirement age, Gruber and Wise (1998) argue that pension systems must be restructured. They find that most national social security programs incentivize individuals to retire earlier than what is optimal for the financial integrity of the social security system. In other words, too many people are relying on social security because they retire too early. They think countries should change the rate of accrual on pension benefits and increase the age at which citizens are eligible for pension benefits. Increasing the retirement age through pension system reform, however, is politically very unpopular, especially among working class citizens (Bloom, D.E., D. Canning, and G. Fink 2011).

Changing age structures can also impact the national savings rate, and consequently, the amount of money available for investment, holding net exports constant. We can trace this theory to the microeconomic level: the ratio of consumption to saving tends to be high among the youth and the elderly and lower for working age adults. Bloom, Canning, and Malaney (2003) find that high savings rates due to a larger working age population was responsible for nearly a third of East Asia's strong economic growth in the second half of the 20th century. But this doesn't necessarily mean older countries have lower savings rates. In fact, the authors note that higher life expectancy-- which leads to older populations-- can also increase the national savings rate.

In a follow up paper, Bloom, Canning, Mansfield, and Moore (2007) find that savings rates increase with life expectancy in countries with universal pension coverage and retirement incentives, but not in countries with pay-as-you-go systems and high replacement rates. In other words, pension systems partially determine how population aging affects the national savings rate.

An aging population can also strain a country's fiscal system. If more people rely on public retiree benefits, then less money can go towards other investments that contribute to economic growth. Another way to think about the fiscal problem is through the dependency ratio of a country --the non working age population over the working age population. In general, an increasing dependency ratio indicates that more youth and retirees depend on the production of the working age population. From a fiscal perspective, an increasing dependency ratio suggests that more people rely on government social security benefits relative to the number of people that invest in pensions and supply income tax revenue for the government. The severity of the fiscal strain depends on many factors including the size and structure of the social security and pension systems, which Weil (2008) discusses in detail. Since pension systems not only affect the severity of fiscal strain, but also the average retirement age and savings patterns of a country, it is clear that pension systems influence the effect aging has GDP growth.

There is also considerable debate on the effect aging can have on labor productivity. Several papers argue that after a threshold age, productivity declines because of cognitive decline, and an inability of older workers to adapt to new

technology (Feyer 2007,2009; Maestas, Mullen, and Powell 2016). But other studies argue that age does not correlate with productivity, as experience can offset these potentially negative effects (National Research Council, 2012).

The Effect of Migration on Economic Growth

While migration has recently taken centerstage in political discussions throughout the world, migration stocks in OECD countries have been increasing for several decades. In 1980, the share of migrants in the 29 OECD countries in this study was 9%, and in 2010, migrants made up 15% of the population (See Figure 3).

Since much of the economic argument against immigration rests in the labor market, much of the economic literature has analyzed the effect of immigration on native labor. Borjas (2003) finds that the average U.S. wage would decrease with more immigrants in the country, suggesting a downward sloping labor demand curve. Borjas (2006) also suggests that higher immigration rates cause the crowding out of native workers. Both of these papers have been challenged by other economists, who argue that migrant workers can complement native laborers (Card 2005, Peri 2008). Using US census data, Peri and Sparber (2010) showed that low skilled immigrant workers can boost the wages of higher skilled native workers.

Fewer studies have analyzed the effect of immigration on output growth. Past studies have found that migration flows can stifle economic growth through the capital dilution effect-- if a country's output grows more slowly than its population, due to migration, each citizen would have fewer resources (Dolado et al, 1994; Barro and

Sala-i-Martin, 1995). But immigrants can offset the capital dilution effect by increasing the productivity of country. Immigrants to OECD countries are on average more educated than the native population (Boubtane and Dumont 2016). Further, low and medium skilled migrants can increase a country's total productivity by bringing different skills that complement native workers (Alesina, Harnoss and Rapaport 2016).

Since most migrants immigrate before the age of 30 for work, migrants decrease the average age of a country and the share of elderly in the population. The median age of native Europeans in 2016 was 42.6, while the median age of migrants in Europe was 27.8 (Eurostat 2016). In our data set, we see a significantly negative correlation between the elderly share of the population and the immigrant share of the population (see Figure 7). Since most migrants leave their host countries to find work, they could theoretically ameliorate the labor shortages associated with aging countries. Further, Cadena and Kovak (2013) found that low skilled immigrants in the U.S. are more effective at filling local labor shortages compared to natives, since migrants are more willing to move to find work.

Can younger migrants also address the low savings rates and fiscal strain associated with aging countries? If migrants have similar savings behavior to natives, then young migrants would contribute to higher national savings rates, but little research has been conducted on this topic. If anything, migrants likely do not contribute as much to capital investment in host countries, as many migrants send remittances back to their origin country. In 2002, a total of 149 billion dollars was sent back to developing

countries across the world, equivalent to 2.4% of the cumulated GDP of these developing countries (OECD 2006) .

The fiscal impact migrants have on economies is also murky. Liebig and Mo (2013) summarize the existing literature on the topic, and conclude that depending on specifications and assumptions, estimates of the fiscal impact of immigration vary. For most OECD countries the impact, whether positive or negative, is no more than 0.5% of GDP. This analysis didn't account for age differentials of migrants to native populations though. Given that migrants decrease the dependency ratio, a country with more migrants would have more taxpayers that do not rely on old age social security benefits.

It's important to note that migrants cannot halt the aging trend in developed countries: open migration policies can only decrease the rate of aging and its consequences across time. After all, migrants age as well. One could then argue that open migration policies only delay the impact aging has on economies, so a more open migration policy shouldn't be considered a viable solution to the aging problem. There are two counter arguments to that: for one, decreasing the rate of aging gives a country more time to adapt to an older population. Second, migrants in host countries tend to have higher fertility rates than natives, so in the long run, migrants could continue to bring youth to a country by having babies. Sobotka (2008) finds that migrant women in European countries have between 0.3 and 0.8 more babies than native women.

To summarize, migrants can address the aging problem in two ways. They can fill in labor shortages, and more generally, they decrease the dependency ratio in a country.

Specification

To study the effect migrants have on GDP growth in aging OECD countries, I apply a model developed by Maestas Mullen and Powell (2016), which they used to study how aging across U.S. states has affected state GDP growth. Like Maestas, Mullen and Powell (2016), I test the model using two specifications: one that assumes a log log relationship between the dependent variable and independent variables of interest, and another that uses a log linear relationship. In this section, I derive the log log specification. In appendix B, I derive the log-linear specification. Consider a general representation of aggregate economic output:

$$y_{ct} = F[\Omega_{ct}, k_{ct}, l_{ct}] = \Omega_{ct}^{\eta_{\Omega}} k_{ct}^{\eta_k} l_{ct}^{\eta_l} \quad (1)$$

Where y_{ct} is output per capita at time t in country c , Ω_{ct} is the per capita stock of ideas and technology or total factor productivity, k_{ct} is the physical capital per person, and l_{ct} is the labor per capita. All η 's are time and country invariant constants-- their conceptual significance will become apparent shortly.

The age of a country's population can affect l_{ct} since an individual's decision to work varies by age. We incorporate age specific employment by assuming labor per capita is a function, p , of the older population share. So $l_{ct} = p(a_{ct})$, where a_{ct} is the older population share at time t in country c .

To show how changes in the factors of production affect aggregate output growth, we differentiate the production function and rearrange terms to express the percent

change in per capita output as a function of production elasticities (the η 's) and percent changes in each factor of production.

$$\frac{dy_{ct}}{y_{ct}} = \eta_{\Omega} \frac{d\Omega_{ct}}{\Omega_{ct}} + \eta_k \frac{dk_{ct}}{k_{ct}} + \eta_l \frac{dl_{ct}}{l_{ct}} \quad (2)$$

where $\eta_{\Omega} = \frac{\partial F(\Omega_{ct}, k_{ct}, l_{ct})}{\partial \Omega_{ct}} \frac{\Omega_{ct}}{F(\Omega_{ct}, k_{ct}, l_{ct})}$, $\eta_k = \frac{\partial F(\Omega_{ct}, k_{ct}, l_{ct})}{\partial k_{ct}} \frac{k_{ct}}{F(\Omega_{ct}, k_{ct}, l_{ct})}$, and

$$\eta_l = \frac{\partial F(\Omega_{ct}, k_{ct}, l_{ct})}{\partial l_{ct}} \frac{l_{ct}}{F(\Omega_{ct}, k_{ct}, l_{ct})}$$

Since the coefficients associated with a log-log regression are elasticities, we can rewrite equation (2) as:

$$\ln y_{ct} = \eta_{\Omega} \ln \Omega_{ct} + \eta_k \ln k_{ct} + \eta_l \ln a_{ct}$$

Note that the elasticities are constant across time and country, and that they are functions technology, labor per capita, and physical capital per capita. Thus, the model allows the labor input to affect production through interactions with stocks of capital and technology.

Using the definition of l , and letting superscript a designate the elasticity of l with respect to the older population share, we have:

$$\frac{dy_{ct}}{y_{ct}} = \eta_{\Omega} \frac{d\Omega_{ct}}{\Omega_{ct}} + \eta_k \frac{dk_{ct}}{k_{ct}} + \eta_l [\eta_p^a] \frac{da_{ct}}{a_{ct}} \quad (3)$$

$$\eta_p^a = \frac{dp_t(a_{ct})}{da_{ct}} \frac{a_{ct}}{p_t(a_{ct})}$$

Equation (3) suggests the relationship between output growth and the growth of the older population share depends on two elasticities. First, η_p , the elasticity of production with respect to the economy's labor supply. Second, η_p^a , the elasticity of the labor force participation with respect to the older share.

