Online Appendix
Local Ties in Spatial Equilibrium

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Appendix A Data

Data come primarily from the United States Decennial Census and the American Community Survey (ACS). Data on the effect of trade on individual local labor markets come from Autor, Dorn and Hanson (2013). I generally aggregate these data up to Commuting Zones (CZs) and perform analyses at the CZ level (Tolbert and Sizer (1996)).

The data from the U.S. Census Bureau come via IPUMS (Ruggles et al., 2010). I use several Public Use Microdata Samples: For 1970, I use the 1 percent sample at the metro level. For 1980, 1990, and 2000, I use the 5 percent samples. For 2008, I use the ACS three-year estimates from 2006 to 2008. I exclude people residing in group quarters, such as military barracks or dormitories. For worker wages, I exclude unpaid family workers and only include people who worked last year. I also exclude Alaska, Hawaii, and Puerto Rico from the analysis both to match previous studies and because moving costs to and from these locations are likely more expensive.

A few sample restrictions and re weightings allow me to focus on the labor market. I include only 22 to 64 year olds who are not living in group quarters like barracks, prisons, and dorms. I also compute labor supply weights following Autor and Dorn (2013) that weight workers by their total hours worked last year, and I exclude the top and bottom 1 percent of wages from the computation. In addition, I adjust wages and prices using a personal consumption expenditure (PCE) chain type deflator so they represent 2007 dollars.

The roughly 10 year increments are useful for looking at changes because the one-time moving or migration costs for transporting personal effects are small relative to the flows of higher real wages, amenities, or both over 10 years.[1] Indeed, much of the previous literature has focused on 10-year increments, using data from the Census (e.g. Bound and Holzer (2000); Diamond (2016); Notowidigdo (2020)). The one exception to the 10-year rule is the period from 2000 to 2008, when I exclude the Great Recession by using the ACS 3-year estimates covering 2006, 2007, and 2008.

Credit Availability from the Home Mortgage Disclosure Act

I use data on mortgage denials that banks are obliged to provide because of the Home Mortgage Disclosure Act (HMDA). These data cover mortgage applications at regulated financial institutions (most commonly, banks and credit unions) subject to the law's reporting regulations. I use the public files available from the National Archives (Federal Reserve System, 2014).[2]

I rely on denials as a measure of credit availability, following Dell'Ariccia, Igan and Laeven (2012) and Gabriel and Rosenthal (2013), among others. Denials represent instances when someone applied for a loan to buy a house but was not provided with credit. So denials represent a proxy for the willingness to lend to people in that CZ. For example, a high number of denials in a CZ could be due to features like low levels of savings, insufficient credit histories, difficulty documenting incomes, prior delinquencies, a lack of knowledge about the mortgage process, or other features. Denials indicate that credit would be less available to residents moving both in and out. They also are preferable to credit scores in this sample period, because they are available going back to 1990. Credit scores are only available for later dates.

Mechanically, the measure is the raw count of denials in the particular CZ. I restrict to home purchase loans originated in the CZ by excluding banks' loan purchases, refinances, and home improvement loans. I code a denials as a percentage

[2]Exemptions are mainly for very small financial institutions. More information is available in Regulation C, or 12 CFR 203, which is provided with the data files by the National Archives.

of loans where one of three things happened: the loan was originated; the application was approved, but a loan was not originated; or the application was denied. I drop entries where the application was withdrawn or a file was closed due to incompleteness. I include all loan types reported due to HMDA requirements in addition to conventional loans. Denial rates in 1990 are my measure of credit availability from 1990 to 2000. Denial rates in 2000 apply to the period from 2000 to 2008. HMDA data are not available for this purpose in 1980. I exclude observations where less than 30 mortgages are reported in that year, but because the data are close to a universe of mortgages, there is coverage of most CZs.

Commuting Zones

I define places using CZs (Tolbert and Sizer (1996)) that encompass both residences and workplaces. CZs reflect labor markets where workers live and work, based on commuting data collected in the 1990 census. CZs also cover the entire continental United States, which allows me to examine ongoing migration from rural areas. A given CZ can contain multiple states and states can contain multiple CZs. When I cluster by state, it is the state that contains the plurality of the CZ's population. I keep these constructs fixed at their definition in 1990 to avoid spurious changes due to changes in geographic boundaries.

Measures of Local Ties

I use the proportion of residents of a local labor market who are living in the state of their birth as my primary measure of local ties. Because the Decennial Censuses and the ACS only ask for one's state of birth, it is impossible to determine precisely what local labor market a respondent was born in without using another data source.[3]

My primary measure of local ties is highly correlated with measures derived from online social networks, linked administrative data covering birthplaces, and an alternative survey question. It is not currently possible to replicate most analyses with these alternative data sources because of limitations in data coverage and linking.

[3] U.S. territories and foreign countries are generally the finest geographies for people born outside of U.S. states.

However, this analysis, along with some robustness exercises presented in another appendix, does show how this data limitation is unlikely to be driving the main conclusions in the paper.

Measures from Facebook Friendships

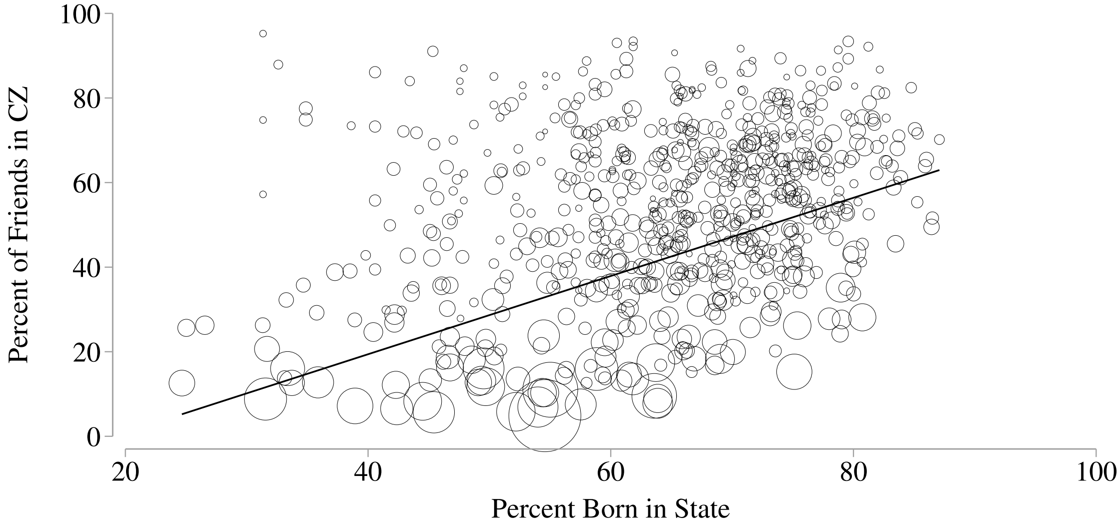
The share of residents born in state is highly correlated with the structure of friendships on social media. Figure A.1 plots the share of residents who were born in state against the share of all Facebook friendships that are within the CZ. The figure shows a clear association between the two measures, which have a correlation coefficient of 0.49. So places where a higher share of people were born locally tend also to contain more inward-focused social networks. Robustness exercises in Appendix D also show that one obtains similar results when using these 2020 measures for the analysis of trade shocks from 1990 to 2012.[4]

Measures from Linked Administrative Data

Linked data show that measures of local ties are quite similar regardless of whether they are measured using birth counties or birth states. Table A.1 presents the share of adults in the complete count data from the 2000 census who are living in their state of birth and who are also living in their CZ of birth, as well as within 50 miles of their birth county. It uses data from the 2000 Census Short Form linked to administrative data from the Social Security Administration on adults' places of birth (developed in Stuart, forthcoming). Seventy-four percent of adults living in their birth state are also living within their birth CZ, compared with 3 percent of adults who are living outside of their birth state. An even higher proportion of people living in their birth state live within 50 miles of their birthplace.

[4]Note that the data for this figure cover 2015 to 2019 for the population estimates and September 2020 for the Facebook friendships. The mismatched time periods are due to a lack of data on social networks in the periods I study. The Facebook friendship data are an aggregation of Facebook's Social Connectedness Index as of September 2020 (Bailey et al., 2018) using county-level population estimates from the same ACS 2019 five-year estimates, via the National Historical Geographic Information System (Manson et al., 2021). Sample restrictions discussed previously are dropped to match Facebook's user base.

Figure A.1: Percent of Facebook Friends in Commuting Zone and Percent Born in State



Note: Commuting Zones (CZs) where a higher share of residents were born in state also had a higher fraction of Facebook friendships containing two residents of the CZ, as opposed to someone outside. Plotted on the x axis is the share of residents who were born in the same state they live in according to the American Community Survey (ACS) 2019 five-year files, via IPUMS (Ruggles et al., 2021) with no additional sample restrictions. Plotted on the y axis is the share of all Facebook friendships for users in the CZ that are with another user in the same CZ. It is based on an aggregation of Facebook's Social Connectedness Index as of September 2020 (Bailey et al., 2018) using county level population estimates from the same ACS 2019 five year estimates, via the National Historical Geographic Information System (Manson et al., 2021). The size of each circle is proportional to the total population in the place measured using IPUMS.

Table A.1: Comparison with More Detailed Places of Birth

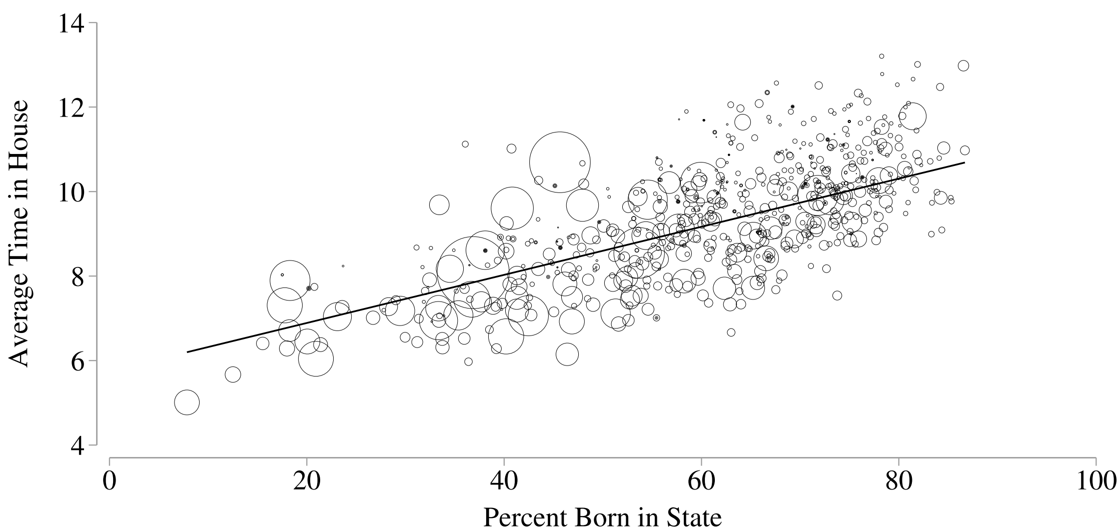
	In CZ	Within 50 miles
In birth state	73.8	80.3
Outside birth state	3.3	7.2

Note: Most people who live in their birth state also live in the same CZ they were born in and within 50 miles of where they were born. This table shows the share of people who live in their CZ of birth and within 50 miles of their birthplace, split by whether or not they already live in their birth state or not. Data come from a link between the Social Security Administration NUMIDENT and the 2000 Census Short Form. Methodological details are contained in Stuart (forthcoming).

Measures from an Alternative Question

Using the amount of time householders have lived in their houses – an alternative question asked in the census and ACS – gives similar results. Figure A.2 shows a strong relationship between the two measures, which have a correlation of 0.69. Because the amount of time someone has spent in their house is not directly affected by county and state boundaries, the strong relationship between the two gives additional reassurance that the results are not driven by geographic definitions of birthplaces.

Figure A.2: Average Time Living in One's House and Percentage Born in State



Note: Commuting zones where a higher share of residents were born in state also have residents who have been living in their houses for longer. Plotted on the x axis is the share of residents who were born in the same state they live in 2008, using the standard sample. Plotted on the y axis is the average amount of time householders have lived in their houses, using the same year and sample. The size of each circle is proportional to the total population.

Discussion

In addition to the similarities between my measure and other measures of local ties, including social network and administrative data, there are several other reasons why mismeasurement is unlikely to be driving the paper's findings. First, using other measures of time spent in a place yields similar empirical results, as shown in Section D.[5] Second, the lack of more detailed information should lead to higher shares of locally born residents in large western states like California and Texas, which is the opposite of what I find. Third, the measure's relationship with historical population is strong and likely to still hold, even if there is mismeasurement in the proportion of people living in their birth CZ. Fourth, the correct measure of proximity to one's birthplace is unclear. Workers who live in their state of birth could still be more likely to have local ties than workers who were born many states away, even if they live in a city on the other side of the state.

Finally, mismeasurement is unlikely to be a problem because my measure of local ties has a strong structural relationship with population changes – a relationship also detailed by Coate and Mangum (2019). Table A.2 gives a granular view of the relationship, also displayed in Figure 6, by presenting the share of locally born adults as well as population changes for all CZs where the population aged 22 to 64 was at least 500,000 in 1980.

[5] In earlier versions of the paper, I also excluded states where measurement error was more likely to be a problem and obtained similar results.

