Local Ties in Spatial Equilibrium

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Abstract

If someone lives in an economically depressed place, they were probably born there. And the presence of people who have local ties – a preference to live in one's birth place – leads to smaller migration responses to wage changes in depressed places. Smaller migration responses lead to lower equilibrium real wages and make real wages more sensitive to demand shocks, a form of hysteresis. And local ties can persist for generations. Place-based policies also cause smaller distortions in depressed places since few wish to move there. Conversely, place-based policies that target newly productive places increase aggregate productivity, since they induce large migration responses.

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I Introduction

Migration should equalize differences across areas, but does it? In canonical models of spatial equilibrium (Rosen, 1979; Roback, 1982), people move until they are indifferent across areas. Empirical explorations, however, have emphasized that this process is imperfect and that migration rates have been falling in the U.S. Many people live near their birthplaces, and so people appear to have local ties – a preference to live near where they were born.

This paper examines these local ties through a Rosen and Roback style model. The model matches the fact that places have very different shares of their populations who were born in the same place. In the model, economically depressed places have residents who were born nearby and who chose to stay because of their strong local ties. Real wages are lower because population shrinks by less after a series of negative shocks. Local ties weaken as people die, but local ties can persist for generations.

This paper extends a literature that documents migration frictions in partial equilibrium to effects on outcomes in general equilibrium. Specifically, I examine real wages after local downturns and place-based policies. Partial equilibrium effects can be undone by crowding out and other processes in equilibrium. So it is important to show that partial equilibrium differences can have effects in a spatial equilibrium that includes more mobile workers. For example, Cadena and Kovak (2016) find that the mobility of immigrants to the U.S. tends to undo the immobility of native born people.[1] And it is important to understand place-based policies in spatial equilibrium. Equilibrium dynamics can lead to misallocation and undo the positive effects of place-based for current residents.[2]

Local ties explain why people continue to live in economically depressed places. Other studies have claimed that people live in depressed places because inexpensive housing attracts people with low incomes (Notowidigdo, 2011; Ganong and Shoag, 2017; Bilal and Rossi-

[1]Similarly, Modestino and Dennett (2012) find evidence that the mobility of renters tends to undo the immobility of home owners with negative equity.

[2]The literature on place-based policies includes Glaeser and Gottlieb (2008); Kline and Moretti (2014*b*); Neumark and Simpson (2015); Bilal and Rossi-Hansberg (2018); Chiara Criscuolo and Reenen (2019).

Hansberg, 2018). But, the presence of local ties can also explain why the people who live in depressed places were very often born in those places.[3]

People with strong local ties are concentrated in depressed places because local ties do not vary with changes in real wages.[4]For example, someone who lives in Syracuse, New York, likely chose to live there in spite of the economy, rather than moving there because of economic conditions. And the accumulation of people with local ties to Syracuse leads to lower equilibrium real wages. Furthermore, these low real wages make Syracuse less appealing to outsiders who lack these local ties. So outsiders are reluctant to move to Syracuse, even after positive shocks. The opposite dynamic occurs in places that have experienced positive shocks. The more fluid migration in growing places acts as a shock absorber, lessening the impact of local shocks through the mechanisms of changing labor and housing demand, as in Blanchard and Katz (1992).

I document four stylized facts that I embed into the model. The first descriptive fact is that a typical American does not move far – the median U.S. born adult lives within around 100 miles of where they were born. The second is a strong positive correlation between population declines and the share of residents born nearby. On average, a place that has been expanding about 2.5 percent slower will have about 30 percent more of its population born nearby. The third fact is that population losses are rare. The fourth fact is that changes in labor demand change population by much less in areas where people have stronger local ties. Instead, they impact other labor supply margins, like labor force participation.[5]

The model matches the four facts, formalizes the mechanisms behind them, forecasts long term dynamics, and allows me to study the impacts of place-based policies on equilibrium outcomes. I match the stylized facts by including local ties – a utility parameter that

[3]Two appendices include the dynamics of worker skill, durable housing, and a non-homothetic preference for housing in my framework. My main policy conclusions are equally relevant when I extend the model to include both features. And my empirical results survive robustness checks for several alternative hypotheses.

[4]The accumulation is in contrast to dynamics surrounding convex migration frictions, as in Rappaport (2004), though this approach has similar implications for convergence.

[5]These four facts do not appear to be widely known, but it is unlikely that I am the first to point them out. For example, Glaeser and Gyourko (2005) also document that population losses are rare and several authors have noted that people are quite unlikely to move (Kennan and Walker, 2011; Diamond, 2016).

describes a worker's preference for living in their birthplace. People with strong local ties – high utility payoffs for living in their birthplaces – stay in depressed places when these places become unattractive to outsiders, leading to lower real wages and smaller migration elasticities. The model shows that smaller migration elasticities reflect the preferences of outsiders as much as the preferences of locals. I also include a law of motion for people's birthplaces that leads the model to converge to a steady state. In the steady state, people's local ties are a function of economic fundamentals like productivity. But convergence takes generations.

The model shows that place-based policies, which I model as wage subsidies, can be efficacious if they target places that are either economically depressed or that have recently become especially productive. This asymmetry arises from two often conflicting motivations behind place-based policies. The first is transferring resources to depressed places while the second is inducing people to move to productive places. In a world with local ties, subsidies to depressed places will transfer resources without distorting where people live because migration elasticities are lower in depressed places. Subsidies to productive places move people into productive places since migration elasticities are higher in productive places. And movements into productive places increase aggregate productivity. They also increase wages in other places because both of this increase in aggregate productivity and also since they leave a smaller supply of workers in other places. So increases in wages in other places can offset the cost of providing the subsidy. And this is particularly true over a period of 50 years or more, since temporary subsidies can lead future generations to grow up tied to more productive places.

These results build on several other papers that have suggested mechanisms that can lead to relatively slow migration. One literature focuses on how social networks influence people's decisions to migrate (e.g. Munshi (2003); Yannay Spitzer (2015); Black et al. (2015)). Other papers have documented reasons why people live near where they were born. Workers receive some labor market benefits when they live close to their parents (Kaplan, 2012; Kramarz and

Skans, 2014; Coate, Krolikowski and Zabek, 2019) and workers also appear to move closer to their birth places after job displacements (Huttunen, Møen and Salvanes, 2018). But young people can also earn more when they move away from their birth places (Shoag and Carollo, 2016; Nakamura, Sigurdsson and Steinsson, 2016), implying that many people have a strong preference for remaining there. Many recent papers have also noted that migration seems to be unusually slow given high returns to migration (Bound and Holzer, 2000; Dao, Furceri and Loungani, 2017; Yagan, 2017; Chetty and Hendren, 2018). Several papers also find that there are frictions in the housing market that have increased geographic inequality (Glaeser and Gyourko, 2005; Notowidigdo, 2011; Hsieh and Moretti, 2015; Ganong and Shoag, 2017).[6]

The most direct contribution to the literature on migration is a framework showing the general equilibrium effects of workers with differing migration elasticities. Most notably, Cadena and Kovak (2016) and Albert and Monras (2018) show that immigrants are more mobile than natives. And Mangum and Coate (2018) show that changes in people's levels of local ties have mirrored declines in migration rates.[7] This paper enriches those studies by showing how increases in local productivity can lead mobile people to concentrate in areas with high real wages, making migration relatively fluid in economically vibrant places.[8]

The paper also contributes by connecting spatial equilibrium models to more realistic microeconomic foundations. Other recent papers in this spirit look at the permeability of local labor market boundaries (Manning and Petrongolo, 2017; Green, Morissette and Sand, 2017), introduce frictional unemployment into spatial equilibrium (Kline and Moretti, 2013; Beaudry, Green and Sand, 2014), calculate indirect effects of local shocks on other areas (Hornbeck and Moretti, 2018), and add additional micro foundations to spatial equilibrium models (Coen-Pirani, 2010; Kennan and Walker, 2011; Davis, Fisher and Veracierto, 2013; Gregory, 2013; Monras, 2015; Diamond, 2016; Fu and Gregory, 2018).

[6]Appendices C and D show how literatures on differential migration elasticities by worker skill and frictions in the housing market are consistent with the main results of the paper.

[7]Mangum and Coate (2018) refer to these preferences to live in one's (and one's parents') birthplace as "home attachments," but they appear to be similar in spirit to what I refer to as local ties.

[8]An interesting extension would be to study the effects of having a larger pool of relatively mobile workers, for example through increased immigration.

The paper proceeds as follows. First, I document four empirical facts about declining places. Second, I embed the four facts in a model. Third, I show how places with high levels of local ties have lower real wages and I use the model to analyze place-based subsidies. I conclude with recommendations for policy and further research.

II Empirics

This section introduces documents the four empirical facts that will guide further analysis. First, most people do not move far from their birth place. Second, migrants concentrate in growing places and depressed places contain people who were born nearby. Third, places infrequently lose population. Fourth, migration responses are smaller in places where a higher share of the population was born nearby. I begin by briefly describing my data and I quickly move on to the empirical facts.

Data

The U.S. Census long form (Ruggles et al., 2010) is the source for most of my analyses. The IPUMS Census and American Community Survey (ACS) data is well suited for this study because it contains data on wages, rents, labor force status, and measures birth places. These variables cover the main equilibrium outcomes that are of interest in spatial equilibrium. Additionally, the data is from a cross section of three percent of the population in the ACS and five percent of the population in the Census. This large size is necessary for examining outcomes in smaller, rural areas.

I proxy for local ties by comparing people's current location with their birthplace. Birthplaces perform important administrative functions – determining citizenship and social security numbers – and so administrative and survey data often include them. Birthplaces also predict people's subsequent location quite well, so they have been widely used by researches, particularly to estimate the long run impacts of childhood interventions (e.g. Kearney and

Levine (2015); Stuart (2017)). Birthplaces imply local ties since someone's identity and childhood experiences are usually tied to their birthplace.

I define individual places using Commuting Zones (CZs, Tolbert and Sizer (1996)) that encompass both people's residences and people's workplaces. CZs match the intuition that people choose a discrete place to live based both on its employment prospects and its quality as a place to live more generally, but they do not do this perfectly (Manning and Petrongolo, 2017; Foote, Kutzbach and Vilhuber, 2017). CZs also cover the entire U.S. mainland, which allows me to examine ongoing migration from rural areas. I keep these constructs fixed at their definition in 1990 to avoid spurious changes due to changes in geographic boundaries.[9]

I observe someone's birth state, not their birth CZ, using public Census data. So my measure of local ties is of people living in their state of birth, not their CZ of birth. Though could lead to imprecision in my empirical exercises, it does not change the main conclusions. I recover very similar effects and patterns both when I use more detailed administrative data on people's birth locations, when I use other measures of local ties, like the amount of time someone has lived in their house, and also when I exclude states that are particularly worrisome.[10] The imprecision due to measuring only states of birth most likely increases my estimates of local ties in big, western states and to lowers my estimates in smaller, eastern states. Since, the overwhelming pattern is that western states have much lower fractions of their populations being born nearby, it likely leads me to under-state differences in local ties.

I focus on outcomes in roughly ten year increments: in 1980, 1990, 2000, and 2008. The roughly ten year increments are useful for looking at changes because the one time moving costs for transporting personal effects are small relative to the flows of higher real wages and/or amenities over ten years.[11] Indeed, much of the previous literature has focused

[9]These are concerns when using metro areas, which do not cover rural areas and which boundaries over time because of expansions and contractions. Additionally, it is important not to over state the point about rural areas relative to using metro areas, since my empirical results are population weighted. Another important note is that I use a strategy developed by Autor and Dorn (2013) to convert public Census geographies into CZs.

[10]Results are available upon request. It also may be optimal to use a wider geographic area in thinking about local ties (as in Diamond (2016)) than simply comparing a worker's current CZ with the CZ they were born in.

on these time increments, using data from the Census (e.g. Bound and Holzer (2000); Notowidigdo (2011); Diamond (2016)). The one exception to the ten year rule is the period from 2000 to 2008, when I exclude the Great Recession by using the ACS three year estimates covering 2006, 2007, and 2008.

A few sample restrictions and data adjustments allow me to focus on changes in 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 restrict the sample to private sector workers with weights proportional to each person's total hours worked to compute wages. In addition, I adjust wages and prices using a PCE deflator so they represent 2007 dollars. I report more details about the data in Appendix A.

II.I Descriptive Facts

Most People Live Close to their Birth Places

The first fact that guides this analysis is that half of U.S. born adults live within 50 miles of their birth place. Figure 1 shows this through an adaptive kernel cumulative density function of people's distances from their birth places in the 2000 Census.[12] The relationship is roughly linear with a log scale on the horizontal axis. About a quarter of adults live within ten miles of their birth places, about 60 percent live within 100 miles, and about 20 percent live more than 500 miles away.

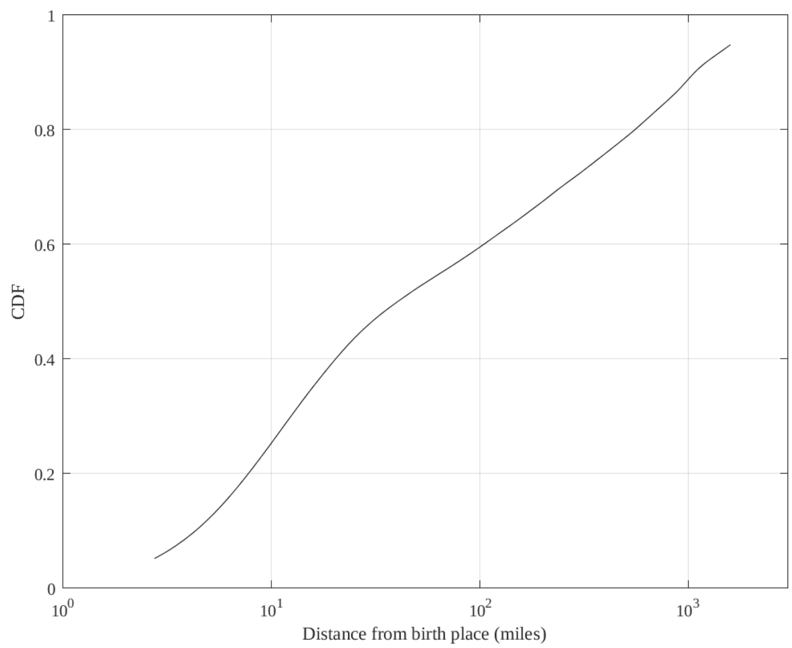
More broadly, Figure 1 shows shows that migrants are a small, select group. Most people live close to their birth places.[13] And the fact that the group of migrants is so small will

[11] I also exclude Alaska, Hawaii, and Puerto Rico from the analysis since moving costs from these locations are likely to be much larger.

[12] The data for this figure are based on a match between the 2000 census complete count files and the Social Security Administration NUMIDENT. The comparison is between the census tract that someone lives in in the 2000 census and the population weighted center of the county that they are reported as being born in according to the NUMIDENT, which is based on a classification of the text box describing their place of birth. This is for people who can be matched from the U.S. Census complete count data to the SSA NUMIDENT based on having a social security number and who were born somewhere in the U.S. according to the file. Stuart (2017) provides more details about the methodology underlying the data. The datasets and the linking variables are available after an approval process via U.S. Census Restricted Data Centers.

influence the analysis that follows in two ways. First, this relatively small group has become quite concentrated in places with low ties. Second, the tastes of this relatively select group of migrants will determine how many people will move in or out after a shock. Places that were unattractive to previous migrants will draw fewer migrants after a subsequent shocks.

Figure 1: Distances Adults Live from their Birthplaces



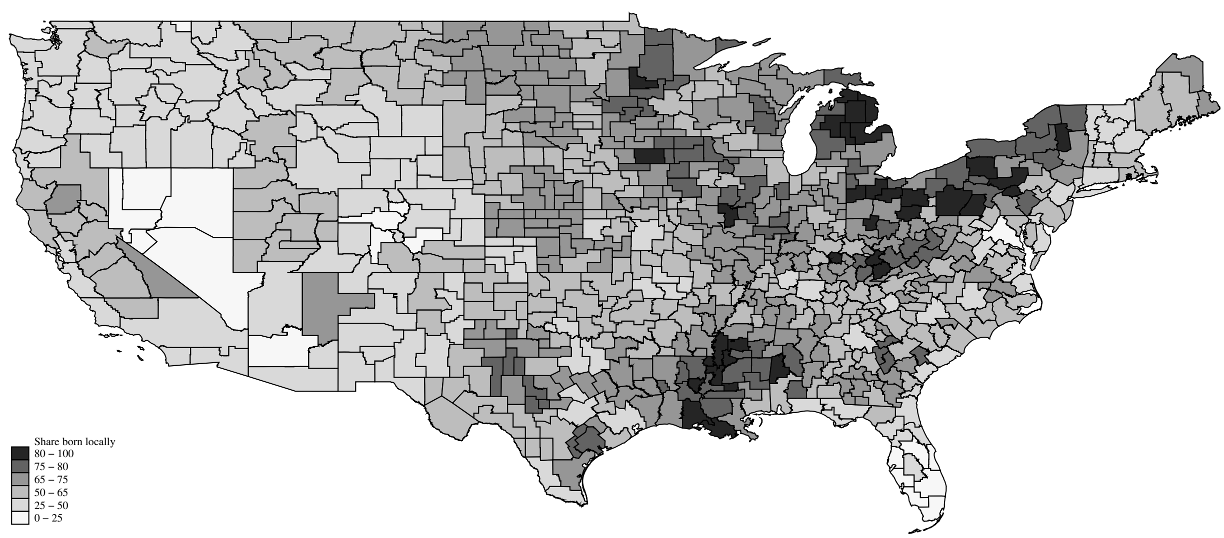
Note: Most U.S. born adults live within around 50 miles of their birthplaces. However, a substantial minority of people also live very far from where they were born. This shows an adaptive kernel density plot of the distances that people live from their birthplaces. The underlying data is the 2000 census complete count RDC data linked to the SSA NUMIDENT, which includes a text field identifying people's birthplaces. Top and bottom tails are suppressed to ensure respondent confidentiality. Stuart (2017) provides more details about the methodology underlying the data.