Empirical Strategy

Maestas, Mullen, and Powell (2016) specification

Again, since the coefficients associated with a log-log regression are elasticities, equation (3) is equivalent to:

$$\ln y_{ct} = \eta_\Omega \ln \Omega_{ct} + \eta_k \ln k_{ct} + \eta_l [\eta_p^a] \ln a_{ct} \quad (4)$$

Using this specification, I could estimate how a 1% increase in the share of migrants leads to a $(\eta_p \eta_p^a)\%$ change in GDP per capita, however the elderly share variable is endogenous. Specifically, increases in GDP per capita has allowed the share of the 60+ population to increase. Further, I could not find a paper that constructed a valid instrument to correct this endogeneity issue. Maestas, Mullen, and Powell (2016) skirt the problem by taking first differences of equation (4) and adding a few control variables:

$$\ln y_{c,t+5} - \ln y_{c,t} = \phi_t + \beta \left(\ln \frac{A_{c,t+5}}{N_{c,t+5}} - \ln \frac{A_{c,t}}{N_{c,t}} \right) + X'_{ct} \delta_t + (\epsilon_{c,t+5} - \epsilon_{c,t}) \quad (5)$$

This is the exact equation Maestas, Mullen, and Powell (2016) used to estimate the effect of aging across states. A represents the number of individuals aged 60 or older, and N is the total population aged 20 or older. When I discuss the instrumental variable I use for

the older share in $t+5$, it will become apparent why N isn't the total population. For the sake of common denominators, y equals Y/N , where Y is GDP. The coefficient β equals the elasticity of output growth with respect to aging. This log-log specification normalizes comparisons of growth across countries with different populations.

Without state level data on physical capital and technology, Maestas, Mullen and Powell (2016) used several control variables in levels that would predispose countries to particular growth paths. φ_t incorporates fixed effects for the time interval t to $t+5$ into the specification. Further, the vector X contains a set of time-varying control variables whose influences are also allowed to vary across time, hence the coefficient vector δ has a subscript t . In X , Maestas, Mullen, and Powell (2016) include the initial (period t) two digit economic sector composition of each state's labor force, specifically the log fraction of workers in each economic sector. In this study, I only had data for the log fraction of workers in services, industry, and agriculture in each country. The effect of economic sector composition varies with time because worker productivity in service jobs has grown faster than in industrial and agricultural jobs over the past 40 years (Maestas, Mullen, and Powell, 2013).

These workforce composition controls prevent an omitted variable issue that could bias the aging coefficient. A country with more service oriented jobs experiences greater GDP growth. Older people also tend to retire later in life in countries that have more service jobs, since they are less physically demanding than agricultural and industrial jobs (Maestas, Mullen and Powell, 2013). Thus, if we didn't include economic

sector composition variables, β would be biased upward, since our data set contains countries where the majority of jobs are in the service sector.

The Aging Instrument

Maestas, Mullen and Powell (2016) argue that the rate of aging across states may depend on output growth, creating an endogeneity issue. The working age population in a state with a struggling economy may move to a state with a booming economy, while retirees are less likely to move. Consequently, the state with the struggling economy would age. Given that I'm studying developed countries in the OECD-- which includes the European Union, the United States, and Canada-- I assume this endogeneity issue could also occur across countries. In other words, I think the labor force in the OECD is mobile enough to migrate across countries in response to output shocks. I test this assumption post regression with Wooldridge's test of Endogeneity (Wooldridge 1995).

To create an instrument that predicts the share of elderly in country c at $t+5$, I scale the instrument Maestas, Mullen and Powell (2016) used for state aging to predict aging across countries. First, I construct international survival rates, or the ratio of the international population age $j+5$ to the age cohort's population size at time t , when they were age j . Then I multiply the number of individuals age j in a country c at time t by the international survival rate to predict the number of individuals of age $j+5$ at time $t+5$. As an example, to predict the number of 60-64 year olds in Finland in 2000, we multiply the number of 55 -59 years olds in Finland in 1995 by the ratio of 60-64 year olds in the

world in 2000 to 55-59 year olds in the world in 1995. In other words, the instrument equals:

$$\ln \frac{\hat{A}_{c,t+5}}{\hat{N}_{c,t+5}} - \ln \frac{A_{c,t}}{N_{c,t}}$$

where

$$\hat{A}_{c,t+5} = \sum_{j \geq 55} C_{jct} \left(\frac{I_{j+5,t+5}}{I_{jt}} \right)$$

and

$$\hat{N}_{c,t+5} = \sum_{j \geq 15} C_{jct} \left(\frac{I_{j+5,t+5}}{I_{jt}} \right)$$

C_{jct} is the population of the j to $j+4$ cohort in country c at time t , and I_{jt} is the international population of cohort j to $j+4$ at time t . To calculate an international survival rate, I only use data from the 29 countries I study. In this approach, countries with a large population of 55-59 year olds in time t are expected to age in time $t+5$, independent of GDP growth. Since we predict age cohorts in time $t+5$ with the population at time t , we could not define N as the whole country's population, as we could not predict the population of the 0-4 age cohort at time $t+5$ using this method. Later in the paper, I will refer to this instrument as the Bartik Instrument, as Bartik (1991) pioneered this instrument to predict local economic growth by interacting national industry specific growth with initial local industry composition.

Expanding the Model to an International Context

While running equation (5) with the aging instrument creates valid estimates for data on one country, using the same specification to study the effect of aging across

countries poses several issues. While Maestas, Mullen and Powell (2016) can assume that U.S. states have similar retirement norms, national pension systems, migration policies, and national fiscal health, an international study cannot assume these factors are constant across countries. By omitting variables that capture the effects from these missing factors, the coefficients in equation (5) may be biased.

Consider the effect migrants have on economic growth and the rate of aging. If migrants have a positive effect on economic growth, then the β in equation (5) would be biased downwards. Take country A that has an open migration policy and an aging native population. Not only would the new migrants in country A lower the rate of aging, reducing the negative effects, they contribute to economic growth regardless of their effect on the age distribution. Since equation (5) does not control for migration, an increase in the rate of aging also correlates with a decrease in the rate of migration, the β in equation (5) would also capture the positive effects migrants have on country A. Further, the Bartik instrument does not control for migration. A country with an open migration policy would have relatively fewer people in older age cohorts at time t ; therefore, the share of migrants in an economy correlates with the predicted aging rate. Further, the flow of migrants from countries outside of the 29 OECD countries would influence the international growth rate, further influencing the predicted aging rate of each country. Specifically, if a country has closed migration policies, then the Bartik instrument may underpredict the rate of aging if there were a large flow of migrants into the 29 countries.

I account for several additional controls in this estimable specification:

$$\begin{aligned} \Delta \ln y_{c,t,t+5} = & \beta_1 \Delta \left(\ln \frac{A}{N} \right)_{c,t,t+5} + \beta_2 \Delta \left(\ln \frac{M}{N} \right)_{c,t,t+5} + \beta_3 \Delta \left(\ln \frac{K}{N} \right)_{c,t,t+5} \\ & + Z'_{ct} \theta + \phi_t + m_c + \Delta \epsilon_{c,t,t+5} \end{aligned} \quad (6)$$

M_{ct} is the population of migrants in country c at time t . A/N_{ct} , and ϕ_t are identical to their counterparts in equation (5). Note that I omit time varying control vector X_{ct} . An F-test revealed that economic sector controls with time varying effects did not have significantly more explanatory power than a specification with sector controls constant over time (See Appendix C). The Z_{ct} vector includes control variables in levels whose influence do not vary over time. Variables in Z_{ct} include the average retirement age, the share of the population with some tertiary education, openness to trade, and the log fraction of workers in industry, agriculture, and services. Since data on physical capital is available on the country scale, we include the growth rate of K/N , which Maestas had to exclude. m_c accounts for time invariant country fixed effects. Note that a fixed effects specification in this first differenced equation equals a country's time invariant gdp growth over time. I review several specification tests to justify the presence of fixed effects in Appendix C. There were no panel data on pension systems, so I assume that m_c , $\Delta \epsilon_{c,t,t+5}$ account for any effect pensions have on gdp growth across countries.

Note that most studies which analyze the effect of migration on output growth specify an estimable equation in levels (Ortega and Peri 2011; Boubtane and Dumont 2016; Aleksynska 2016). In other words, these studies investigate how the migrant share affects the log of GDP per capita, while while my study analyzes how changes in the migrant share affect output growth (the first differenced log of GDP per capita). Given

that previous literature has studied migration in levels, I have a weaker theoretical justification for my first differenced model. I have to specify equation (6) in differences in order to include a valid aging variable.

Let me justify the inclusion of all my additional control variables: I include an openness to trade control since countries with more open trade policies tend to have more open migration policies and higher output growth rates (Ortega and Peri 2011). Excluding a retirement age variable would bias the aging coefficient since a country with a higher average retirement age would likely experience less of the negative effects associated with aging. The physical capital variable would capture any effects aging has on the national savings rates. As discussed in the literature review, more educated countries likely have higher growth rates, and more educated countries tend to be older (Lee and Mason 2010). I also include five additional variables that control for immigrant education, lagged migration flow, business cycles in alternate specifications. I discuss the theoretical justification for these additional controls in Appendix B. In general, I don't include all these controls at once because the original specification in equation (7) already has many independent variables. Including five more controls would introduce more multicollinearity, preventing precise estimates.

As mentioned earlier, I also run the regression with the variables of interest in a log-linear relationship with the dependent variable (see Appendix A for derivation).

Specifically:

$$\Delta \ln y_{c,t,t+5} = \beta_1 \Delta \left(\frac{A}{N} \right)_{c,t,t+5} + \beta_2 \Delta \left(\frac{M}{N} \right)_{c,t,t+5} + \beta_3 \Delta \left(\frac{K}{N} \right)_{c,t,t+5} \quad (7)$$

$$+ Z'_{ct} \theta + \phi_t + m_c + \Delta \epsilon_{c,t,t+5}$$

β_1 , β_2 , β_3 have slightly different interpretations. For example, under this specification: an absolute change in the share of migrants--as opposed to a percent change in the migrant share-- in a country would lead to $\beta_2\%$ change in the growth rate of output. In other words, under this specification, if a country increases its share of migrants from 40% to 41% of the population, it would have the same effect on output if the country's share of migrants increased from 2% to 3%. Under the log-log specification, the latter case would result in a much greater effect on output.