Table A.2: Shares Born Locally in Large Cities

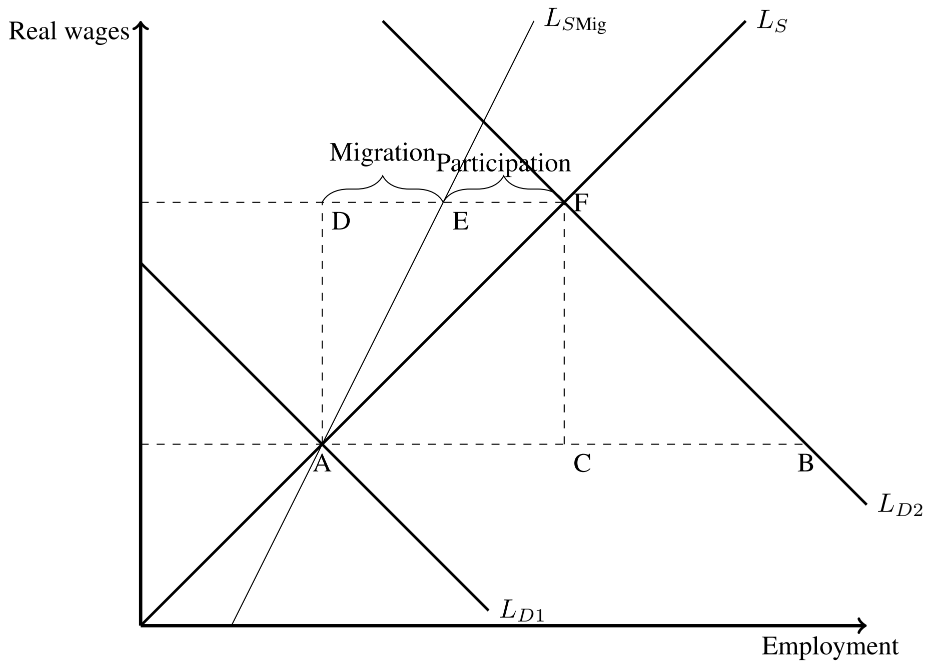
	Share locals Percent	Population Pct change	Population Millions in 1980
Miami, FL	18	90	1.24
Washington, DC	18	60	1.90
Phoenix, AZ	21	175	0.85
Tampa, FL	23	88	0.80
Denver, CO	30	78	0.92
Portland, OR	33	76	0.70
Atlanta, GA	33	146	1.13
San Jose, CA	34	43	0.99
San Diego, CA	35	69	0.97
Seattle, WA	37	75	1.40
Los Angeles, CA	37	58	6.24
San Francisco, CA	38	38	2.04
Dallas, TX	40	118	1.08
Newark, NJ	41	18	2.88
Houston, TX	42	84	1.67
New York, NY	46	22	5.75
Kansas City, MO	46	42	0.77
Fort Worth, TX	47	110	0.57
Bridgeport, CT	48	18	1.66
Sacramento, CA	51	96	0.85
Chicago, IL	54	27	3.84
Baltimore, MD	54	27	1.17
Boston, MA	55	25	2.34
Providence, RI	57	23	0.74
Minneapolis, MN	58	58	1.16
San Antonio, TX	58	86	0.58
Philadelphia, PA	60	16	2.73
Indianapolis, IN	62	51	0.64
Louisville, KY	64	27	0.53
Columbus, OH	65	48	0.70
St. Louis, MO	65	22	1.12
Cincinnati, OH	67	32	0.89
Milwaukee, WI	67	20	0.80
Dayton, OH	70	5	0.61
New Orleans, LA	72	-11	0.70
Detroit, MI	72	10	2.76
Cleveland, OH	73	2	1.43
Albany, NY	74	22	0.51
Grand Rapids, MI	75	49	0.50
Buffalo, NY	78	4	1.24
Syracuse, NY	79	6	0.55
Pittsburgh, PA	81	-7	1.49

Note: This table shows an inverse relationship between the share locally born in 2008 and population changes from 1980 to 2008 by showing values of each for all commuting zones with prime-aged adult populations of 500,000 or more in 1980. All statistics reflect the paper's sample of prime-aged adults.

Appendix B A System of Labor Supply and Demand

The system of labor demand and supply in Figure A.3 illustrates the effects of lower migration on equilibrium outcomes. It plots total employment against real wages (which include wages and rents) in a local labor market that begins in equilibrium at point A. Labor demand is downward sloping and initially at L_{D1}, and labor supply is upward sloping at L_S. Labor supply incorporates two different margins – migration and participation. To separate these two effects, $L_{S\text{Mig}}$ shows how labor supply would change if participation was held constant at the same level as point A and only migration were allowed to vary.

Figure A.3: Effects of a Labor Demand Shock Along Multiple Margins



A change in labor demand from L_{D1} to L_{D2} shows the relative importance of the two margins of labor supply – migration and participation. The overall effect is to move the equilibrium from point A to point F, with higher levels of both employment and real wages. To see the impact of the two labor supply margins, consider how each responds to the equilibrium increase in real wages from A to D. The increase in real wages induces a net in migration, increasing employment from D to E, and it also increases participation among people already in the area, from E to F. If one is interested in the migration elasticity, or the slope of $L_{S\text{Mig}}$, then one can use these two responses to see its relative magnitude.[6] Empirically, I can proxy for the distance from D to E by using the change in population after the labor demand shock. Similarly, I can proxy for the distance from E to F by using the change in labor force participation. If the change in population is large relative to either the change in participation, the increase in real wages, or both, then migration is relatively fluid.

Responses along each margin show the equilibrium implications of a lower migration elasticity. As $L_{S\text{Mig}}$ gets more vertical, so does L_S, and thus the equilibrium real-wage response to the change in demand tends to be larger. This larger real wage response will also tend to increase the participation margin response, meaning that more people will be drawn into the labor force after an equivalent change in labor demand. In the case of this increase in labor demand, the implication is that residents of places with lower migration elasticities will have more to gain from an increase in labor demand, as they will earn higher real wages after equivalent demand shocks. The increases in participation may also be advantageous if policymakers have concerns about the long-term effects of joblessness (Austin, Glaeser and Summers, 2018). Areas with smaller migration elasticities, however, will have more to lose from decreases in labor demand.

Appendix C Estimating Migration Elasticities

It is possible to directly measure the migration elasticities by measuring changes in population after the Bartik and Import shocks. The equation below shows the basic empirical specification that I use to recover the migration elasticity, $\eta_{\text{Mig},j}$. The migration elasticity measures the effect of an increase in log incomes on log population, including the endogenous responses of other local prices. Because I intend to include the effects of these other local prices, like housing prices, I do not attempt to control for them. I do control for decade fixed effects, γ_t, and the standard set of controls from the reduced form regressions in the main text, βX_{jt}. These ensure that the regressions are not being driven by different trends for places where people are of different ages, different education levels, or places where more people are foreign born, for example. Following regressions in the main text, I allow heterogeneity across places, j, by splitting places into bins based on their levels of local ties and by including a continuous interaction with the level of local

[6] If I assume a constant elasticity of labor demand (η_D), labor supply due to migration ($\eta_{S\text{Mig}}$), and labor supply due to participation ($\eta_{S\text{Part}}$), then the size of the equilibrium changes will be simple functions of the three elasticities and the size of the labor demand shock, $B - A$. The change due to migration ($E - F$) is $\eta_{S\text{Mig}} \frac{B-A}{\eta_D + \eta_{S\text{Mig}} + \eta_{S\text{Part}}}$ and the total change in employment ($F - D$) is be $(\eta_{S\text{Mig}} + \eta_{S\text{Part}}) \frac{B-A}{\eta_D + \eta_{S\text{Mig}} + \eta_{S\text{Part}}}$. Conveniently, the ratio of these two terms is the ratio of the migration elasticity to the total labor supply elasticity. Also, the change in wages ($F - C$) is $\frac{B-A}{\eta_D + \eta_{S\text{Mig}} + \eta_{S\text{Part}}}$.

ties in each place.

$$\Delta \text{log pop}_{jt} = \eta_{\text{Mig},j} \Delta \text{income}_{jt} + \gamma_t + \beta X_{jt} + \epsilon_{jt} \tag{1}$$

To isolate plausibly exogenous changes in local incomes, I use both the Bartik shifters in the 1980s and the Chinese import measures in the 1990s and early 2000s.[7] To maximize power, I stack the data for each of the three decades and estimate one set of parameters in the second stage. I allow the Bartik instruments to have different first-stage effects from the trade instruments, but I assume the impact of the trade instruments is the same in each decade. [8]

I measure changes in incomes by combining information about changes in wages with information about the availability of jobs, as measured by the employment-to-population (EPOP) ratio. Wages are an imperfect measure of labor incomes because there appear to be significant frictions to their adjustments, particularly in periods when labor demand is falling. Workers and employees may be reluctant to accept declines in nominal wages, for example, and search frictions could also play a role.

Labor incomes are the product of wages once one is employed times one's probability of being employed, as in Harris and Todaro (1970). Potential migrants consider not only wages, but also the difficulty of finding and keeping a job. I use the EPOP ratio as a measure of this probability. Changes in log labor income, then, are changes in log wages, Δwage_{jt}, plus changes in the local EPOP ratio, $\Delta \text{emp ratio}_{jt}$.

$$\Delta \text{income}_{jt} = \Delta \text{wage}_{jt} + \Delta \text{emp ratio}_{jt}$$

The estimated migration elasticities – reported in Table A.3 – are an order of magnitude lower in places with higher levels of local ties. The migration elasticities in column 1 are 0.08 in high-ties places and 0.99 in low-ties places. These are statistically different from one another at the 10 percent level. The instrument also appears to be strong enough to support this inference, as traditional Wald and Kleibergen-Paap corrected Wald F statistics for the first stage are above traditional thresholds.

The slope of the continuous linear interaction in column 2 of Table A.3 implies that migration elasticities decline by around 0.35 for every 10 percent increase in the share of locals. I also plot the estimate in Figure A.4. To get an idea of the magnitudes, around 15 percent of people who live in Miami were born in Florida. So

[8]Another point about the instruments is that the use of labor incomes abstracts from people's labor leisure choices. In the model in the main text, and in much of the literature on spatial equilibrium, an increase in labor incomes has an identical effect as an equivalent increase in local subsidies, because people work for a fixed number of hours in the place where they live.

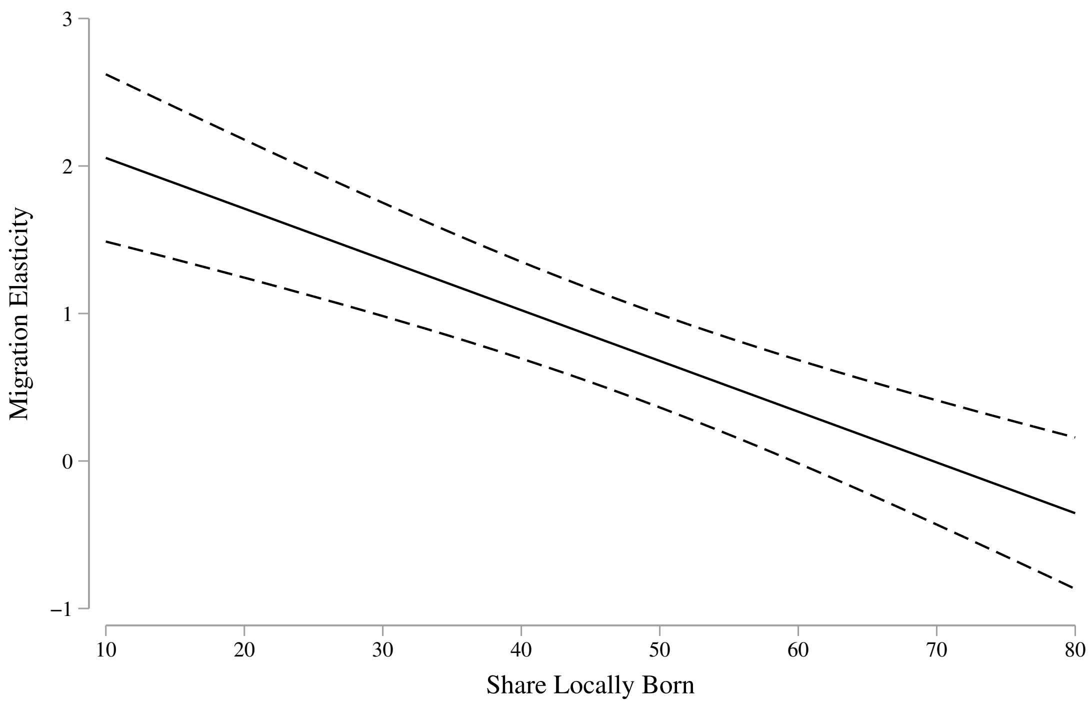
the estimated migration elasticity is around two in Miami. In places with very high levels of local ties, the estimated migration elasticity reaches zero. The continuous linear interaction term is statistically different from 0 at the 1 percent level, and the regression also passes conventional thresholds for having a sufficiently strong instrument.

Table A.3: Estimated Migration Elasticities from Demand Shocks

	(1)	(2)	(3)
High ties: Incomes	0.08		
	(0.24)		
Low ties: Incomes	0.99		
	(0.39)		
High ties indicator	-0.95		
	(1.14)		
Main effect of incomes		2.40	1.35
		(0.34)	(0.58)
Interaction (x100)		-3.44	
		(0.64)	
Main effect of ties		-0.14	
		(0.07)	
Year fixed effects	Y	Y	Y
Controls	Y	Y	Y
P-val: No difference	0.03	0.00	
First stage F: Wald	35	37	46
First stage F: K-P	12	11	14
Observations	2,166	2,166	2,166

Note: Estimated migration elasticities are much lower in places with high shares of locally born residents, or high local ties. This table displays the estimated coefficients from a regression using the two labor demand shocks – due to trade and national industry level changes – to instrument for log incomes in a regression predicting log population. So, the estimated relationship is an estimated migration elasticity. The regressions use the standard set of controls and standard errors clustered at the state level, as in Table 2 of the main text. The statistics at the bottom report a Wald test for no difference in the elasticities between low- and high-ties places, the first stage partial Wald F statistic, and Kleibergen-Paap corrected Wald F statistic.

Figure A.4: Estimated Migration Elasticities



Note: Estimated migration elasticities are much lower in places with high shares of locally born residents, or high-ties places. This figure displays the migration elasticities implied by column 2 of Table A.3 based on the methodology reported in that table. The dotted lines represent 95 percent confidence intervals of the values.

Appendix D Robustness Checks

This section shows robustness of the regression results that depressed places have lower migration responses to labor demand shocks. First, I briefly discuss the triple difference specification that I use here both to show the robustness to departures from the bins specification used in Table 2 and for simplicity in comparing many specifications. Second, I discuss groupings of each of the possible concerns. Results follow in several tables at the end of this section.

