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Heterogeneity in the Effect of Size on Internal Migration in the United States: A Gravity Model and PPML Estimator Approach

Heterogeneity in the Effect of Size on Internal Migration in the United States: A Gravity Model and PPML Estimator Approach

Nawaraj S. Paudel [§] and Sajal Lahiri [‡]

Abstract

This paper explores the influence of economic size on inter-state migration within the USA, addressing whether people relocate from larger to smaller states and whether regional differences affect this trend. This study utilizes the structural gravity model and panel data spanning 2000 — 2017. The metrics used to gauge state size include GDP, Population, and land area. We find fairly strong support for our hypothesis that individuals are relocating from larger states to smaller ones. The impact of size on internal migration within the USA shows no distinction between the Mid-West and South regions. However, the influence of size on migration varies for the West and North-East compared to interstate migration. We carry out a series of robustness checks, and the qualitative results remain the same. Internal migration between states and regions in the USA can have significant policy implications for state and federal resource allocation, labor markets, tax revenues, economic resilience, and regional disparities.

Keywords: Inter-States Migration, Regional Migration, U.S.A, Size, Gravity Model
JEL Classifications: R23, R12, O15.

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1 Introduction

Does economic size matter for USA inter-state migration? Do people move from bigger to smaller states? Are there differences between regions in this respect? These are the main research questions that this paper addresses. Internal migration[1] rates between regions, states, or cities in the United States are higher compared to other nations, despite their consistent decline over more than three decades. Recently, the intensity of interstate migration has begun to stabilize. (Jia, Molloy, Smith and Wozniak 2023; Alvarez, Bernard and Lieske 2021; Molloy and Smith 2019; Molloy, Smith, and Wozniak 2011, and Fischer 2002). Around 8.2 million people moved between states in 2022. The national average state-to-state migration rate was 19.9 percent in 2022, whereas people moving into southern and western regions were higher than the national average[2]. At the state and county levels, the large flow of interstate migration is in the South and the West. Considering the largest states and country level flows are to or from Florida, California, or Arizona.[3]. It has a great implication at the policy level to know where and why people are moving between states/regions in the United States.

From the basis for most modern research on migration Ravenstein (1885) in the paper "The Law of Migration" states that people migrate even to considerable distance to find work or employment. The reason why people in the U.S. migrate between the states is possibly very different than international migration. The rate of Americans moving in search of job/work decreases drastically in 2023[4]. Hicks (1963) states,"... differences in net economic advantages – chiefly differences in wages, are the main causes of migration". Todaro (1969) finds in the model of labor migration that as long as the origin and destination real income differential continues, migration between two different locations remains.

Many studies examine the U.S. inter-state mobility of people in response to income taxes. Most recent studies show that high-income tax is one of the big push factors of the United States internal migration. Cassidy, Dincecco, and Troiano (2024) show that middle and high-income households outmigrate from high-

[1]This study does not cover the intra-state and county-level migration. Internal migration is the movement of people between usual residences within national states (Rees, 2001).

[2]https://www.census.gov/library/stories/2023/11/state-to-state-migration.html

[3]https://www.census.gov/library/stories/2019/04/moves-from-south-west-dominate-recent-migration-flows.html

[4]https://www.cbsnews.com/news/moving-for-work-mobilty-record-low-1-6-percent-challenger/

income tax states to low-income tax states. Drukker (2024) examines the mobility response of high-income households in the United States to a provision in a 2017 tax law and argues that the high-income tax caused high-income households to leave high-tax states in favor of low-tax states. Akcigit et al. (2018 and 2016) examine the effect of corporate and personal taxes on innovation in the U.S. over the twentieth century and find that the tax system significantly affects the overall quantity, quality, and the location of innovation. Similarly, in terms of international mobility, leading inventors are significantly affected by high tax rates when deciding where to locate. Kleven et al. (2020 and 2013) argue that taxes can affect the geographic location of people both within and across countries. By analyzing the effects of top tax rates on the international migration of football players in 14 European countries since 1985, they claim that tax rate differences in origin and destination countries may induce highly paid workers to migrate where the tax burden is lower. Moretti and Wilson (2017 and 2023) analyze the effect of state tax on the geographical location of top earners, using data on the universe of U.S. patents filed between 1976 and 2010. They find that top inventors are strongly mobile across U.S. states. The state taxes have a significant effect on the geographical location of star scientists and possibly other highly skilled workers. They also examine the effect of state estate taxes using Forbes 400 richest Americans data and conclude that 35 percent of local billionaires leave states with an estate tax.