Since migrants tend to immigrate to countries with booming economies, the migration rate variable may be endogenous (Ortega and Peri 2011). I try two different instrumental variable approaches to address this potential endogeneity issue. The first instrument uses an autoregressive model: it predicts the growth rate in the migration share from t to $t+5$ with the growth rate of the migrant share from $t-5$ to t . The second instrument predicts the migrant share of country c at time $t+5$ by assuming that migrants from origin country o tend to settle in a country that already have migrants from country o . Card (2001) pioneered this instrument, and accurately predicted that migrants immigrating to the U.S. tend to settle in cities where other immigrants from their origin country live. To predict the number of migrants coming from country o at time period $t+5$, I first calculate the net change in migration stocks from a country o . This net change functions as a proxy for the flow of migrants out of country o . If host country c has 13%

of the total migrant population from country o at time period t , I assume that 13% of the flow of migrants goes to host country c . To calculate the total number of migrants coming into country c , we add all the predicted number of migrants coming from each origin country. In other words:

$$\frac{\hat{M}_{c,t+5}}{N_{c,t+5}} - \frac{M_c}{N_c}$$

where

$$\hat{M}_{c,t+5} = M_{c,t} + \sum_{o=1}^n (T_{o,t+5} - T_{o,t}) \left(\frac{M_{o,c,t}}{T_{o,t}} \right)$$

T_{ot} is the total number of migrants from from origin country o at time t living throughout the world. There are n countries in the world where migrants come from. Since the share of migrants from origin country o at time t in country c isn't influenced by output growth from t to $t+5$ in country c , this instrument predicts migrant stocks in $t+5$ that are independent of output growth, purging the endogeneity issue. Later in the paper, I will refer to this second instrument as the Card Instrument.

Last two important points on my econometric strategy: First, I run all regressions with clustered (by country) robust standard errors to avoid autocorrelation across panels and heteroskedasticity. Second, in all regressions, I weigh each data point by population since more populated countries effectively have more information on the effect migration rates and aging have on GDP growth. Further, smaller countries are more likely to have outlying data points.

Dataset

This study uses unbalanced panel data from 29 different countries in the OECD from 1975 to 2015 over 5 year intervals. I study only 29 OECD countries since I could not gather all the necessary data for all other countries. Table 2 provides descriptive statistics for all variables relevant to the study. The Penn World Table provided output side real GDP in millions of 2011 dollars at chained PPP's (Feenstra 2015). Figure 1 illustrates that the per capita growth rates in these countries have been positive but declining. I obtained population data by age cohorts from the United Nations Population Division (2015). Figure 2a illustrates that these countries have been aging over time: the average share of 60+ year olds in a country has increased from 23% in 1975 to 28% in 2010. While countries have been aging, it's important to note that the dependency ratio decreased between 1975-2005, which suggests that declining fertility rates have caused the youth share in the dependency ratio to fall faster than the elderly share has increased. Figure 2b shows that the change in the dependency ratio-- the ratio 0 to 20 and 60+ year old population over population of 20-60 year olds-- was negative between 1975-2005.

The United Nations Population Division (2016) provided data on migrant stocks in each host country from 1975-2015, and in 2015, they also released a report that organized host country migrant stocks by origin country from 1990-2015. I used the origin country data to construct the Card instrument. Figure 2 illustrates how the migrant share of the 20+ population has increased from 10% in 1975 to 17% in 2010 in the host countries studied.

As for the controls, the Penn World Table provided a measure of total physical capital as a fraction of GDP-- specifically, the gross capital formation at current PPPs as

% of real GDP. To transform this measure into physical investment per capita, I multiplied this statistic by GDP over the population of 20+ years olds. Barro and Lee (2016) provided data on the percent of the population aged 25+ with some tertiary education in each country over time. Brucker (2013) provided data on the education of immigrants aged 20+ in 20 of the host countries studied from 1990 to 2010. I obtained data on the average effective retirement age of each country at time t from the OECD (2013). To calculate openness to trade, I used the formula: $OPT = \frac{Imports + Exports}{GDP}$. I gathered and added data on the merchandise imports at current PPPs as a percent of real GDP and merchandise exports at current PPPs as a percent of real GDP from the Penn World Table (2016).

I obtained data on the fraction of workers in the industrial, agricultural and service sectors of each country from the OECD (2016). The raw data were indexed to the 2010 economic sector breakdown, classified according to revision two of the International Standard Industrial Classification system. To de-index the data, I used this formula: $pop_{i,t} = pop_{i,2010} \frac{index\ value\ in\ t}{index\ value\ in\ 2010}$, where pop_i is the number of workers in industry i .

Results

Specification Tests

To preface the results of my empirical analysis, I want to discuss several specification tests which indicate that an ordinary least squares regression without instrumental variables likely yields the most efficient and consistent estimation of the data. I first test if the instruments are weak using Shea's adjusted R squared statistic, the appropriate test for cluster robust estimates with more than one instrumental variable

(STATA Corp. 2016)¹. I report the first stage coefficients of the instrumental variables and the corresponding Shea's statistic in Table 4. Under all specifications, the Bartik aging instrument is strong, while both migration instruments are weak. Shea's statistic measures the degree to which the instrumental variable accounts for variation in the endogenous variable that other exogenous variables cannot explain in the first stage regression. While there isn't a universal threshold value for the Shea's statistic which suggests a weak instrument, a negative adjusted R^2 suggests that the instrumental variables do not help predict the potentially endogenous variable at all. Using weak instruments often bias coefficients more than using potentially endogenous variables; therefore, in my main regression I do not run the migration variables with instruments.

Further, to test the endogeneity of the aging variable, I run two stage least squares and conduct a Wooldridge test for endogeneity (Wooldridge 1995)². After running the regression using the log-log and log linear specification, I cannot reject the null hypothesis that the aging variables are exogenous (see Table 5 for exact p values). Since the Wooldridge test suggests that the aging variable is exogenous, I do not use any instrumental variables. Thus, an ordinary least squares estimate yields the most efficient and consistent estimate of the data.

Since the aging variable is exogenous, my instrumental variable analysis suggests that output growth does not affect the aging rate. In other words, workers in the countries studied do not move in significant numbers to other countries in response to a sluggish

¹ I test the Bartik and Card instruments in the log log and log linear specifications. I only test the lagged migrant instrument in the log log specification, since in the log linear specification, the instrument contains a unit root. See Appendix C for further explanation.

² I do not test the endogeneity of the migration variable, since I assume it is exogenous. The Wooldridge test is invalid if the endogenous variable in question is associated with a weak instrument.

economy at home. Given that the migration variables are weak, I cannot conclude that the migration variable is also exogenous.

Preliminary Graphical Analysis

Scatterplots of the variables of interest mostly support the theoretical justification behind this study, especially under the log linear specification. Note that it would be naive to draw any strong conclusions about the relationships between aging, migration and economic growth from these scatter plots. The plots only show correlation and do not account for important control variables. If anything, the scatterplots show the merit of investigating the relationship between aging, migration and economic growth. Figures 3a and 3b confirmed a significantly negative association between aging and the growth rate of per capita GDP. I call the correlation significant because the trendline slope is significantly less than 0 with 95% confidence. The relationship between migration and GDP growth rates depended on specification. Figure 4a suggests a significantly positive correlation between the growth in the migrant share of the population ($\Delta(M/N)$) and the growth rate of per capita GDP, while Figure 4b suggests an insignificantly negative relationship between the growth *rate* of the migrant share ($\%(\Delta M/N)$) and the growth rate of per capita GDP.

Figure 5a shows an insignificantly negative relationship between $\%(\Delta M/N)$ and $\% \Delta(A/N)$ while Figure 5b illustrates a significantly negative relationship between $\Delta(M/N)$ and $\Delta(A/N)$. Further, Figure 6 shows the significantly negative relationship between the migrant share and the share of elderly in the population, which suggests that

migrants tend to be younger than the native population. Overall, the scatter plots that use the log-linear specification support the theoretical justification of this study: migrants promote GDP growth, aging stifles growth, and migrants curb aging. Meanwhile, the log-log specification suggests a murkier relationship between aging, migration rates, and GDP growth.

Analysis of Variables of Interest

The coefficients associated with the aging and migration flow variables were insignificant for nearly every log-log and log-linear specification (Tables 3a and 3b). Column (1) in both tables contains results on the original specification (equations 6 and 7), and Column (2) has results on the specification excluding migration. If the coefficient on the aging variable in Column (1) were significantly higher than the equivalent coefficient in column (2)-- in either the the log-log or log-linear specification--I would have confirmed my hypothesis that excluding migration from the estimate biases the effect of aging on GDP growth. I conduct a crude test on the equality of the coefficients by analyzing their 95% confidence intervals. In both the log-log and log-linear specifications, the aging coefficient in column 1 falls in the confidence interval of the aging coefficient in column 2, and vice versa.

I further analyze the potential for migrants to ameliorate the negative effects of aging by comparing the results from column (1) and (3) in Tables 3a and 3b. The coefficient in column 1 signifies the effect that migration share growth has on GDP per capita, holding aging constant. The corresponding coefficient in column (3) allows aging

variation, so if the migrant coefficient in column (3) were significantly higher than the coefficient in column (1), I would argue that migrants ameliorate the negative effects of aging. The migrant coefficient is insignificantly higher in column (3) under both the log-log and log-linear specifications.