Triple Differences Specification

With the exception of Table A.11, I show the robustness of the results in Table 2 by presenting results using a single linear interaction term – a triple difference. The triple difference shows variation in the responses of places with different levels of local ties using one as opposed to two statistics. Presenting a single statistic is important for controlling the size of these tables because I use many alternative specifications and dependent variables. Using a linear interaction term also shows that the specifications in Table 2 are not sensitive to the 60 percent cutoff.

$$\Delta y_{j,t} = \alpha_t + \beta_1 \text{Ties}_{j,t-1}\Delta\hat{L}_{j,t} + \beta_2 \text{Ties}_{j,t-1} + \beta_3 \Delta\hat{L}_{j,t} + \gamma_X X_{j,t-1} + \epsilon_{j,t} \quad (2)$$

The linear interaction term has a different interpretation than the coefficients in the specification in the main text, equation 1. In equation 2, the effect of a labor demand shock linearly scales with the share of residents who are living in their state of birth. A positive main effect (β_3) and a negative linear interaction term (β_1) mean that a labor demand shock increases the dependent variable by more in places with low levels of local ties than it does in places with high levels of local ties. The unmodified linear interaction term, which I multiply by 100 for readability when using shares, gives the difference between a place where no residents live where they were born and a place where everyone lives where they were born. However, no places have either full or zero local ties. A more reasonable number is to divide each linear interaction term by three, because Table 1 in the main text shows that two standard deviations of the share of locals across places is around 30 percent.

To address concerns about omitting other explanatory factors, I include them both in additional interaction terms with the labor demand shifter and as controls. Including additional terms purges the estimates of differences in reactions associated with these other explanatory factors, as opposed to local ties. So it rules out the possibility that differences in these variables are driving the effects I observe.

Specification, Weights, and Controls

The most basic concerns are standard econometric ones related to the specification, starting with my arbitrary cutoff of places with a high level of local ties as having at least 60 percent locals. I address concerns about the cutoff by using the triple differences specification (columns labeled "Base"), which substitutes an assumption of a linear functional form for having a specific cutoff between groups. The triple differences give a very similar result to the specifications in Table 2.

My use of weights and control variables also does not appear to be driving the results. I address possible issues about controls by excluding the controls (columns labeled "Direct") and issues about weights by presenting results without weights (columns labeled "Un-Wt").

Another useful specification check is to show the ordinary least squares (OLS) results in addition to the instrumental variables (IV) estimates of the impacts of Chinese import competition. I show these results in Table A.11 using the bins specification and in columns labeled "OLS" for the triple difference specification. Finally, using an OLS specification relating outcomes to Chinese imports directly, rather than through lagged changes in Chinese exports to other countries gives similar results. So the use of the instrumental variable does not appear to be driving the results.

Aging, Education, and Labor Force Participation

Places with more local ties also differ in terms of other demographic variables that could affect how places respond to labor demand shocks. Table 1 shows that places with more local ties have somewhat higher shares over 50 and higher shares of college educated workers. Because migration rates tend to decline with age and increase with educational attainment, these variables could lade to different migration responses by themselves. Differences in labor force attachment could also drive different migration responses. Though Table 1 does show that places with more local ties have similar EPOP ratios.

In terms of the empirical specifications, I address these concerns by allowing for heterogeneous effects due to observable differences in these variables.[9] The column labeled "Age" shows that the effects of local ties are not driven by the age composition of the population by including additional interactions of the labor demand shock, with the share of adults under age 35 in interaction two and over age 50 in interaction three. The column labeled "College" shows that the effects are

[9] Another appendix presents an extension of the model to include differences in educational attainment, among other features.

not due to differences in residents' educational attainment by including the share of people who are college educated as interaction two. The column labeled "NILF" shows that the results are not driven by differences in labor force participation by including the share of adults who are outside the labor force as interaction two.

Cash, Credit, Poverty, and Housing Costs

Other concerns relate to people's ability to finance a move with either credit or savings. Most estimated mobility costs are too large to reasonably reflect only cash costs, suggesting that other factors like local ties could be at play. Kennan and Walker (2011) give estimates of moving costs on the order of $300,000, around 100 times the cost of a typical rented moving truck for a home with three or more bedrooms. None-the-less, a lack of cash or credit could also play a role.[10]

I address concerns about credit, liquidity, and poverty more broadly by introducing the variables in two specifications and showing they have minimal effects on the main results. The column labeled Credit addresses concerns about residents' access to credit by using the share of mortgages denied in the CZ according to HMDA filings.[11] The column labeled "Wealth" addresses concerns about liquidity constraints by including the local poverty rate as interaction two and the log of the average level of investment income.

Another, related factor could be differences in the relative cost of housing across places. Glaeser and Gyourko (2005) and Notowidigdo (2020) argue that low rent places are particularly attractive to low-income households who spend relatively high shares of their incomes on housing (Larrimore and Schuetz, 2017). Declines in the price of housing could also lock owners in their homes, but the literature on the size of the housing lock-in effect on owners is mixed (Ferreira, Gyourko and Tracy, 2010; Bricker and Bucks, 2013; Valletta, 2013). In aggregate, the effect is likely to be even more muted, as lock-in effects do not apply to the 40 percent of the population that are renters.

The columns labeled "Rents" address concerns about the low level as well as abrupt declines in the price of local housing by showing that the results survive their inclusion. The "Rents" columns include several variables similar to those in Glaeser and Gyourko (2005) – the level of local log rents as interaction two and the lagged 10-year change in log rents as interaction three.

[10] An international literature, including Munshi (2003), has found evidence that insurance and liquidity can encourage migration. Krolikowski, Zabek and Coate (2020) also show evidence of the insurance channel in the United States.

[11] These measures are more fully explained in Appendix A and are unfortunately not available in 1980, so they do not appear in that regression table.

Alternative Measures of Local Ties

This paper uses an empirically convenient definition of local ties – living in one's birth state – that encompasses many different underlying processes. Some obvious ones are the numerous benefits of having a dense social network nearby (Topa (2011) and Krolikowski, Zabek and Coate (2020)), endogenously formed attachments to nearby amenities, and other locally specific investments like the local social capital from participating in community organizations. Wilson (2021) even argues that people form attachments to state identities themselves. While most of the takeaways would apply regardless of the specific underlying mechanisms, my use of people's birth states could introduce biases due to quirks of state and CZ geographies or mechanical correlations with other factors that the empirical specifications cannot fully control for.

This section shows that the results remain using alternative measures of local ties, building on analysis in the data appendix showing that alternative measures of local ties are highly correlated with my preferred measure. So mismeasurement of my preferred measure does not appear to be driving the results. In columns labeled "Friends" I find similar results using the share of 2020 Facebook friendships involving two residents of the CZ (as opposed to only one) as a measure of social connections in the area.[12] In columns labeled "Time," I use time spent in one's house. Time in one's house is not sensitive to issues of measuring local ties in a CZ with the share of people residing in their birth state, and results are similar.[13]

Differences in the Shocks Themselves

Another possibility is that there are systematic differences in the labor demand shocks themselves. Table 1 shows that places with higher levels of local ties generally experienced more negative labor demand shocks than other places and that high-ties places have a higher share of employment in manufacturing. Figure A.5 shows the relationship between local ties and the magnitude of labor demand shifters for individual CZs. Because high-ties places experienced more negative labor demand shocks, dynamics in high-ties places are more relevant for understanding effects of negative labor demand shocks, like automation and trade. The negative relationship between local ties and labor demand, however, also leaves open the

[12]The data are only available after my sample period, so I only use them in the trade shock regressions from 1990 to 2008. Even then, the timing of the friendship data is after all of the other variables, and there is a distinct possibility of reverse causality. Also, note that the Facebook variable has a standard deviation that is only slightly higher than that of the share of residents who are locally born. So the magnitudes of coefficients are roughly comparable.

[13]Note that the interacted coefficients are not multiplied by 100 for this variable.

possibility that the main empirical results could be due to other nonlinearities in responses to negative demand shocks and not local ties.

To address the possibility that the different magnitudes of labor demand shocks are themselves leading to different responses across high- and low-ties places, I introduce non-linear terms in the labor demand shocks. Nonlinear terms allow the impacts of labor demand shocks to vary between places that experience large and small shocks and to avoid these differences loading on differences in local ties. Specifically, the column labeled "Square" allows for nonlinearity in the impacts of the shifter by adding a square term in the shifter. The columns labeled either "Low" or "Big" allow the effect of the shifter to vary based on the Bartik shifter being below the weighted mean labor demand shifter across places (so unusually negative). Each of these approaches gives similar results to the preferred specification.

Another possibility is that the results are due to differences in how labor demand shocks affected different industries, like manufacturing. So I address differences in industrial composition by including interactions with the share of employment in manufacturing in the columns labeled "Manuf." Results are similar after introducing these controls.

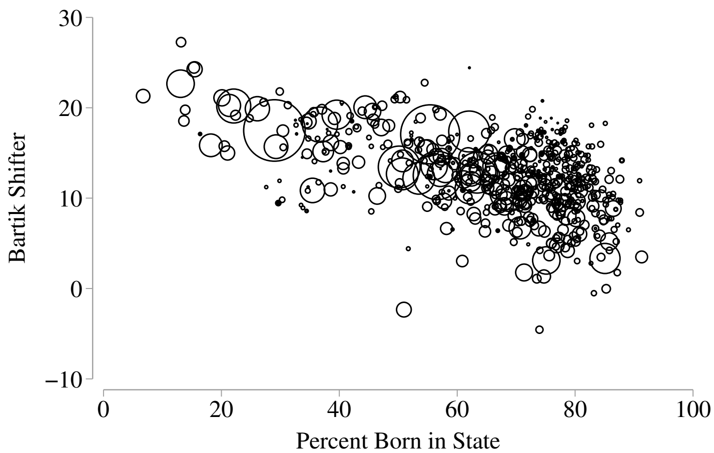
Results for Bartik Shifters

The main result for the Bartik labor demand shifters – that population responses are smaller in places with more local ties – is similar in the robustness specifications in Table A.4. The linear interaction term in the triple difference specification for population, shown in the column labeled "Base" in Table A.4, has a statistically and economically significantly negative coefficient. The coefficient shows that a two standard deviation increase in the share born locally is associated with a 1 percentage point smaller population response to the Bartik shifter, which lines up well with estimates in Table 2.

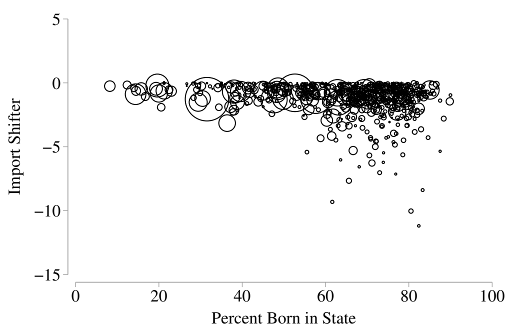
Including different interaction terms, omitting controls, and omitting weights gives similarly sized negative estimates in the first row of Table A.4. The coefficient is significantly below zero and between negative 1.6 to negative 5.2 in magnitude – the most negative when omitting weights and of the smallest magnitude when omitting controls. Estimates also do not suggest that the Bartik shifter had measurably asymmetric effects. The square term in the column labeled "Square" is insignificantly different from zero. Additionally, interactions with an indicator for being a relatively negative labor demand shock in the column labeled "Low" are similarly insignificantly different from zero as well as small in magnitude.

Population effects of labor demand shocks are also smaller when I measure ties by the time people have spent in their current house as opposed to living in their

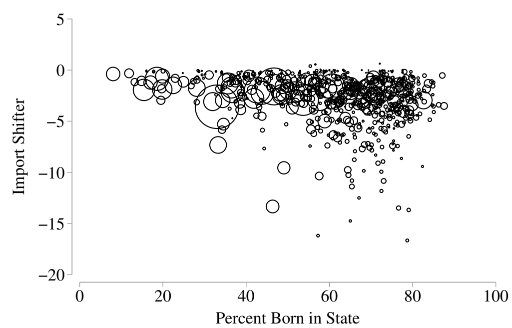
Figure A.5: Local Ties and Labor Demand Shifters



Panel A: Bartik Shifters from 1980 to 1990



Panel B: Trade Shifters from 1990 to 2000



Panel C: Trade Shifters from 2000 to 2008

Note: Places with more local ties also tended to experience more negative shocks. Over the 1980's most industries gained employment, on net, implying positive average Bartik shifters. Trade shifters were negative and tended to affect some places much more than others. Plotted is a scatter-plot of local ties on the x axis alongside Bartik shifters and Chinese import (to the United States) shifters on the y axis for the specified period. Each circle represents a commuting zone (CZ) in the continental United States and the radius is proportionate to population in the beginning of the period. For readability, two CZs are excluded from the plots of Chinese import shifters due to extremely negative import shocks.

state of birth. The coefficient in the column labeled "Time" also shows a significantly negative interaction term. The magnitudes are also similar when evaluated in standard deviations of the measure of ties.[14]

Results for Trade Shocks

The main result for the trade shocks are similarly robust across specifications in Tables A.5 through A.10.

The larger impacts of labor demand shocks on participation rates in places with more local ties are apparent throughout Table A.5. The column labeled "Base" shows that an increase of two standard deviations in the share of local residents is associated with around a 0.8 percentage point larger increase in the labor force participation rate per every thousand dollars of import competition per worker. And the difference in the effect of the trade shock between low- and high-ties places in Table 2 is also around 0.8 percentage point. With one exception, coefficient estimates are similar and statistically significant with additional interactions, regressions without controls, and regressions without weights. The exception is the Big column, where the coefficient is also significant but much larger – 8.6 as opposed to 2.5. Interpreting that coefficient alongside the interaction between an indicator for a large import shock, the size of the shock, and being a high-ties place shows that ties actually led to larger differences in effects of import shocks on labor force participation in places that received relatively small (less negative) import shocks.

Table A.6 also shows that the main results are robust to alternative measures of local ties that require fewer assumptions about geography and that more directly reflect social connections. The coefficient in the column labeled "Time," which uses the average time people have lived in their houses as the measure of local ties, is detectably different from zero. The magnitude of the coefficient in the Time column is also similar to the first column in that a standard deviation change in this measure of ties has a similarly sized effect.[15] The coefficient on the column labeled "Friends," which uses the share of intra-CZ Facebook friendships, is also detectably different from zero in the expected direction. It is somewhat smaller in magnitude than the Base column, but the measure of Facebook friends also has a slightly larger standard deviation in the data (and a lower mean, as seen in Figure A.1).