[13]Some demographic groups, like people with college educations, are more likely to move, but even then they typically find that at least 40 percent of college educated adults live in their state of birth (Bartik, 2009).

Migrants Concentrate in Growing Places and Depressed Places Contain People Born Nearby

Figure 2 shows the concentration of migrants in particular parts of the U.S. by plotting the proportion of people who live in their birth states across all 722 CZs in the continental US.[14] Looking at the scale, the differences between the light and dark shades is quite large – the dark shade for Syracuse, New York, implies that 80 percent of residents were born nearby, while the light shade for Denver, Colorado, implies that around 30 percent of residents were born nearby. The most obvious pattern is higher shares of migrants in the west, and lower shares of migrants in the east, with the exception of the Atlantic seaboard. The darkest areas are in Appalachia, the Rustbelt, and the Mississippi Delta – areas that many would classify as economically depressed.

Figure 2: Shares of Residents Born in the Same State



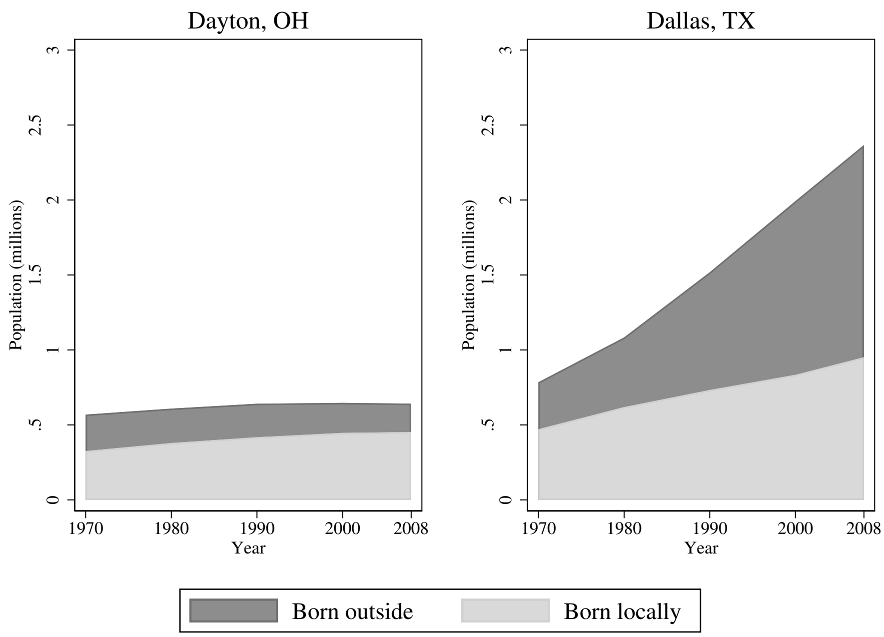
Note: This maps commuting zones in the continental U.S. with shading proportionate to the share of residents who were born in the same state they live in. Places in the west and cities in the south have much lower shares than places like Appalachia, the Rustbelt, and the Mississippi Delta. Data are from the 2006-2008 ACS three year estimates and use nationally representative weights.

To see how economic distress leads to stronger local ties, consider the experiences of

[14]The figure using the amount of time someone has been in their house, which is not affected by a state's size, is in Appendix C.

Dayton, Ohio, and Dallas, Texas.[15] Figure 3 shows the population in each city, broken out by people who were born in the same state (born locally) and people who were born anywhere else (born outside, which includes the foreign born). In 1970, Dallas and Dayton had a similar populations and two thirds of people were born locally in each area. But Dallas has grown much faster since 1980 because outsiders have moved in. In 2008, less than half of Dallas' population was born in Texas. Dayton still contains mostly people who were born in Ohio.

Figure 3: Population Changes in Two Cities



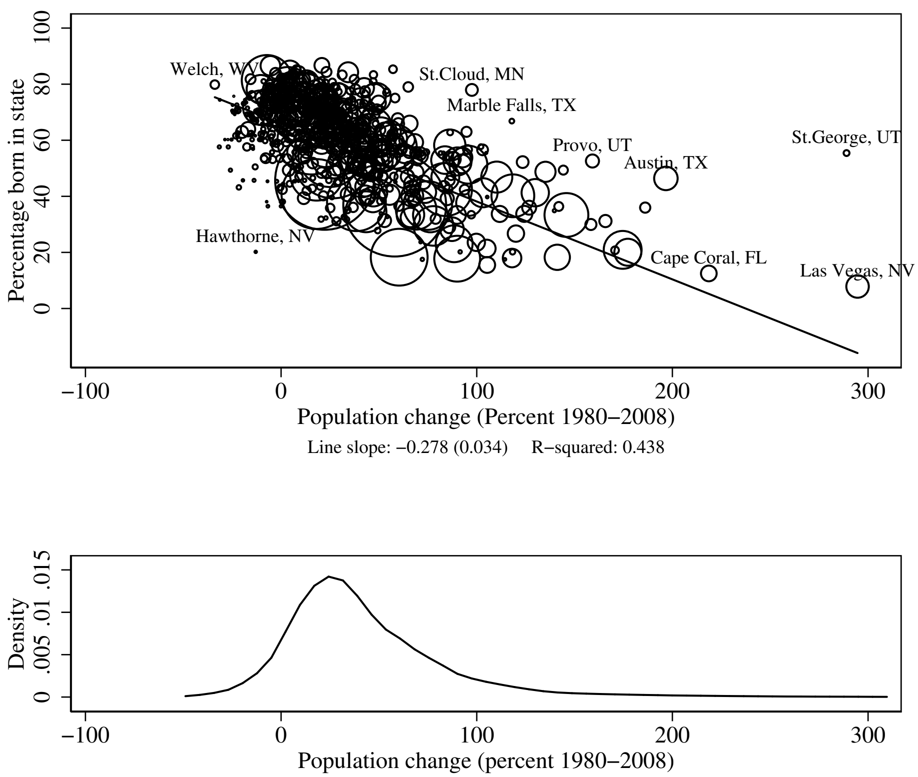
Note: Each figure shows population in each year, broken out by the number of people born in the state and the number born outside of the state. Dallas grew by much more than Dayton over the period by attracting people who were born outside of the state. Data are from the long form decennial census and the ACS 3 year estimates (2006-2008) and are weighted to be nationally representative. The two cities correspond to commuting zones 21501 and 9100.

This link between outsiders moving in and increases in population applies more generally. The plot to the top of Figure 4 shows the robust negative relationship between population growth from 1980 to 2008 on the horizontal axis and the percentage of residents who were

[15]Specifically, I am comparing population changes in 1990 commuting zones 21501 and 9100. The former includes the city of Dallas while the latter contains Dayton.

born locally on the vertical axis, measured in 2008. The interpretation of the regression line is that in a CZ whose population increased 100 percent between 1980 to 2008, about 30 percent less of the population will have been born in the same state.

Figure 4: Population Changes and Local Ties



Note: The top plot is a scatter plot of population changes and the proportion of residents born nearby while the bottom plot is an adaptive kernel density plot of the distribution of population changes from 1980 to 2008 across CZs, weighted by initial population. The figures show a strong and economically significant negative relationship between population changes and the share of population born nearby. They also show that the distribution of population growth is strongly right skewed, and that long term population decline is rare. Data are from the 1980 census and 2006-2008 ACS. Each circle is a commuting zone and its radius is proportional to its population in 1980, and outliers are marked. The regression line is from a weighted least squares regression, using the population weight. the adaptive kernel density uses an epanechnikov kernel with a bandwidth parameter of 15. Share variables are multiplied by 100.

Places where people have higher levels of local ties also show signs of economic distress. Table 1 presents summary statistics broken out for places with high ties – places where more than 60 percent of workers born were locally. Places with high ties have smaller populations, lower wages, lower rents, lower shares of college graduates, slightly older populations, and lower shares of foreign born residents. They also have similar rates of labor force participation and unemployment, despite having lower wages and lower shares of college graduates.[16]

Table 1: Summary Statistics

	Mean	StD	Low Ties	High Ties
Population (thousands)	187.5	531.6	325.9	123.4
Percent in labor force	74.8	5.4	74.6	74.9
Real wages (hourly)	15.6	2.2	16.6	15.2
Real rents (monthly)	524.1	116.9	604.6	486.9
Percent locals	64.4	15.8	45.0	73.3
Average time in house (yrs)	9.0	1.4	7.7	9.5
Percent unemployed	3.8	1.3	3.9	3.8
Percent foreign born	4.2	5.4	7.8	2.5
Percent migrated	11.3	5.4	16.7	8.8
Percent college educated	42.7	11.3	49.2	39.7
Percent under 35	37.9	5.7	38.5	37.7
Percent over 50	25.9	3.1	24.8	26.4
Bartik shifter (percent)	-9.5	22.5	-11.2	-8.6
Chinese imports in 1990s	-1.2	1.8	-0.7	-1.4
Chinese imports in 2000s	-2.6	3.0	-1.8	-3.1

Note: The tables show unweighted summary statistics for the sample of 722 continental CZs for 1980, 1990, and 2000. The first columns show the mean and standard deviation among all CZs, the next two show means for areas with low and high ties (above or below 60 percent locals). The Bartik and Chinese import variables are measured as changes in the period when they are relevant.

[16]Appendices C and D assess robustness of my empirical results and my modeling framework to other differences between places with high and low ties. Empirically, the results are not sensitive to allowing differing responses by an area's age composition, the share of the population that is college educated, the share of the population working at baseline, two measures of rents in the spirit of Glaeser and Gyourko (2005), and other robustness exercises. The model results are equally meaningful when I extend the model to include a concave housing supply curve, heterogeneous housing expenditure shares, and imperfectly substitutable worker skill levels.

Population Losses are Rare

The adaptive kernel density on the bottom of Figure 4 also shows that the distribution of population changes is right skewed and that population declines are rare. Several commuting zones have doubled in size or more over roughly thirty years. But it is rare for a commuting zone to shrink, and it is exceptionally rare for a CZ to lose more than a quarter of its population.

Many authors have focused on the right tail of this distribution, including many papers focusing on Zipf's law (Gabaix, 1999), but fewer authors have focused on the lack of mass below zero. The lack of mass below zero suggests that some friction prevents populations from shrinking by too much. One possibility is the presence of local ties, or connections that people form to the places where they have lived. Another possibility, explored in Glaeser and Gyourko (2005), is that the durability of the housing stock makes housing so inexpensive that people are still willing to live in depressed places. Yet another is some combination of these effects.

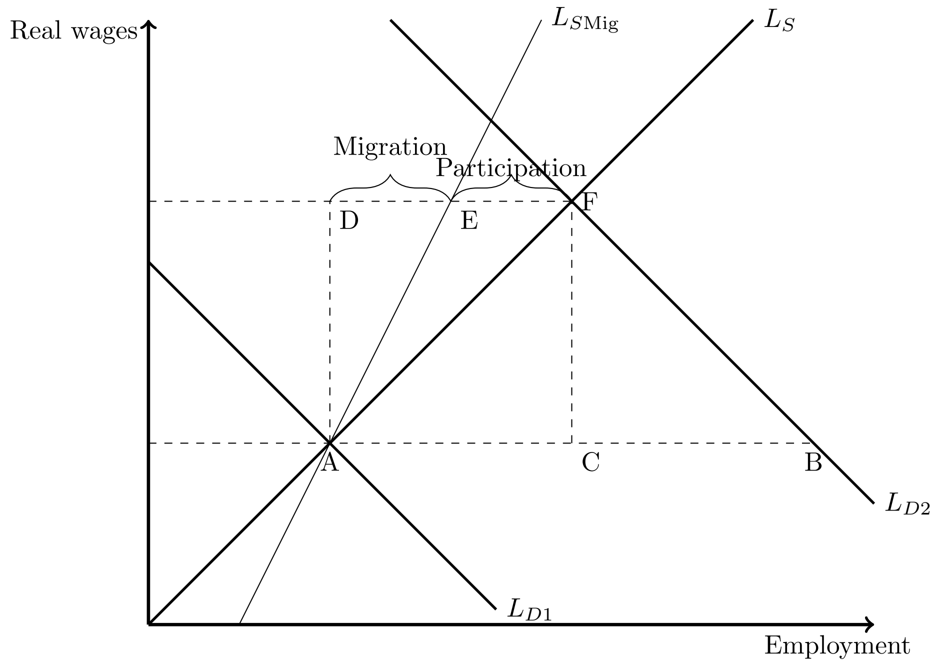
Smaller Migration Responses in Depressed Places

This section provides the first evidence that the presence of residents with local ties influences policy relevant equilibrium objects, like wages and local quality of life. It shows that places where residents have these higher levels of local ties respond to changes in labor demand with smaller changes in population and larger changes in the labor force participation ratio and in wages. Since the literature on place-based policies (Glaeser and Gottlieb, 2008; Kline and Moretti, 2014*b*; Neumark and Simpson, 2015) generally assumes that population movements are relatively fluid across depressed and non-depressed areas, finding smaller population responses in depressed areas changes their cost-benefit analysis.

Migration and Equilibrium in a Local Labor Market

To gain intuition about the impact of lower migration in a simple model of spatial equilibrium, consider the system of labor demand and supply in Figure 5. It plots out 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 out 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.[17]

Figure 5: 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 of real

[17]Empirically, I do not attempt to compute real wages. Instead I present separate results for nominal wages and rents (for housing). These could be combined to compute a proxy; Albouy (2016) suggests that local rents can proxy for 1/2 of local consumption, while national accounts suggest that about 1/3 of consumption is spent on housing and utilities.

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.[18] 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 or to the increase in real wages, or both, then migration is relatively fluid.

In addition to highlighting the size of the migration response, the size of each response hints at the broader implications of an area having lower migration elasticities, or a steeper slope of $L_{S\text{Mig}}$. As $L_{S\text{Mig}}$ gets more vertical, so does L_S and so 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, since they will earn higher real wages after equivalent demand shocks. The increases in participation may also be advantageous if there are concerns about the long term effects of joblessness (Austin, Glaeser and Summers, 2018). But areas with smaller migration elasticities will have more to lose from decreases in labor demand.

[18] 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 $\frac{B-A}{\eta_D + \eta_{S\text{Mig}} + \eta_{S\text{Part}}}$.

Measuring Changes in Labor Demand

A first step towards understanding equilibrium dynamics is isolating plausibly exogenous shocks to labor demand. I gather evidence using two distinct approaches that project aggregate economic phenomena onto local areas using initial industrial composition. The first, developed in Bartik (1991), projects national employment changes. The second, developed in Autor, Dorn and Hanson (2013), projects changes in imports from China. The two approaches give reassuringly similar results.

The first approach is a Bartik (1991) shifter, which I construct for the period from 1980 to 1990. For area j from 1980 to 1990, the Bartik shifter is a weighted average of changes in industry level employment (L) outside the of an area ($-j$), where the weights are the industry's initial share of employment in area j. The last rows of Table 1 shows that these shifters had a wide spread in terms of predicted percentage point changes in employment, but similar average values in places with high and low ties.[19]

$$\Delta \hat{L}_{j,1990} = \sum_{i \in \text{ind}} \left(\frac{\Delta L_{i,-j,1990}}{L_{i,-j,1980}} \right) \frac{L_{i,j,1980}}{L_{j,1980}}$$

The second approach uses increases in Chinese imports in particular industries in the 1990s and early 2000s, owing to Autor, Dorn and Hanson (2013). And the equation is quite similar. For area j from period $t-1$ to t, the trade shifter is a weighted average of changes in Chinese imports to the US, where the weights are the industry's initial share of employment in areas j. In the equation, $\Delta M_{i,t}$ measures changes in imports from China in thousands of dollars. For comparability with the sign of the earlier regressions, I multiply it by negative one and so the instrument is in units of thousands of dollars *fewer* imports per worker. The last rows of Table 1 shows that these shocks had somewhat larger impacts on places with

[19]Bartik (1991), Blanchard and Katz (1992), and Bound and Holzer (2000) include changes in employment within the region in question in their calculation of industry wide changes in national employment, which simplifies the construction of the variables. I follow more recent practice, however, and calculate "leave one out" Bartik instruments by excluding each local labor market in question from the nationwide changes used to project employment changes in each industry.

high ties.[20]

$$\Delta \hat{L}_{j,t} = \sum_{i \in \text{ind}} \left(\frac{-\Delta M_{i,t}}{L_{i,t-1}} \right) \frac{L_{i,j,t-1}}{L_{j,t-1}}$$

These two approaches rely on the aggregate changes being large and unrelated to unobservable changes in labor supply in areas that were the most affected (Borusyak, Hull and Jaravel, 2018; Goldsmith-Pinkham, Sorkin and Swift, 2018). In the early 1980s, changes in trade patterns, exchange rates, and capital investment greatly affected particular industries, like auto manufacturing. These changes are unlikely to have been due to changes in labor supply behavior in affected areas. And the emergence of Chinese import competition was similarly driven by factors unrelated to local labor supply behavior. In fact, the changes were literally outside of the US, since I follow Autor, Dorn and Hanson (2013) in instrumenting using Chinese import penetration in other countries.[21]

I estimate the effects of these changes in labor demand separately for areas with high and low levels of local ties using roughly 10 year changes in the population, in the labor force participation ratio, in residualized wages, and in local rents.[22] The proxy for local ties is having more than 60 percent of workers born locally ($\mathbf{1}_H = 1$) at the beginning of the roughly ten year period.[23] $\Delta \hat{L}_{j,t}$ is the labor demand shifter and so the β coefficients in the equation below show the effect of these shocks for the specified subset of local labor markets.