I test the original specifications on data from 1975 to 1995 and then from 1995-2015 to investigate if the effect of aging and migrant growth is insignificant across time periods (see Table 3c). Under both the log-linear and log-log specifications, the coefficient on migration flows insignificantly changed from negative to positive. Both specifications also indicate that the effect of aging on economic growth was significantly negative from 1975-1995, and insignificant from 1995-2015. This could indicate that countries are adapting to an aging population. As for another explanation, I could not include data from Eastern Bloc countries in the 1975-1995 regression--the countries didn't exist-- so these countries could significantly affect the aging coefficient from 1995-2015. To test this latter hypothesis, I exclude the Eastern Block countries while using data from 1995-2015 in Columns (1) and (2) in Table 3d, and find that with or without the Eastern block countries, the coefficients from 1995-2015 look about the same. Overall, this suggests that countries may be adapting to aging economies.

Given that aging significantly hindered GDP growth from 1975 to 1995, I test if migration influenced these significant coefficients using the same procedure described above. Specifically, in Table 3d, columns (3) (4) display regression results for both specifications from 1975 to 1995, excluding migration. If the aging coefficients were significantly more negative, then migrants alleviated some of the negative effects of

aging during 1975-1995. Since the aging coefficients in these regressions do not significantly differ from the aging coefficients in Columns (1) and (3) in Table 3c, we cannot say migration lessened the negative effects of aging. I further test for the effects of migrants in this time interval in columns (5) and (6) of Table 3d. These regressions reveal that the migrant coefficients were not significantly higher when I excluded the aging coefficient.

Due to the insignificance of both variables of interest in columns (1), (2), and (3) in Tables 8a and 8b, I add additional controls to the regressions described in columns (4)-(8). See Appendix B for a theoretical justification on these additional controls. In column (4), I use a one period lagged migration flow variable. If immigrants begin to perform at their economic potential after 5 years, then one would expect the lagged migrant flow variable to have an effect on current GDP growth. Unexpectedly, the coefficient is negative and significant under the log-log specification. This result suggests that a 1% increase in the migrant share growth rate from $t-5$ to t leads to a -0.06% decrease in the growth rate of GDP per capita. By contrast, the corresponding coefficient in the log linear specification is positive and insignificant (see Table 8b). These results suggest that increasing the lagged migrant flows slows growth in countries that have very few migrants in the initial period, while increasing lagged migrant flows has little effect on growth in countries that have a greater share of migrants. Under the log log specification, a country that has very few migrants initially will experience a much greater percent increase in the migrant share than a country with more migrants initially, holding $\Delta M/N$ constant. Consequently, countries with fewer initial migrants have

greater influence on value of the coefficient in the log log specification. Therefore, countries with small initial shares of migrants are likely responsible for the negative coefficient in the log log specification.

The regression in column (4) accounts for the change in the dependency ratio in a country. In order to include the dependency ratio, I have to exclude the aging variable. If both variables are included, their coefficients make little sense: the effect of aging, holding the dependency ratio constant. Under both specifications, the dependency ratio variable and the migration variables were insignificant.

Column (5) contains results on a regression that includes the “residual” variable that proxies the output gap of a country. While the variables of interest are insignificant, the output gap’s coefficient is negative and significant, which indicates that a country below potential at time t is likely going to experience a higher growth rate from t to $t+5$.

In Column (6), the migration variable has varying influences over time. This regression is slightly different from the time restricted regressions in Table 3c, since this regression investigates the migrant growth variable’s effect on output over 7 time intervals, as opposed to the 2 studied in Table 3c. Further, I exclude the aging variable in this equation to allow the rate of aging to vary across panels. If migrants have a greater impact on a country with an older population, one would expect migration flows in the 2000s to have a more positive impact on the host country’s economy than migration flows in the 1980s. Our results in both the log-log and log-linear specification indicate no upward trend in the impact migrants have on their host economy-- all the coefficients are insignificant and nearly all coefficients fall within each other's confidence intervals.

Column (7) in Tables 3a and 3b control for the initial level of immigrant education. While the additional variable has no effect on the migration flow variable, the aging variable in both specifications became significant and negative. This occurred because including an immigrant education variable cut the sample size in half due to data limitations. Only 20 countries from from 1990 to 2015 were used in this regression, so the difference in sample sizes likely caused significantly different coefficient on aging. This result suggests that the effect aging has on economic growth across countries is sensitive to what countries are included in the regression.

Before moving on to the discussion section, I'll briefly how the controls present in all the regressions behaved. The initial openness to trade coefficients are all positive, but only half are significant. Further, coefficients associated with the initial share of the population with some tertiary education were all positive, but only some were significant. While I expected these two variables to have coefficients with positive signs, the occasional insignificance suggests the presence of multicollinearity. As expected, the first differenced capital per capita coefficients were significant and positive for all regressions. The initial effective retirement age coefficients are nearly always negative and significant. Spurious correlation is likely responsible for this result: the retirement age has increased over the period of this study, while GDP growth has been positive but declining over the time period (Table 1)

Discussion and Conclusion

The insignificant results across so many specifications suggest that the effect of migration on the economic growth of aging countries should be studied in individual countries. I have two explanations for my widespread insignificant results. For one, the time and country fixed effects in my study failed to properly capture the effects of pensions systems on GDP growth. Though it is unlikely that the error term captured these policy effects since the R^2 on all my regressions hovered ranged from 0.8 to 0.9. Studying the effect of migration in individual countries would avoid this issue, since each data point is affected by the same national policies.

A second explanation for my insignificant results: I include 4 more controls than Maestas, Mullen and Powell (2016) use and 29 country dummies in order to conduct a cross country analysis. Not only do more variables increase multicollinearity, they may prevent the variables of interest from adequately capturing the effects they have on economic growth. To avoid using so many controls, I recommend again that individual countries should be studied.

How could Bloom, Canning, and Finlay (2010) discern significantly negative effects of aging in Asian Countries? Either they used a more efficient specification, their estimation techniques lead to bias, or the countries they sampled allowed them to discern a significant relationship. Both studies use a log linear specification: specifically, $\% \Delta Lny$ is the dependent variable and $\Delta A/Pop$ is the independent variable of interest. While they don't include industry control variables or country specific dummies, they include a lagged dependent variable in levels, the elderly share at the base year, regional dummies. I treat their results with some skepticism because they do not use an Arellano Bond

estimator, even though all their specifications use a lagged dependent variable with fixed effects. By running all their regressions in either OLS or 2SLS with fixed effects and a lagged dependent variable, they obtain inconsistent estimates (Arellano and Bond 1991). I also question why they instrument their aging variable, since my instrumental variable analysis suggests that contemporaneous economic growth has no effect on the rate of aging in a country. Assuming their estimation techniques are valid, their significant results suggest that the effects of aging depend on the countries studied. If I had time, I would have tested my data with their model.

The insignificant migrant variables suggest that increasing the migrant share growth rate does not affect the GDP growth rate, even if increasing the migrant share may increase GDP per capita, as past studies have shown. To verify this fact, future studies should first address the potential endogeneity issues associated with the migrant growth rate. As a starting point, future research can apply the gravity based instrument that Ortega and Peri (2011) used in a levels model to a first differenced model.

Future studies should also develop a valid instrument for the elderly share of the population in a levels model (see equation 4). If I estimate equation 4 in OLS, the elderly share coefficient ($n_{1n_p}^a$) would capture the effect of GDP per capita has on the elderly share, biasing the coefficient. Future research should develop an instrument that purges the endogeneity in the 60+ share. Once this instrument is developed we can study how the migrant share affects the 60+ share, and how these two variables affect GDP per capita. Further, we can be more confident that the migrant share will increase output per capita, as past studies have shown (Ortega and Peri 2011; Aleksynska 2016).

Even with so many insignificant results, the instrumental variable analysis revealed several interesting findings. While the Card instrument may work to predict immigrant settlement within countries, this study suggests that it cannot predict settlement across countries. Our results call into question at least two studies that have used a Card instrument to study immigrant behavior across countries (Boubtane and Dumont 2016, Dolado et al 1994). I also found that contemporaneous economic growth does not affect the rate of aging in a country. This result calls into question the use of aging instruments in other cross country studies (Bloom Canning, and Malaney 2000; Bloom Canning, Finlay 2010).

Lastly, our results suggest that from 1975-1995, aging significantly hindered GDP growth, while from 1995-2015, aging had little effect. I had no time to further investigate if countries have been adapting to aging populations. Further studies should investigate if this is actually true, and how countries have adapted. Even if developed countries in this study have adapted to older populations in the past 20 years, countries may not be prepared for the next 40 years, as the share of people aged 60+ in population is projected to increase to 33% by 2050, a 50% increase from the 2005 level (United Nations 2009). Furthermore, the United Nations (2015) projects an additional 91 million migrants will live in developed countries in 2050, a 50% increase from 2010 levels. As developed countries prepare for this inevitable demographic shift, each country should analyze the effect of aging and migrants on their past economic growth patterns to develop a better understanding of how they should act in the future.

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Appendix A: Derivation of Log-Linear Production Function

To arrive at the estimable equation (7), I begin with a different production function given in equation (1). Consider:

$$\ln y_{ct} = \beta_4 \Omega_{ct} + \beta_3 k_{ct} + \beta_1 l_{ct}$$

The factors of production have a log linear relationship with GDP per capita, instead of a log-log relationship described in equation (1). I assume that l_{ct} , the share of workers in the population in country c at time t , is linear function of the share of elderly in the population. Specifically, $l_{ct} = d * (A/N)_{ct}$, where d is some constant. We can then rewrite the production function as:

$$\ln y_{ct} = \beta_4 \Omega_{ct} + \beta_3 \frac{K_{ct}}{N_{ct}} + \beta_1 [d] \frac{A_{ct}}{N_{ct}}$$

By taking first differences, and adding the change in migration share and the same controls from equation (6), we arrive at the estimable equation (7):

$$\begin{aligned} \Delta \ln y_{c,t,t+5} = & \beta_1 \Delta \left(\frac{A}{N} \right)_{c,t,t+5} + \beta_2 \Delta \left(\frac{M}{N} \right)_{c,t,t+5} + \beta_3 \Delta \left(\frac{K}{N} \right)_{c,t,t+5} \\ & + Z'_{ct} \theta + \phi_t + m_c + \Delta \epsilon_{c,t,t+5} \end{aligned} \quad (7)$$

Like in the main derivation, I remove Ω from the specification and proxy it with the additional controls. Since I specify the dependent variable and the additional controls identically in equation (7) as equation (6), the control coefficients have the same conceptual meaning.