The results for population and wage responses in Tables A.7 through A.10 also reinforce the results in Table 2, though they are sometimes noisy. The interaction

[14]The standard deviation of the time people have spent in their house is around an order of magnitude smaller than the standard deviation of the share of residents living in their state of birth (when measured from 0 to 100).

[15]The standard deviation of average time in one's house is roughly an order of magnitude smaller than the standard deviation of the share of people born in their state of residence across CZs.

Table A.4: Population Responses to Labor Demand Shocks in the 1980s

	Base	Age	College	NILF	Rents	Wealth	Manuf	Square	Low	Direct	Un-Wt	Time
Bartik and local ties	-2.93	-3.33	-4.77	-3.70	-3.65	-2.76	-2.74	-3.68	-2.71	-1.65	-5.20	-0.38
	(0.93)	(0.76)	(0.78)	(0.75)	(1.26)	(1.08)	(0.85)	(1.07)	(0.97)	(0.84)	(1.11)	(0.08)
Bartik shock	2.56	-12.41	5.86	-0.45	9.19	-3.14	3.07	3.81	2.44	1.58	4.02	3.94
	(0.61)	(7.01)	(0.90)	(0.92)	(9.58)	(4.94)	(0.65)	(1.03)	(0.67)	(0.54)	(0.82)	(0.70)
Local ties	0.22	0.31	0.42	0.33	0.36	0.16	0.25	0.30	0.16	-0.07	0.65	1.86
	(0.18)	(0.17)	(0.14)	(0.14)	(0.16)	(0.18)	(0.18)	(0.18)	(0.18)	(0.13)	(0.18)	(1.17)
Interaction 2		18.76	-6.23	12.15	-1.05	6.23	-1.56					
		(10.67)	(1.77)	(2.64)	(1.43)	(3.95)	(1.77)					
Interaction 3		26.33			3.50	0.51						
		(9.15)			(1.21)	(0.44)						
Bartik squared								-0.03				
								(0.02)				
Bartik low									-0.38			
									(0.60)			
Bartik low times ties									0.82			
									(0.96)			
Observations	722	722	722	722	722	722	722	722	722	722	722	722
R^2	0.604	0.629	0.626	0.641	0.620	0.619	0.624	0.607	0.608	0.474	0.297	0.645

Note: This table shows robustness of the population responses reported in Table 2. The column labeled "Base" shows a triple difference specification interacting the labor demand shock with the share of locals. The next few columns include other variables that could lead to different responses: "Age" includes the share of people under age 35 and over 50, "College" includes the share college educated, "NILF" includes the share outside the labor force, "Rents" includes the level of local log rents and the lagged 10-year change in log rents, "Wealth" includes the poverty rate and the log of average interest and dividend income as a measure of wealth and poverty, "Manuf" includes the share of employment in manufacturing, "Square" includes a square term on the Bartik shifter, and "Low" separates out below average (more negative) Bartik shocks. Additionally, "Direct" shows the specification without controls, and "Un-Wt" shows the specification without weights. Finally, "Time" measures ties by the average amount of time people have been in their house. Share coefficients are multiplied by 100, as are the lagged log change in rents and the log average investment income. Additional details follow Table 2.

terms in the first row of each panel continue to be in the expected direction, but they sometimes fall below statistical significance, reflecting the relative imprecision that is also inherent in the table.

In addition to results in the OLS columns of the other tables, Table A.11 shows that the same qualitative results are apparent using an OLS regression, as opposed to the IV specification in Table A.11. Impacts of labor demand shocks on labor force participation are clearly larger in places with higher levels of local ties. Impacts on residualized wages are also distinguishable from zero in high-ties places, but imprecision in low-ties places makes these differences statistically indistinguishable.

Appendix E Model Equilibrium

The model's equilibrium is a set of prices and quantities (p_j, w_j, r_j, N_j) conditional on the distribution of workers' local ties (all μ_i and N_{ik} terms) where agents behave optimally and markets clear.

$$N_j = \sum_{k' \in K} \sum_{i'} \psi_{i'jk'} N_{i'k'} \tag{3}$$

$$w_j = (1 - \alpha^Y)(p_j \theta_j)^{1/(1-\alpha^Y)} \left(\frac{\alpha^Y}{\rho} \right)^{\alpha^Y/(1-\alpha^Y)} \tag{4}$$

$$r_j = \left[\alpha^H w_j N_j \right]^{\frac{1}{1+\eta^H}} \tag{5}$$

$$\theta_j N_j \left(\frac{p_j \theta_j \alpha^Y}{\rho} \right)^{1/(1-\alpha^Y)} = Y \frac{\phi_j}{p_j^{\eta^Y}} \tag{6}$$

Appendix F Expanded Model with Skill Levels and Durable Housing

This section extends the baseline model to include heterogeneity in workers' skills and a concave housing supply curve due to a durable housing stock. Including heterogeneous skills and concave housing supply connects to the literature and policy discussion about workers' differing location choices by skill. Adding worker skill also allows the model to match several dynamics observed in the literature on regional migration, including a growing concentration of skilled workers in highly

Table A.5: Participation Responses to Trade Shocks

	Base	Age	College	NILF	Rents	Credit	Wealth	Manuf	Square	Big	Direct	Un-Wt
Imports and local ties	2.50	2.19	2.83	2.56	2.67	2.06	2.07	2.35	2.57	8.66	2.60	0.84
	(0.55)	(0.59)	(0.87)	(0.55)	(0.73)	(0.63)	(0.62)	(0.55)	(0.52)	(1.59)	(0.54)	(0.46)
Imports	-0.99	-3.57	-1.60	-0.69	-5.29	-0.05	6.85	-1.15	-0.82	-3.68	-1.05	-0.27
	(0.27)	(1.87)	(0.97)	(0.49)	(2.20)	(0.25)	(2.05)	(0.38)	(0.30)	(0.86)	(0.27)	(0.29)
Local ties	0.08	0.08	0.09	0.09	0.10	0.07	0.08	0.08	0.08	0.12	0.06	0.04
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Interaction 2		3.55	0.79	-1.42	0.65	-2.31	-8.19	1.03				
		(3.04)	(1.09)	(2.13)	(0.28)	(0.78)	(2.83)	(0.88)				
Interaction 3		6.16			-1.02		-0.59					
		(3.33)			(0.81)		(0.17)					
Imports squared and ties									0.02			
									(0.01)			
Big imports and ties										-0.06		
										(0.01)		
Big imports										2.91		
										(0.78)		
Observations	1444	1444	1444	1444	1444	1229	1444	1444	1444	1444	1444	1444
R^2	0.545	0.543	0.547	0.541	0.648	0.608	0.542	0.551	0.556	0.545	0.488	0.223

Note: This table shows robustness of the labor force participation responses to trade shocks presented in Table 2. The column labeled “Base” shows a triple difference specification. The following columns include interactions of the shifter with additional variables to show the continuing relevance of local ties: “Age” includes interactions with the share of people under age 35 and over 50, “College” includes the share of people college educated, “NILF” includes the share who are outside the labor force, “Rents” includes the level of local log rents and the lagged ten year change in log rents, “Credit” includes the share of mortgage applications denied as a measure of credit availability, “Wealth” includes the poverty rate and the log of average investment income, “Manuf” includes the share of employment in manufacturing, “Square” includes the square of the shifter, and “Big” interacts the shifter with an indicator that it is of above-average magnitude. Finally, “Direct” shows the results without controls and “Un-Wt” shows results without weights. For readability, all of the share coefficients are multiplied by 100, as are the lagged log change in rents and the log of investment income. The specifications follow the notes in Table 2 and include standard errors that are clustered by state.

Table A.6: Labor Force Participation Responses to Trade Shocks: Alternative Functional Forms

	Base	OLS	Time	Friends
Imports and local ties	2.50	1.78	0.22	1.43
	(0.55)	(0.57)	(0.07)	(0.51)
Imports	-0.99	-0.92	-1.54	-0.16
	(0.27)	(0.34)	(0.62)	(0.20)
Local ties	0.08	0.07	0.66	0.03
	(0.02)	(0.02)	(0.19)	(0.01)
Observations	1444	1444	1444	1444
R^2	0.545	0.580	0.547	0.548

Note: This table shows robustness of the labor force participation responses to trade shocks presented in Table 2 using an ordinary least squares (OLS) specification and alternative measures of local ties. "Base" shows the triple differences specification (also in table A.5). "OLS" shows the specification estimated using OLS, without instruments. "Time" shows the specification using the amount of time householders have been in their house as a measure of local ties and "Friends" uses the share of people's Facebook friends within the same place as the measure of local ties. For readability, all of the share coefficients are multiplied by 100. The specifications follow the notes in Table 2 and include standard errors that are clustered by state.

Table A.7: Population Responses to Trade Shocks

	Base	Age	College	NILF	Rents	Credit	Wealth	Manuf	Square	Big	Direct	Un-Wt
Imports and local ties	-1.47	-2.60	-3.55	-1.73	-4.16	-2.87	-2.40	-2.16	-1.48	-0.76	-4.26	-1.83
	(1.77)	(1.77)	(1.97)	(1.64)	(2.45)	(1.63)	(2.48)	(1.60)	(1.71)	(5.39)	(1.93)	(1.65)
Imports	1.09	-1.94	4.83	-0.16	11.35	0.76	5.67	-0.33	1.08	-1.18	2.55	0.55
	(1.14)	(7.59)	(2.19)	(1.85)	(8.15)	(1.58)	(11.04)	(1.27)	(1.30)	(3.44)	(1.37)	(1.11)
Local ties	-0.29	-0.32	-0.34	-0.30	-0.34	-0.33	-0.30	-0.32	-0.29	-0.30	-0.29	-0.22
	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.05)	(0.09)
Interaction 2		2.11	-4.84	5.99	-1.36	3.61	6.35	6.50				
		(12.30)	(2.69)	(4.69)	(1.13)	(2.56)	(8.60)	(4.47)				
Interaction 3		11.96			-0.05		-0.42					
		(14.81)			(1.81)		(0.79)					
Imports squared and ties									-0.00			
									(0.03)			
Big imports and ties										-0.01		
										(0.05)		
Big imports										2.13		
										(2.89)		
Observations	1444	1444	1444	1444	1444	1229	1444	1444	1444	1444	1444	1444
R^2	0.485	0.491	0.490	0.487	0.521	0.496	0.529	0.497	0.485	0.493	0.298	0.290

Note: This table shows robustness of the population and residualized wage responses to trade shocks presented in Table 2. The specifications follow the notes in Table A.5 and include standard errors that are clustered by state.

Table A.8: Residualized Wage Responses to Trade Shocks

	Base	Age	College	NILF	Rents	Credit	Wealth	Manuf	Square	Big	Direct	Un-Wt
Imports and local ties	2.05	2.19	2.56	2.23	1.15	1.23	2.40	2.44	2.18	7.13	1.06	1.10
	(1.07)	(1.08)	(1.44)	(1.07)	(0.91)	(0.97)	(1.31)	(1.10)	(1.06)	(3.17)	(0.90)	(0.91)
Imports	-0.79	2.21	-1.69	0.07	-0.39	-0.45	1.45	-0.88	-0.50	-3.10	-0.17	-0.23
	(0.64)	(3.29)	(1.47)	(0.60)	(3.11)	(0.55)	(5.28)	(0.62)	(0.67)	(1.83)	(0.52)	(0.57)
Local ties	-0.04	-0.03	-0.02	-0.03	-0.04	-0.06	-0.02	-0.03	-0.04	-0.01	-0.01	0.05
	(0.04)	(0.04)	(0.05)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)	(0.04)
Interaction 2		-4.69	1.17	-4.10	-0.01	0.33	-5.39	-1.49				
		(6.46)	(1.40)	(2.45)	(0.43)	(0.97)	(3.15)	(1.98)				
Interaction 3		-5.79			-0.14		-0.17					
		(5.22)			(1.60)		(0.41)					
Imports squared and ties									0.03			
									(0.02)			
Big imports and ties										-0.05		
										(0.02)		
Big imports										2.48		
										(1.26)		
Observations	1444	1444	1444	1444	1444	1229	1444	1444	1444	1444	1444	1444
R^2	0.135	0.142	0.138	0.126	0.320	0.178	0.226	0.168	0.137	0.149	0.031	0.107

Note: This table shows robustness of the population and residualized wage responses to trade shocks presented in Table 2. The specifications follow the notes in Table A.5 and include standard errors that are clustered by state.

Table A.9: Population Responses to Trade Shocks: Alternative Functional Forms

	Base	OLS	Time	Friends
Imports and local ties	-1.47	-0.34	-0.18	-0.42
	(1.77)	(1.41)	(0.12)	(0.98)
Imports	1.09	0.27	1.68	0.30
	(1.14)	(0.94)	(1.08)	(0.66)
Local ties	-0.29	-0.28	-3.61	-0.09
	(0.07)	(0.07)	(0.51)	(0.04)
Observations	1444	1444	1444	1444
R^2	0.485	0.487	0.580	0.468

Note: This table shows robustness of the population responses to trade shocks presented in Table 2 using an ordinary least squares specification and alternative measures of local ties. See Table A.6 for more details.

Table A.10: Residualized Wage Responses to Trade Shocks: Alternative Functional Forms

	Base	OLS	Time	Friends
Imports and local ties	2.05	1.58	0.01	0.22
	(1.07)	(0.93)	(0.16)	(0.73)
Imports	-0.79	-0.82	0.30	0.37
	(0.64)	(0.60)	(1.47)	(0.38)
Local ties	-0.04	-0.05	-0.65	0.03
	(0.04)	(0.04)	(0.38)	(0.02)
Observations	1444	1444	1444	1444
R^2	0.135	0.157	0.152	0.118

Note: This table shows robustness of the residualized wage responses to trade shocks presented in Table 2 using an ordinary least squares specification and alternative measures of local ties. See Table A.6 for more details.