[20] Autor, Dorn and Hanson (2013) present their regressors using different notation and with a different ordering of terms, but I mirror the earlier notation here to keep the exposition as simple as possible. I also use the variables from their published dataset, so I am mechanically using the same variation.

[21] Note that this argument does not rely on industry employment shares being exogenous. Also note that the critiques in Borusyak, Hull and Jaravel (2018) of Autor, Dorn and Hanson (2013) style instruments are focused on attributing changes in industry demand to changes in international trade. They do not appear to apply to my use case, where the interpretation of the instrument is simply as a plausibly exogenous labor demand shifter.

[22] Residualized wages are residuals from a regression of log wages on four categories of education, gender, whether the worker was African American, and whether the worker was foreign born. I do this separately in each year using the labor supply weights.

[23] I chose 60 percent because it creates roughly two equal sized groups in most years. Triple differences specifications that do not rely on a specific cutoff are presented in Appendix C and give similar results.

$$\Delta y_{j,t} \quad = \quad \alpha_t + (\beta_L(1-\mathbf{1}_H) + \beta_H \mathbf{1}_H)\Delta \hat{L}_{j,t} + \gamma_H \mathbf{1}_H + \gamma_X X_{j,t-1} + \epsilon_{j,t} \tag{1}$$

I estimate the equation in first differences, which controls for time invariant effects, and I include other controls to pick up differences in trends. The controls include time dummies (α_t) and several other demographic characteristics of individual local areas (X).[24] Additionally, standard errors that are clustered by the state the CZ had the plurality of its population within.

Regression Results

The regression results in Table 2 support the idea that migration responses are smaller in areas with higher levels of local ties. The Bartik results in Panel A show smaller population changes in areas with high local ties and larger population changes in places with higher local ties after changes in the Bartik shifters. There is little evidence of differences in other coefficients. The Chinese import shifter results in Panel B show that places with higher ties adjust on margins besides migration, with statistically significant changes in participation and wages, but statistically insignificant changes in population in places with high levels of local ties. There also is evidence in Panel B that migration responses are larger in areas with lower levels of local ties, and that these larger migration responses lead to smaller changes in participation and in wages.

[24] In addition to dummy variables for each bin of local labor markets, I control for the share of working age adults outside the labor force, unemployed, foreign born, having entered the state in the past five years, and the share of adults who are under 35 and 50 to 64. Generally, specifications are not sensitive to the choice of controls. I also include interactions of some of these controls with the labor demand shifters to check if these differences drive the differential responses, and I find no evidence that this is the case.

Table 2: Labor Demand Shocks by Share Born Locally

Panel A: Bartik Shifter in the 1980s

	Population	Participation	Wages	Rents
Bartik: High ties	0.37	0.08	0.29	0.29
	(0.22)	(0.03)	(0.21)	(0.25)
Bartik: Low ties	1.46	0.05	0.26	0.25
	(0.39)	(0.03)	(0.24)	(0.33)
High ties	15.40	-0.42	-0.35	-1.22
	(5.32)	(0.45)	(4.40)	(5.52)
P-val: No diff	0.01	0.29	0.92	0.93
R^2	0.58	0.36	0.35	0.54
Observations		722		

Panel B: Chinese Import Shifter in the 1990s and Early 2000s

	Population	Participation	Wages	Rents
Imports: High ties	-0.10	0.78	0.64	1.19
	(0.30)	(0.17)	(0.18)	(0.57)
Imports: Low ties	0.78	-0.01	0.09	1.37
	(0.38)	(0.10)	(0.25)	(0.28)
High ties	-5.42	2.17	0.36	-2.76
	(1.58)	(0.41)	(0.89)	(1.81)
P-val: No diff	0.02	0.00	0.08	0.78
R^2	0.47	0.54	0.12	0.18
Observations		1444		

Note: Panel A reports OLS regression coefficients from regressing each outcome on a predicted percentage change in employment (Bartik, 1991) and Panel B reports two stage least squares estimates using Chinese trade with other countries to instrument for Chinese imports to the U.S. in thousands of dollars per worker (Autor, Dorn and Hanson, 2013). The estimates are allowed to vary by whether a place has a population with high ties, which is defined as having 60 percent of residents born in the state they currently live in. The p-values are from Wald tests for the hypothesis that the effect is constant for high and low ties areas. Population stands for changes in log population 22 to 64, participation stands for the labor force participation rate (in percent), wages are residualized log wages, and rents are log gross rents. Units of observation are 1990 Commuting Zones, which are are weighted by initial population, and the controls are: the birth share variable used in the interaction term, the share of working age adults outside the labor force, unemployed, with a college education, foreign born, having entered the state in the past five years, and the share of adults who are under 35 and 50 to 64. Standard errors in parentheses are clustered by state, which is determined by the plurality of residents. Data are from the decennial census and ACS including all CZs in the continental US.

In Panel A, the only statistically significant difference between high and low ties areas is in the size of population responses after changes in local labor demand. A one percent predicted increase in employment in an area with a high level of local ties increases the population by a statistically insignificant 0.4 percent, which is more than a full percentage point below the population increase that occurs in an areas with lower levels of local ties. This increase of almost 1.5 percent in a low ties area is quite substantial in response to a one percent predicted increase in employment. There are no significant differences in any of the other outcomes in low ties areas, which supports the findings of Blanchard and Katz (1992) that areas can adjust to shocks through changes in population alone. I also am unable to detect any differential responses in the rental market, which suggests that the rental market plays a limited role in generating the different responses in low and high ties areas.

In Panel B of Table 2, areas with low ties adjust in terms of population, while places with higher ties adjust in terms of wages and labor force participation. A $1,000 per worker decrease in import competition from Chinese firms in a low ties area leads to a 0.8 percent increase in population in a low ties area and a statistically insignificant change in a high ties area. Instead, high ties areas see labor force participation increase by 0.8 percentage points and wages increase by around 0.6 percent. High and low ties areas experience similar increases in rents.[25]

Overall, Table 2 suggests that migration elasticities are smaller in places where people have stronger local ties. Appendix B shows this by using the labor demand shocks as instruments for changes in local incomes in a regression on log local population. And Appendix Table 6 reports that migration elasticities are an order of magnitude lower in places with high levels of local ties, at 0.1 vs around 1 in less depressed places.

The results in Table 2 are also persist after a number of robustness checks that report in Appendix C. These robustness check if other differences between places – in terms of educational attainment, the local age structure, and local housing markets – drive the results. An area's level of local ties continues to predict the different response that I report here after I include interactions of these variables with the labor demand shifters. So my mea-

[25]Panel B keeps with Autor, Dorn and Hanson (2013). It shows large effects in terms of participation after Chinese import shocks. It also shows evidence that there were migration responses in low ties areas. However, Table 1 shows that the shocks did not tend to affect these areas as much as they hit high ties areas.

sure of local ties predicts differences in responses independently of differences in population age, education, and the housing market.[26] The tables also do this using a triple difference specification, which shows that the 60 percent cutoff does not drive the results.

III Model

Here I present a Rosen and Roback style model of spatial equilibrium model that incorporates local ties – a preference for living in one's birth place. Incorporating local ties allows me to match all of the facts that I laid out above – that people do not move very far, that residents of depressed places have strong local ties, that population declines are rare, and that migration responses are smaller in depressed places – in a relatively parsimonious model of spatial equilibrium.[27]

The model also allows me to go further in analyzing the equilibrium dynamics surrounding these local ties. An increase in a place's local ties leads real wages to fall by more, since people with strong local ties will accept low real wages. This drop in real wages makes depressed places even more unattractive to outsiders, and this lowers migration responses by even more. So depressed places are bad places to live, at least economically.

In the long run, the model enters a steady state where all places are equally nice to live in. Steady state occurs because people with strong local ties to depressed places die over time. Children are born with more ties to productive places, since I assume that new

[26]Another piece of evidence that suggests that these effects are driven by local ties themselves is the near equal sized impacts on rents in high and low ties places. Glaeser and Gyourko (2005) and Notowidigdo (2011) emphasize the importance of durable housing. Durable housing can lead to an inelastic housing supply in areas where population is declining. Since houses depreciate slowly, decreases in labor demand (and amenities) can lead to very low rents, which keep people in the area. This is particularly true for poorer residents, since poor people spend a higher share of their incomes on housing.

[27]There are several other explanations for several of these facts, most notably the persistence of people in economically depressed places. One hypothesis is that people live in depressed places because housing is especially cheap. Glaeser and Gyourko (2005) show how the durability of housing can lead housing prices to fall well below a house's replacement value. Cheap housing could be especially valuable to people who are either poor (Notowidigdo, 2011; Ganong and Shoag, 2017) or who are liquidity constrained (Bilal and Rossi-Hansberg, 2018). And durable housing combined with a non-homothetic preference for housing can explain why people would continue to live in depressed places. But including durable housing combined with non-homothetic preferences gives no guidance for why the people who live in depressed places tend to be from there, why people move so little, and why migration elasticities appear to be lower in depressed areas.

births are proportionate to current population. Permanent subsidies to depressed places are undesirable, since they keep populations, and new births, in depressed places permanently. But a subsidy that slowly declines will have a only small effect, since convergence is so slow.[28]

Setting and agents The model is in Rosen and Roback type spatial equilibrium across a large number of places, indexed by j. Workers can move in each period without any mobility cost, but they have ties to their birthplace, indexed by k. I use i to index the size of these local ties, which are utility benefits that workers enjoy when they live in their birthplaces. In addition, each place has an amenity value (A_j) and a wage (w_j) that apply to both locals and outsiders. Local firms set local wages based on market conditions, which includes the level of local productivity (θ_j). Landlords set rents (r_j) based on an imperfectly elastic supply of potential housing. I also allow the government to levy net subsidies to particular places (g_j) so long as they balance the budget.

Workers

Workers choose where to live based on their consumption in the place as well as the amenity value that they attach to living in the place, which varies based on the worker's birth place. Specifically, a worker of type i, living in place j, and with birth place k, has Cobb-Douglas utility in a consumption good (c_j) and local housing (h_j) with a housing share parameter of α^H. The worker also values a local amenity (A_j) and a type I extreme value distributed error term (ξ_{ij}).[29]

$$u_{ijk} = (1-\alpha^H)\ln(c_j) + \alpha^H \ln(h_j) + A_j + \mathbb{1}(k=j)\mu_i + \xi_{ij}$$

A worker's local tie to k is the μ_i term that gives them additional utility when they live in k. For tractability, I assume that the distribution μ_i is normal and that it has the same shape

[28] Rappaport (2004) similarly shows slow convergence using convex adjustment costs in labor and capital reallocation.

[29] Appendix D extends the model to include multiple worker skill levels with differing expenditure shares on housing.

in all places. So people are no more attached to depressed places at birth. Instead, these aggregate differences in local ties emerge as a result of people selecting to live in depressed places.

The budget constraint in place j balances local wages w_j, local rents r_j, and the possibility of a net subsidy from the government g_j that varies based on where someone lives. I following much of the literature in assuming that workers always supply one unit of labor and that there is no heterogeneity in worker quality. Each would complicate the equilibrium. I also normalize the price of the consumption good to one.

$$c_j + r_j h_j = w_j + g_j$$

The setup gives a log linear indirect utility function that is a function of the prices, subsidies, and amenities that apply to everyone living in j, as well as people's local ties in that place and their idiosyncratic enjoyment of it (ξ_{ij}). To separate common from idiosyncratic factors, I denote the prices, subsidies, and amenities that apply to all residents with ω_j.

$$u_{ijk} = \ln(w_j + g_j) - \alpha^H \ln(r_j) + A_j + \mu_i \mathbb{1}(k = j) + \xi_{ij}$$
$$u_{ijk} = \omega_j + \mu_i \mathbb{1}(k = j) + \xi_{ij}$$

The payoff is a convenient formula for the likelihood that an individual worker lives in place j (ψ_{ijk}), which is an important part of the analytic migration elasticity in the model. The parameter ψ_{ijk} increases in both ω_j and μ_i. It also varies with the spread of the type I extreme value term (σ_ξ).

$$\psi_{ijk} = \frac{\exp\left(\frac{\omega_j + \mu_i \mathbb{1}(k=j)}{\sigma_\xi}\right)}{\sum_{j' \in J} \exp\left(\frac{\omega_{j'} + \mu_i \mathbb{1}(k=j')}{\sigma_\xi}\right)}$$

Production

Local good varieties for each place are produced by a representative, perfectly competitive local firm. The local firm uses a Cobb-Douglas production function to combine capital (K_j), supplied at interest rate ρ with local labor (N_j) to produce Y_j of the local good. The place has a specific productivity θ_j that is effectively a proxy for the place's economic prospects. The α_Y parameter is the same everywhere.

$$Y_j = \theta_j K_j^{\alpha^Y} N_j^{1-\alpha^Y}$$

A perfectly competitive national firm produces consumption goods out of local goods using a CES aggregator. It buys each local good at a price of p_j, to combine them into the numeraire consumption good Y. Here, η^Y is the Armington elasticity (of substitution) between local goods, and ϕ_j is a demand shifter for each local good.

$$Y = \left(\sum_{j' \in J} \phi_{j'}^{\frac{1}{\eta^Y}} \left(Y_{j'}\right)^{\frac{\eta^Y - 1}{\eta^Y}} \right)^{\frac{\eta^Y}{\eta^Y - 1}}$$

Housing

As places grow, housing becomes more expensive. Local rents, r_j depend on demand from workers and an upward sloping housing supply curve, with elasticity η^H.[30]

$$H_j^S = r_j^{\eta^H}$$

[30]The common interpretation of this setup is that absentee landlords provide housing by developing land that becomes less and less desirable as more is built up. It contains two important simplifying assumptions. The first is the abstraction from the investment motive for owning a home, which is difficult to model realistically. A concern in this context is that people are locked into houses due to housing price declines. However, the literature on the size of this housing lock in is mixed, particularly if one examines the whole population, where around 40 percent of people are renters (e.g. Ferreira, Gyourko and Tracy (2010); Bricker and Bucks (2013); Valletta (2013)). A second simplifying assumption is that it ignores the durable nature of housing. Appendix D includes a convex supply curve.

Equilibrium

Given a distribution of people's local ties, the model's equilibrium is a set of prices and quantities (p_j, w_j, r_j, N_j) where agents behave optimally to allow markets to clear. So labor supply equals labor demand, housing markets clear, and local goods markets clear.

$$N_j = \sum_{j' \in J} \sum_{k' \in K} \psi_{i'jk'} N_{i'k'} \tag{2}$$

$$w_j = (1 - \alpha^Y)(p_j \theta_j)^{1/(1-\alpha^Y)} \left(\frac{\alpha^Y}{\rho} \right)^{\alpha^Y/(1-\alpha^Y)} \tag{3}$$

$$r_j = \left[\alpha^H w_j N_j \right]^{\frac{1}{1+\eta^H}} \tag{4}$$

$$\theta_j N_j \left(\frac{p_j \theta_j \alpha^Y}{\rho} \right)^{1/(1-\alpha^Y)} = Y \frac{\phi_j}{p_j^{\eta^Y}} \tag{5}$$

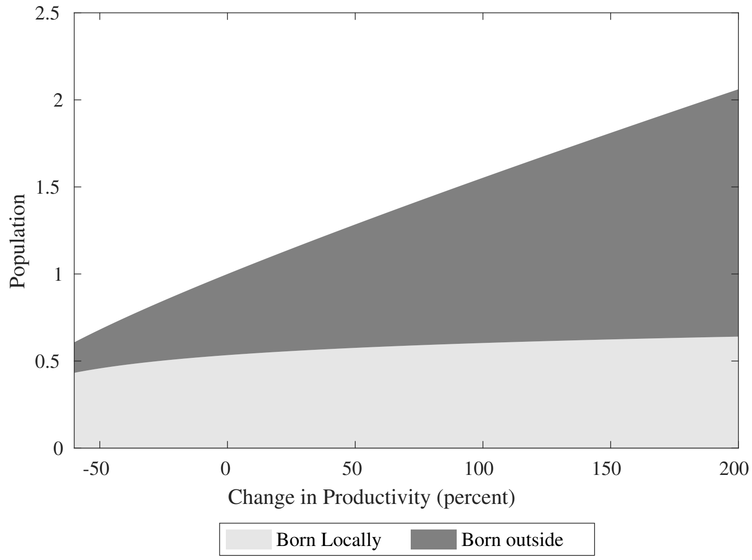
The Distribution of Local Ties Across Places

What determines the model's distribution of local ties? Historical changes in productivity. Mechanically, I start the model at a steady state where all places have equal proportions of their populations born nearby. To get a distribution of places with different proportions of residents born nearby that matches the data, I change the local productivity terms (θ_j).

Figure 6 shows model simulations of how large, one time productivity changes that lead to changes in both total population and the share of people born locally.[31] The x axis shows positive and negative productivity shocks, while the y axis shows population, broken out by where workers were born and normalized to one in a place with no change in productivity. Positive productivity shocks lead to increases in population through increases in the number of outsiders, while negative productivity shocks lead to a concentration of locals and smaller decreases in population, since the place becomes unappealing to outsiders.