For United States interstate migration several empirical studies have examined the effect of economic factors on migration. Greenwood (1975, 1985 and 1997) shows that the difference in income and unemployment are the most influential factors of migration. Treyz et al. (1993) find that the dynamic response of net interstate migration is induced by amenity differentials and the various components of relative economic opportunities. Local labor markets in the United States are characterized by enormous differences in worker earnings, factor productivity, and firms' innovation (Enrico 2011). The workers and firms are free to move in search of welfare and profits. Employing US census data and using a structural spatial equilibrium model Diamond (2016) finds that cities attract more high-skilled workers. Kennan and Walker (2011) show a significant effect of expected income differences on interstate migration in the USA for white male high-school graduates using panel data from the National Longitudinal Survey of Youth. Moreover, in the cross-section analysis of interstate migration, Karahan and Rhee (2014) find that the aging population and availability of local job make to decrease the interstate migration rate. Anjomani, A.(2002) examines a simultaneous

equation model of U.S. interstate migration over the period 1975–1980 and argues that states with lower income growth and larger increases in unemployment will produce out-migrants to states with lower crime rates, lower population densities, and high population growth. Cebula, R. J. (2005) investigates the determinants of internal migration in the U.S. over the period 1999-2002 and claimed that expected income and actual income each play an important role on the migration decision. He also argued that in-migration was an increasing function of the availability of state parks, recreation, and warmer temperatures.

Furthermore, the effect of political competition on U.S. internal migration has been analyzed by Liu and Ngo (2020) using IRS and U.S census migration data from 1940 to 2010 and find that political competition positively effect the U.S. inter-state migration. Chakrabarti and Sengupta (2017) assert that differences in industrial and regional total factor productivity positively affect the inter-state migration in the United States. On a different note, we are investigating the role of size in the United States inter-state migration.

There is no specific federal policy governing internal migration in the USA[5] however, many States have been practicing different programs to retain and attract new workers and businesses in the States. For example, Vermont[6] and West Virginia's[7] Remote Worker Grant Program, Maine's[8] Educational Opportunity Tax Credit (EOTC) program, Kansas's[9] Rural Opportunity Zones (ROZ) program, and New York[10] and California[11] offer various tax credits and incentives for businesses, especially in industries like film production, technology, and renewable energy. Moreover, there are also programs to support startups and small businesses and initiatives related to climate change and environmental sustainability.

Our study makes a novel contribution to the existing literature by introducing a new dimension that has not received attention so far. This study fulfills the research gap found in the migration literature by analyzing the effect of size on U.S. interstate migration. Fedotenkov (2015) analyzes the relationship between

[5] Jia, Molloy, Smith, and Wozniak (2023)

[6] https://accd.vermont.gov/content/new-remote-worker-grant-program-guidelines

[7] https://governor.wv.gov/News/press-releases/2021/Pages/Ascend-West-Virginia-announces-inaugural-class-of-remote-workers.aspx

[8] https://www.maine.gov/revenue/taxes/tax-relief-credits-programs/income-tax-credits/educational-opportunity-tax-credit

[9] https://www.republiccountykansas.com/rural-opportunity-zone-incentive-guidelines/

[10] https://edc.nyc/sites/default/files/2024-02/NYCEDC-Business-Incentives-Guide-2024.pdf

[11] https://lao.ca.gov/Publications/Report/4713

international trade and migration to country size using an international trade model. He explains why small countries have a larger percentage of migrants in their populations, and concludes that higher wages in small countries incite migrants to come. To investigate the relationship between GDP rate and net migration in Central and Eastern European (CEE) countries, Simionescu at el. (2016) use panel data (1991 - 2013) and the Bayesian approach and find that the GDP has a negative influence on the net migration in the CEE countries.

In this paper, we utilize the GDP ratio, population ratio, and the U.S. States' land mass ratio as size proxies. We use the recently developed structural gravity model employing 18 years (2000 - 2017) of panel data. We include origin-states-time fixed effects, destination-states-time fixed effects, and pair-fixed effects to deal with endogeneity arising from unobserved heterogeneity. We follow the literature (see, for examples, Agnosteva et al., (2014) and Anderson and Yotov (2016) on gravity analysis and employ a two-stage procedure to estimate the coefficient of time-independent variables.

The paper is organized as follows. Section 2 explains the estimation methodology, data introduction, and the definition of variables. In section 3, we present the empirical results. We discuss the robustness check of the result in Section 4. A separate analysis of heterogeneity in terms of inter-regional migration is presented in section 5. We present the conclusion and policy implication of the study in section 6.

2 Estimation Methodology and Data

2.1 Econometric Specification

As in the trade model, migration is also driven by the gravity force between the origin and destination countries or states. We use the same structural gravity equation estimated by Anderson (1979) and Anderson and Van Wincoop (2003). The gravity equation has been derived theoretically by Anderson (2011):

$$M_{ij} = \frac{L_j * N_i}{N} * \left(\frac{\delta_{ij}}{\Omega_i * \omega_j}\right)^{1-\theta}$$

where, M_{ij} denotes the flow of migration from State i to State j, L_j is the total population flow in State j, N_i is the population stock in State i and N is the U.S. labor supply. Ω_i and ω_j represent respectively outward

and inward multilateral resistances[12], δ_{ij} denotes migration cost from State i to State j, and θ is the constant relative risk aversion of migration between two States. Moreover, in the equations, the right-hand side first ratio represents the migration pattern of a frictionless world and the second ratio represents the effects of migration frictions. The bilateral migration frictions (δ_{ij}) reduce migration flow between states or countries. Baldwin and Taglioni (2006) suggest controlling the multilateral resistance term to make the result robust.