Table A.11: Ordinary Least Squares Responses to Trade Shocks

	Population	Participation	Wages	Rents
Imports: High ties	0.02	0.33	0.27	0.51
	(0.15)	(0.09)	(0.09)	(0.25)
Imports: Low ties	0.20	-0.16	-0.08	0.51
	(0.25)	(0.11)	(0.23)	(0.38)
High ties	-4.23	1.58	-0.05	-2.55
	(1.52)	(0.37)	(0.77)	(1.57)
P-val: No diff	0.50	0.00	0.17	1.00
R^2	0.48	0.58	0.14	0.21
Observations	1444	1444	1444	1444

Note: Ordinary least squares results of estimating effects of Chinese imports on local outcomes. This table shows results from estimating the same specification relating the specified outcomes to measures of Chinese import competition in the United States in Table 2 but without using instruments.

productive, rich cities. The basic model is flexible enough to accommodate additional features that have been emphasized in the literature on domestic migration.[16]

The main policy takeaways of the main text – that place-based subsidies can be efficacious in economically depressed as well as fast-growing places – are equally apparent in the expanded model. The effects of skill heterogeneity, imperfect skill substitutability, durable housing, and differences in housing expenditures tend to balance each other out in terms of the effects of productivity shocks and of place-based subsidies on real wages. There are differences in how the mechanisms play out that match other literature, but these are less of a concern than the first-order impacts of workers with high levels of local ties making up most of the population of depressed places, regardless of their level of skills.

Including skill heterogeneity, however, does allow me to match the finding that high-skilled workers are more mobile (Malamud and Wozniak, 2012) and explore dynamics in workhorse models of worker productivity (Katz and Murphy, 1992) that lead to larger nominal wage losses among low-skilled workers in economically depressed places. The clustering of low-skilled workers in depressed places with few high-skilled workers leads to larger declines in low-skill wages, as in Giannone (2017).[17] Low-skilled workers earn less in depressed places because of the limited

[16] I do not include these dynamics in the main text because the emphasis on multiple types of workers distracts from the main mechanisms of workers with higher levels of local ties accumulating in economically depressed places. This section shows that the mechanisms I describe in the main text indeed survive the inclusion of these additional features.

[17] Bound and Holzer (2000); Notowidigdo (2020) verify empirically that less skilled workers con-

substitutability of high- and low-skilled labor (Moretti, 2013; Diamond, 2016) and the limited supply of high-skilled labor in depressed places.

Including a concave housing supply and heterogeneous expenditure shares on housing across skill groups also reinforces the dynamic of immobile, low-skilled workers accumulating in economically depressed places. More low-skilled workers choose to live in economically depressed places because they benefit more from inexpensive rents (Ganong and Shoag, 2017; Bilal and Rossi-Hansberg, 2018; Notowidigdo, 2020). And inexpensive rents arise because of the inelastic supply of already built housing in a place with weak demand for housing from high-skilled workers. In my calibration, the differential impact of cheap housing leads to similar declines in the real wages of high- and low-skilled workers because it roughly balances the negative effect of the lack of high-skilled workers on low-skilled worker wages.

The effects of durable housing persist over the medium run, or a period of under 20 years, which is significantly shorter than the period that I find that ties matter over.[18] Intuitively, the durability of housing has fewer long-run impacts because landlords make directed and forward-looking decisions based on economic conditions. Workers form local ties in a less directed way.

Additions to the Baseline Model

Skill Levels

I include worker skills using the workhorse nested constant elasticity of substitution production function that includes labor with two skill levels ($l \in H, L$) in each place. The parameter A_H defines the productivity of high-skilled labor relative to low-skilled labor, and η_N is the elasticity of substitution between the two types.

$$N_j = \left[(1 - A_H) N_{Lj}^{\frac{\eta_N - 1}{\eta_N}} + A_H N_{Hj}^{\frac{\eta_N - 1}{\eta_N}}\right]^{\frac{\eta_N}{\eta_N - 1}} \tag{7}$$

Heterogeneous Housing Expenditures

To allow workers to have heterogeneous expenditures on housing and to allow heterogeneous wage rates, the specification of utility is different between high- and low-skilled workers. The result is an indirect utility function that includes heterogeneous wages, governmental subsidies, a distribution of locational preferences that

centrate in economically depressed places despite earning less.

[18]Consistent with the focus of Glaeser and Gyourko (2005).

can vary by skill group, and the possibility of a different housing share by group α_l^H.

$$
\begin{aligned}
u_{ijkl} &= \ln(w_{jl} + g_{jl}) - \alpha_l^H \ln(r_j) + A_j + \mu_{il}\mathbb{1}(k = j) + \xi_{ijl} \\
u_{ijkl} &= \omega_{jl} + \mu_{il}\mathbb{1}(k = j) + \xi_{ijl}
\end{aligned}
$$

Concave Housing Supply

To keep the housing market relatively tractable and to match the intuition of Glaeser and Gyourko (2005), I include a piecewise linear housing supply function. The function exhibits a kink at the supply of housing in the previous period multiplied by a depreciation rate. Intuitively, the concavity allows the cost of maintaining existing housing to be lower than the cost of new construction.[19]

$$
H_s = \begin{cases} \theta_E^H r_j^{\eta_E^H} & \text{if } H_s > \gamma_\delta H_s' \\ \theta_C^H r_j^{\eta_C^H} & \text{if } H_s \leq \gamma_\delta H_s' \end{cases}
$$

Results

The model implies a few analytical results as well as a larger number of computational results. The analytic results reinforce many of the intuitions from the literature in labor economics. The computational results echo the main themes of the paper.

Analytic Results

Wages Workers are still paid their marginal product but now their marginal product depends on an additional term proportional to the relative supply of their skill level. Less-skilled workers receive higher wages when there are relatively more high-skilled workers, as high-skilled workers make them more productive.

$$
\frac{\partial Y_j}{\partial N_{Lj}} = \underbrace{(1-\alpha^Y)(p_j\theta_j)^{\frac{1}{1-\alpha^Y}} \left(\frac{\alpha^Y}{\rho}\right)^{\frac{\alpha^Y}{1-\alpha^Y}}}_{\text{Unchanged}} \underbrace{(1 - A_{Hj}) \left(\frac{N_j}{N_{Lj}}\right)^{1/\eta_N}}_{\text{New}} \tag{8}
$$

[19] I set the implied elasticities and depreciation rate to match empirical estimates in Glaeser and Gyourko (2005).

The skill premium, or the ratio of high- to low-skilled wages, depends both on the relative productivity of high-skilled labor, A_H, and the relative supply of high-skilled workers. And the extent that the ratio of the two types of workers is relevant is governed by the elasticity of substitution.

$$\frac{w_{Hj}}{w_{Lj}} = \frac{A_{Hj}}{1 - A_{Hj}} \left(\frac{N_{Lj}}{N_{Hj}} \right)^{1/\eta_N} \tag{9}$$

Partial equilibrium changes in absolute wages Another way of seeing how the movements of high-skilled workers affect low-skilled workers is to look at the *cetrus paribus* effect of an increase in the number of high-skilled workers on low-skilled workers' wages. Having more high-skilled workers increases low-skilled workers' wages, and it does so by more when the elasticity of substitution between the two types is lower. Increasing the number of high-skilled workers also tends to increase low-skilled workers' wages by more when high-skilled workers are more productive.

$$\frac{\partial \ln(w_{Lj})}{\partial \ln(N_{Hj})} = \frac{1}{\eta_N} \times \frac{A_{Hj} \left(\frac{N_{Hj}}{N_{Lj}} \right)^{\frac{\eta_N - 1}{\eta_N}}}{1 - A_{Hj} + A_{Hj} \left(\frac{N_{Hj}}{N_{Lj}} \right)^{\frac{\eta_N - 1}{\eta_N}}}$$

Calibration

Calibrated parameters, which build off my earlier calibration, are presented in Table A.12. I allow the spread of the logit distribution for each type to vary based on a 30 percent higher migration elasticity among college-educated workers in Malamud and Wozniak (2012). I also assume that housing expenditures are 40 percent among low-skilled workers and 25 percent among high-skilled workers – estimates that are in keeping with an elasticity of housing demand with respect to income that is below one, fitting the literature. Finally, I use the estimated elasticities in Table 1 (Glaeser and Gyourko, 2005) applying to places where population is increasing and decreasing to characterize the piecewise housing supply function.

Table A.12: Parameter Values for the Expanded Model

Parameter	Description	Value	Reasoning
μ_{Li}	Local ties values for low-skilled workers	$[0.15, 8.73]$	Estimated
$\frac{N_{Li}}{N_L}$	Share of low-skilled with each local tie	$[0.32, 0.68]$	Estimated
$\sigma_{\xi L}$	Idiosyncratic preference spread, low	0.52	Suarez Serrato and Zidar (2016)
$\frac{N_H}{N}$	Share of high-skilled workers	0.45	Table 1
μ_{Hi}	Local ties values for high-skilled workers	$[4.35, 8.93]$	Estimated
$\frac{N_{Hi}}{N_H}$	Share of high-skilled with each local tie	$[0.89, 0.11]$	Estimated
$\sigma_{\xi H}$	Idiosyncratic preference spread, high	0.69	Malamud and Wozniak (2012)
η_N	Elasticity of substitution for workers	2	Autor, Katz and Kearney (2008)
A_H	Productivity of high-skilled workers	0.66	75 percent average skill premium
η_E^H	Housing supply elasticity, expanding	4.35	Table 1 of Glaeser and Gyourko (2005)
η_C^H	Housing supply elasticity, contracting	0.56	Table 1 of Glaeser and Gyourko (2005)
γ_δ	Depreciation rate of housing per year	1	Table 1 of Glaeser and Gyourko (2005)

Note: These are the additional calibrated parameters for the extended model. Other parameters follow from the main calibration in Table 3.

My target moments for the estimation are the distribution of changes in the number of high- and low-skilled workers living across places and the share of each population living in their birth place. I chose changes in the population of high- and low-skilled workers across places because they have been the focus of a robust literature in labor economics. I chose the proportion of people in each skill group living in their birth place across places because it is the analogue to the approach that I used in the main text.

The model matches the three distributions, as shown in Figure A.6. The relatively good match is despite taking the spread of the logit distribution from the literature and including only two possible levels of local ties in the name of computational tractability.

Computational Results

Places grow by attracting outsiders, who tend to be highly skilled. Figure A.7 shows how the population of a place adjusts in terms of low- and high-skilled locals and outsiders. The population of locals is relatively stable, as before, but the population of outsiders fluctuates. And the group that fluctuates the most is the population of high-skill outsiders, who tend to drive population increases in places where productivity has increased. High-skill outsiders drive population increases because they are more mobile and because they are more willing to pay high rents, as in Ganong and Shoag (2017), Bilal and Rossi-Hansberg (2018), and Notowidigdo (2020).

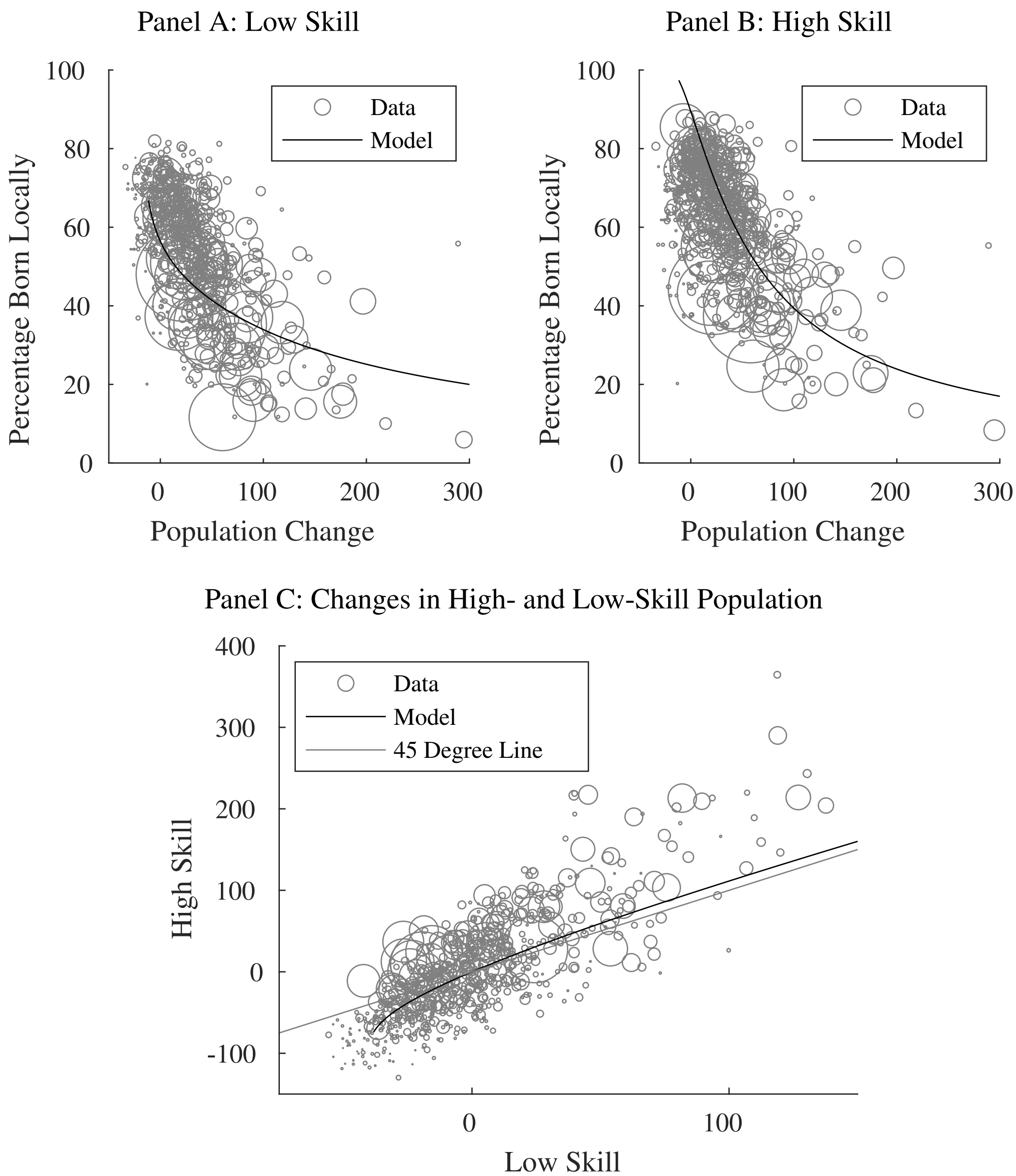
The lower supply of higher-skilled workers in depressed places increases the nominal wages of high-skilled workers and decreases the nominal wages of low-skilled workers. Panel A of Figure A.8 shows that the share of high-skilled workers is lower in places that saw declines in productivity, as explained in Figure A.7. Panel B shows that the smaller supply of high-skilled workers leads to a larger high-skill wage premium, as in Katz and Murphy (1992) and many other studies of relative wages. Intuitively, high-skilled workers earn more relative to low-skilled workers because the two types of workers are imperfectly substitutable. Analytically, equation 9 gives the skill premium and describes its dependence on the elasticity of substitution parameter, η_N.