Appendix B: More Econometric Specification Tests

Theoretical Justifications for the Additional Controls

I constructed 5 additional specifications which account for any other variables that could affect the coefficients associated with migration and aging. In general, I run additional regressions with additional controls that could help reveal a significant relationship between the variables of interest.

Instead of running the migration variable from t to $t+5$, I try running the regression with a one period lagged version of the migration variable. The logic behind including the lag is twofold: first, it avoids any potential endogeneity with the dependent variable; second, immigrants experience a steep learning curve when they they move to a new country. In other words, immigrant workers tend to perform below their potential in their first five years in a new country, so a five year lagged migrant variable may capture the economic contribution of migrants who have been in a country between five and ten years (Duleep 2008).

In the second alternative specification, I include a variable that captures the change in the dependency ratio, which I define to equal the number of elderly (60+) and young (under 20) over the working age population (20-60). The dependency ratio variable addresses a potential omitted variable problem in the aging variable: A country

that has a high share of elderly people and a high share of younger people has a higher dependency ratio and likely a lower growth rate, compared to a country with a high share of elderly people and a low share of young folks. In other words, the second country may avoid the negative effects aging has on economy, since it has a lower dependency ratio. I don't include this variable in all regressions because I cannot run this variable and the aging variable in the same regression. The coefficients would make little sense: a change in the dependency ratio, holding aging constant.

The third alternate specification includes a variable that accounts for the initial output gap in each country. I constructed this variable by collecting the residuals from a regression on the equation:

$$y_{ct} = a_c + b_{ct}t + \epsilon_{ct}$$

The residuals equal the estimated difference between actual output and the fitted values of the regression. The fitted values fall on the line $y_c = b_c t$. In other words the line doesn't account for cyclical fluctuations in output, rather it models the linear trend of output growth across time. I include this variable since the output gap at time t can predispose a country to a particular growth path from t to $t+5$. Further, migrants may be less inclined to move to a country between time t and $t+5$ if the economy is sluggish at time t .

In the fourth alternate specification, I interact the growth rate of migrants in a country with a time dummy. If migrants have a greater impact on a country with an aging population, one would expect migration flows in the 2000s to have a more positive impact on the host country's economy than migration flows in the 1980s.

In the fifth alternative specification, I control for migrant education. On average, 28% of the migrants in the host countries studied have some tertiary education, while only 19% of the overall population has some tertiary education. By controlling for migrant education at time t , the impact of migrant flows in this specification would be due to factors other than human capital accumulation. In other words, this specification attempts to isolate the effect migrants have on the demographic makeup of a country. I don't control for immigrant education in all regressions, since that would cut my sample size in half-- I only have immigrant education data for 20 host countries from 1990 to 2010.

Appendix C: Further Econometric Specification Tests

Eliminating Economic Sector Controls With Time Varying Effects

I simplified the Maestas Mullen and Powell specification (equation 5) after an F test confirmed that the economic sector composition controls need not interact with time dummies. So while the equation 5 specification allowed the effects of economic sectors to vary with time, I accepted the null hypothesis that the coefficients on all the time interacted economic sector variables are jointly 0 (p value equaled .13). This test allowed me to eliminate 21 control variables, reducing the potential for multicollinearity in my estimation.

Excluding the Lagged $\Delta(M/N)$ Instrumental Variable from Instrument Tests

I did not consider using the lagged migrant instrument in the log-linear specification since the Fisher Unit Root Test suggests that the first differenced migrant share variable ($\Delta(M/N)$) contains a unit root (see Table 7). A unit root would lead to contemporaneous correlation in the autoregressive first stage estimate, biasing the migration coefficient in the second stage estimate (Keele and Kelly 2004). By contrast, the lagged migrant instrument in the log-log specification is stationary (see Table 6).

Justifying Fixed Effects

I confirm the presence of country fixed effects with 3 tests. First I conduct an F test to investigate if the coefficients associated with the country dummies are jointly zero. I strongly reject the null hypothesis that the coefficients are all 0. I then conduct a Breusch and Pagan Lagrangian multiplier test for random effects and accept the null hypothesis that the variance across panels equals zero, suggesting that random effects is not appropriate. Lastly, I conduct a Hausman test on a Random effects and Fixed effects model, which suggested that the Random Effects model is inconsistent. Overall, all three tests confirm the use of fixed effects.

Rejecting the Presence of Cross Sectional Dependency

I also test for cross sectional dependency among panels which suggests the errors within panels are correlated. This would lead to contemporaneous correlation and biased standard errors. I conduct Pesaran's test and narrowly accept the null hypothesis with a p value of 0.0648 that the errors within panels are independent.

Appendix D: Figures and Tables

For all figures below, population refers to the population aged 20 or over. I provide the trendline slope coefficients below each graph. If the slope is significantly different from 0 with a 95% confidence interval, I denote the slope with an asterisk. The size of the bubbles reflects the country population size.

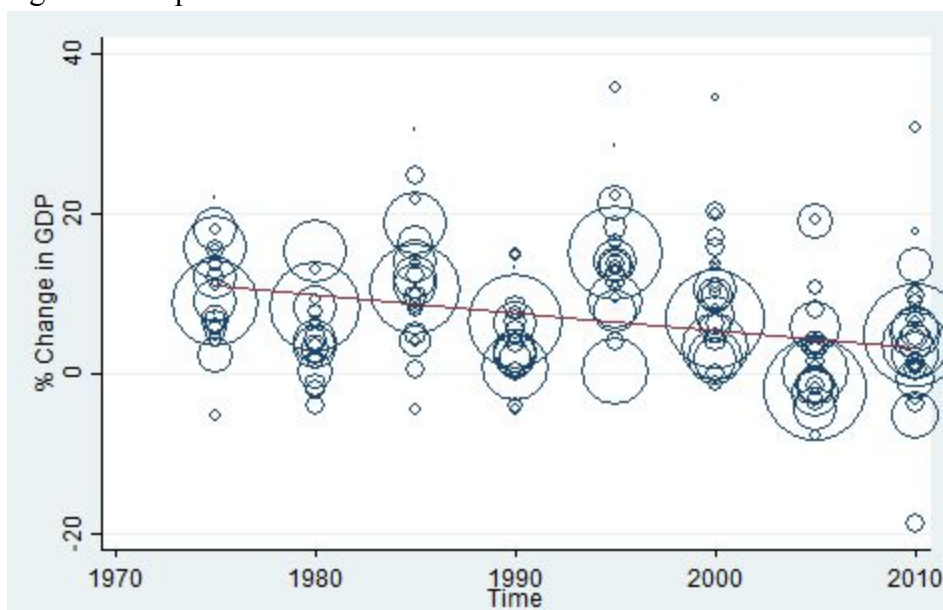
Table 1. The 29 Countries Analyzed in this Study

Australia	Japan
Austria	Luxembourg
Belgium	Netherlands
Canada	New Zealand
Czech Republic	Norway
Estonia	Poland
Finland	Portugal
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Iceland	Switzerland
Ireland	United Kingdom
Israel	United States
Italy	

Table 2: Descriptive Statistics

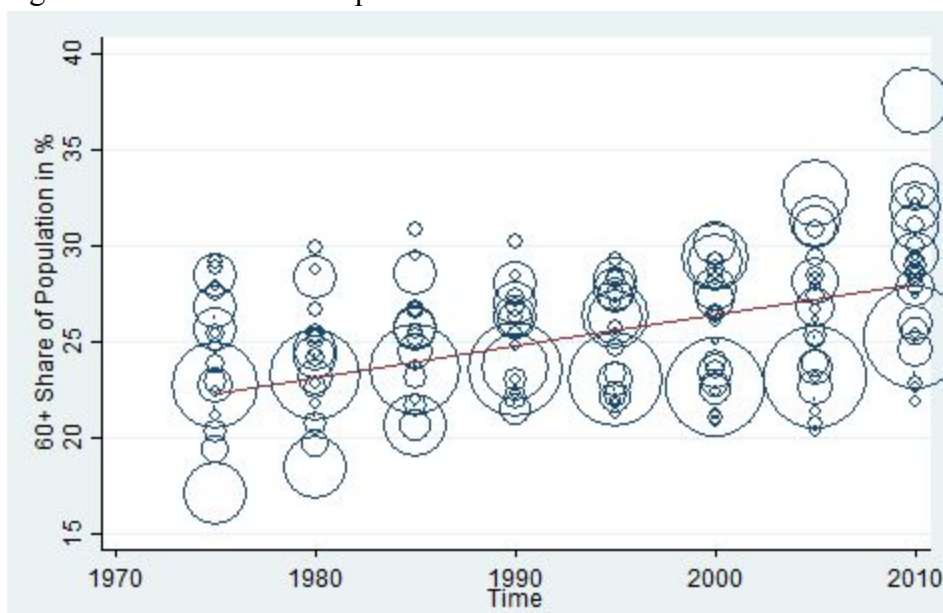
Label	variable	N	mean	max	min	sd
GDP per N	yp	190	30295.6	85193.5	11038	11340.23
%ΔGDP/N	hdlny	190	7.462136	35.73691	-18.65762	8.006231
%ΔA/N	hdlna	190	3.233752	14.9239	-10.2442	4.645676
A/N in %	han	190	25.54551	37.42692	17.06713	3.267778
Population	pop	190	32852.31	309876	217	56438.27
% of Workers in Agriculture	hag	190	9.405323	36.93586	1.623443	7.568081
% of Workers in Industry	hind	190	30.50643	72.46061	14.31783	9.594536
% of Workers in Services	hser	190	60.08825	78.96931	6.254061	14.01818
%ΔM/N	hdlnmp	190	6.717727	81.33257	-48.05969	18.30982
M/N in %	hmn	190	13.8092	54.49027	.998	10.95138
M/Pop in %	hmigpop	190	10.01233	33.61818	.6922623	7.773238
% of Capital per N	kn	190	11343.53	42574.84	2701.484	5058.715
%ΔK/N	hdlnkl	190	-5.152596	123.857	-80.19408	22.85219
Openness to Trade	hopt	190	78.76974	248.12	13.91	46.96661
Retirement Age	retage	190	63.26686	71.13743	57.26397	3.194095
% of Pop with Tert. Ed	ed	190	19.36	57.30	2.30	11.05
ΔDependency Ratio	hddep	190	-1.565752	13.59818	-16.04553	5.539877
Dependency Ratio in %	dyln	190	.856	1.603	.637	.856
% Migrants with Tert. Ed	himed	83	28.29873	68.16112	9.57801	11.93279
Output Gap	boom	190	-4.42e-06	6077.65	-5948.774	1620.617