PPML estimator accounts for heteroskedasticity and makes the estimation more robust than traditional OLS. The OLS in logs is likely to be inconsistent.(see, for examples, Silva and Tenreyro (2006 , 2022), Head and Mayer(2014) and Weidner, and Zylkin, (2021)). Hence, we focus on PPML estimation. The gravity model of migration can be empirically estimated (in the first stage) by using the following equation:

$$Migration_{ijt} = exp[\beta_0 + \beta_1 \ln(\text{Wage})_{ijt} + \beta_2 \ln(\text{SIZE})_{ijt} + \beta_3 \ln(\text{Income Tax})\text{ijt}_{ijt} + \eta_{it} + \theta_{jt} + \delta_{ij}] + \epsilon_{ijt}$$

where Migration_{ijt} is the U.S. domestic migration flows between state i and state j at time t, ϵ_{ijt} is the error term, and n_{it}, θ_{jt} and δ_{ij} are respectively Origin-Time fixed effect, Destination-Time fixed effect, and bilateral fixed effects. As an additional dependent variable of migration, we use migration as a proportion of the population ($Migration - POP_{ijt}$) for robustness check.

We use the Origin State Time fixed effect, and Destination State Time fixed effect as suggested by (Anderson and van Wincoop, 2003) to control the unobservable multilateral resistance and observable state-specific characteristics that vary over time. Moreover, Head and Mayer(2014) and Yotov et al. (2016) state that the Origin State Time fixed effect, Destination State Time fixed effects will capture all state-specific, time-dependent variables, and similarly, the bilateral fixed effects will absorb all time-independent, bilateral variables like distance (see, for examples, Egger and Nigai, 2015; Agnosteva et al., 2014). The pair fixed effects can account for endogeneity (Baier and Bergstrand, 2007).

Classical economists, Hicks (1963) and Raimon (1962) found that wage differences between origin and destination states influence migration. In this paper, we use the ratio of wages in two states as $Wage - Ratio_{ijt} = \frac{Wage_{jt}}{Wage_{it}}$, where $wage_{it}$ represents the average weekly wage in the dollar in statei at time t. Our main variable of interest is $SIZE_{ijt}$. We employ $GDP - Ratio_{ijt}$, $POP - Ratio_{ijt}$ and $LAND - Ratio_{ij}$, as proxies of size. Bogue and Thompson (1949) discuss about the U.S. domestic migration and distance. As

[12]See Beine et al. (2014); Bertoli and Moraga (2013) and Anderson (2011)

a proxy of distance, we use travel time. The variable $TIME_{ij}$ is defined as driving time between the U.S. States from capital cities ($DT-Capital-Cities_{ij}$). The inflow and outflow of migration is larger in some big cities than capital, for example, in Illinois, the capital is Springfield, but this is not the largest population city. The same is true for many other states, such as Texas. In Texas, Dallas may be closer to the border than Austin. Therefore, we use driving time between big cities ($DT-Big-Cities_{ij}$) as well.

We can not identify the coefficients of time-invariant variables, for example, $LAND-Ratio_{ij}$ and $TIME_{ij}$ ($DT-Capital-Cities_{ij}$ and $DT-Big-Cities_{ij}$) in the first stage. Agnosteva et al., (2014) and Anderson and Yotov (2016) suggest to use two-stage procedure. Estimation of the pair fixed effects from the first-stage structural gravity equations is regressed on standard gravity variables in a second-stage estimation. We can estimate the coefficient of the time-invariant bilateral variable by using the following second-step equation:

$$\hat{\delta}_{ij} = \beta_0 + \beta_1 \ln(\text{Land})_{ij} + \beta_2 \ln(\text{Time})_{ij} + \eta_i + \theta_j + \mu_{ij}$$

where $\hat{\delta_{ij}}$ is the estimated pair fixed effect from the first step, η_i and θ_j are the origin State and destination State fixed effects, respectively and μ_{ij} is the error term.

2.2 Data Sources

We use U.S. domestic migration yearly data collected by Internal Revenue Service (IRS)[13] covering 18 years period of 2000 to 2017 by including fifty states plus the District of Columbia as the unit of analysis. The migration data are based on year-to-year address changes by several individuals reported on individual income tax returns filed with the IRS. For the regional analysis, we include four regions namely; West, Midwest, Northeast, and South, as suggested by Census Regions and Divisions of the United States[14]. We get the weekly wage ($Wage_{ijt}$) data from U.S. Bureau of Labor Statistics[15]. Similarly, the data of population (POP_{ijt}), gross domestic product (GDP_{ijt}) come from Bureau of Economic Analysis(BEA)[16]. We use various sources to get the data for the time-invariant variables like $Land(ij)$, $DT-Capital-Cities_{ij}$,

[13]https://www.irs.gov/statistics/soi-tax-stats-migration-data
[14]See for detail:$https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf$
[15]https://www.bls.gov/
[16]https://www.bea.gov/

and $DT - Big - Cities_{ij}$. We get the land area data from statesymbolsusa.org[17]. The total area of land is in square miles by state. We collect the data for Driving Time in Hours between states from Capital Cities $DT - Capital - Cities_{ij}$ and Big Cities $DT - Big - Cities_{ij}$ from Google Maps. Similarly, We get the data of Income Tax by States (Income Tax $_{ijt} = \frac{Income-Tax_{it}}{Income-Tax_{jt}}$) from the U.S. Census Bureau. The detailed definition of the variables and summary statistics tables are presented below.