[31] The simulations use the model's baseline calibration, which I explain below.

Figure 6: Population after Productivity Changes in the Model



Note: Positive productivity shocks lead to increases in population through increases in the number of outsiders, while negative productivity shocks lead to a concentration of people in the place and smaller decreases in population. The y axis shows total population broken out by people who were and were not born in the place, normalized to 100 for no change in productivity. The x axis shows percentage changes in productivity times. The results are for the baseline calibration after the specified change in the model's productivity parameter, θ_j.

Figure 6 also shows that the model is able to match the empirical facts that I outlined above. Places that had negative productivity shocks have a similar number of people who were born locally, but a much smaller number of outsiders. This lack of outsiders matches with the finding that economically depressed places tend to house mostly people who were born locally. Additionally, the figure's convexity shows that strong negative shocks will decrease population by less than similarly strong positive shocks. So this convexity implies that it will be quite uncommon for a place to lose very much population. Later sections return to the underlying reasons for this asymmetry by explaining how migration elasticities vary with residents' levels of local ties.

I use one time changes in productivity to mimic economic decline over a decade or two. Since population changes are quite persistent (Blanchard and Katz, 1992), cumulative changes can be quite large over ten to twenty years. The model does not include transaction costs associated with moving, like hiring a moving truck or selling a house. So it is the most realistic in modeling processes that last a decade or more.

It should be possible for local ties to form over time frames longer than a few decades, however, and so I include a law of motion for local ties to model how these evolve over longer periods of time while keeping total population stable.[32] The essential assumptions are that new ties are formed proportionate to population and that new people all receive a local tie to their birthplace that comes from the same distribution for everyone, across all birth places.

Formally, the number of people born in place k in the next period is equal to the number of people with ties last period who survive from last period plus the number who are born this period. I assume that people have a fixed and unchanging likelihood of dying each period (s_D) so $N_k(1 - s_D)$ people will survive with a local tie to place k. New people – children – are born to replace the dead according to the current distribution of population, which implies that $\sum_{k'} N_{kk'} \frac{s_D}{1+s_F}$ people will be born – the first term is the current population and the second term is a scaling parameter to keep both a constant population and a constant share of the population being foreign born.[33]

$$N'_k = N_k(1 - s_D) + \sum_{k'} N_{kk'} \frac{s_D}{1 + s_F}$$

In the long run, the law of motion implies a steady state where the number of people who were born in the place is equal to the population over one plus the share of foreign born people in the country.[34]

$$N_k = \frac{\sum_{k'} N_{kk'}}{1 + s_F}$$

[32]It would be straightforward to adapt the model to include a balanced growth path.

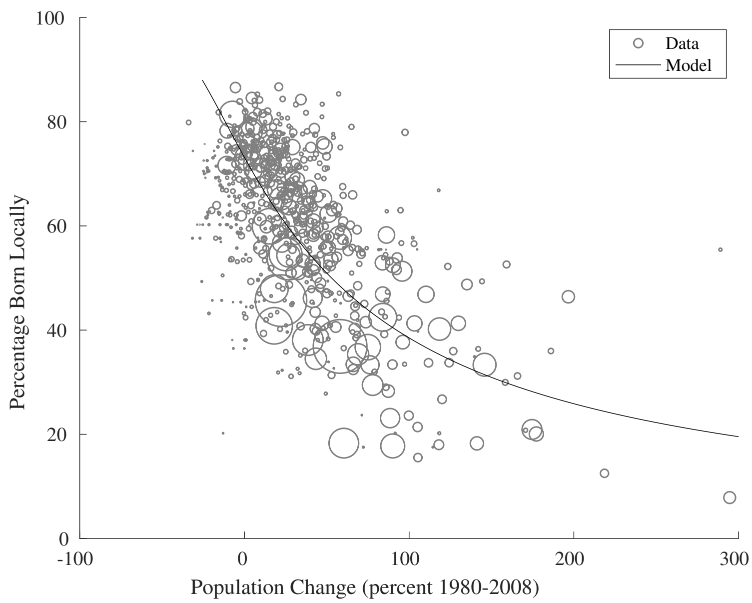
[33]I assume is that people change the distribution of people's future local ties by moving without considering how this will affect future periods. This rules out either a parent deciding to live in their birth place because it will lead their children to have a connection to the place, or a parent deciding to live somewhere else to cultivate an attachment to that place by their child.

[34]It is straightforward to show that this steady state is stable and unique. Also, note that not all of these people will live in their birth place.

Calibration

The objective of the calibration is to find realistic parameter values to illustrate the impact of adding local ties into an otherwise quite standard model of spatial equilibrium. So I mostly use parameters from the literature. But an obvious exception is the distribution of local ties, since I cannot rely on previous literature.[35] To overcome this I use the method of simulated moments to match an important empirical fact that I outlined above.

Figure 7: Estimation: Predicted and Observed Percentages Born Locally



Note: I set the distribution of local ties (μ_i) to minimize the squared deviation with the joint distribution of population changes from 1980 to 2008 and the percent of residents born locally in the data. The line in this figure shows the relationship in the model while the circles show the observations in the data with their radius representing each CZ's initial population.

The target for the estimated distribution of local ties (μ) is the joint distribution of commuting zone level population changes from 1980 to 2008 and the share of people who were born locally in 2008. The inverse relationship of these two variables, shown in Figure 4, is what connects local ties to depressed areas. So it is important that the model be able to match it. Figure 7 shows both a scatter plot of the data and the relationship between these

[35] Empirically I calculate the normal distribution of μ_i using Gaussian quadrature with 100 nodes per area.

two variables in the model after a series of productivity draws that change the population of the affected area.[36] The model matches the distribution fairly well.

I set the other parameters according to the literature. All of the relevant parameters are in Table 3. I set the other term determining worker's preferences about particular places, σ_ξ, at 0.6 to match estimates in Suarez Serrato and Zidar (2016).I follow Feenstra et al. (2018) and choose an Armington elasticity (η^Y) of 4. I set the share of non-tradeable goods in consumption (α^H) at 0.33 based on Albouy (2009). I also assume that 13 percent of workers are foreign born and so do not have any ties to any places in the model.[37]

Table 3: Parameter Values

	Description	Value	Reason
σ_ξ	Preference spread	0.6	Suarez Serrato and Zidar (2016)
η^Y	Armington elast	4	Feenstra et al. (2018)
α^H	Non-tradeable share of cons	0.33	Albouy (2009)
η^H	Housing supply elasticity	15	Green, Malpezzi and Mayo (2005)
α^Y	Capital share	0.33	Standard
ρ	Real interest rate	0.05	Standard
J	Number of areas	722	Number of CZ's
μ_{μ_i}	Local ties mean	4.48	Distribution of percentage locals
σ_{μ_i}	Local ties variance	2.98	Distribution of percentage locals
s_F	Share foreign	0.13	US population
s_D	Share dying	0.02	60 year avg lifespan

Note: These are the parameter values used for the model's calibration, including a text description and a note describing the reasoning behind each value. Variables noted with "distribution of percentage locals" were computed using the method of simulated moments to match the joint distribution of population changes and the share of residents who are locally born displayed in Figure 7.

I assume a single, baseline set of local parameters governing productivity, amenities, and housing supply since my goal is distinct from understanding different levels of productivity, quality of life, geographic accessibility, and zoning.[38] In practice, this means that I set the housing supply elasticity term (η^H) to roughly the middle of the estimates in Green, Malpezzi

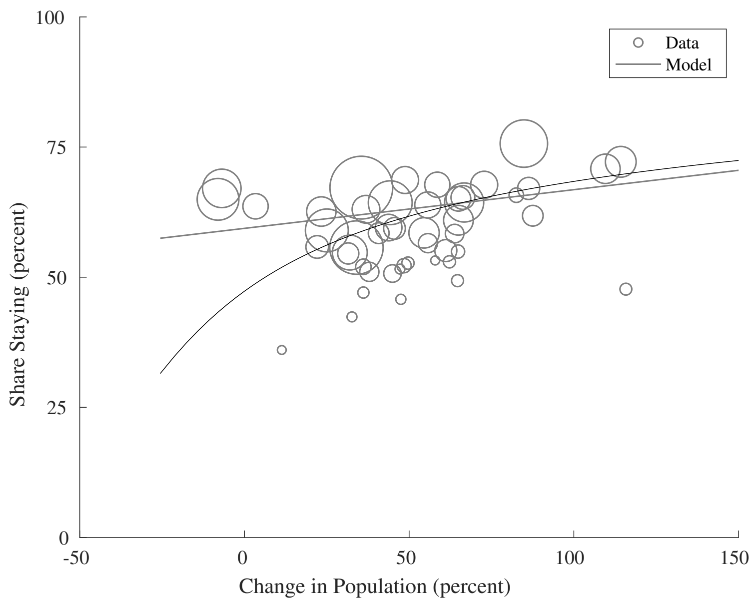
[36]This is without loss of generality. Changes in amenities would also lead to the same relationship between population changes and the share of the population that were born locally. This relationship also does not vary with any of the other parameters, except for σ_ξ.

[37]Foreign born workers have $\mu_i = 0$ for all places, since these workers were not born in the US. I assume a fixed number of people are migrants, so changes in individual places will not lead to changes in this number.

and Mayo (2005) for all cities. I set all of the other local place specific terms to be identically equal to one, with the exception of productivity, which is the variable that I shock in my quantitative exercises.

Figure 8 shows that the model's estimated parameters allow it to approximate an untargeted moment – the relationship between population changes and share of people born in a place who stay in it as adults. The share of people who stay in a growing state is actually quite similar to the share who stay in a declining one, and the model predicts a slightly less modest relationship. So, since the line becomes more flat when there are larger differences between people with different levels of local ties, the difference suggests that the estimated parameters could actually be under-estimating the extent of people's local ties.

Figure 8: Share of People Staying in Places: Model and Data



Note: The model's estimated parameters allow it to approximate the share of people who stay in their state of birth when states experience various population changes. The line in this figure shows this relationship in the model, for CZs, and the circles show this relationship in the data, among states in the Continental United States. The radius of the circles is proportionate to the state's initial population and the grey line is the line of best fit, incorporating the weights.

[38]Substantial literatures examine variations in all of these terms. Rosen (1979), Roback (1982), Albouy (2016), Diamond (2016), and many others study variation in productivity and amenities. Similarly, Saiz (2010) and many others study differences in housing supply elasticites.

Why There is Less Migration in Depressed Places

The model both matches the fact that there are smaller migration responses in areas with high local ties, and its structure gives an idea of why this should be the case. To see why there is less migration in places with higher local ties, consider the analytic formula for the percentage increase in population after an increase in real wages (ω_j).

$$\frac{\partial \ln(N_j)}{\partial \omega_j} = \frac{(1-\bar{\psi}_j)}{\sigma_\xi} \tag{6}$$

The impact of this change in real wages, holding all else constant, depends on a $\bar{\psi}_j$. Since $\bar{\psi}_j$ is the average level of attractiveness of the place relative to all other places for residents, it increases higher when people have higher levels of μ_i. So higher local ties imply lower migration elasticities.[39]

Simplified Example

The migration decisions of outsiders actually help to create low migration elasticities in depressed places. To show how outsiders can actually determine migration elasticities in high ties places I present a simplified version of the model with two areas and two types. The simplifications as well as the analytical tractability of the logit distribution allow me to show the exact relationship above. But the features of the logit distribution that lead to the result are common across many discrete choice probability distributions and the basic intuition extends to much more complex modeling strategies.

To see how outsiders help to determine migration elasticities in depressed places, consider a simplified world there are stayers who were born in a place and who always want to stay there, so $\psi_S = 1$, and outsiders who were born elsewhere and who have no special affection for it, so $\psi_O < 1$. This probability has a logit distribution. The place that we are considering

[39] Formally, $\bar{\psi}_j = \sum_{k'} \sum_{i'} \psi_{i'jk'} \frac{N_{i'jk'}}{N_j}$ where ψ_{ijk} is defined in III. The traditional force spread of people's idiosyncratic preferences about places is σ_ξ.

is small relative to the all of the places people could live, so there are ten times as many outsiders as stayers.[40]

In the model, the partial equilibrium effect of a change in real wages on the likelihood that someone lives in a place ($\frac{\delta\psi_i}{\delta\omega}$) is a function of their baseline likelihood of living there (ψ_i).[41] And this function peaks when the worker has an even likelihood of being there, as shown in Figure 9. So people are the most responsive to changes in places that they are actively considering against attractive alternatives.

Why does partial equilibrium effect of a change in real wages vary with the baseline likelihood that someone lives in a place? It turns out that this relationship is an important component of estimating a model of discrete choice. Nearly all discrete choice probability distributions are S curves that has a linear portion in the middle and a lower slopes at extreme values – at least in two dimensions. The lower slope at extreme values allows the model to have a zero to one range also allows the model to include a minority of agents who make choices that seem to contradict the model's predictions (Train, 2009). Each feature is important for taking the model to the data and so each feature is used across many types of discreet choice probability distributions – logit, probit, generalized extreme value, mixed logit, etc.

So there are very low levels of migration by outsiders in places with high ties, or places with many stayers and few outsiders. Take a place where 3/4 of residents are stayers in Figure 9. In the simplified model $\psi_O = 1/90$ and so outsiders will be at the point labeled "Few Outsiders" and relatively unresponsive to increases in real wages. Contrast this with a situation where 1/4 of residents are stayers. Here, $\psi_O = 1/10$, outsiders are at the point labeled "Many Outsiders," and outsiders are more responsive to changes in real wages. The aggregate equation that I presented above emerges from aggregating the responses among both groups into a percentage change in population after a shock. Since the number of people in the place is equal to the number of each type times their probability of being in

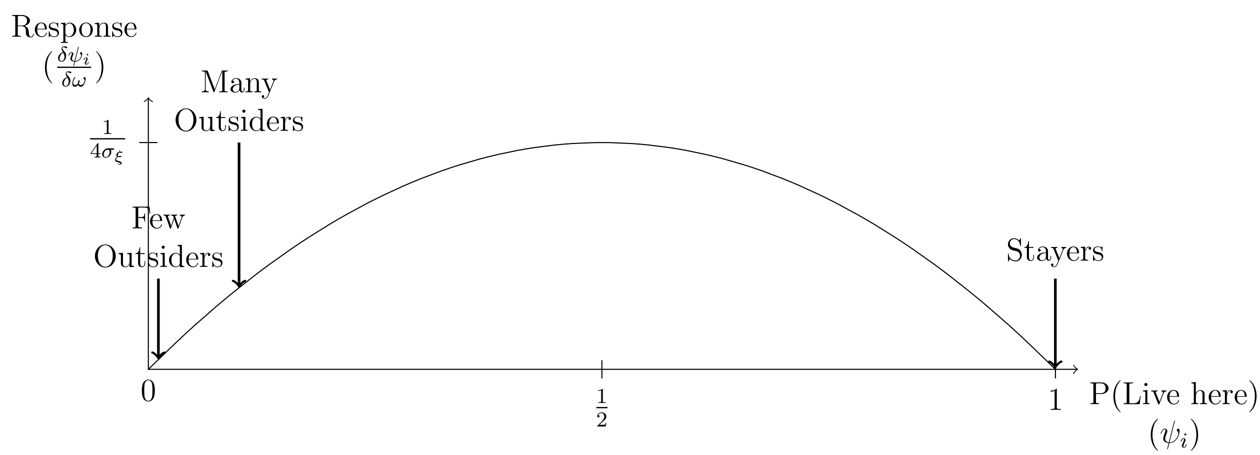
[40]Note that I drop the j and k subscripts since they are implied in this exercise.

[41]The function is $\frac{1}{\sigma_\xi}(1-\psi_i)\psi_i$ and so the maximum at $\psi_i = 1/2$ gives a value of $\frac{1}{4\sigma_\xi}$ (Train, 2009).

the place, the value is equal to an average of $\frac{1-\bar{\psi}_{i}i}{\sigma_\xi}$ where the weights are each type's share of the current population.

$$\frac{\delta \ln(N_j)}{\delta \omega_j} = \frac{N_O\psi_O(1-\psi_O)\frac{1}{\sigma_\xi} + N_S\psi_S(1-\psi_S)\frac{1}{\sigma_\xi}}{N_O\psi_O + N_S\psi_S}$$
$$= \frac{1-\bar{\psi}}{\sigma_\xi}$$

Figure 9: Migration Responses in the Simplified Model



Note: The figure plots the function $\frac{d\psi_i}{d\omega} = \frac{1}{\sigma_\xi}(1-\psi_i)\psi_i$, which is the change in the likelihood of residing somewhere after an increase in real wages for an individual worker in the model. The arrows give the positions of stayers, who will always remain in the place, and outsiders in two cases. The arrow few outsiders gives outsiders' position in the graph when they make up 1/4 of the population, and the arrow labeled many outsiders gives their position when they are 3/4 of the population, according to the exercise presented in the text. When there are few outsiders, outsiders are not very likely to live in the place and so an increase in a place's desirability has a small impact on their likelihood of living in a place ($\frac{d\psi_i}{d\omega}$). When there are many outsiders who live in the place, outsiders are more responsive to increases in the places' desirability.