Figure 1: Output Growth Rate over Time



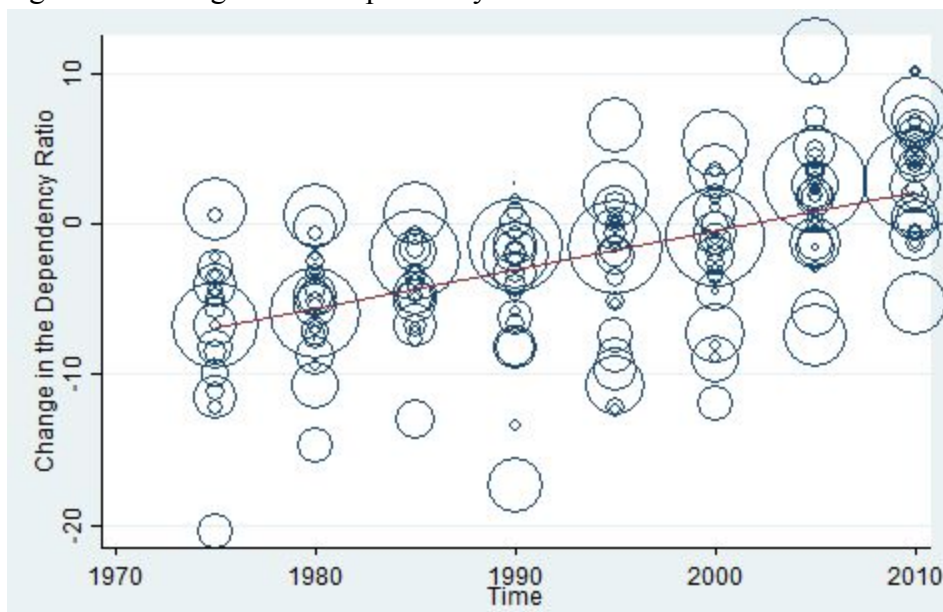
Notes: slope of the trendline equals 0.19*. Asterisk indicates the slope is significantly different from zero. Size of circle represents population of country c at time t .

Figure 2a: 60+ Share in Population over time



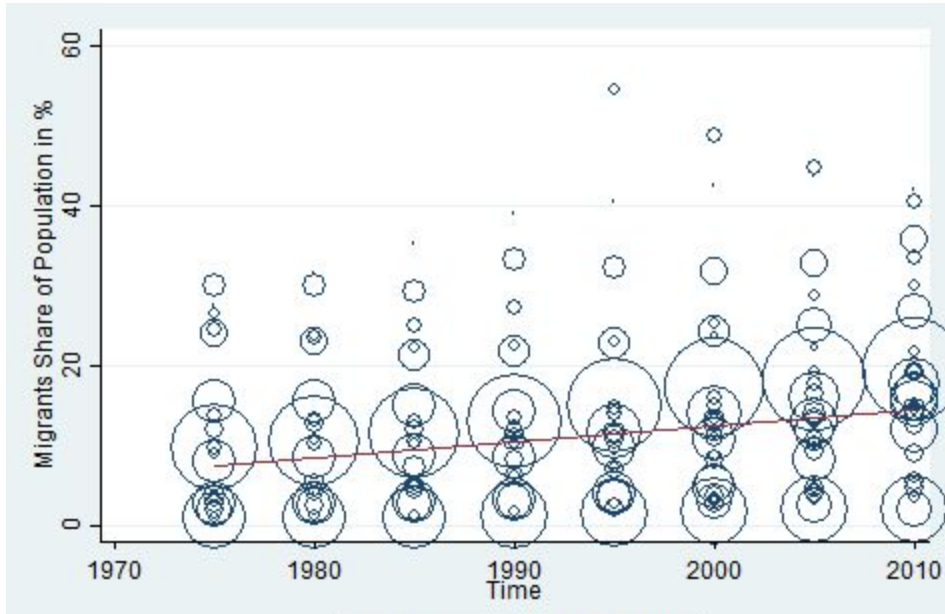
Notes: the slope of the trendline equals 0.10^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t.

Figure 2b: Change in the Dependency Ratio over time



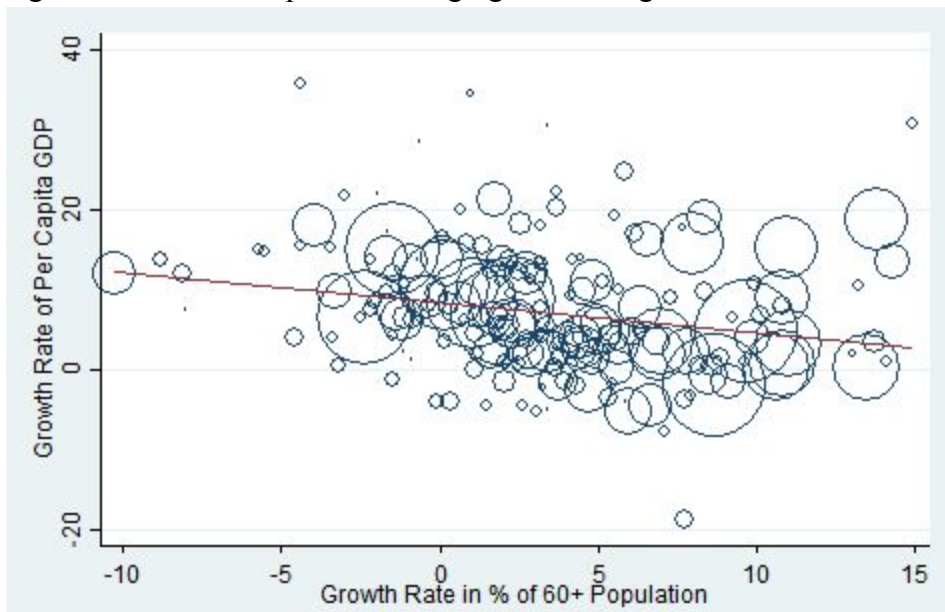
Notes: the slope of the trendline equals 0.02^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t.

Figure 3: Migrant Share in Population over Time



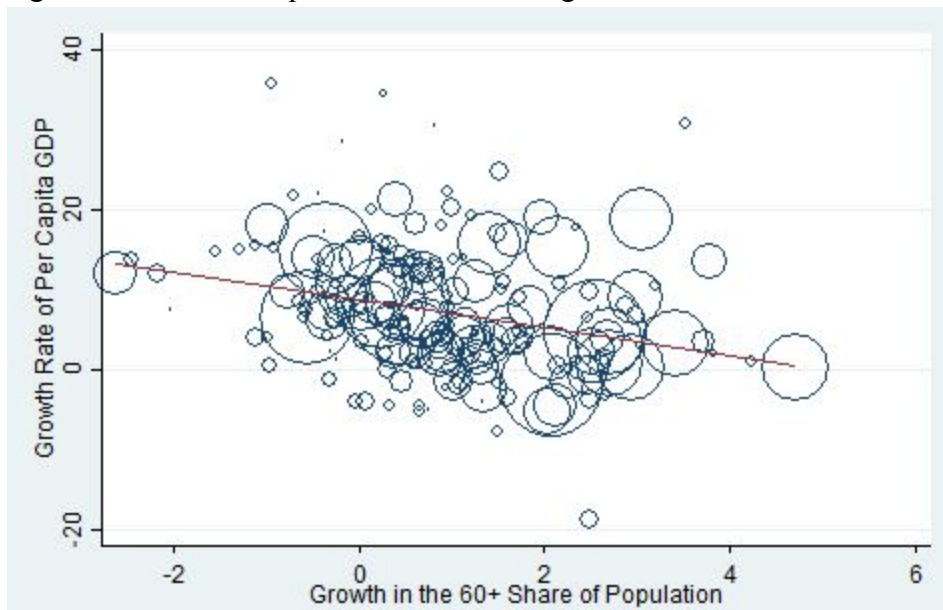
Notes: The slope of the trendline equals 0.18^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t .