TABLE 1: Descriptive Statistics

Variables	Obs	Mean	Std. Dev	Min	Max
Migration$_{ijt}$	45802	2343.4471	4881.2793	0	94564
Migration-POP$_{ijt}$	45774	326.2182	505.7843	0	8853.3771
Wage$_{ijt}$	45900	1.0143	0.1615	0.5671	1.7632
ln(Wage)$_{ijt}$	45900	0.0021	0.1581	-0.5671	0.5671
GDP$_{ijt}$	45900	2.7811	5.4432	0.0115	86.9301
ln(GDP)$_{ijt}$	45900	0	1.4713	-4.4651	4.4651
POP$_{ijt}$	45900	2.7786	5.3000	0.0141	70.7122
ln(POP)$_{ijt}$	45900	0	1.4747	-4.2586	4.2586
Income-Tax$_{ijt}$	40624	8.5740	138.2836	0	20073.8313
ln(Income-Tax)$_{ijt}$	37223	0.0026	1.8301	-9.9072	9.9072
ln(Land)$_{ij}$	2550	7.08e-10	2.0768	-9.0300	9.0300
ln(DT-Big-Cities)$_{ij}$	2550	2.8623	0.5583	1.7934	4.3694
ln(DT-Cap-Cities)$_{ij}$	2550	2.9233	0.5595	1.7951	5.5601
GDP$_{ijt}$*MWSO	45900	0.6018	2.8206	0	77.8812
GDP$_{ijt}$*MWSD	45900	0.6018	2.8206	0	77.8812
GDP$_{ijt}$*SSO	45900	0.6365	2.0637	0	39.5621
GDP$_{ijt}$*SSD	45900	0.9418	3.0098	0	53.8697
GDP$_{ijt}$*WSO	45900	0.9346	3.5760	0	81.3698
GDP$_{ijt}$*WSD	45900	0.6766	3.8616	0	86.9301
GDP$_{ijt}$*NESO	45900	0.6081	3.2170	0	86.9300
GDP$_{ijt}$*NESD	45900	0.5824	2.7276	0	49.6743
POP$_{ijt}$*MWSO	45900	0.5820	2.5906	0	56.2679
POP$_{ijt}$*MWSD	45900	0.5820	2.5906	0	56.2679
POP$_{ijt}$*SSO	45900	0.7053	2.7205	0	63.7672
POP$_{ijt}$*SSD	45900	1.0226	3.2938	0	48.3330
POP$_{ijt}$*WSO	45900	0.9284	3.5196	0	70.7122
POP$_{ijt}$*WSD	45900	0.6432	3.5678	0	70.7122
POP$_{ijt}$*NESO	45900	0.5629	2.7010	0	64.1378
POP$_{ijt}$*NESD	45900	0.5040	2.3759	0	38.4382

[17]https://statesymbolsusa.org/symbol-official-item/national-us/uncategorized/states-size

TABLE 2: Definition of the Variables

Variables	Definitions
Migration(ijt)	Domestic Migration between the U.S states. We get the Migration data from the Internal Revenue Service (IRS). Migration is defined as the number of residents leaving a state and the number of new residents who moved to a State.
Migration-POP(ijt)	Migration as a proportion of population. Migration-POP$_{ijt}$ = $\frac{Migration_{ijt}}{Population-in-Million}$. We use this as an alternative definition of migration.
Wage $_{ijt}$	Median Weekly Wage in dollars. Wage $_(ijt)$ = $\frac{Wage_{jt}}{Wage_{it}}$. We get the data from the U.S. Bureau of Labor Statistics.
ln(Wage)$_{ijt}$	$ln(\frac{Wage_{jt}}{Wage_{it}})$.
GDP$_{ijt}$	Gross domestic product (in millions of dollars) by the U.S. States. GDP$_{ijt}$= $\frac{GDP_{jt}}{GDP_{it}}$. We get the data from the Bureau of Economic Analysis (BEA)
ln(GDP)$_{ijt}$	$ln\frac{GDP_{jt}}{GDP_{it}}$.
ln(POP)$_{ijt}$	Total population by states.
ln(POP)$_{ijt}$	$\frac{POP_{jt}}{POP_{it}}$. We get the data from the Bureau of Economic Analysis (BEA).
Income Tax$_{ijt}$	Per Capita Income Tax by States. Income Tax$_{ijt}$ = $\frac{Income-Tax(jt)}{IncomeTax(it)}$. We get the individual income tax (in thousand dollars) by State Government data from the U.S Census Bureau.
ln(Income Tax)$_{ijt}$	$ln(\frac{Income-Tax(jt)}{IncomeTax(it)})$.
Land$_{ij}$	Total area of land in square miles by states. Land$_{ij}$ = $\frac{Land-Area(j)}{Land-Area(i)}$. We get the data from https://statesymbolsusa.org/
DT-Capital-Cities (ij)	Driving Time in hours between states from Capital cities. We get the data from Google Maps.
DT-Big-Cities (ij)	Driving Time between the States from Big Cities. We get the data from Google Maps.
MWSO and MWSD	Mid-West Region's Origin states and Mid-West Region's Destination States. MWSO is 1 if the origin state is Midwest, and MWSD is 1 if the destination country is Mid-west, 0 otherwise.
WSO and WSD	West Region's Origin state and the West Region's Destination States. WSO is 1 if the origin state is West, and WSD is 1 if the destination state is West, 0 otherwise.
SSO and SSD	Southern Origin states and Southern Destination States. SSO is 1 if the origin state is Southern, and SSD is 1 if the destination state is Southern, 0 otherwise.
NESO and NESD	North East Origin states and North East Destination States. NESO, which is 1 if the origin state is North East, and NESD, which is 1 if the destination state is North East, 0 otherwise.