Equilibrium Migration Responses

In equilibrium the elasticity of population with respect to nominal wages is equal to the elasticity with real wages times a factor proportionate to how much rents will increase. A basic property of Rosen and Roback style equilibrium is that bigger increases in rents will lower migration. Here, a less elastic market will have a higher η^H and α^H will be higher if people spend more on housing. Each will cause rent increases to be larger and each tends to lower the migration elasticity.

$$\frac{d\ln(N_j)}{d\ln(w_j)} = \frac{(1-\bar{\psi}_j)}{\sigma_\xi} \times \frac{1+\eta^H-\alpha^H}{1+\eta^H+\alpha^H(1-\bar{\psi}_j)/\sigma_\xi} \tag{7}$$

IV Dynamics of Decline

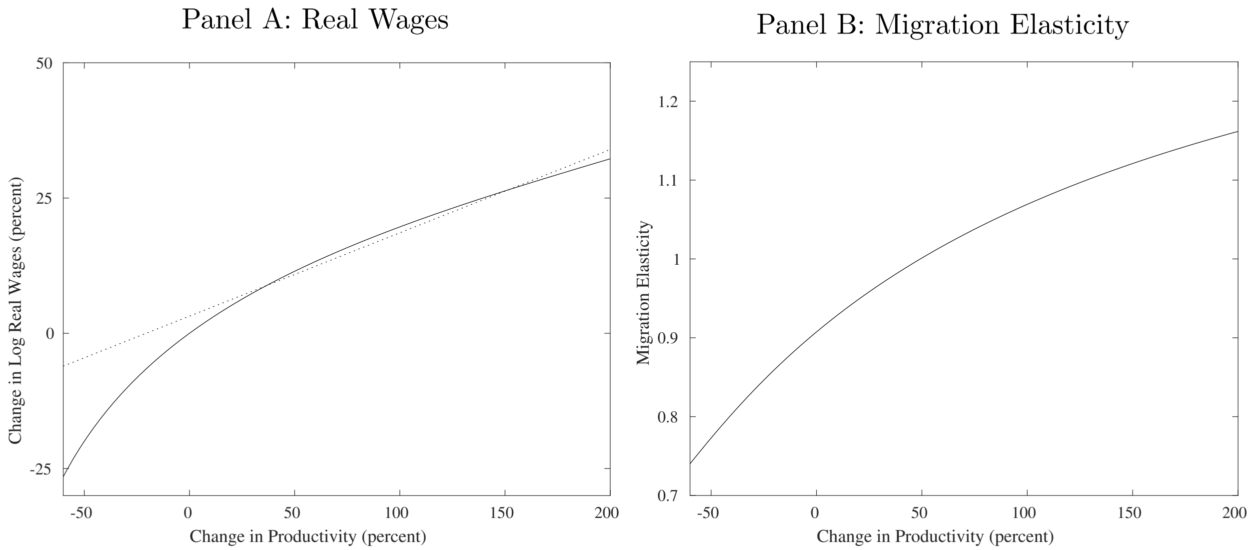
What are the longer term implications of these build ups of local ties? This section shows how local ties affect equilibrium dynamics in the model. Local ties imply hysteresis, since shocks can lead real wages to be depressed for long periods of time and since the build up of local ties implies that a second decline in productivity can decreases wages by more than the first did, even if the two are the same size. The presence of local ties also changes the cost-benefit analysis for policies aimed at depressed places. The presence of local ties implies that policies that are targeted at declining places – e.g. as suggested in Austin, Glaeser and Summers (2018) – will have smaller efficiency trade offs than policies that stimulate places that are not depressed. It also implies that places based policies that target highly productive places will induce many people to move into these productive places, increasing aggregate productivity.

Hysteresis

Declines in local productivity lead places to have residents with strong local ties, which keeps keeps population up, and real wages down in spatial equilibrium. Additionally, migration elasticities are lower in places that have seen productivity declines. This means that repeated negative shocks to an area will lead to successively larger declines in real wages.

Panel A of Figure 10 also shows this dynamic in terms of the asymmetric response of real wages to changes in productivity on the x axis. This asymmetry is particularly apparent if one compares the line with the dotted line of best fit for the half of the graph with positive

Figure 10: Real Wages and Migration Elasticities after Productivity Changes



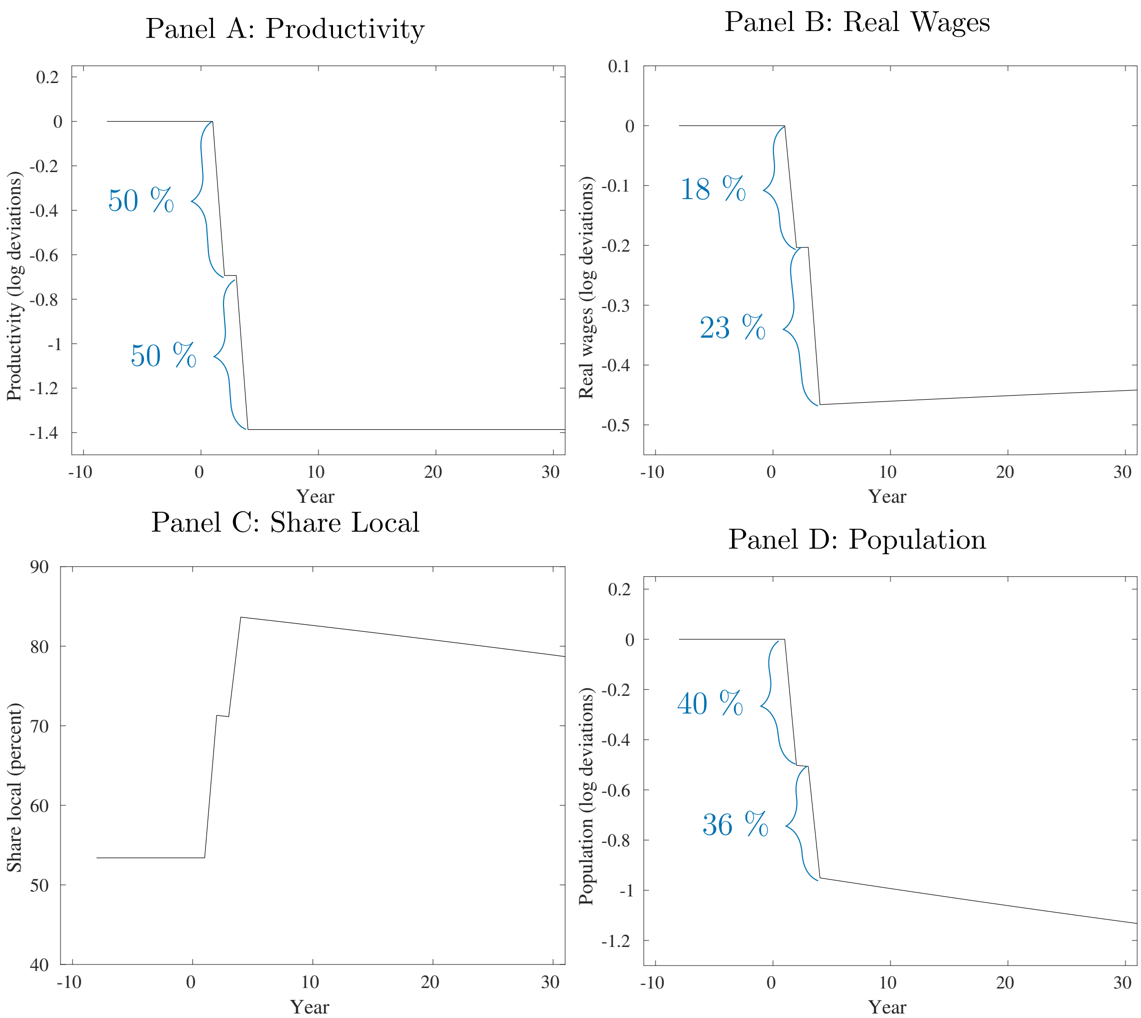
Note: Positive productivity shocks lead to smaller changes in real wages because migration elasticities increase when areas are positively shocked. The x axis of each panel shows log changes in productivity times 100. The y-axis shows the impacts on real wages and migration elasticities. The results are for the baseline calibration after the specified change in the model's productivity parameter, θ_j.

productivity shocks. This dynamic of larger real wage responses after negative productivity shocks is due to the changing share of locals, and its impact on the migration elasticity in Panel B. Since the migration elasticity is lower after declines in productivity, there is a lower population response and a larger decline in real wages.

Figure 11 shows how a history of negative shocks leads to smaller population responses and larger real wage responses after new shocks. It plots the impact of two fifty percent declines in productivity that happen within two years of each other, shown in Panel A. The mechanism that leads to this is the change in the share of locals after the first shock, shown in Panel B.

Panels B and D of Figure 11 plot out the differences in the population and real wage responses. The initial shock involves a real wage decline of about 18 percentage points and a population decline of around 40 percentage points. The second shock changes productivity by the same percentage, but leads to a 27 percent larger decline in real wages and a ten percent smaller decline in population. So places with high ties that have residents who were

Figure 11: Responses after Two Negative Shocks



Note: Real wages decline by more and population declines by less and after a second 50 percent decline in local productivity. Shown is the equilibrium response of the specified variables after the noted change in productivity in an area. The blue labels give the percent changes each time, which differ slightly from the log changes due to the size of the changes.

born nearby experience smaller population changes after shocks to labor demand.

The Persistence of Local Ties

The model drives hysteresis through changes in local ties, so a reasonable question is how persistent are these dynamics? The answer is that they appear to be quite persistent.

Table 4 shows that population and real wages are still evolving nearly fifty years after a change in productivity. The first column of the table shows the size of the initial shock the productivity – positive or negative. The second through sixth columns show the initial percentage change in population, the change in population after fifty years, the change after 100 years, and the half life of population in terms of its deviation from steady state. The following columns show the same process for real wages in the model (ω). The broad take away is that the speed of convergence is quite slow regardless of the size of the productivity shock. For example, the 50 percent decline in productivity in the first row leads to a 32 percentage point initial decline in population. And this decline is only about 60 percent of the total decline of 50 percent. After 50 years – almost a generation in this calibration – population has declined by an additional eight percentage points, but it still has to fall by another ten to reach its steady state. This slow convergence is apparent in all rows, though it scaled by magnitude of the productivity changes.

Table 4: Long Term Convergence After Various Shocks

Productivity change	Population Impact	50	100	Final	HL	Real Wages Impact	50	100	Final	HL
-50	-31.9	-39.7	-44.3	-0.5	65	-13.8	-12.7	-12.1	-0.1	65
-25	-15.3	-19.4	-21.8	-0.3	69	-5.7	-5.2	-5.0	-0.0	69
-10	-6.0	-7.7	-8.7	-0.1	70	-2.1	-1.9	-1.8	-0.0	70
-05	-3.0	-3.8	-4.3	-0.1	69	-1.0	-0.9	-0.9	-0.0	69
50	28.5	37.0	42.5	0.5	76	7.9	7.4	7.0	0.1	76

Note: This table shows the slow convergence after changes in productivity and that real wages overshoot their steady state values. It plots responses in the model after the specified percent change in local productivity assuming the area does not receive and governmental subsidies. The first column shows the change in productivity. The next five columns show the population response with the second showing the initial percentage change, the third the percentage change after fifty years, the fourth after 100 years, and the fifth showing the time it takes for the gap between the initial and the steady state value to halve. The next five columns show the same values for real wages, ω.

Real wages overshoot their steady state values in Table 4 and the slow convergence process implies that they take a very long time to come back up after declines in productivity. After the same 50 percent decline in productivity, real wages drop by 14 percentage points initially, which is about one quarter larger than their eventual decline. Even after fifty years, they are about two percentage points lower than their eventual steady state.

The convergence process is slow because it takes generations for local ties to be reallocated. After a decrease in productivity, population falls due to the fall in real wages. Since people still have local ties, however, the change in population is smaller than the change in steady state. This smaller population response leads to the overshooting in real wages and the low real wages keep people moving out of the area each generation. Local ties also decline with each generation because the flow of people with local ties who die is greater than the flow of new people born with local ties. The very gradual downward slope of the line at the end of Panel C in Figure 11 shows this dynamic and highlights how slowly these local ties change. As population declines by more, real wages recover to the steady state.[42]

[42] For the changes in productivity that I show here, real wages never fully recover. This is because the area has a high level of amenities relative to its now lower level of productivity and because the dynamics of the ξ term imply that workers will have idiosyncratic attachments to the place that will lead them to forego

Place Based Subsidies

Policymakers have become more and more interested in reversing local economic decline. Migration rates have been falling, places no longer seem to be converging economically, and many perceive a wider cultural divide between places in the U.S. These developments have emphasized efforts to stimulate particular places. These policy pushes range from empowerment zones (Busso, Gregory and Kline, 2013), to opportunity zones, to the community reinvestment act, to changes in federal tax credits, to legislation to equalize school funding, to local "promise" programs, to state and local tax incentives designed to spur investments like Amazon's second (and third) headquarters.

In response to policymakers' interests, the economics literature cautions that population reallocations are desirable, and that it would be inefficient if a policy favored a particular place. Albouy (2009) notes that federal tax policy tends to favor low wage places, leading people to live in less productive places. Glaeser and Gottlieb (2008) are skeptical of the wisdom of subsidizing the rebuilding of New Orleans after Hurricane Katrina for much the same reason as Albouy (2009). Broadly, a popular response has been to focus interventions on moving people out of depressed places. Since economically depressed places are unproductive and offer fewer opportunities, people appear to be better off if they move to opportunities in more productive places (Neumark and Simpson, 2015; Chetty and Hendren, 2018).

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higher wages.

Table 5: Effects of Subsidies to Depressed and to Growing Places

Productivity change	Real Wages			Real Wages Elsewhere			Population		
	Initial	50	PDV	Initial	50	PDV	Initial	50	100
-50	3.7	0.4	59.7	-3.0	-0.4	-49.2	7.0	1.5	0.6
-25	2.8	0.3	45.2	-3.0	-0.4	-50.3	7.2	1.6	0.7
0	2.3	0.2	37.1	-2.6	-0.2	-40.1	7.4	1.8	0.7
25	2.0	0.2	31.9	-1.4	0.1	-13.6	7.7	1.9	0.8
50	1.8	0.2	28.2	0.8	0.7	34.5	7.9	2.0	0.9

Note: This table shows that subsidies to depressed places lead to larger effects on local real wages and smaller population increases. Subsidies to very productive places lead to smaller increases in local real wages, but also increases in real wages in other places. The table shows the impacts of a 10 percent subsidy that declines at four percent per year that coincides with the specified percent change in local productivity. It includes the impacts of this subsidy on real wages in the affected area, real wages in other places multiplied the relative population of the other areas before the shock, and population in the area. Initial refers to the initial percentage point change, 50 refers to the percentage point change after 50 years, 100 refers to the percentage point change after a 100 years, and PDV gives the present discounted value with a two percent discount rate.

To assess the role of these place-based policies in the model, Table 5 reports the equilibrium impacts of subsidies to places that have had negative, zero, and positive productivity shocks. Since local ties can lead to such long term dynamics, Table 5 reports out the impact of a ten percent subsidy to the individual area initially, after 50 years, and again after 100 years. In keeping with the history of large place-based policies, most notably the Tennessee Valley Authority (Kline and Moretti, 2014a), I assume that the subsidy declines by four percent per year. So, it is a 1.3 percentage point subsidy after 50 years and a 0.2 percentage point subsidy after 100. I plot out the program's impacts on real wages net of taxes (ω) in the model. I show the impact for real wages – net of taxes and/or subsidies – in the place as well as real wages in all other places, but for comparability I scale the impact on real wages outside of the area by the number of other places in the model (721 in this calibration). Real wages determine workers' welfare in the model, and so these are the most relevant objects for assessing the impact of these subsidies on workers. The last columns also show effects on population, which I mentioned is the primary objection to such policies, and which are useful in understanding the effects on real wages.

The effects of the subsidy on real wages are more favorable in depressed places compared with average ones. In Table 5, each of the real wage impacts in columns two through four are decreasing as one moves down to areas that have been more positively shocked. And the higher increase in real wages in row one as opposed to row two is accompanied approximately the same decrease in real wages in other areas. Population, as well, seems to not increase by as much in these highly depressed places despite the higher changes in real wages. Each is consistent with smaller migration elasticities. So subsidies have a smaller distortionary effects if they are targeted at depressed areas.

Subsidies directed to places where productivity has increased lead to smaller increases in real wages in the affected areas. But they also cause more favorable changes in other places where workers pay taxes to finance the subsidies. The final two rows in Table 5 shows that the subsidy has both a small positive effects on real wages in productive places, and either small negative or meaningfully positive effects on real wages – net of taxes and subsidies – in other places. These effects are especially meaningful in the medium to long run, since they are apparent in both rows at 50 years. In the last row these changes in after tax real wages actually are positive in other areas, despite the higher tax rate.[43]

Subsidies to productive places increase real wages in other places for two reasons. First they increase aggregate productivity and second they move workers in from other areas. In the model, some workers avoid highly productive places because they prefer amenities in other places. However, since there is a large group of workers who are almost indifferent about the productive place, a modest subsidy can lead many people to move into the productive place from other places. This movement into a productive place increases aggregate productivity.[44] The movement out of other places also increases real wages in other places

[43]It is important to note two somewhat subtle points about this result. First, the numbers in the "Real Wages Elsewhere" columns are multiplied by the number of other areas affected by the change (721 in the current calibration), so in any one place they are quite small. Second, policies that increase real wages everywhere do not necessarily lead to pareto improvements, since landlords can still be made worse off. Since landlords' welfare depends on local rents, landlords in unsubsidized areas will generally be worse off since rents will tend to go down in unsubsidized areas.

through the reduction in labor supply, as in (Hornbeck and Moretti, 2018).