Rents also fall by more in depressed places, however, so real wages fall by only slightly more for low-skilled workers. Panel C of Figure A.8 shows that rents decline by more in places that received strongly negative productivity shocks. The larger declines in Panel C also reflect the concavity of the housing supply function. Rents fall by more when population is declining and the housing stock is less elastic due to the durability of housing (as in Glaeser and Gyourko, 2005). And the effects on real wages in Panel D balance the larger declines in nominal wages for low-skilled workers with the fact that low-skilled workers spend larger fractions of their incomes on housing, which becomes much cheaper in depressed places. Thus, real wages in Panel D fall only by slightly more for low-skilled workers.

Dynamic Impacts of Durable Housing

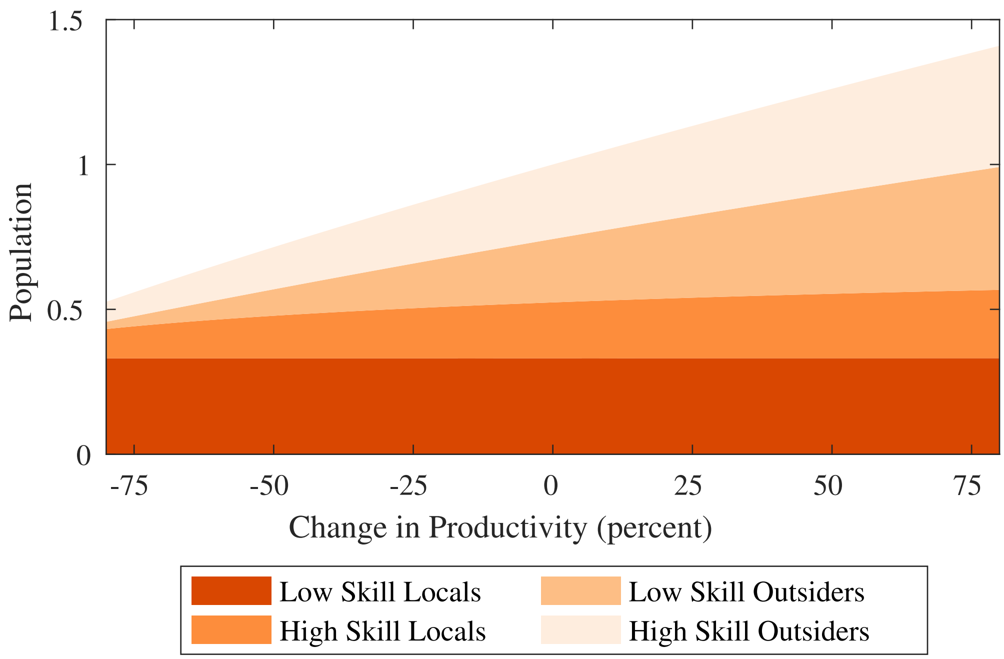
Durable housing can have a large impact initially, but including durable housing does not have the same generational impacts that including local ties has on equilibrium outcomes. To show how the effects of durable housing are large at first but then wane, Table A.13 reports changes in the population of low-skilled workers in both the expanded model with durable housing (Exp) and the expanded model when I allow housing to immediately depreciate (NDH). Table A.13 reports population immediately and 50 years after the specified change in productivity as well as the

Figure A.6: Two Skill Estimation Moments and Targets



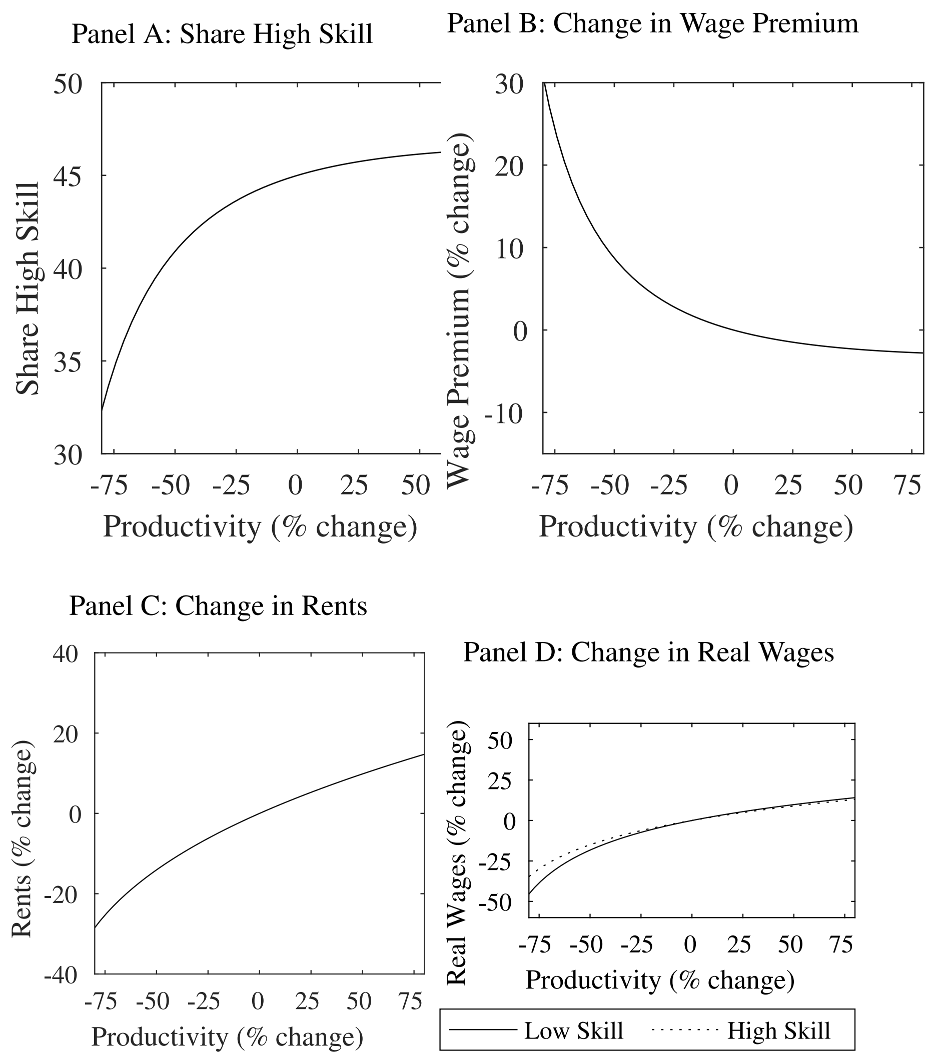
Note: The model matches the distribution of low- and high-skilled workers born locally across places as well as population changes for each group. This figure plots each distribution in the data as well as the model analogue I use to approximate it in my estimation procedure.

Figure A.7: Populations of Outsiders and Local of Two Skill Levels



Note: Places that grow in population do so by attracting outsiders, particularly high-skill outsiders. This figure plots how the high- and low-skilled population of locals and outsiders changes with productivity shocks. Each height represents the population at that productivity level. They are normalized so the total population is one in a place that has no shocks.

Figure A.8: Effects of Productivity Changes in the Expanded Model



Note: There are fewer high-skilled workers in economically depressed places, despite high-skilled workers earning higher relative wages. Including a convex housing supply and a higher demand for housing among low-skilled workers mutes the effects of nominal wage decreases in terms of the real wages of low-skilled workers, however. The panels plot the levels of the variables immediately after the specified change in productivity in the expanded model.

time it takes the difference between the immediate decline and the model's steady-state value to halve (the Half Life). Initial population responses are around one-third smaller when I include durable housing after a negative productivity shock. However, the effects are very similar after 50 years because housing rapidly deteriorates after the shock. So there is a much faster half-life of population changes in the expanded model with durable housing.

Figure A.9 shows how durable housing affects the low-skilled population. It plots the change in the low-skilled population after a 50 percent decline in productivity (as in the first row of Table A.13). Comparing the response with and without durable housing shows that durable housing leads to a smaller initial drop in population but a quicker decline after the initial drop. The quicker decline in population in the model with durable housing leads to similar declines in population after 10 years or less.

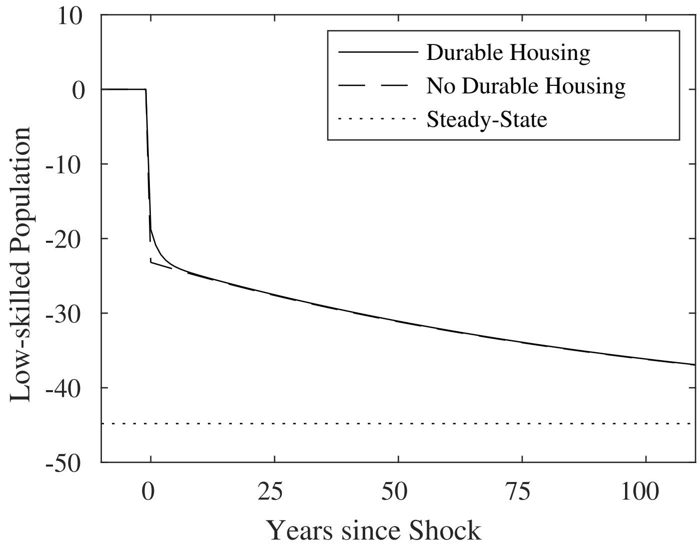
Table A.13: Population Changes after Productivity Changes with and without Durable Housing

Productivity	Initial		50 years		Half-life	
change	Exp	NDH	Exp	NDH	Exp	NDH
-50	-18.8	-23.2	-31.1	-31.2	56	75
-25	-9.0	-11.7	-15.4	-15.5	50	75
-10	-3.5	-4.7	-6.2	-6.2	47	75
-5	-1.8	-2.4	-3.1	-3.1	47	75
50	23.5	23.5	30.1	30.1	76	76

Note: Durable housing leads to smaller immediate declines in the low-skilled population productivity declines, but faster declines afterward make its impact negligible within 50 years. Shown are changes in the population after the specified changes in productivity initially, after 50 years, and the half-life of population's difference from its eventual steady state. "Exp" stands for effects in the expanded model including durable housing, and "NDH" stands for the expanded model without durable housing.

Why do local ties have longer-term impacts than durable housing? Local ties are formed incidentally based on experience in a place, while housing is formed based on workers' willingness to pay for new construction. Intuitively, local ties continue to be formed in economically depressed places because parents still live there, but housing is only constructed when rents cover the cost of new construction.

Figure A.9: Population Responses with and without Durable Housing



Note: Durable housing limits immediate population responses to a negative productivity shock, but the effect of durable housing declines with time. Plotted are percent changes in the population of low-skilled workers in a place that experiences a 50 percent persistent decline in productivity in year zero.

Place-Based Subsidies

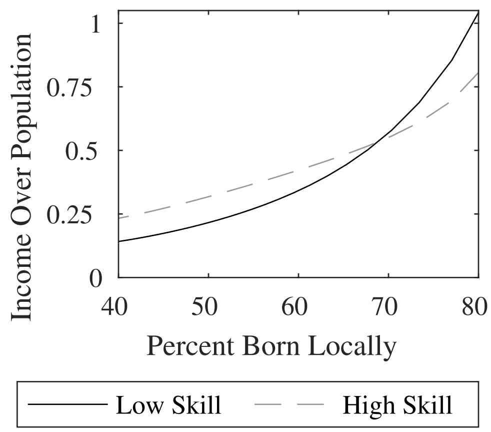
The policy conclusions in the main text – that subsidies to economically depressed and to growing places are efficacious for different reasons – also apply to the extended model. Subsidies to depressed places increase incomes among both skill groups at a modest cost because they lead to relatively small changes in population. Subsidies to productive places move workers and produce wage gains for both groups of workers in other places.

Figure A.10 presents the same metrics as Figure 11 in the main text. Each metric behaves similarly for the two skill groups, and each metric also has similar patterns to Figure 11. Subsidies to economically depressed places do not distort population by much. In places with higher shares born locally, income responses for both groups are larger both absolutely and relative to population responses. In growing places, with lower shares born locally, population responses are larger and incomes in other places rise among both groups. Besides the larger differences in population responses shown by the steeper line in Panel A of Figure A.10, there are few differences in the metrics for high- and low-skilled workers.