3 Empirical Results

The first-stage baseline results are presented in Table 3 and Table 5. The estimates presented in all specifications of both tables are obtained by the PPML estimation method. In Table 3, we present results without a log of explanatory variables but with all three fixed effects (origin-state-time, destination-state-time, and pair) whereas in Table 4 we present the results with a log of explanatory variables but with only two fixed effects (destination-state-time and pair) along with important origin-state-time variables, like $ln(POP)_{it}$ and $ln(GDP)_{it}$. In both tables, we used $Wage_{ijt}$ and Income Tax_{ijt} as control variables and fixed effects. The reason behind presenting two types of results is that there is collinearity between explanatory variables with logarithm and fixed effects. A detailed explanation is presented in each specific table's notes.

To analyze the effect of $SIZE$ on U.S. inter-state migration, we use GDP_{ijt} and POP_{ijt} as proxies in the first stage. All the first-stage regressions without a logarithm of explanatory variables include origin-state-time fixed effects, destination-state-time fixed effects, and pairwise fixed effects. We find the coefficients of GDP_{ijt} and POP_{ijt} negative and significant. Similarly, the control variable; Wage_{ijt} is positive and significant, and Income Tax_{ijt} is negative and significant throughout the regressions. The rich set of fixed effects controls for many observable and unobservable determinants of bilateral migration and takes care of possible endogeneity issues arising from omitted variables.

The negative coefficient of the GDP and POP signifies that people are moving from big and large urbanized states to small states. With a higher GDP and Population, the local labor market might become more competitive and the state may become less affordable, this could be a reason people move to small states. Similarly, higher wages attract more people to the states whereas higher income tax deters the in-flow of migration to the states. On average, our finding from the first stage estimation shows that a 10 percent increase in the GDP ratio and Population ratio between states leads to an average 6 percent and 4 percent decrease in interstate migration, respectively. In the second stage, the estimates presented in columns (1a) and (1b) of Table 4 correspond to first-stage estimates in columns (1), (2a), and (2b) to first-stage estimates in column 2, and so on.

As for the dependent variable in the second stage, we estimate the exporter-time fixed effects (η_{it})

TABLE 3: Baseline Result — PPML Estimation without Log

Migration_{ijt}	(1)	(2)	(3)	(4)
Wage_{ijt}	2.967***	3.295***	2.861***	3.180***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP_{ijt}	-0.028***	-0.032***		
	(0.000)	(0.000)		
Income Tax_{ijt}		-0.000*		-0.000*
		(0.054)		(0.059)
POP_{ijt}			-0.018**	-0.020**
			(0.047)	(0.036)
Constant	5.771***	5.455***	5.848***	5.538***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	45,802	40,528	45,802	40,528
R-squared	0.9442	0.9455	0.9442	0.9454

All explanatory variables are in ratios. There is collinearity between explanatory variables with logarithm and fixed effects, therefore we are presenting the table without logarithm of explanatory variables but with three fixed effects: origin state time, destination state time, and pair fixed effects, in all specifications. We also present tables with the log of explanatory variables below. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

from the first stage. We use origin-state fixed effects and destination-state fixed effects in all specifications. The negative and significant coefficient of the Land_{ij} further endorses our first stage finding that people are moving from big states to small states. For the TIME_{ij} variable, we use driving time between states from the capital cities and driving time from big cities. Both time variables give negative and significant results. We find the inverse relation between driving time and inter-state migration. In Table 6, all explanatory variables are in logarithm. All columns presented in Table 6 correspond with the Table 5. The explanatory variables land ratio in logarithm Land_{ij} collinear with fixed effect therefore we employed only the Destination-state fixed effect in all the specifications.

4 Robustness Check

To examine the consistency of our first-stage baseline results, we use various robustness checks. First of all, we present OLS (Ordinary Least Squares) estimation in Table 7, with a logarithm of explanatory variables. The coefficient of size variables (GDP_{ijt} and POP_{ijt}) are negative and significant in all specifications. In comparison to PPML, the OLS gives a little larger value of the coefficient. The Wage and Income Tax variables are significant and consistent with the baseline results.

TABLE 4: Baseline Result — Second Stage Estimation from TABLE 3.