Additionally, workers have a positive externality by moving into a productive place and increasing the number of workers from future generations will be born in that place. Since local ties are sticky, a higher population in one period leads to a persistently higher population. This effect leads to increases in real wages in other places in the medium to long run. And real wages increase for the same reason as above – a higher population in productive areas implies a lower population in other areas and higher aggregate productivity. A second effect is that people who are born with ties to productive places are better off than people born with ties to economically depressed places. This is because they do not have to trade off higher wages in a productive place with living in a place where they have local ties.[45] Parents do not consider this dynamic when they move and so a subsidy can induce them closer to socially optimal level of migration.

So place-based policies make the most sense when they are directed at outliers in the productivity distribution – for very different reasons. Policies that subsidize depressed places will increase local real wages by more and induce small changes in population. These two facts make them a fairly effective way to distribute resources to people in depressed places. Policies that subsidize very productive places, however, lead to large changes in population and these large changes in population benefit everyone through general equilibrium effects. Moving people to highly productive places can also lead to increases in wages in places they left behind, particularly in the medium to long run.

V Conclusion

Local ties keep people in depressed places. Places with high levels of local ties have lower real wages that change by more in response to local shocks. And local ties persist for generations.

[44]Since the model features free entry and a perfectly competitive local labor market, a worker will increase Y and hence aggregate productivity by moving to an area with a higher nominal wage. This often – but not always – coincides with a higher level of local productivity.

[45]Discrete choice models generally only identify relative utility so this is a modeling assumption.

Local ties also change the equilibrium impacts of place-based subsidies in both economically depressed and in growing places. High levels of local ties in depressed palces mean that place-based subsidies will lead to small population reallocations and larger increases in real incomes. Low levels of local ties in growing areas mean that place based subsidies will lead to larger population reallocations that can improve aggregate productivity and increase real wages in other places.

Place-based policies can be efficacious in places that are economically depressed and in places that have recently become productive. In depressed places, residents' local ties imply that place-based policies will lead to small population changes. So place-based polcies can target residents more effectively. In newly productive places, residents' lack of local ties suggest that others will move in after a place-based policy. So place-based policies in growing places can improve aggregate productivity and increase wages outside of the area. Place-based policies in growing areas also increase the number of people born with ties to newly productive areas.

Several phenomena could lead to local ties. Local ties could be due to job referral networks (Topa, 2011) and interconnections with family members (Kaplan, 2012; Kramarz and Skans, 2014; Coate, Krolikowski and Zabek, 2019). It would be useful to quantify how much of people's local ties can be related to these phenomena and how unchanging local ties are in the face of various interventions.

More knowledge of local ties could inform policy responses that shape how people form local ties. Social networks could be transportable if local conditions become particularly unfavorable (Yannay Spitzer, 2015), governments could provide loans to encourage mobility, and certain interventions could address information frictions (Wilson, 2016). Recognizing heterogeneity in residents' local ties could also inform policies so that they balance the benefits of population reallocation with the reality that most people live close to their birthplaces.

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Appendix A Data

The data comes primarily from the decennial census and ACS as collected by IPUMS at the University of Minnesota (Ruggles et al. (2010)). Data on the impact of trade on individual local labor markets comes from Autor, Dorn and Hanson (2013), and the vital statistics data comes from the NBER. I restrict my sample to prime-aged (16-64 inclusive) people not living in group quarters (barracks and dorms). In computing wages I exclude unpaid family workers and workers who did not work for pay last year. Generally, I aggregate these data up to the Commuting Zone (Tolbert and Sizer (1996)) level and perform my analyses at this level, except in some cases where I focused on states to better match Vital Statistics and migration data.

IPUMS

The data from the U.S. Census comes via the IPUMS sample detailed in Ruggles et al. (2010). I use several PUMS samples: For 1970 I use the form 1 one percent sample at either the state or metro level, depending on whether the analysis uses states or commuting zones. For 1980, 1990, and 2000 I use the five percent samples. For 2008 I use the ACS 3 year estimates from 2006 to 2008. For the bulk of specifications I exclude people residing in group quarters, such as military barracks or dormitories. The only exception is the growth accounting by state that I performed in section two. In that case I include people residing in group quarters because this exclusion might cause me to lose young adults born 16 to 21 years earlier. For worker wages I exclude unpaid family workers and only include people who worked last year. In regressions using commuting zone data in 1970 I exclude 1990 commuting zone number 24600 because I suspect its geographic definition was mis-coded.[46]

I also compute "labor supply weights" following Autor and Dorn (2013) that weight each worker by their total hours worked last year, and I exclude the top and bottom 1 percent

[46] Using the commuting zone crosswalks from David Dorn suggests that its population in 1970 was ten times larger than its population in 1980.

of wages from the computation. All wages are deflated using the personal consumption expenditure chain type price index available from the Federal Reserve Bank of St. Louis via their FRED service. The reference year is 2007.

Birth Locations

The best available data I have access to concerns workers' states of birth. Unfortunately, this is the most detailed geography that the census bureau asks for, so it is impossible to determine precisely what local labor market a respondent was born in without using an outside data source. Consequently, I tally the proportion of residents of a local labor market who are living in the state of their birth. For large states with many local labor markets (California and Texas are examples) this should lead me to overshoot the proportion of residents living in the area of their birth. For labor markets that cut across state lines (New York for example) I would be understating the proportion of residents living in the same area they were born in since a resident could be in a different state, but the same commuting zone they were born in. On the one hand, imprecision in the measure of the proportion of residents born in the same local labor market is a concern. It is important to note that in a world where areas are not unique islands, the ideal geographic construct may be different in terms of work, family, and other considerations. For example, a worker may prefer to live further away from her parents compared with her work and a worker living in the same state but a different commuting zone as they were born might be almost as constrained as a worker living in the same commuting zone.

Another other issue with the variable is that most births are in hospitals and sometimes children will be born in a hospital in a different state from where their mother lives. Bartik (2009), for example, documents this using data from the PSID. In this situation, the question appears to ask for the state of the hospital, which is a poor proxy for the concepts I am examining. While this variable is far from perfect, its concordance with other measures of a respondent's local "ties" such as their tenure in their home should suggest that it is still meaningful for this application.

For all of these reasons, I include alternative specifications that use alternative measures of local ties. Generally these results are quite similar.

Local Labor Markets

I define a local area for this project as a Commuting Zone (CZ) defined by Tolbert and Sizer (1996). Commuting Zones are designed to reflect local labor markets where workers live and work, based on commuting data collected in the 1990 Census.[47] A given CZ can contain multiple states and states can contain multiple CZs. CZs are quite similar to Metropolitan Statistical Areas (MSAs) that are more commonly used, but CZs also include rural areas, covering the entire area of each of the 50 states. They are constructed to be an ideal analogue to the areas in traditional models of migration where workers live and work in the same area. To merge the IPUMS data I use in my specification I use the crosswalks created by David Dorn and available via his academic website. For historical charts, I exclude commuting zone 24600, which I believe may be improperly coded in 1970.

Appendix B Estimating Migration Elasticities

It is possible to directly measure the migration elasticities by measuring changes in population after the Bartik and China demand shocks. The equation below shows the basic empirical specification that I use to recover the migration elasticity, $\eta_{\text{Mig},j}$. The migration elasticity, $\eta_{\text{Mig},j}$, measures the effect of an increase in log incomes on log population, including the endogenous responses of other local prices. Since I intend to include the effects of these other local prices, like housing prices, I do not attempt to control for them. Following the reduced form results, I do control for decade fixed effects, γ_t, and the standard set of

[47] Different Commuting Zones exist following the 2000 census, however I keep with Autor, Dorn and Hanson (2013) and use the 1990 definitions. I do this to keep CZ definitions constant and I use 1990 because it reflects local areas at the beginning of the sample.

controls from the reduced form regressions, βX_{jt}. These ensure that the regressions are not being driven by different trends for areas where people are of different ages, different education levels, or places where more people are foreign born, for example. Following my earlier regressions, I allow heterogeneity across areas, j, by splitting areas into bins based on their levels of local ties, and also by including a continuous interaction with the level of local ties in each area.

$$\Delta \log \text{pop}_{jt} = \eta_{\text{Mig},j} \Delta \text{income}_{jt} + \gamma_t + \beta X_{jt} + \epsilon_{jt} \tag{8}$$

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.[48] 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. [49]

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 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.

In my empirical setup, 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

[49]Another point about the instruments is that the use of labor incomes abstracts from people's labor leisure choices. In my model, 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. By the logic of the sufficient statistics derivation, however, the impacts on people's labor leisure choice should fall out from the first order welfare impacts of a local subsidy. Intuitively, people are roughly indifferent about working more or searching harder for a job. The most serious limitation for my empirical work appears to in terms of attracting population; local subsidies may be more or less appealing to migrants than increases in wages.

consider not only wages, but also the difficulty of finding and keeping a job. I use the employment to population 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 employment to population 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 6 – are an order of magnitude lower in areas with higher levels of local ties. The migration elasticities in column one are 0.08 in high ties areas and 0.99 in low ties areas. These are statistically significantly different from one another at the ten percent level. The instrument also appears to be strong enough to support this inference, since the first stage since traditional Wald and Kleibergen-Paap corrected Wald F statistics are above traditional thresholds.

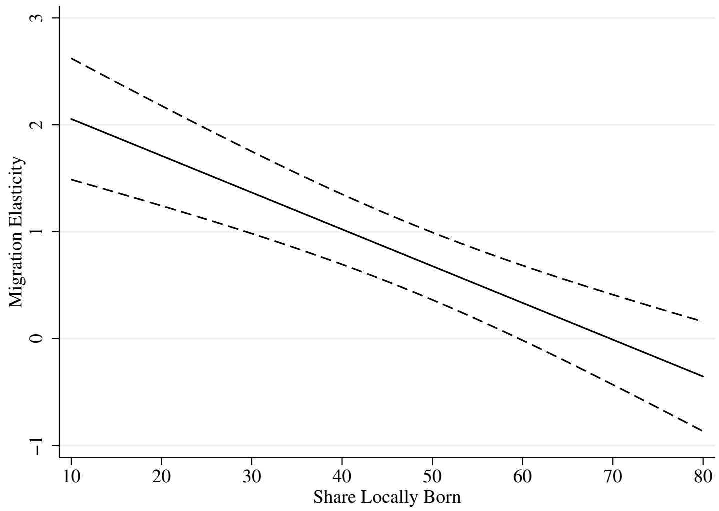
The slope of the continuous linear interaction in column two of Table 6 implies that migration elasticities decline by around 0.35 for every 10 percent increase in the share of locals. I also plot the estimate in Figure 12. To get an idea of the magnitudes, around 15 percent of people who live in Miami were born in Florida. So the estimated migration elasticity is around two in Miami. In areas with very high levels of local ties, the estimated migration elasticity reaches zero. The continuous linear interaction term is statistically different from zero at the one percent level, and the regression also passes conventional thresholds for having a sufficiently strong instrument.

Table 6: 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 diff	0.03	0.00	
First stage F: Wald	35	37	46
First stage F: K-P	12	11	14
Observations	2166	2166	2166

Note: Estimated migration elasticities are much lower in areas 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 2. The statistics at the bottom report a Wald test for no difference in the elasticities between low and high ties areas, the first stage partial Wald F statistic and Kleibergen-Paap corrected Wald F statistic.

Figure 12: Estimated Migration Elasticities



Note: Estimated migration elasticities are much lower in areas with high shares of locally born residents, or high local ties. This figure displays the migration elasticities implied by column two of Table 6 based on the methodology reported in that table. The dotted lines represent 95 percent confidence intervals of the values.

Appendix C Robustness Checks

This section shows that the results in Table 2 are not driven by other observable differences across areas, by mis-measurement of local ties, or by other specification choices, like my cutoff for a having high ties. The results in Table 2 are not due to differences in education, due to asymmetries in the housing market caused by durable housing, due to differences in the average age of residents, or due to differences in labor force participation. When I include each variable as an additional interaction with the labor demand shock, the effects of local ties are quite similar to those in Table 2. Similarly, the results in Table 2 are not due to the inaccuracy of using state of birth because I find similar results when I use an alternative measure of local ties – the average amount of time a residents have spent living in their houses. Finally, results in Table 2o not due to my choice of 60 % as the cutoff for having a high level of local ties because I obtain similar results without a fixed cutoff.

I show the robustness of the results in Table 2, by presenting results using single linear interaction term, or a triple difference, to show differences in the responses of places with different levels of local ties. Using a linear interaction term allows me to present a single statistic for each relationship. 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 % cutoff because they do not use a 60 % cutoff.

$$\Delta y_{j,t} = \alpha_t + \beta_1 \text{Ties}_{j,t-1} \Delta \hat{L}_{j,t} + \beta_2 \text{Ties}_{j,t-1} + \beta_3 \Delta \hat{L}_{j,t} + \gamma_2 \text{Ties}_{j,t-1} + \gamma_X X_{j,t-1} + \epsilon_{j,t} \quad (9)$$

The linear interaction term has a different interpretation than the coefficients in the main specification, equation 1. Equation 9 shows the triple difference specification, which allows the effect of a labor demand shock to linearly scale with the level of local ties, which I proxy for 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 in places with low levels of local ties. Labor demand shocks increase the dependent variable by less in places with higher levels of local ties. So the linear interaction term itself shows differences between places with high and low ties. The unmodified linear interaction term, which I multiply by 100 for readability, 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. So a more reasonable number is to divide each linear interaction term by three, since Table 1 shows that two standard deviation of the share of locals across areas is around 30 percent.

I show robustness by presenting several variations on equation 9 for outcomes where I observe meaningful effects in Table 2. The first column of each robustness table shows the effect of the arbitrary cutoff for having high ties by using the basic triple difference specification in equation 9. Column two 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 35 in interaction 2 and over 50 in interaction 3. Column three shows that the effects are not due to differences in resident's educational attainment by including the share of people who are college educated as interaction 2. Column four 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 2. Column five addresses concerns about the durability of housing by including several variables similar to those in Glaeser and Gyourko (2005) – the level of local log rents as interaction 2 and the lagged ten year change in log rents as interactions 3. Column six omits controls and column seven omits weights. Finally, column eight measures ties by the average amount of time people have been living in their current house.[50]

I replicate the main results for the Bartik labor demand shifters in terms of population and rent in Table 7. The triple difference specification for population, shown in column one of Panel A in Table 7 has a statistically and economically significantly negative coefficient on the linear interaction. 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. This effect is consistently negative across the bulk of specifications, though the magnitude does vary around that baseline number. I also find a significantly negative coefficient when I use the average number of years that adults have lived in their houses as the measure of local ties in the last column. Finally, Panel B shows that rents do not appear to increase by more in places with higher levels of local ties.

The the results for the trade shocks are similarly robust. The only major departure in Tables 8 and 9 is that the interaction term in column one of Panel A of Table 8 is insignificantly different from zero and its magnitude is somewhat modest compared. Column

[50]Note that the coefficient's magnitude has a different interpretation for this column.

Table 7: Population and Rent Responses to Labor Demand Shocks in the 1980's

Panel A: Population

	Base	Age	College	NILF	Rents	Direct	Un-Wt	Alt Tie
Bartik and Local Ties	-2.93	-3.33	-4.77	-3.70	-3.65	-1.65	-5.19	-0.38
	(0.92)	(0.76)	(0.78)	(0.75)	(1.26)	(0.84)	(1.11)	(0.08)
Bartik Shock	2.56	-12.41	5.86	-0.45	9.18	1.58	4.01	3.94
	(0.61)	(7.01)	(0.90)	(0.92)	(9.58)	(0.54)	(0.82)	(0.70)
Local Ties	0.22	0.31	0.42	0.33	0.36	-0.07	0.65	1.86
	(0.18)	(0.17)	(0.14)	(0.14)	(0.16)	(0.13)	(0.18)	(1.17)
Interaction 2		18.75	-6.23	12.15	-1.05			
		(10.67)	(1.77)	(2.64)	(1.43)			
Interaction 3		26.33			3.50			
		(9.15)			(1.21)			
Observations	722	722	722	722	722	722	722	722
R^2	0.604	0.629	0.626	0.641	0.620	0.474	0.297	0.645

Panel B: Percent in the Labor Force

	Base	Age	College	NILF	Rents	Direct	Un-Wt	Alt Tie
Bartik and Local Ties	0.48	0.59	0.42	0.15	1.90	1.80	-1.73	-0.06
	(0.98)	(0.91)	(1.09)	(0.96)	(1.22)	(1.22)	(0.84)	(0.14)
Bartik Shock	-0.08	-15.26	0.03	-1.38	-18.58	-0.73	1.43	1.02
	(0.67)	(9.70)	(1.13)	(1.19)	(9.28)	(0.92)	(0.58)	(1.21)
Local Ties	-0.23	-0.21	-0.22	-0.18	-0.36	-0.52	0.08	2.85
	(0.17)	(0.16)	(0.20)	(0.17)	(0.20)	(0.25)	(0.17)	(1.70)
Interaction 2		23.78	-0.21	5.26	2.75			
		(14.25)	(1.94)	(2.92)	(1.42)			
Interaction 3		18.24			2.50			
		(12.70)			(1.61)			
Observations	722	722	722	722	722	722	722	722
R^2	0.548	0.555	0.548	0.553	0.559	0.199	0.186	0.555

Note: This table shows robustness of the population and rent responses reported in Table 2 to different specifications. The first column shows a triple difference specification where I interact the labor demand shock with the share of locals in the place. The second through fifth show the effects of including various other possible reasons for the heterogeneous responses. Column two includes interactions with the share of people under 35 and over 50. Column three includes the share of people college educated. Column four includes the share who are outside the labor force. Column five includes the level of local log rents and the lagged ten year change in log rents. Column six omits controls and column seven omits weights. Finally, column eight measures ties by the average amount of time people have been in their house. For readability, all of the share coefficients are multiplied by 100, as is the lagged log change in rents. The specifications follow the notes in Table 2 and include standard errors that are clustered by state.

one is the smallest in magnitude of any of the columns on the table, but the term is only significantly negative in some of these columns. The insignificance across columns appears to mostly be due to imprecision.