Figure 4a: Relationship between Aging and GDP growth



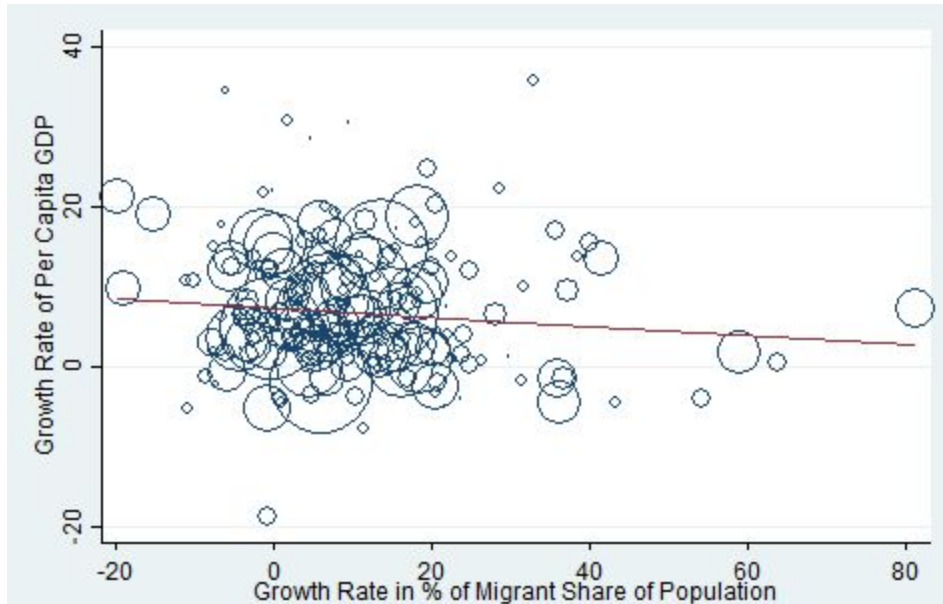
Notes: Scatterplot of $\% \Delta(A/N)$ and $\% \Delta y$ weighted by population. The trendline slope equals -0.38^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t .

Figure 4b: Relationship between 60+ share growth and GDP Growth



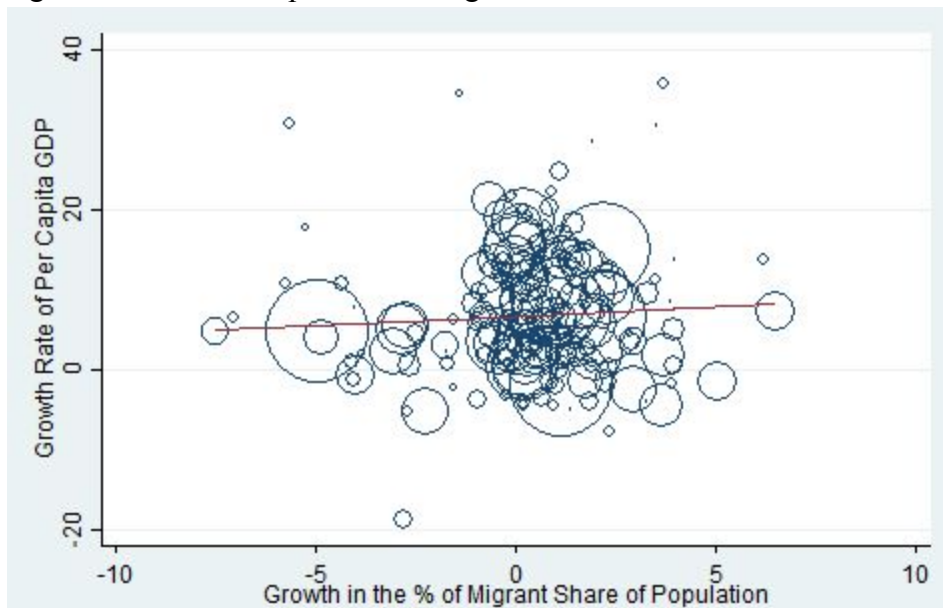
Notes: Scatterplot of $\Delta(A/N)$ and $\% \Delta y$ weighted by population. The trendline slope equals -1.73^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t .

Figure 5a: Relationship between Migration Share Growth Rates to GDP Growth



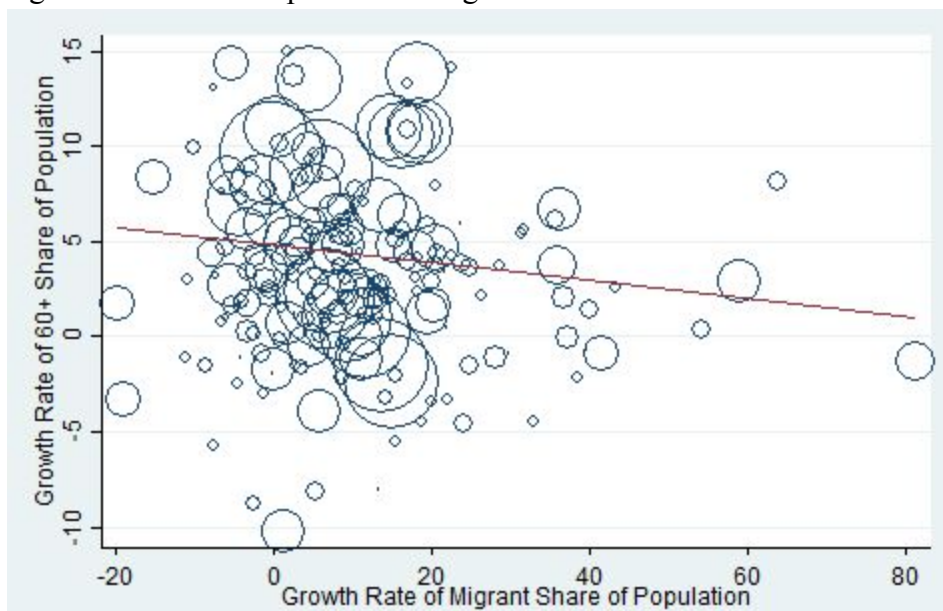
Notes: Scatterplot of $\% \Delta(M/N)$ and $\% \Delta y$ weighted by population. The trendline slope equals -0.02 .

Figure 5b: Relationship between Migration Share Growth and GDP Growth



Notes: Scatterplot of $\Delta(M/N)$ and $\% \Delta y$ weighted by population. The trendline slope equals .228*. Asterisk indicates the slope is significantly different from zero.

Figure 6a: Relationship between Migrant Share Growth Rate and the Rate of Aging



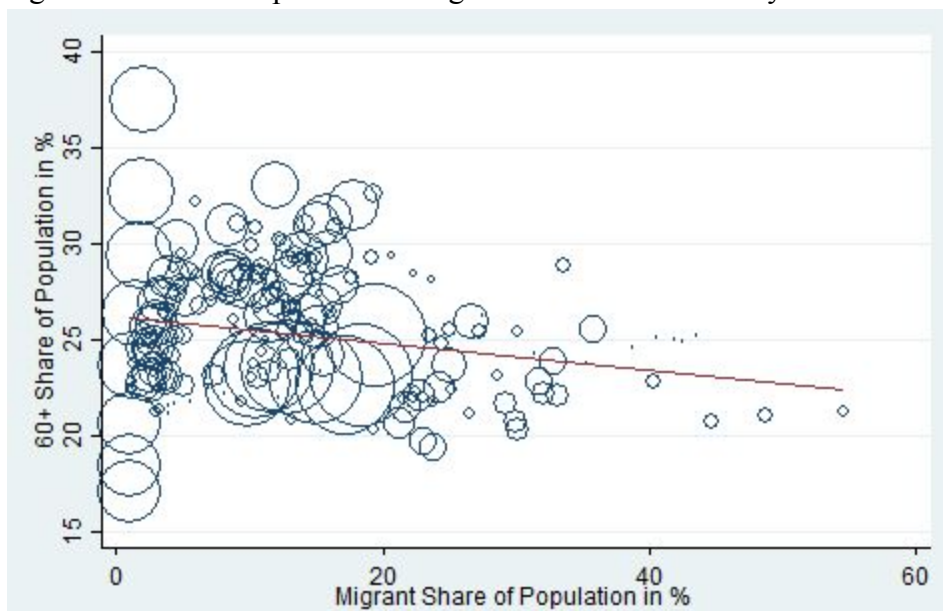
Notes: Scatterplot of $\% \Delta(M/N)$ and $\% \Delta(A/N)$ weighted by population. The trendline slope equals -0.02. Size of circles represents population of country c at time t .

Figure 6b: Relationship between Migrant Share growth and 60+ share growth



Notes: Scatterplot of $\Delta(M/N)$ and $\Delta(A/N)$ weighted by population. The trendline slope equals -0.16^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t .

Figure 7: Relationship between Migration shares and Elderly shares of the population



Notes: Scatter plot of M/N and A/N weighted by population. The trendline slope equals -0.06^* . Asterisk indicates the slope is significantly different from zero. Size of circles represents population of country c at time t .

Table 3a: OLS Estimates with Log-Log Specification
 -Dependent Variable: Per Capita GDP Growth Rate (% Δy)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	W/Migration	w/o Migration	w/o Aging	w/ Migrant Lag	w/Dependency Ratio	w/ Cyclical Control	w/Migration Interacted w/ Time	w/ Immigrant Education
% $\Delta A/N$	-0.129 (0.0956)	-0.131 (0.0927)		-0.109 (0.0848)		0.0239 (0.110)		-0.255* (0.103)
% $\Delta M/N$	-0.0409 (0.0201)		-0.0326 (0.0199)		-0.0276 (0.0200)	-0.00668 (0.0256)		-0.0210 (0.0295)
% $\Delta K/N$	0.167*** (0.0275)	0.160*** (0.0257)	0.173*** (0.0249)	0.173*** (0.0218)	0.172*** (0.0261)	0.147*** (0.0273)	0.168*** (0.0274)	0.134* (0.0488)
Share of Pop w/ Tertiary Ed	0.00235* (0.00101)	0.00236* (0.00105)	0.00233* (0.00105)	0.00170 (0.000892)	0.00199* (0.000756)	0.00322** (0.000968)	0.00211* (0.00101)	0.00292 (0.00205)
% Δ Dependency Ratio					0.0882 (0.128)			
Share of Migrant Pop w/ Tertiary Ed								-0.216 (0.107)
Retirement Age	-0.0129* (0.00596)	-0.0130* (0.00600)	-0.0122 (0.00610)	-0.0125* (0.00553)	-0.0117 (0.00578)	-0.00740 (0.00438)	-0.0113 (0.00655)	0.00858 (0.00818)
Openness to Trade	0.0632* (0.0306)	0.0613 (0.0314)	0.0626 (0.0310)	0.0597 (0.0302)	0.0571 (0.0319)	0.0848* (0.0353)	0.0671* (0.0316)	0.0112 (0.0789)
Lagged % $\Delta M/N$				-0.0630*** (0.0136)				
Residuals						-0.0000146*** (0.00000298)		
% $\Delta M/N$ 1980							-0.0770 (0.127)	
% $\Delta M/N$ 1985							0.0471 (0.101)	
% $\Delta M/N$ 1990							-0.0369 (0.102)	
% $\Delta M/N$ 1995							0.104 (0.102)	
% $\Delta M/N$ 2000							0.0871 (0.0823)	
% $\Delta M/N$ 2005							-0.035 (0.0871)	
% $\Delta M/N$ 2010							0.0597 (0.105)	
Observations	190	190	190	190	190	190	190	83
R ²	0.833	0.830		0.838	0.843	0.866	0.836	0.889

Standard errors in parentheses
 * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Standard errors are robust and adjusted for clustering at the country level. Each observation is weighted by population in country c at time period t . Other variables included: time dummies, the log fraction of workers in period t working in agriculture, services, and industry.