PAIR-FE$_{ij}$	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
DT-Capital$_{ij}$	-0.04***		-0.04***		-0.04***		-0.04***	
	(0.00)		(0.00)		(0.00)		(0.00)	
Land$_{ij}$	-0.01**	-0.00	-0.01**	-0.00	-0.00**	-0.00	-0.00**	-0.00
	(0.01)	(0.63)	(0.01)	(0.65)	(0.01)	(0.84)	(0.01)	(0.90)
DT-Big-cities$_{ij}$		-0.07***		-0.07***		-0.06***		-0.07***
		(0.00)		(0.00)		(0.00)		(0.00)
Constant	-0.14	0.30***	-0.17	0.30***	-0.15	0.31***	-0.16	0.32***
	(0.41)	(0.00)	(0.38)	(0.00)	(0.44)	(0.00)	(0.41)	(0.00)
Observations	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550
R-squared	0.48	0.62	0.50	0.63	0.48	0.62	0.48	0.63

All specifications include origin state fixed effect and destination state fixed effect. DT-Capital$_{ij}$ and DT-Big-cities$_{ij}$ are the driving time between two states from the capital cities and big cities respectively. The Land$_{ij}$ variable is in ratio. P-value in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Second, we use the different definitions of the dependent variable, migration as a proportion of the population ($Migration - POP_{ijt}$) as suggested by Kirchberger (2021). In Table 8, we present the PPML estimation result without a logarithm of explanatory variables, and in Table 9, PPML estimation with a logarithm of explanatory variable result is given. The qualitative results remain the same throughout the regressions.

TABLE 5: Baseline Result — PPML Estimation with Log

Migration_{ijt}	(1)	(2)	(3)	(4)
$\ln(\text{Wage})_{ijt}$	0.647***	0.695***	0.647***	0.6952***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\ln(\text{GDP})_{ijt}$	-0.609***	-0.676***		
	(0.0000)	(0.0000)		
$\ln(\text{POP})_{it}$	0.376***	0.390***		
	(0.0000)	(0.0001)		
$\ln(\text{Income Tax})_{ijt}$		-0.008***		-0.008***
		(0.0011)		(0.0011)
$\ln(\text{POP})_{ijt}$			-0.376***	-0.390***
			(0.0000)	(0.0001)
$\ln(\text{GDP})_{it}$			0.609***	0.676***
			(0.0000)	(0.0000)
Constant	2.744**	2.482	0.918	0.044
	(0.0493)	(0.1268)	(0.3207)	(0.9666)
Observations	45,802	37,122	45,802	37,122
R-squared	0.9368	0.9373	0.9368	0.9373

[a] All explanatory variables are in the log of ratios. There is collinearity between explanatory variables with logarithm and fixed effects. For example, $\ln(\text{GDP})_{ijt} = \ln(\text{GDP})_{jt} / \ln(\text{GDP})_{it}$, $\ln(\text{GDP})_{jt} - \ln(\text{GDP})_{it}$. The $\ln(\text{GDP})_{jt}$ will be absorbed by destination time fixed effects and $\ln(\text{GDP})_{it}$ will be observed by origin-time fixed effects, therefore we drop the origin-time fixed effect and include only destination-time fixed effects, and pair fixed effects in all specifications. In that case, we control for some important origin time variables, like $\ln(\text{POP})_{it}$ when the explanatory variable for size is $\ln(\text{GDP})_{ijt}$, and $\ln(\text{GDP})_{it}$ when the explanatory variable for size is $\ln(\text{POP})_{ijt}$. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

TABLE 6: Baseline Result — Second Stage Estimation from TABLE 3.

PAIR-FE_{ij}	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
$\ln(\text{DT-Capital})_{ij}$	-0.69***		-0.67***		-0.69***		-0.67***	
	(0.00)		(0.00)		(0.00)		(0.00)	
$\ln(\text{Land})_{ij}$	-0.14***	-0.19***	-0.13***	-0.18***	-0.14***	-0.19***	-0.13***	-0.18***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\ln(\text{DT-Big-City})_{ij}$		-0.77***		-0.75***		-0.77***		-0.75***
		(0.00)		(0.00)		(0.00)		(0.00)
Constant	1.16***	1.34***	1.19***	1.37***	1.16***	1.34***	1.19***	1.37***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550
R-squared	0.38	0.45	0.34	0.40	0.38	0.45	0.34	0.40

In the above table, the explanatory variables land ratio in logarithm $Land_{ij}$ collinear with fixed effect therefore we employed only the Destination fixed effect in all the specifications. DT-Capital_{ij} and $\text{DT-Big-cities}_{ij}$ are the driving time between two states from the capital cities and big cities respectively. P-value in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

TABLE 7: Robustness Check — OLS Estimation with Log

$\ln(\text{Migration})_{ijt}$	(1)	(2)	(3)	(4)
$\ln(\text{Wage})_{ijt}$	0.323***	0.361***	0.323***	0.361***
	(0.000)	(0.000)	(0.000)	(0.000)
$\ln(\text{GDP})_{ijt}$	-0.738***	-0.773***		
	(0.000)	(0.000)		
$\ln(\text{POP})_{it}$	0.351***	0.357***		
	(0.000)	(0.000)		
$\ln(\text{Income Tax})_{ijt}$		-0.015***		-0.015***
		(0.000)		(0.000)
$\ln(\text{POP})_{ijt}$			-0.351***	-0.357***
			(0.000)	(0.000)
$\ln(\text{GDP})_{it}$			0.738***	0.773***
			(0.000)	(0.000)
Constant	1.304	1.238	-2.254***	-2.653***
	(0.196)	(0.281)	(0.000)	(0.000)
Observations	45,802	37,122	45,802	37,122
R-squared	0.927	0.929	0.927	0.929