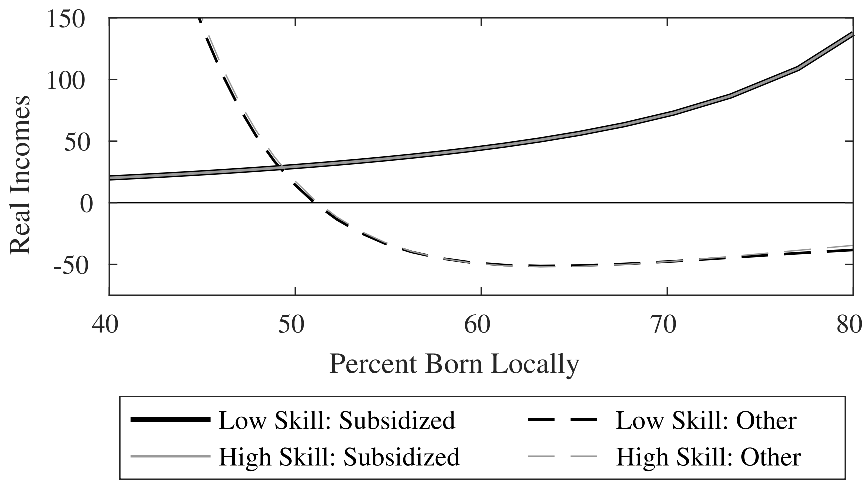
The steeper slope in the ratio of incomes to populations among low-skilled workers in Figure A.10 does reflect some underlying differences in how subsidies affect the two groups in high and low-ties places. Table A.14 shows that rents rise quite

Figure A.10: Real Income Changes after Place-Based Subsidies

Panel A: Ratio of Income to Population Changes



Panel B: Real Income Changes



Note: The main findings for place-based policies apply to both skill groups in the extended model. Subsidies to places with high shares born locally, or high ties, increase real incomes by more relative to population. And subsidies to newly productive places with low levels of local ties increase wages in other places. Panel A plots the ratio of the present discounted value of percentage changes in local real incomes relative to percentage changes in population due to a subsidy. Panel B plots the present discounted value of changes in real incomes per worker (ω) after the subsidy. The percent born locally in each figure includes both groups. The subsidy is the same as in the main text – 10 percent of initial wages decaying at 4 percent per year. Real incomes include wages net of taxes and rents. The line for other places is multiplied by the number of other places – 721.

Table A.14: Impact of Subsidies to Growing and Depressed Places in the Extended Model

Panel A: High-Ties, Economically Depressed Place (50 Percent Productivity Decline)

	Extended			No durable housing			One skill level		
	Initial	50	100	Initial	50	100	Initial	50	100
Low - Real wages	3.9	0.5	-0.0	5.2	0.5	-0.0	3.9	0.4	-0.0
Low - Population	4.3	1.3	0.6	4.8	1.2	0.6	6.3	1.4	0.5
Low - RW outside	-2.9	-0.4	-0.0	-4.0	-0.4	-0.0	-3.0	-0.4	-0.1
Rents	45.7	1.7	0.4	13.8	2.1	0.4	8.7	1.2	0.2
High - Real wages	3.3	0.6	0.1	3.9	0.5	0.1	3.9	0.4	-0.0
High - Population	7.0	1.0	0.2	7.7	1.0	0.2	6.3	1.4	0.5
High - RW outside	-2.5	-0.4	-0.1	-3.1	-0.4	-0.1	-3.0	-0.4	-0.1

Panel B: Low-Ties, Productive Place (50 Percent Productivity Increase)

	Extended			One skill level		
	Initial	50	100	Initial	50	100
Low - Real wages	2.1	0.2	-0.0	1.8	0.2	-0.0
Low - Population	6.6	1.6	0.7	6.5	1.6	0.7
Low - RW outside	0.8	0.4	0.3	0.3	0.5	0.4
Rents	7.4	1.0	0.2	4.2	0.6	0.1
High - Real wages	2.0	0.3	0.0	1.8	0.2	-0.0
High - Population	7.9	1.1	0.2	6.5	1.6	0.7
High - RW outside	0.7	0.3	0.1	0.3	0.5	0.4

Note: Subsidies to economically depressed places lead to similar increases in real wages for low and high-skilled workers. Larger inflows of high-skilled workers increase low-skilled workers' wages by enough to counteract the large increases in rent due to durable housing. Subsidies to growing places have similar impacts for both groups. This table shows responses of variables for each worker skill level across each row. Initial, 50, and 100 refer to the number of years after both the subsidy begins and the productivity shock hits. Columns labeled "Extended" represent the model with two skill levels and durable housing, columns labeled "No Durable Housing" apply to the model with two skill levels but no durable housing, and columns labeled "One Skill Level" signify the baseline model. I omit the no durable housing columns in Panel B because they are identical to the extended model.

substantially after a subsidy to a high-ties place that has recently experienced a 50 percent decline in productivity. Rents rise because durable housing leads to a very inelastic housing supply in a declining place. And the increase in rents undoes part of both the direct impact of the subsidy on low-skilled workers' incomes and the increases in low-skilled workers' nominal wages because of the influx of high-skilled workers. So the two elements of the model tend to undo each other, at least in terms of workers' real wages in the subsidized place.

Appendix G Alternative Ties Formulations

This section gives more detail about local ties in two ways. First, it compares local ties with moving costs and other commonly used empirical formulations. Second, it assesses how much the model's predictions would change if parents were altruistic toward their children in terms of preferring that they be born with ties to more prosperous places.

I show differences relative to previous work by adding and removing two elements. First, I show how the spread of local ties adds to a more typical formulation (following Diamond, 2016; Piyapromdee, 2021) that assumes everyone has the same, relatively large preference for living in their birthplace. Second, I show how ties differ from literal moving costs by showing how ties to birthplaces make population much more persistent than do moving costs from present locations.

Additionally, I show how parental altruism affects the main results by introducing it into the model. I introduce altruism by allowing parents to gain utility from their children's utility according to their children's local ties. So parents make decisions about where to locate taking into account the probability that they may have children with ties to the place where they locate. Including altruistic preferences makes workers consider their children's ties when they make location decisions, which differs from the primary specification where workers are only concerned with their own fixed local ties.[20]

Variance in the Magnitude of Local Ties

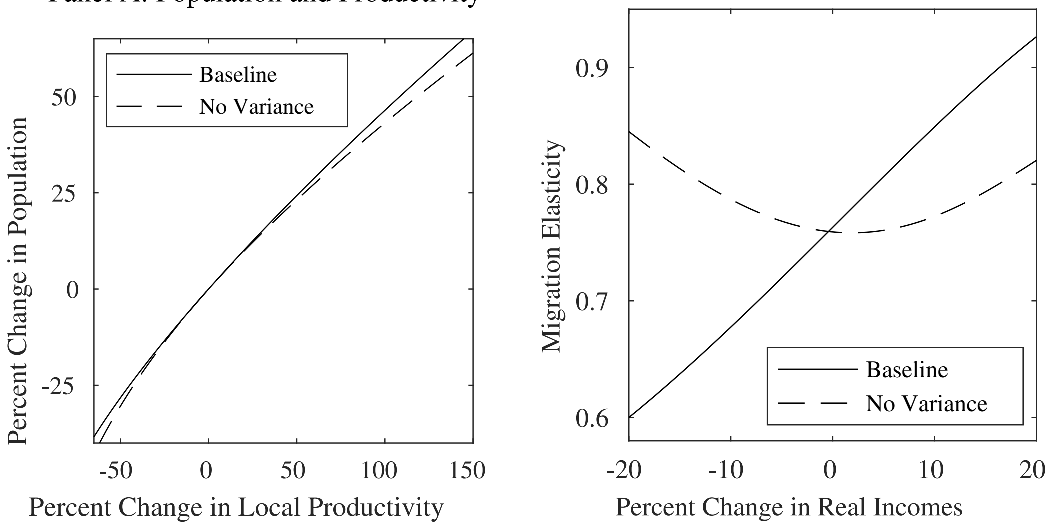
To show the implications of allowing for variation in the magnitude of local ties, I follow previous papers (e.g. Diamond, 2016; Piyapromdee, 2021) by assuming that μ_i is a single value as opposed to a distribution. In practice, this exercise is very

[20]Given the structure of the model including these elements is extremely computationally taxing. So I include a simplified calibration procedure that is more computationally feasible.

Figure A.11: Migration Without Variation in the Magnitude of Local Ties

Panel A: Population and Productivity

Panel B: Migration Elasticities and Real Incomes



Note: Panel A shows that negative productivity shocks lead to smaller population declines and positive productivity shocks to larger population increases when the model allows for a distribution of magnitudes of local ties. Panel B shows that allowing for variance in local ties leads to a positive relationship between migration elasticities and changes in real incomes. Each panel plots values of the specified variables from the baseline model calibration in the solid line and the model with no variance in the magnitude of local ties.

simple – I set the variance of μ_i to zero and instead assign a single utility benefit of $\mu = \text{mean}(\mu_i)$ to all workers.[21]

Including variance in the magnitude of local ties implies that the population of a place experiencing declines in real incomes will decrease by less. Panel A of Figure A.11 gives percent changes in local productivity on the x axis and percent changes in population on the y axis. The solid line gives the baseline model and the dashed the model without variance in the magnitude of local ties. The solid line is well above the dashed line for negative changes in productivity, implying smaller population decreases.

Increases in real wages also lead to larger population increases when I include variance in the magnitude of local ties. Panel A of Figure A.11 shows that, for positive changes in productivity, the solid line depicting the baseline model where there is variance in the magnitude of local ties is higher than the dashed line where

[21] Foreign-born workers are assumed to have zero ties in all locations, as before. So their presence allows for similar dynamics to the “outsiders” in the simplified model in the text.

there is not.

Population responses vary in part because removing variance in the magnitude of local ties removes the correlation between changes in real incomes and migration elasticities. Panel B of Figure A.11 shows that the dashed line of migration elasticities is not uniformly increasing with productivity changes once variation in the magnitude of local ties is removed. The solid line, from the baseline model with a relatively wide variance, is clearly upward sloping.

Thus, allowing for variation in the magnitude of local ties leads to smaller migration responses in declining places and larger ones in growing places. Smaller migration responses in declining places then lead to hysteresis due to this asymmetry as described in the model. Larger migration responses lead to larger inflows of workers after local subsidies, which increases aggregate productivity.

Moving Costs Compared with Local Ties

Local ties differ from simple moving costs in that local ties are preferences to live in one's birthplace, while moving costs are penalties for moving away from one's current location. Because there is no way of recovering levels of utility in discrete choice (Train, 2009), it is tempting to think that the two should have similar effects, and in some empirical contexts, they do. This section analyzes differences in how the model responds with moving costs as opposed to local ties, showing that there are meaningful differences in terms of dynamics.

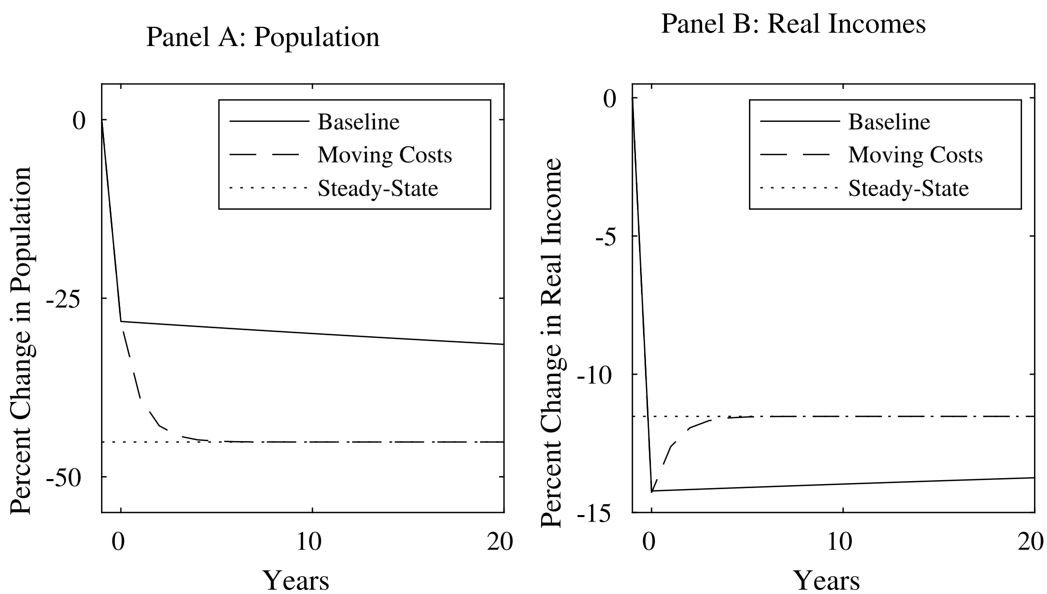
This section analyzes the model where people face a distribution of moving costs each period, without having any local ties to their birthplace. For ease of comparisons, I assume that workers face a distribution of costs of moving from their current location in each period that matches the assumed distribution of local ties. I set $s_D = 1$ so each worker is faced with a new distribution of costs of moving in each period.

The local ties and moving costs lead to big differences in the persistence of local shocks in the model. Figure A.12 shows changes in population and real wages after a very large, 50 percent decline in productivity with moving costs and local ties.[22] In the model with moving costs shown by the solid line, the steep decline in population continues into the next period, leading to a steady-state decline within around five years. In the model with dashed lines, however, the population reallocation slows dramatically after the initial impact in the first period, because relatively few ties are being reallocated each period.

The slower population reallocation in the model also means that incomes are depressed for a shorter period after negative shocks. Panel B of Figure A.12 shows

[22]Dynamics are similarly quicker with other changes in productivity.

Figure A.12: Productivity Shocks with Moving Costs



Note: Population and real wages reach their steady-state values extremely slowly in the baseline model where local ties are only assigned very 60 years on average. When attachments are instead specified as moving costs and immediately reallocated on moving, the model reaches steady state in about five years. Panel A shows percent changes in population after a 50 percent decline in local productivity and Panel B shows percent change in real wages, including both wages and rents, after the same change. The solid line in each figure gives results with the baseline calibration, the dashed line the calibration with moving costs (ties reallocated in each year), and the dotted line the eventual steady-state value, which is the same for both calibrations.

that real incomes overshoot, as before, but then recover much faster to reach their steady-state value after around five years. As with population, the steady-state level is identical, but the amount of time it takes to reach it varies considerably.

The main takeaway is that the pace at which people form ties dramatically changes the persistence of local shocks. Assuming that attachments are specified as moving costs that are reallocated once one arrives in a new place makes shocks much less persistent than assuming that people have nearly lifelong ties to the places where they are born. Especially since local ties can lead to much more persistence than the durability of physical capital like housing (analyzed in Appendix F), it is important to understand how quickly people are able to form new ties.

Including Altruism

A possible concern with the baseline model is the assumption that workers take their own ties as given. While it seems reasonable that workers should regard their own ties as fixed, there is an inherent tension about workers disregarding the process of their ties being reallocated in the next generation based on their current location decisions.