The results for labor force participation, wage responses, and rent responses to a trade shock all reinforce the results in Table 2. For example, the labor force participation rate results in Panel B of Table 8 show 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 areas in Table 2 is also around 0.8. A similar story applies for wages, and the differences in rents are similarly insignificant.

Table 8: Population and LFP Responses to Trade Shocks

Panel A: Population

	Base	Age	College	NILF	Rents	Direct	Un-Wt	Alt Tie
Bartik and Local Ties	-1.47	-2.60	-3.55	-1.73	-4.16	-4.26	-1.83	-0.18
	(1.77)	(1.77)	(1.97)	(1.64)	(2.45)	(1.93)	(1.65)	(0.12)
Bartik Shock	1.09	-1.94	4.83	-0.16	11.35	2.55	0.55	1.68
	(1.14)	(7.59)	(2.19)	(1.85)	(8.15)	(1.37)	(1.11)	(1.08)
Local Ties	-0.29	-0.32	-0.34	-0.30	-0.34	-0.29	-0.22	-3.61
	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)	(0.05)	(0.09)	(0.51)
Interaction 2		2.11	-4.84	5.99	-1.36			
		(12.30)	(2.69)	(4.69)	(1.13)			
Interaction 3		11.96			-0.05			
		(14.81)			(1.81)			
Observations	1444	1444	1444	1444	1444	1444	1444	1444
R^2	0.485	0.491	0.490	0.487	0.521	0.298	0.290	0.580

Panel B: Percent in the Labor Force

	Base	Age	College	NILF	Rents	Direct	Un-Wt	Alt Tie
Bartik and Local Ties	2.50	2.19	2.83	2.56	2.67	2.60	0.84	0.22
	(0.55)	(0.59)	(0.87)	(0.55)	(0.73)	(0.54)	(0.46)	(0.07)
Bartik Shock	-0.99	-3.57	-1.60	-0.69	-5.29	-1.05	-0.27	-1.54
	(0.27)	(1.87)	(0.97)	(0.49)	(2.20)	(0.27)	(0.29)	(0.62)
Local Ties	0.08	0.08	0.09	0.09	0.10	0.06	0.04	0.66
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.19)
Interaction 2		3.55	0.79	-1.42	0.65			
		(3.04)	(1.09)	(2.13)	(0.28)			
Interaction 3		6.16			-1.02			
		(3.33)			(0.81)			
Observations	1444	1444	1444	1444	1444	1444	1444	1444
R^2	0.545	0.543	0.547	0.541	0.648	0.488	0.223	0.547

Note: This table shows robustness of the population and labor force participation responses to trade shocks presented in Table 2. The first column shows a triple difference specification where I interact the labor demand shock with the share of locals in the place. The second through fifth show the effects of including various other possible reasons for the heterogeneous responses. Column two includes interactions with the share of people under 35 and over 50. Column three includes the share of people college educated. Column four includes the share who are outside the labor force. Column five includes the level of local log rents and the lagged ten year change in log rents. Column six omits controls and column seven omits weights. Finally, column eight measures ties by the average amount of time people have been in their house. For readability, all of the share coefficients are multiplied by 100, as is the lagged log change in rents. For readability, all of the share coefficients are multiplied by 100, as is the lagged log change in rents. The specifications follow the notes in Table 2 and include standard errors that are clustered by state.

Table 9: Wage and Rent Responses to Trade Shocks

Panel A: Wage

	Base	Age	College	NILF	Rents	Direct	Un-Wt	Alt Tie
Bartik and Local Ties	2.05	2.19	2.56	2.23	1.15	1.06	1.10	0.01
	(1.07)	(1.08)	(1.44)	(1.07)	(0.91)	(0.90)	(0.91)	(0.16)
Bartik Shock	-0.79	2.21	-1.69	0.07	-0.39	-0.17	-0.23	0.30
	(0.64)	(3.29)	(1.47)	(0.60)	(3.11)	(0.52)	(0.57)	(1.47)
Local Ties	-0.04	-0.03	-0.02	-0.03	-0.04	-0.01	0.05	-0.65
	(0.04)	(0.04)	(0.05)	(0.04)	(0.03)	(0.03)	(0.04)	(0.38)
Interaction 2		-4.69	1.17	-4.10	-0.01			
		(6.46)	(1.40)	(2.45)	(0.43)			
Interaction 3		-5.79			-0.14			
		(5.22)			(1.60)			
Observations	1444	1444	1444	1444	1444	1444	1444	1444
R^2	0.135	0.142	0.138	0.126	0.320	0.031	0.107	0.152

Panel B: Rent

	Base	Age	College	NILF	Rents	Direct	Un-Wt	Alt Tie
Bartik and Local Ties	-0.83	0.29	1.85	-0.31	0.80	-0.04	-2.28	-0.23
	(2.16)	(2.05)	(3.76)	(2.25)	(2.81)	(2.04)	(1.57)	(0.31)
Bartik Shock	1.73	9.33	-3.08	4.25	-15.80	1.28	1.83	3.32
	(1.01)	(6.86)	(4.02)	(1.54)	(9.09)	(0.92)	(0.99)	(2.48)
Local Ties	-0.10	-0.08	-0.04	-0.08	-0.01	-0.02	-0.20	-0.92
	(0.09)	(0.09)	(0.12)	(0.10)	(0.11)	(0.05)	(0.07)	(0.83)
Interaction 2		-9.85	6.24	-12.02	2.42			
		(13.32)	(4.18)	(8.03)	(1.19)			
Interaction 3		-19.40			2.49			
		(9.91)			(2.35)			
Observations	1444	1444	1444	1444	1444	1444	1444	1444
R^2	0.177	0.176	0.186	0.172	0.444	0.091	0.043	0.175

Note: This table shows robustness of the residualized wage and unresidualized gross rent responses to trade shocks presented in Table 2. The first column shows a triple difference specification where I interact the labor demand shock with the share of locals in the place. The second through fifth show the effects of including various other possible reasons for the heterogeneous responses. Column two includes interactions with the share of people under 35 and over 50. Column three includes the share of people college educated. Column four includes the share who are outside the labor force. Column five includes the level of local log rents and the lagged ten year change in log rents. Column six omits controls and column seven omits weights. Finally, column eight measures ties by the average amount of time people have been in their house. For readability, all of the share coefficients are multiplied by 100, as is the lagged log change in rents. For readability, all of the share coefficients are multiplied by 100, as is the lagged log change in rents. The specifications follow the notes in Table 2 and include standard errors that are clustered by state.

Appendix D The Expanded Model with Worker Skills and Housing Durability

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 literatures and policy discussion about workers differing location choices by skill. Adding worker skill also allows the model to match several major dynamics observed in the literature on regional migration, including a growing concentration of skilled workers in highly productive, rich cities. And adding worker skills also shows that the basic model is flexible enough to accommodate additional features that have been emphasized in the literature on domestic migration.[51]

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 literatures, 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 areas, 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

[51] I do not include these dynamics in the main text because the emphasis on multiple types of workers could distract readers 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.

low skill wages, as in Giannone (2017).[52] Low skilled workers earn less in depressed places because of the limited 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 (Notowidigdo, 2011; Ganong and Shoag, 2017; Bilal and Rossi-Hansberg, 2018). And inexpensive rents arise because of the inelastic supply of already built housing in an area 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, however.

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.[53] 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

Heterogeneous Labor in Production

I include worker skills using the workhorse nested Constant Elasticity of Substitution (CES) 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.

[52] Bound and Holzer (2000); Notowidigdo (2011) verify empirically that less skilled workers concentrate in economically depressed places despite earning less in these places.

[53] This is consistent with the focus of Glaeser and Gyourko (2005).

$$N_j = \left[(1 - A_H) N_{Lj}^{\frac{\eta_N - 1}{\eta_N}} + A_H N_{Hj}^{\frac{\eta_N - 1}{\eta_N}}\right]^{\frac{\eta_N}{\eta_N - 1}} \tag{10}$$

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 can vary by skill group, and the possibility of a different housing share by group α_l^H.[54]

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

Concave Housing Supply

To keep the housing market relatively tractable and to match the intuition of Glaeser and Gyourko (2005), I include a piece wise linear housing supply function. At the supply of housing in the previous period multiplied by a depreciation rate, the function exhibits a kink. Intuitively, this would cover a case where a fixed, random percentage of the housing stock is destroyed each period, as in their model. The function is concave so long as the housing supply elasticity below the kink is lower than the one above it, $\eta_E > \eta_C > 0$.[55]

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

[54] This has the advantage of being extremely tractable and keeping the problem mostly unchanged. Another likely more realistic but less tractable way to induce differing housing expenditure shares is by allowing them to vary with income by introducing non-homothetic preferences.

[55] The two lines intersect at $r^* = \left(\frac{\gamma_\delta H_s'}{\theta_E^H}\right)^{1/\eta_C^H}$ and $\theta_C^H = \frac{\gamma_\delta H_s'}{r^{*\eta_C^H}}$.

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 literature in labor economics. The computational results echo the main themes of the paper.

Analytic Results

Wages Based on this setup, each worker is still paid their marginal product, but their marginal product now decreases with the relative supply of their skill level. Less skilled workers receive higher wages when there are more high skilled workers than low skilled workers.

$$\frac{\partial Y_j}{\partial N_{Lj}} = \underbrace{(1-\alpha^Y)(p_j\theta_j)^{\frac{1}{1-\alpha^Y}}\left(\frac{\alpha^Y}{\rho}\right)^{\frac{\alpha^Y}{1-\alpha^Y}}}_{\text{Unchanged}}\underbrace{(1-A_{Hj})\left(\frac{N_j}{N_{Lj}}\right)^{1/\eta_N}}_{\text{New}} \tag{11}$$

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.

$$\frac{w_{Hj}}{w_{Lj}} = \frac{A_{Hj}}{1-A_{Hj}}\left(\frac{N_{Lj}}{N_{Hj}}\right)^{1/\eta_N} \tag{12}$$

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 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

Adding skill groups, heterogeneous housing expenditures, and a concave supply of housing not only complicates the dynamics of the model, it also increases the number of parameters that I have to calibrate and estimate. To provide the best estimates possible, I continue estimating the distribution of local ties using a simulated method of moments procedure conditional on other parameters calibrated based on relevant literatures.

The calibrated parameters, which build off my earlier calibration, are presented in Table 10. The most important parameters are the spread of the logit distribution for each type, which I allow to vary based on a 30 percent higher migration elasticity among college educated workers from Malamud and Wozniak (2012). I also assume that housing expenditures are 40 percent among low skill workers and 25 percent among high skill 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 assume that housing depreciates at a rate of around two percent and that the housing supply elasticity is 0.1 in places where demand is too low for landlords to build new housing (Glaeser and Gyourko, 2005). The housing supply elasticity in expanding places that matches the calibration of the model in the main text.

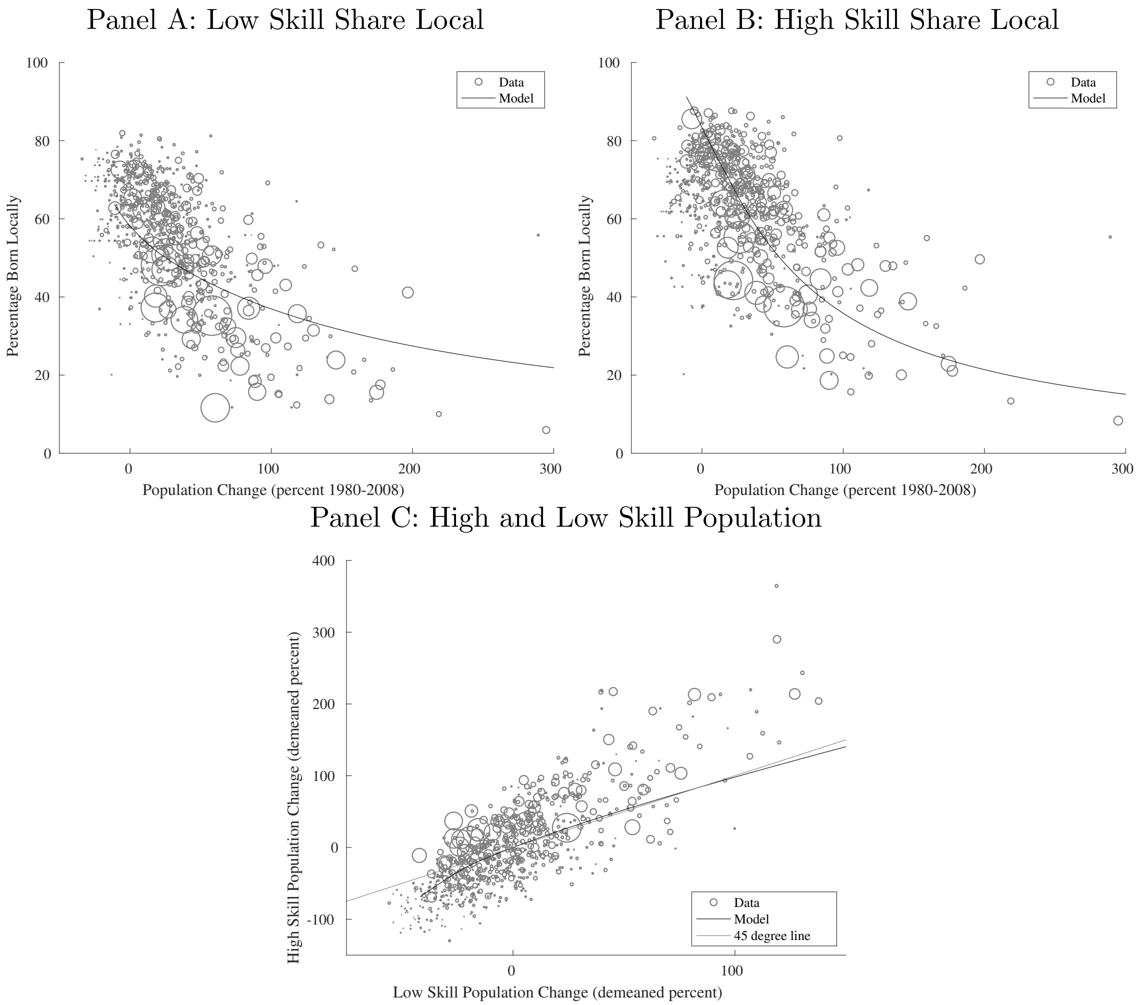
Table 10: Parameter Values for the Expanded Model

	Description	Value	Reason
η_N	Elasticity of substitution for workers	2	Autor, Katz and Kearney (2008)
A_H	Productivity of high skilled workers	0.659	75 % avg skill premium
$\frac{N_H}{N}$	Share high skill workers	0.45	Table 1
η_E^H	Housing supply elasticity, expanding	15	Main text
η_C^H	Housing supply elasticity, contracting	0.1	Glaeser and Gyourko (2005)
γ_δ	Depreciation rate of housing per yr.	0.98	Glaeser and Gyourko (2005)
$\sigma_{\xi L}$	Idiosyncratic preference spread, low	0.522	Suarez Serrato and Zidar (2016)
$\sigma_{\xi H}$	Idiosyncratic preference spread, high	0.695	& Malamud and Wozniak (2012)
μ_{Li}	Local ties values for low skill workers	$[0.00, 6.09]$	Estimated
$\frac{N_{Li}}{N_L}$	Share low skill with each local tie	$[0.37, 0.63]$	Estimated
μ_{Hi}	Local ties values for high skill workers	$[4.527, 13/030]$	Estimated
$\frac{N_{Li}}{N_H}$	Share high skill with each local tie	$[0.93, 0.07]$	Estimated

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 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 these changes 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 I used in the main text.