All explanatory variables are in the log of ratios. Similar to Table 5, there is collinearity between explanatory variables with logarithm and fixed effects, therefore we drop the origin-time fixed effect and include only destination-time fixed effects, and pair fixed effects in all specifications. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

TABLE 8: Robustness Check — PPML Estimation without Log

$\text{Migration-POP}_{ijt}$	(1)	(2)	(3)	(4)
Wage_{ijt}	3.849***	4.263***	3.671***	4.071***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP_{ijt}	-0.042***	-0.048***		
	(0.000)	(0.000)		
Income Tax_{ijt}		-0.000		-0.000
		(0.185)		(0.193)
POP_{ijt}			-0.061***	-0.067***
			(0.000)	(0.000)
Constant	2.588***	2.199***	2.806***	2.429***
	(0.001)	(0.004)	(0.000)	(0.001)
Observations	45,774	40,509	45,774	40,509
R-squared	0.8872	0.8917	0.8872	0.8916

The dependent variable is $\text{Migration-POP}_{ijt}$. All explanatory variables are in ratios. In all specifications, we use origin state time fixed effects, destination state time fixed effects, and pair fixed effects. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

TABLE 9: Robustness Check — PPML Estimation with Log

Migration-POP$_{ijt}$	(1)	(2)	(3)	(4)
ln(Wage)$_{ijt}$	0.325***	0.279**	0.325***	0.279**
	(0.003)	(0.021)	(0.003)	(0.021)
ln(GDP)$_{ijt}$	-0.248***	-0.224***		
	(0.000)	(0.001)		
ln(POP)$_{it}$	0.285***	0.293***		
	(0.002)	(0.006)		
ln(Income-Tax)$_{ijt}$		-0.008**		-0.008**
		(0.015)		(0.015)
ln(POP)$_{ijt}$			-0.285***	-0.293***
			(0.002)	(0.006)
ln(GDP)$_{it}$			0.248***	0.224***
			(0.000)	(0.001)
Constant	2.010	1.856	3.342***	3.620***
	(0.148)	(0.262)	(0.000)	(0.000)
Observations	45,774	37,104	45,774	37,104
R-squared	0.8753	0.8783	0.8753	0.8783

[a] The dependent variable, Migration-POP$_{ijt}$, is migration as a proportion of population. All explanatory variables are in the log of ratios. Like above we only include the destination-state time fixed effects, and pair fixed effects in all the specifications. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

5 Analysis of Heterogeneity

Does the effect of the Size on USA internal migration difference between regions? The answer to this question could lead the paper into another interesting dimension to the analysis of heterogeneity. The relationship between size and migration could be different than the inter-state estimation if the origin or destination country is a southern, West, Midwest, or North state.

We generate the four different regions' origin and destination dummies and interact with the size variables. The detailed definition of variables is presented in Table 2. All PPML estimations for the Midwest, West, South, and North regions are presented in Table 10, Table 11, Table 12, and Table 13, respectively.

All explanatory variables in all the tables are in ratio and without logarithm. For the Mid-west region[18], in Table 10, all size variables interacted with the Mid-West origin and destination regions' dummies (MWSO and MWSD) give negative and significant results.

We present the result for the southern region[19] in Table 11. The result of all the size variables is negative and significant except GDP_{ijt}*SSO and POP_{ijt}. This shows that there is no difference between Mid-West and South regions and states in the effect of Size on USA internal migration. However, the effect of Size on regional Migration for the West[20] and North-East[21] is different than the inter-state migration in the USA.

[18]List of Midwest States: Indiana, Illinois, Michigan, Ohio, Wisconsin, Iowa, Nebraska, Kansas, North Dakota, Minnesota, South Dakota, Missouri

[19]List of States in South Region: Delaware, District of Columbia Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas

[20]List of States in West Region: Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, Wyoming, Alaska, California, Hawaii, Oregon, and Washington

[21]List of States in North East Region: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania

TABLE 10: Mid-West Region — PPML Estimation

Migration_{ijt}	(1)	(2)	(3)	(4)
Wage_{ijt}	3.291***	3.291***	3.175***	3.175***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP_{ijt}	-0.025***	-0.025***		
	(0.000)	(0.000)		
GDP_{ijt}*MWSO	-0.030***			
	(0.003)			
Income Tax_{ijt}	-.0000535 *	-.0000535 *	-.0000511*	-.0000511*
	(0.056)	(0.056)	(0.058)	(0.058)
GDP_{ijt}*MWSD		-0.030***		
		(0.003)		
POP_{ijt}			-0.012	-0.012
			(0.186)	(0.186)
POP_{ijt}*MWSO			-0.076**	
			(0.010)	
POP_{ijt}*MWSD				-0.076**
				(0.010)
Constant	5.452***	5.452***	5.554***	5.554***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	40,528	40,528	40,528	40,528
R-squared	0.9455	0.9455	0.9454	0.9454

All specifications include origin state time, destination state time, and pair fixed effects. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All explanatory variables are in ratios. The MWSO and MWSD are Mid-West Region's Origin states and Mid-West Region's Destination States, dummies. MWSO is 1 if the origin state is Midwest, and MWSD is 1 if the destination country is Mid-west, 0 otherwise.