To assess the implications of workers attempting to influence this reallocation I introduce altruism into the model. In this context, altruism is workers gaining utility themselves based on their expectation of their children's own utility, including their children's ties to the place the workers are deciding about moving to.[23]

While important additional dynamics can likely be uncovered by including altruism, including it here has relatively small impacts on the main findings in the paper. Altruistic workers are more responsive to wages, leading to larger population reallocations. Including altruism also has minimal impacts on dynamics after place-based subsidies.

Model Additions

I add in parental altruism to the model by including discounted future expected utility, both of the worker themselves and of their children in the worker's problem. This makes the worker more forward looking in terms of expected future real incomes and amenities that their children would enjoy if they developed ties in growing places. This is different from the baseline model where workers' optimal

[23]Another possibility could be to introduce paternalism, or workers gaining utility based on their children's attachment to the same place they are attached to. I do not include that here, however, because a utility benefit from having a child with a tie to the same place would be equivalent to increasing μ_i.

choice of j in the current period has no effect on their utility in subsequent periods.

Including expected future utility changes the worker's problem to the following recursive equation where two parameters determine the importance of expected future utility. The parent's level of altruism is given by γ_A. I show the importance of altruism by presenting results with full and no altruism ($\gamma_A = 1$ and $\gamma_A = 0$). I also sometimes present an intermediate case where $\gamma_A = 0.5$. The worker's discount rate is given by ρ, which I set to be the same as the main calibration in Table 3.

To put these together, the utility in year t of living in place j for a worker with a tie to place k of intensity indexed by i is given by the following equation. It mirrors equation 3 in the main text, but with new terms on the second line.[24] First, it includes the worker's expected utility next period if the worker survives with the same i tie to place k ($E[u_{ikt+1}]$). It also includes the expected utility of the worker's possible child who will be assigned a tie in the place where the worker chooses to live, $E[u_{jt+1}]$. The expected utility will vary based on the child's likelihood of having different strengths of ties, which is given by the share of people with that strength of tie (N_i/N). It also is implicitly a function of parameters (A_j) and equilibrium outcomes (c_j and h_j) in subsequent periods. The weight the worker places on this term is increasing in the worker's level of altruism, γ_A.

$$
\begin{aligned}
u_{ijkt} = (1-\alpha^H)\ln(c_{jt}) + \alpha^H \ln(h_{jt}) + A_{jt} + \mathbb{1}(k=j)\mu_i + \xi_{ijt} \\
+ (1-\rho)\left[(1-s_D)E\left[u_{ikt+1}\right] + s_D\gamma_A E\left[u_{jt+1}\right]\right]
\end{aligned}
$$

The recursive formulation makes the model much more taxing to compute. Expected future utilities depend on the path of prices in each place, which are themselves determined in equilibrium based on workers' current utility, the workers' expected future utility, and possible children's expected future utilities in each of 722 different places in the model's calibration.

To ensure that prices, workers' current choices, and workers' expected future utilities are consistent, I solve the model by value function iteration. I set prices based on workers' choices, compute expected utilities based on those prices, and then update workers' choices. In a steady-state solution, I take an expected future utility term alongside a population, compute implied prices, and then use those prices to update the distribution of population and the expected future utility, which will be the same in the next period. I continue this process until the results converge.

Computing transitions to new steady states is extremely computationally taxing. Instead of setting a single value function and population distribution, I set a distri-

[24]It also includes time subscripts, which I omitted in equation 3

bution for a large number of future years (up to 1,000). I then move between one and the next, updating productivity parameters and government taxes and subsidies according to laws of motion. With each period, I take the pre-existing population distribution and compute prices that I then use to update the population distribution, the local ties distribution, and the expected value function in that period. I repeat this process until the entire sequence of populations, prices, and local ties converge. Thus, the procedure gives a solution under complete certainty.

As the process is more computationally involved, I use a different distribution of local ties to reduce the memory and processor requirements of the computation. Instead of using a normal distribution of local ties that I compute with many nodes and quadrature, I allow for two levels of local ties (μ_i), as in Appendix F. I set the two levels based on the estimation in Appendix F by averaging the lowest level of local ties for the high- and low-skilled workers according to their population shares. So 58 percent of workers have the lower level of ties, at $\mu_i = 3.07$, and 42 percent have the higher level, at $\mu_i = 8.75$. Additionally, the fact that the results are so similar with this different distributional assumption about local ties shows that the main results are robust to these departures from the baseline framework.

Results

Adding parental altruism limits the effects of local ties but only slightly. Table A.15 shows that when parents have perfect altruism, they are more responsive to wages both initially and in the steady state. Population responses after productivity changes are larger initially and in steady state in Panel A, where workers are fully altruistic, than they are in Panel B, where workers do not care about their children's utility. Additionally, real-wage changes are less dramatic in Panel A than Panel B.

Parental altruism also does speed up convergence, but only slightly. Comparing the half-lives in Panel A with Panel B shows a difference of only 1 or 2 years from a base of around 60 years. So, convergence is only 2 or 3 percent faster.

The effects of placed-based subsidies on equilibrium populations and wages are also very similar once parental altruism is included. Figure A.13 shows that subsidies to declining places increase local real wages by less. However, the differences between including and not including altruism are small relative to the differences across places. To see how, compare the darker lines with full altruism with the lighter lines with no altruism in Panels A and B. Panel A plots present discounted changes in real incomes relative to population after a subsidy, and Panel B plots the present discounted value of only real incomes. While the darker lines with full altruism are increasing by less with the percent born locally, they still are increasing. So the results are quite similar to the main specification in Figure 11 regardless of the level of parental altruism.

Table A.15: Including Altruism for Convergence after Productivity Shocks

Panel A: Full Altruism

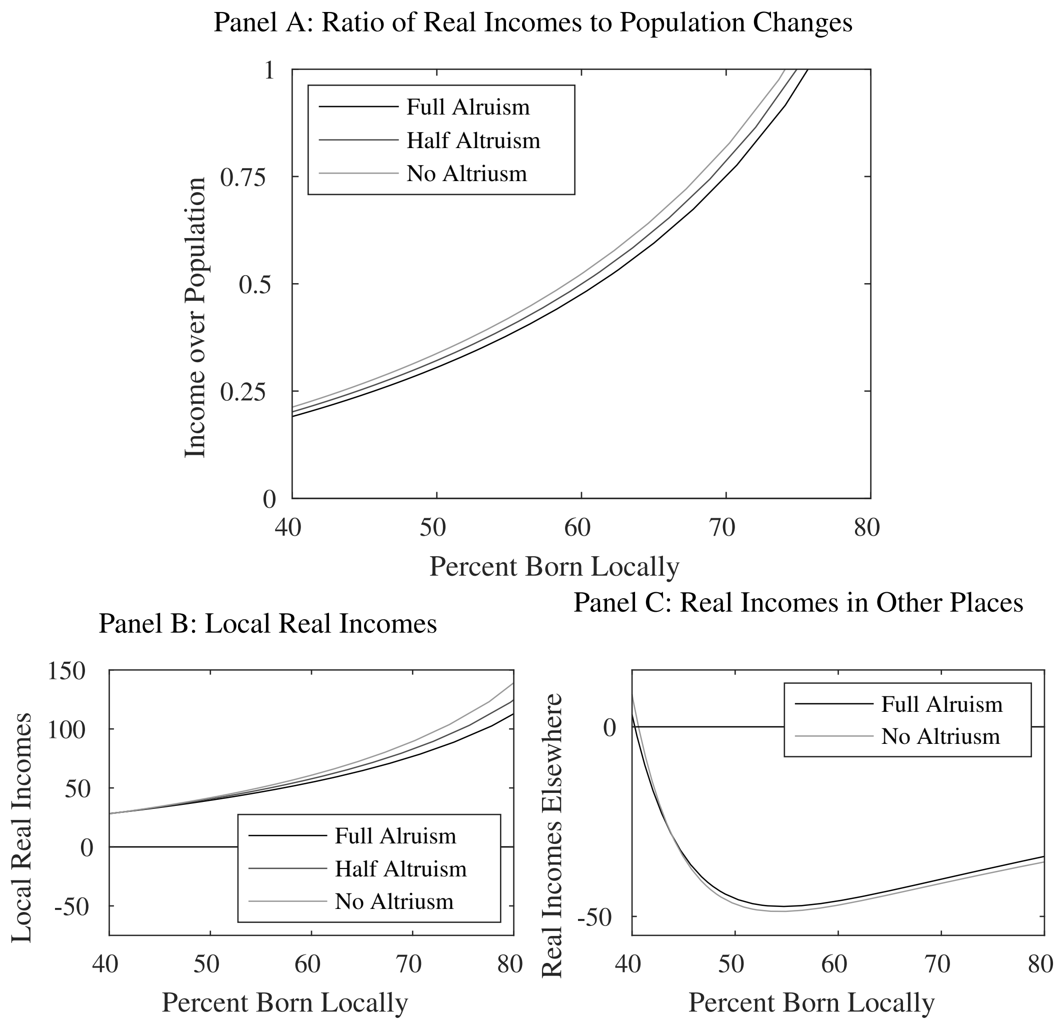
Productivity change	Population Initial	50	100	SS	HL	Real wages Initial	50	100	SS	HL
-50	-32.7	-39.2	-42.9	-47.4	58	-13.7	-12.4	-11.5	-10.4	64
-25	-16.2	-19.4	-21.2	-23.6	60	-5.4	-4.9	-4.6	-4.2	62
-10	-6.4	-7.7	-8.5	-9.4	61	-2.0	-1.8	-1.7	-1.5	61
-5	-3.2	-3.9	-4.2	-4.7	61	-1.0	-0.9	-0.8	-0.8	61
50	31.3	38.0	41.9	47.4	63	7.4	6.8	6.4	5.9	61

Panel B: No Altruism

Productivity change	Population Initial	50	100	SS	HL	Real wages Initial	50	100	SS	HL
-50	-29.2	-35.3	-38.7	-43.2	60	-14.4	-13.2	-12.4	-11.4	65
-25	-14.1	-17.0	-18.8	-21.0	61	-5.7	-5.3	-5.0	-4.6	63
-10	-5.5	-6.7	-7.4	-8.3	62	-2.1	-1.9	-1.8	-1.7	63
-5	-2.7	-3.3	-3.7	-4.1	62	-1.0	-0.9	-0.9	-0.8	63
50	25.9	31.7	35.2	40.2	65	8.0	7.4	7.0	6.6	62

Note: Population changes are larger and real-wage changes smaller when parents are fully altruistic in terms of treating their children's expected utility the same as their own. Still, convergence is quite slow in either case. Panel A replicates Table 5 for the model with full altruism and Panel B for the model with no altruism.

Figure A.13: Including Altruism for Real Income Changes after Place-Based Subsidies



Note: Effects of subsidies on real incomes are similar with and without altruism. Panel A shows the ratio of the present discounted value of a 10 percent wage subsides' effect on real incomes over the present discounted value of their effects on populations, both in percentage terms. Panel B shows the same subsidies' effect on local real incomes, and panel C shows their effect on real incomes in other places, summing over all other places. Each is shown relative to the percent of residents born locally where parents treat their children's expected utility as equal to their own (full altruism, darkest line), parents treat their children's utility as half as important as their own (half altruism, lighter line), and parents do not consider their child's utility (no altruism, lightest line). Each is similar to the results for the same outcomes in the baseline model and calibration in Figure 11.

Including altruism also decreases the benefits of subsidizing productive places for other places but only slightly. Panel C shows impacts of subsidies to one place on real incomes (including taxes) in other places compared with the percent born locally. The dark line showing the result with full altruism has a less dramatic slope at the left than does the lighter line. However, both lines are positive for very low values. The dark line is also less dramatically negative on the right. Note that the differences are so slight that they are only apparent when the lines are magnified relative to their presentation in Figure 11.

The dynamic impacts of subsidies are also fairly similar with and without altruism, though there are some detectable differences. Table A.16 shows that in low-ties places, including altruism leads to larger changes in population and somewhat smaller changes in local real incomes both initially and after 50 years. High-ties places also experience smaller population and real income changes due to subsidies in the model with full altruism. Incomes in other places are affected similarly by subsidies regardless of the level of altruism. The effects of subsidies on incomes in other places are slightly more negative in the model with full altruism, especially initially.

Table A.16: Including Altruism for Effects of Subsidies to Depressed and Growing Places

Panel A: Full Altruism

	Subsidized place						Other places		
Share	Population			Real income			Real income		
locals	0	50	100	0	50	100	0	50	100
40	8.4	1.9	0.7	1.9	0.2	-0.0	-0.6	0.3	0.2
50	7.5	1.6	0.5	2.7	0.3	-0.0	-3.1	-0.4	-0.0
60	6.8	1.4	0.5	3.8	0.4	-0.0	-3.1	-0.4	-0.1
70	6.0	1.2	0.4	5.2	0.6	-0.0	-2.7	-0.3	-0.1
80	5.2	1.1	0.4	7.5	0.9	0.0	-2.4	-0.3	-0.1

Panel B: No Altruism

	Subsidized place						Other places		
Share	Population			Real income			Real income		
locals	0	50	100	0	50	100	0	50	100
40	7.4	1.7	0.6	1.9	0.2	-0.0	-0.2	0.4	0.3
50	7.1	1.5	0.5	2.9	0.3	-0.0	-3.2	-0.4	-0.0
60	6.8	1.4	0.5	4.2	0.5	-0.0	-3.2	-0.4	-0.1
70	6.4	1.3	0.4	6.0	0.7	-0.0	-2.8	-0.4	-0.1
80	5.9	1.2	0.4	9.1	1.1	0.0	-2.5	-0.3	-0.1

Note: Subsidies have larger effects on local real wages in places with higher shares of locals, and the relationship is slightly stronger when parents are not altruistic, though it is still meaningful when parents are fully altruistic. Subsidies to places with very low shares of locals can also increase incomes elsewhere (net of taxes) regardless of parental altruism, though the effect is slightly larger when parents are fully altruistic. Shown are impacts of a 10 percent declining wage subsidy initially, after 50 years, and after 100 years on local population, local real incomes, and incomes in other places as a percentage of initial values. Panel A gives the effects when parents are fully altruistic in terms of treating their children's expected utility the same as their own. Panel B gives the effects when parents do not consider their children's utility. Each is very similar to the baseline effects in Table 4.

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