Table 3b: Log-Linear OLS Estimates
 -Dependent Variable: Per Capita GDP Growth Rate (% Δy)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	W/Migration	% Migration	% Aging	% Migrant Lag	% Dependency Ratio	% Cyclical Control	% Migration Interacted w/ Time	% Immigrant Education
$\Delta A/N$	-0.944 (0.506)	-0.748 (0.375)		-0.127 (0.586)		-0.440 (0.536)		-1.489** (0.449)
$\Delta M/N$			-0.127 (0.283)		-0.137 (0.278)	-0.247 (0.267)		-0.579 (0.325)
Share of Pop w/ Tertiary Ed	0.00174 (0.000958)	0.00188* (0.000913)	0.00189 (0.00106)	0.000614 (0.000912)	0.00114 (0.000774)	0.00270** (0.000937)	0.00122 (0.000995)	0.00262 (0.00190)
Share of Migrant Pop w/ Tertiary Ed								-0.177 (0.115)
$\Delta K/N$	0.0000123*** (0.00000247)	0.0000121*** (0.00000245)	0.0000132*** (0.00000242)	0.0000120*** (0.00000228)	0.0000128*** (0.00000245)	0.0000107*** (0.00000256)	0.0000115*** (0.00000258)	0.00000810* (0.00000317)
Retirement Age	-0.0135* (0.00551)	-0.0127* (0.00554)	-0.0124* (0.00580)	-0.0162 (0.00901)	-0.0120* (0.00467)	-0.00855 (0.00452)	-0.0123* (0.00511)	0.00765 (0.0101)
Openness to Trade	0.0546 (0.0292)	0.0516 (0.0301)	0.0561 (0.0315)	0.0747* (0.0340)	0.0500 (0.0286)	0.0796* (0.0329)	0.0608* (0.0283)	0.0123 (0.0693)
Lagged $\Delta M/P$				0.261 (0.414)				
Δ in Dependency Ratio					0.0661 (0.160)			
Residuals						-0.0000138*** (0.00000294)		
$\Delta M/N$ 1980							0.490 (2.175)	
$\Delta M/N$ 1985							0.670 (1.892)	
$\Delta M/N$ 1990							2.047 (1.643)	
$\Delta M/N$ 1995							1.427 (1.614)	
$\Delta M/N$ 2000							1.088 (1.552)	
$\Delta M/N$ 2005							0.424 (1.540)	
$\Delta M/N$ 2010							.657 (1.756)	
Observations	190	190		190	190	190	190	83
R^2	0.816	0.813		0.828	0.829	0.848	0.822	0.878

Standard errors in parentheses
 * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Standard errors are robust and adjusted for clustering at the country level. Each observation is weighted by population in country c at time period t . Other variables included: time dummies, the log fraction of workers in period t working in agriculture, services, and industry.

Table 3c: Estimates Over Different Time Intervals
-Dependent Variable: Per Capita GDP Growth Rate (% Δy)

	(1) Log-Lin 1975-1995	(2) Log-Lin 1995-2015	(3) Log-Log 1975-1995	(4) Log Log 1995-2015
% Change A/N			-0.350* (0.154)	0.168 (0.147)
% Change M/N			-0.00107 (0.00727)	0.0611 (0.0650)
Change A/N	-2.335** (0.770)	0.658 (0.930)		
Change M/N	-0.773 (0.570)	0.402 (0.558)		
Observations	94	117	94	118
R ²	0.930	0.807	0.917	0.859

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Standard errors are robust and adjusted for clustering at the country level. Each observation is weighted by population in country c at time period t . Other variables included: time dummies, the log fraction of workers in period t working in agriculture, services, and industry, the % change in K/N from period t to $t+5$, average retirement age, % of population with some tertiary education, and openness to trade.

Table 3d: Alternate Regressions over Time Intervals
-Dependent Variable: Per Capita GDP Growth Rate (% Δy)

	(1) log-lin restricted 95-15	(2) log-log restricted 95-15	(3) log-lin 75-95 w/o migration	(4) log-log 75-95 w/o migration	(5) log-lin 75-95 w/o aging	(6) log-log 75-95 w/o aging
% Change A/N		0.0775 (0.174)		-0.354* (0.135)		
% Change M/N		0.0748 (0.0780)				-0.00837 (0.00487)
Change A/N	0.435 (0.942)		-2.253** (0.795)			
Change M/N	0.436 (0.645)				-0.521 (0.675)	
Observations	91	92	94	94	94	94
R ²	0.817	0.864	0.928	0.917	0.906	0.909

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Standard errors are robust and adjusted for clustering at the country level. Each observation is weighted by population in country c at time period t . Other variables included: time dummies, the log fraction of workers in period t working in agriculture, services, and industry, the % change in K/N from period t to $t+5$, average retirement age, % of population with some tertiary education, and openness to trade.

Table 4: First Stage Estimates

	(1) Lagged Instrument	(2) Card w/o log	(3) Card w/ log	(4) Bartick w/ Log	(5) Bartick w/o Log
Lagged % $\Delta \ln(M/N)$	0.289** (0.0891)			-0.0134 (0.0132)	
% $\Delta \ln(A/N)$ IV	0.00878 (0.337)		-0.0971 (0.415)	1.017*** (0.0401)	
Card IV		0.356* (0.136)			-0.00323 (0.0447)
$\Delta(A/N)$ IV		-0.168 (0.272)			1.058*** (0.0546)
Log Card IV			0.522 (0.312)		
Observations	190	127	127	190	127
R^2	0.772	0.802	0.832	0.939	0.955
Shea's Partial R^2	0.0938	0.0348	0.0424	.8214	.7590
Shea's Adj. R^2	-3.702	-9.616	-9.461	0.7300	0.5103

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Dependent variable(DV) in column (1) is % $\Delta(M/N)$, DV in col (2) is $\Delta(M/N)$, DV in col (3) is % $\Delta(M/N)$, DV in col (4) is % $\Delta(A/N)$, DV in col 5 is $\Delta(A/N)$. Standard errors are robust and adjusted for clustering at the country level. Each observation is weighted by population in country c at time period t. Other variables included: time dummies, the log fraction of workers in period t working in agriculture, services, and industry, the % change in K/N from period t to t+5, average retirement age, % of population with some tertiary education, and openness to trade.

Table 5: Comparing Results Using Different Instrumental Variables.
-Dependent Variable: Per Capita GDP Growth Rate (% Δy)

	(1) Log-Log	(2) Log-Linear
% $\Delta A/N$	0.0718 (0.155)	
$\Delta(A/N)$		0.381 (0.519)
Observations	190	127
R^2	0.710	0.881
Wooldridge	0.2245	0.4276

Endogeneity Test

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: The independent variable in each regression is % $\Delta \ln(y)$. Standard errors are robust and adjusted for clustering at the country level. Each observation is weighted by population in country c at time period t. Other variables included: time dummies, the log fraction of workers in period t working in agriculture, services, and industry, the % change in K/N from period t to t+5, average retirement age, % of population with some tertiary education, and openness to trade.

Table 6: Unit Root Test for $\% \Delta(M/P)$

Fisher-type unit-root test for `dlnmp`
Based on Phillips-Perron tests

Ho: All panels contain unit roots Number of panels = 32
Ha: At least one panel is stationary Avg. number of periods = 6.63

AR parameter: Panel-specific Asymptotics: T -> Infinity
Panel means: Included
Time trend: Not included
Newey-West lags: 1 lag

		Statistic	p-value
Inverse chi-squared(64)	P	150.9592	0.0000
Inverse normal	Z	-1.7466	0.0404
Inverse logit t(139)	L*	-4.2881	0.0000
Modified inv. chi-squared	Pm	7.6862	0.0000

P statistic requires number of panels to be finite.
Other statistics are suitable for finite or infinite number of panels.

Notes: For every statistic created by the Fisher Type Unit Root test, we reject the null hypothesis that all panels contain unit roots, thus we assume $\% \Delta(M/P)$ is stationary.

Table 7: Unit Root Test for $\Delta(M/P)$

Fisher-type unit-root test for `dmp`
Based on Phillips-Perron tests

Ho: All panels contain unit roots Number of panels = 32
Ha: At least one panel is stationary Avg. number of periods = 6.63

AR parameter: Panel-specific Asymptotics: T -> Infinity
Panel means: Included
Time trend: Not included
Newey-West lags: 1 lag

		Statistic	p-value
Inverse chi-squared(64)	P	87.0657	0.0292
Inverse normal	Z	-0.6252	0.2659
Inverse logit t(139)	L*	-1.0414	0.1497
Modified inv. chi-squared	Pm	2.0387	0.0207

P statistic requires number of panels to be finite.
Other statistics are suitable for finite or infinite number of panels.

Notes: For half of the statistics created by the Fisher Type Unit Root test, we accept the null hypothesis that all panels contain unit roots, thus we assume $\Delta(M/P)$ contains unit roots.