Figure 13: Two Skill Estimation Moments and Targets



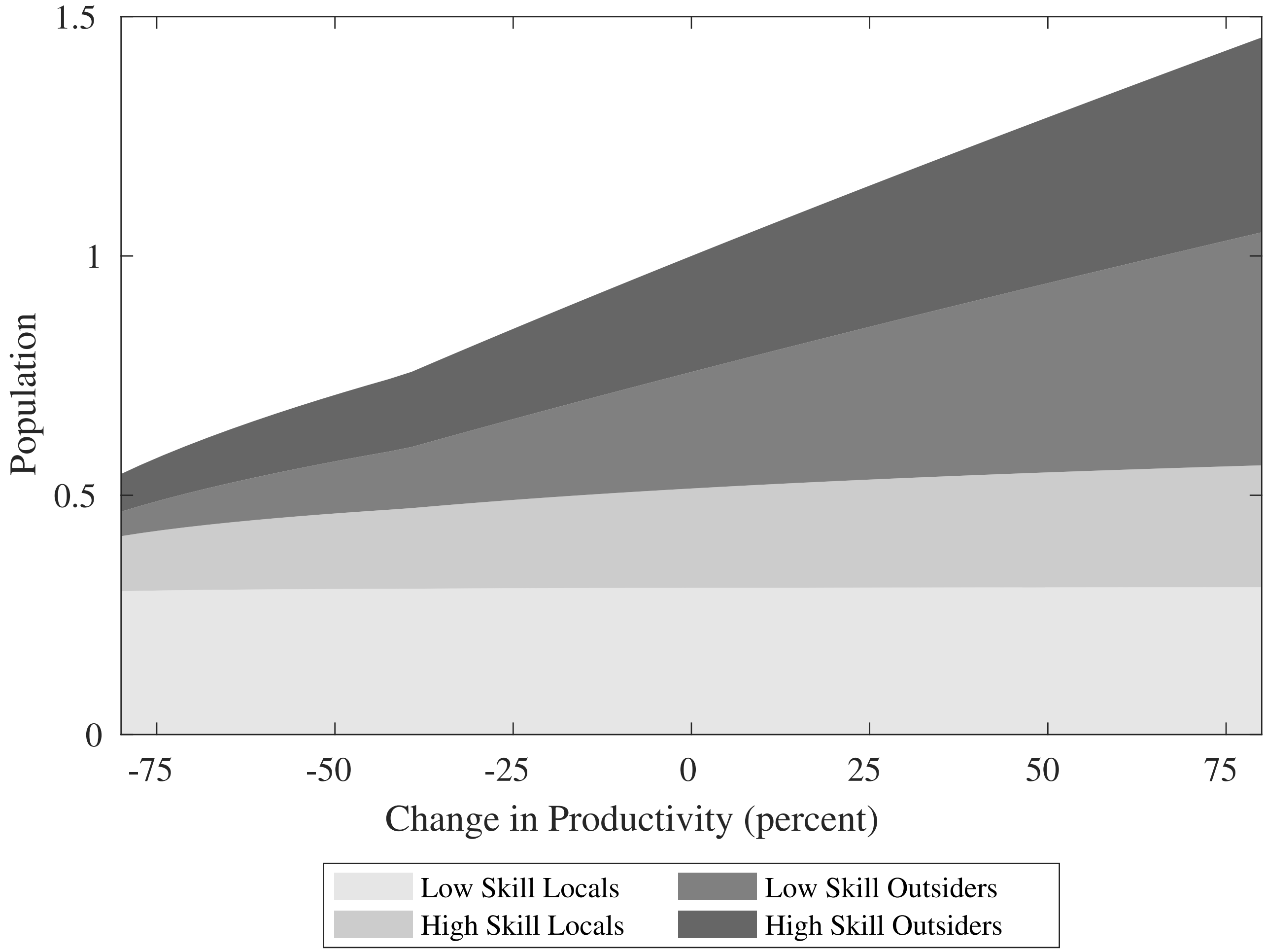
Note: The model matches the distribution of low skill people staying, high skill people staying, and each population growing in places where populations are growing at different rates. This figure plots each distribution in the data as well as the model analogue I use to approximate it in my estimation procedure.

I am able to match these three distributions relatively well, as shown in Figure 13. This relatively good match is despite taking the spread of the logit distribution from the literature and despite 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 high skilled. Figure 14 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 place where productivity has increased. High skill locals drive population increases because they are more mobile and also because they are more willing to pay high rents, as in Notowidigdo (2011); Ganong and Shoag (2017); Bilal and Rossi-Hansberg (2018).

Figure 14: Populations of Outsiders and Local of Two Skill Levels

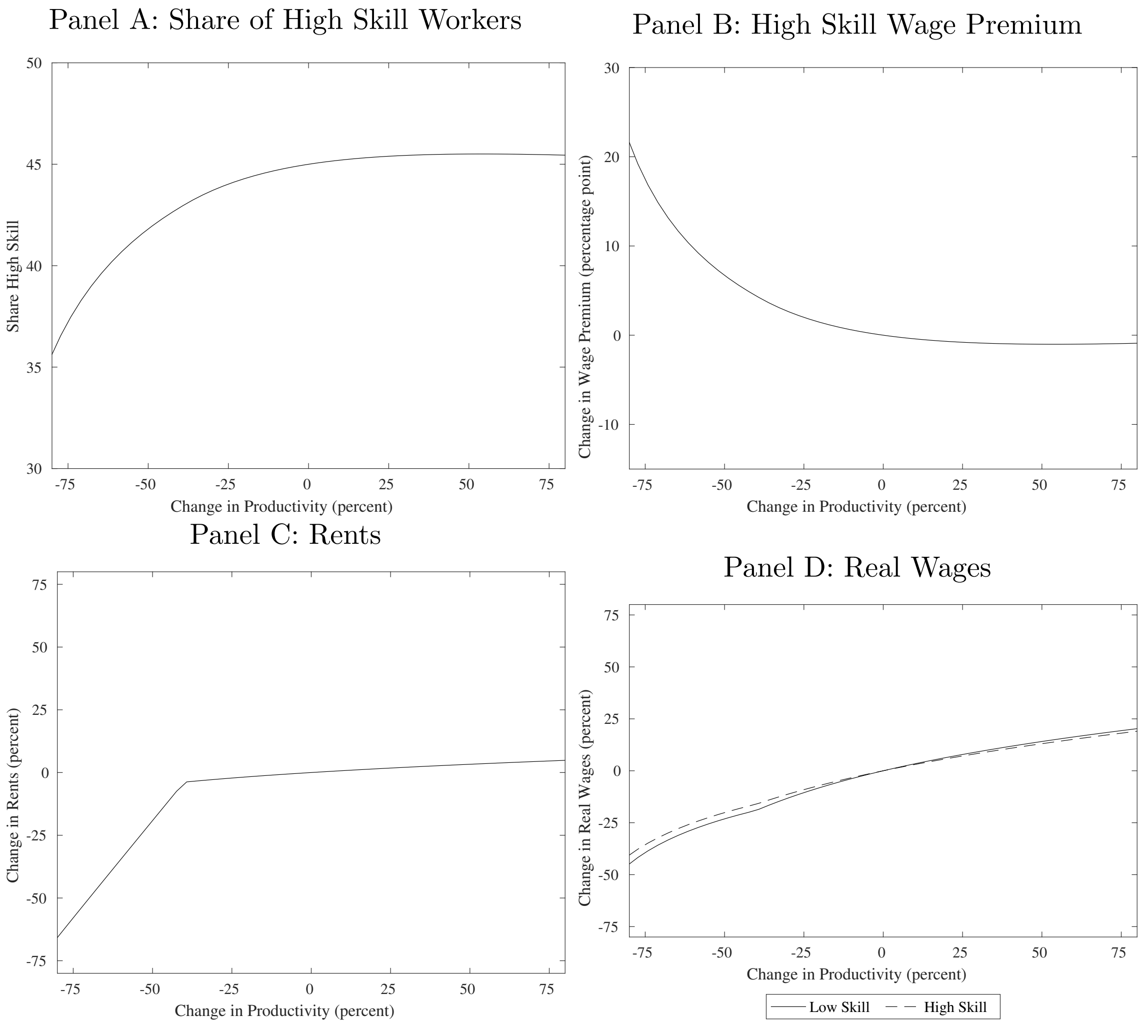


Note: Places that grow in population do so by attracting outsiders, particularly high skill outsiders. This figure plots how the population of locals and outsiders who have high and low skilled changes with productivity shocks. Each height represents the population at that productivity level. They are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

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 15 shows that the share of high skilled workers is lower in places that saw declines in productivity, as explained in Figure 14. Panel B shows that the smaller supply of high skilled worker 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 12 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 15 shows that rents decline by more in places that received strongly negative productivity shocks. Panel C has a kink because rents fall by more in places where the housing stock has not yet had a chance to depreciate, so housing is steadily depreciating in the left section (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 skill workers spend larger fractions of their income on housing, which becomes much cheaper in depressed places. So real wages in Panel D fall only by slightly more for low skilled workers.

Figure 15: 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 skill workers mutes the effects of nominal wage decreases in terms of the real wages of low skilled workers, however. The figures plot the levels of the variables immediately after the specified change in productivity in the expanded model.

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 can have on equilibrium outcomes. To show how the effects of durable housing are large at first but then wane, Table 11 reports changes in the population of low skilled workers in both the expanded model with durable housing (Exp) as well as the expanded model when I allow housing to immediately depreciate (NDH). Table 11 reports population immediately and 50 years after the specified change in productivity as well as the 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.

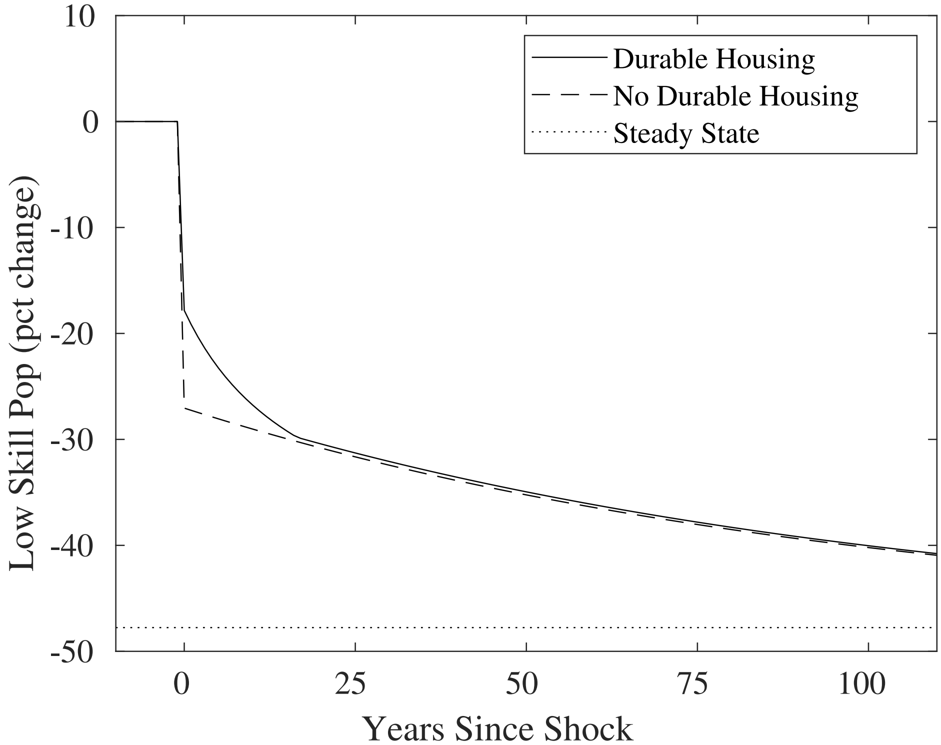
Figure 16 shows how durable housing impacts the low skilled population over a period of around 20 years or less. It plots the change in the low skilled population after a 50 percent decline in productivity (as in the first row of Table 11). Comparing the response with and without durable housing shows 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 around 20 years.

Table 11: Population Changes after Productivty Changes with and without Durable Housing

Productivity	Initial		50 yrs		Half Life	
change	Exp	NDH	Exp	NDH	Exp	NDH
-50	-17.8	-27.0	-34.9	-35.2	35	69
-25	-8.5	-13.7	-17.5	-17.6	28	69
-10	-3.5	-5.5	-7.0	-7.0	28	68
-5	-2.0	-2.8	-3.5	-3.5	32	66
50	27.8	27.8	34.9	34.9	71	71

Note: Durable housing leads to smaller immediate declines in the low skill population productivity declines, but faster declines afterwards 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.

Figure 16: 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.

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 areas because parents still live there. Construction of durable housing, on the other hand, only occurs when rents cover the cost of new construction. So no new construction occurs when rents fall below a certain level.

Place Based Subsidies

The policy conclusions in the main text – that subsidies to depressed and growing areas can be efficacious, but for different reasons – also apply to the extended model. Subsidies to depressed places increase incomes in depressed places at a modest cost to aggregate

Table 12: Extended Model: Impacts of Subsidies

Productivity change		Real Wages Initial	Real Wages 50	Real Wages PDV	Real Wages Elsewhere Initial	Real Wages Elsewhere 50	Real Wages Elsewhere PDV	Population Initial	Population 50	Population 100
	-50	4.1	0.8	100.7	-6.0	-0.6	-92.7	4.2	1.3	0.5
Low	-25	2.9	0.5	72.5	-5.8	-0.6	-90.2	3.9	1.4	0.6
Skill	0	4.2	0.4	65.9	-4.7	-0.4	-71.1	7.0	1.6	0.7
Workers	25	3.5	0.3	55.2	-2.4	-0.0	-28.9	7.6	1.8	0.7
	50	3.0	0.3	48.0	1.7	0.7	44.8	8.0	1.9	0.8
	-50	4.1	0.8	89.2	-4.7	-0.6	-78.5	6.4	1.1	0.2
High	-25	3.2	0.6	70.6	-4.9	-0.7	-82.4	5.9	1.1	0.2
Skill	0	3.8	0.5	65.2	-4.3	-0.5	-70.2	8.1	1.1	0.2
Workers	25	3.3	0.5	57.0	-2.3	-0.2	-32.8	8.2	1.1	0.2
	50	3.0	0.4	51.0	1.4	0.5	35.6	8.2	1.1	0.2

Note: The impacts of place based subsidies in the extended model are very similar to the main model. Subsidies to depressed places can be efficacious at increasing local incomes without large population changes. Subsidies to growing places reallocate more workers and lead to wage gains in other areas – for both skill groups. Plotted are the percentage changes initially, after 50 years, after 100 years, and in present discounted value terms with a 2 percent discount rate after a 10 percent wage subsidy that follows the specified change in local productivity. Real wages elsewhere represent the average real wage change in other places multiplied by the number of other places.

productivity because they lead to relatively small changes in local population. Subsidies to productive places move workers there and produce wage gains in other areas.

Table 12 shows that the results of subsidies in the extended model are qualitatively similar to the results of subsidies in the baseline model in the main text. Real wage gains are the higher and population responses are smaller in economically depressed areas, as before. Real incomes elsewhere are also increasing with how positively shocked the subsidized area was previously, in line with the logic that there are more positive spillovers from allocating a larger number of workers to a productive location.

Despite the basic similarity with the main text, however, there are some subtle differences due to the durability of housing, the higher relative mobility of skilled workers, and the imperfect substitutability of each type of labor. Hints of the differences between the extended and the baseline model appear in Table 12. Population and real wage responses are higher when there is new construction after a 0 percent productivity shock vs. when there is not after a 25 percent decrease in productivity. And population adjustments among high skilled workers are always larger than those of low skilled workers – especially in depressed areas.

The differences with the main model come from the same dynamics balancing the differential mobility of skilled labor with the lower elasticity of housing supply in depressed places and low skilled workers' higher housing expenditure shares. Table 12 shows that after a 50 percent decrease in productivity, a 10 percent wage subsidy has the same impact on high and low skilled workers' real wages, despite leading to a larger increase in the population of high skilled workers. To see why, consider the additional variables plotted in Table 13. Table 13 shows that rents rise quite substantially after the subsidy, since the presence of durable housing leads to a very inelastic housing supply. 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.

Table 13: Impact of Subsidies to Growing and Depressed Places in the Extended Model

Panel A: Economically Depressed Places (50 Percent Productivity Decrease)

	Extended			No Durable Housing			One Skill Level		
	Initial	50	100	Initial	50	100	Initial	50	100
Low - Real Wages	4.1	0.8	-0.1	7.4	0.7	-0.1	3.7	0.4	-0.0
Low - Population	4.2	1.3	0.5	5.5	1.3	0.6	7.0	1.5	0.6
Low - RW Outside	-6.0	-0.6	-0.0	-5.8	-0.6	-0.0	-3.0	-0.4	-0.1
Rents	382.6	4.3	0.9	28.3	4.4	0.9	11.8	1.6	0.2
High - Real Wages	4.1	0.8	0.1	5.6	0.8	0.1	3.7	0.4	-0.0
High - Population	6.4	1.1	0.2	7.9	1.1	0.2	7.0	1.5	0.6
High - RW Outside	-4.7	-0.6	-0.1	-4.6	-0.6	-0.1	-2.9	-0.4	-0.1

Panel B: Growing Place (50 Percent Productivity Increase)

	Extended			One Skill Level		
	Initial	50	100	Initial	50	100
Low - Real Wages	3.0	0.3	-0.0	1.8	0.2	-0.0
Low - Population	8.0	1.9	0.8	7.9	2.0	0.9
Low - RW Outside	1.7	0.7	0.4	0.8	0.7	0.5
Rents	15.5	2.4	0.5	5.9	0.8	0.1
High - Real Wages	3.0	0.4	0.1	1.8	0.2	-0.0
High - Population	8.2	1.1	0.2	7.9	2.0	0.9
High - RW Outside	1.4	0.5	0.2	0.9	0.8	0.5

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. Plotted are the responses of the specified variables across each row that apply to the relevant worker skill level. Initial, 50, and 100 refer to the number of years after both the subsidy begins and the productivity shock hits. Columns that apply to the extended model are labeled "Extended," columns that apply to the extended model without durable housing are labeled "No Durable Housing," and columns that apply to the base model are labeled "One Skill Level." I omit the no durable housing columns in the growing panel because they are all identical to the extended model since there is new construction.

Another insight that comes from explicitly including the two skill groups is that place based subsidies can have have different implications for high and low skilled workers outside of the subsidized place.[56] With a subsidy to an economically depressed place, Table 13 shows

[56] These depend on how the funds for the subsidy are raised. Here I assume that subsidies going to each skill group are raised with a lump sum tax on other members of that skill group, so the place based subsidies do not redistribute income between the two skill groups. If the tax code were progressive, however, then low skilled workers in other places would see their incomes decline by less.

that real wages decline by more for low skilled than for high skilled workers who live outside of the subsidized place. Real wages for low skilled workers in other places tend to decline by more because the subsidy draws fewer low skilled workers away from other places, and so it has a smaller impact on low skilled wages in other places.[57]

[57] The impacts of a place based subsidy on a growing place – also shown in Table 13 – are fairly similar across skill groups.