TABLE 11: South Region — PPML Estimation

Migration_{ijt}	(1)	(2)	(3)	(4)
Wage_{ijt}	3.307***	3.282***	3.199***	3.200***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP_{ijt}	-0.031***	-0.029***		
	(0.000)	(0.000)		
GDP_{ijt}*SSO	-0.007			
	(0.627)			
Income Tax_{ijt}	-.000055*	-.0000547*	-.0000512*	-.0000513*
	(0.054)	(0.054)	(0.059)	(0.058)
GDP_{ijt}*SSD		-0.017**		
		(0.047)		
POP_{ijt}			-0.013	-0.010
			(0.203)	(0.370)
POP_{ijt}*SSO			-0.032*	
			(0.076)	
POP_{ijt}*SSD				-0.029*
				(0.066)
Constant	5.447***	5.474***	5.529***	5.520***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	40,528	40,528	40,528	40,528
R-squared	0.9455	0.9455	0.9454	0.9454

[a] All specifications include origin state time, destination state time, and pair fixed effects. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All explanatory variables are in ratios. The SSO and SSD are Southern Origin states and Southern Destination States, dummies. SSO, which is 1 if the origin state is Southern, and SSD, which is 1 if the destination country is Southern, 0 otherwise.

TABLE 12: West Region — PPML Estimation

$Migration_{ijt}$	(1)	(2)	(3)	(4)
$Wage_{ijt}$	3.298***	3.324***	3.185***	3.203***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP_{ijt}	-0.034***	-0.052***		
	(0.000)	(0.000)		
GDP_{ijt}*WSO	0.003			
	(0.697)			
Income Tax_{ijt}	-.0000548 *	-.0000537*	-.0000511*	-.0000512*
	(0.054)	(0.054)	(0.059)	(0.058)
GDP_{ijt}*WSD		0.029***		
		(0.000)		
POP_{ijt}			-0.026**	-0.043***
			(0.020)	(0.000)
POP_{ijt}*WSO			0.013	
			(0.429)	
POP_{ijt}*WSD				0.043***
				(0.003)
Constant	5.453***	5.449***	5.536***	5.533***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	40,528	40,528	40,528	40,528
R-squared	0.9455	0.9455	0.9454	0.9454

[a] All specifications include origin state time, destination state time, and pair fixed effects. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All explanatory variables are in ratios. The WSO and WSD are West Region's Origin states and West Region's Destination States, dummies. WSO is 1 if the origin state is West, and WSD is 1 if the destination state is West, 0 otherwise.

TABLE 13: North East Region — PPML Estimation

$Migration_{ijt}$	(1)	(2)	(3)	(4)
$Wage_{ijt}$	3.325***	3.295***	3.190***	3.178***
	(0.000)	(0.000)	(0.000)	(0.000)
GDP_{ijt}	-0.038***	-0.032***		
	(0.000)	(0.000)		
GDP_{ijt}*NESO	0.056***			
	(0.000)			
Income Tax_{ijt}	-.000055*	-.0000547*	-.0000511*	-.0000511 *
	(0.054)	(0.054)	(0.059)	(0.059)
GDP_{ijt}*NESD		-0.006		
		(0.466)		
POP_{ijt}			-0.035***	-0.019*
			(0.002)	(0.052)
POP_{ijt}*NESO			0.072***	
			(0.000)	
POP_{ijt}*NESD				-0.009
				(0.600)
Constant	5.422***	5.456***	5.541***	5.541***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	40,528	40,528	40,528	40,528
R-squared	0.9455	0.9455	0.9454	0.9454

[a] All specifications include origin state time, destination state time, and pair fixed effects. P-value in parentheses.*** p<0.01, ** p<0.05, * p<0.1. All explanatory variables are in ratios. The NESO and NESD are North East Origin states and North East Destination States, dummies. NESO is 1 if the origin state is North East, and NESD is 1 if the destination state is North East, 0 otherwise.

6 Conclusion

Does the Size matter for the USA internal migration is the main research question that this paper considers. Although no specific federal policy governs domestic migration in the USA, the answer to this question has many policy implications for the state levels. We use U.S. inter-state migration data from the Internal Revenue Service (IRS) between 2000 and 2017 and employ the structural gravity model and PPML estimation method. We use different definitions of variables, and other estimation methods PPML and OLS to check the robustness of the results. The qualitative result is robust and consistent through the regressions. We conclude that people are moving from large states to small states. The impact of size on internal migration within the USA shows no distinction between the Mid-West and South regions. However, the influence of size on regional migration varies for the West and North-East compared to interstate migration across the country.

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A Appendix

A.1 Regions and Division of USA