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**Local Ties in Spatial Equilibrium**

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# Local Ties in Spatial Equilibrium

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## Abstract

If someone lives in an economically depressed place, they were probably born there. The presence of people with local ties – a preference to live in their birthplace – leads to smaller migration responses. Smaller migration responses to wage declines lead to lower real incomes and make real incomes more sensitive to subsequent demand shocks, a form of hysteresis. Local ties can persist for generations. Place-based policies, like tax subsidies, targeting depressed places cause smaller distortions since few people want to move to depressed places. Place-based policies targeting productive places increase aggregate productivity, since they lead to more migration.

Keywords: Migration, Local Labor Markets, Demography, Growth, Decline

JEL Numbers: J61, R23, E62, R58, H31, D61, J11

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# I Introduction

Migration should equalize differences across places, but does it? In models of spatial equilibrium (Rosen, 1979; Roback, 1982), people move until they are indifferent across places. Empirical papers, however, have found that migration responds slowly to economic shocks and that migration rates have been falling in the United States. Many people live near their birthplaces, and so people appear to have local ties – a preference to live near their birthplace.

This paper examines 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. People form local ties in new places over time, but local ties to depressed places can persist for generations.

This paper contributes to our understanding of migration frictions by integrating them into a general equilibrium model. Several partial equilibrium studies have shown that people are reluctant to move. However, partial equilibrium effects are often undone in general equilibrium. For example, Cadena and Kovak (2016) find that the mobility of immigrants offsets the immobility of natives in equilibrium.<sup>1</sup> In terms of policy impacts, several papers have shown that place-based policies can be ineffectual because equilibrium dynamics tend to undo their effects (Glaeser and Gottlieb, 2008).<sup>2</sup>

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-Hansberg, 2018). Local ties can also explain why the people who live in depressed places

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

<sup>2</sup>The literature on place-based policies also includes Neumark and Simpson (2015); Bilal and Rossi-Hansberg (2018); Chiara Criscuolo, Martin Ralf, Henry G Overman, and John Van Reenen (2019).

were often born in those places.<sup>3</sup>

I find that people with strong local ties are concentrated in depressed places because local ties do not vary with changes in real wages.<sup>4</sup> For example, someone who lives in Syracuse, New York, likely chose to live there more in spite of the labor market than because of it. And the accumulation of people with local ties to Syracuse leads to lower equilibrium real wages. Low real wages make Syracuse less appealing to outsiders who lack local ties. So outsiders are reluctant to move to Syracuse, even after positive shocks. The opposite dynamic occurs in places that have experienced large positive shocks. The more fluid migration in growing places acts as a shock absorber that lessens the impact of local shocks through decreasing labor supply and housing demand, as in Blanchard and Katz (1992).

I empirically document four stylized facts about local ties and economically depressed places. First, the typical American does not move very far – the median U.S. born adult lives within around 100 miles of where they were born. Second, there 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. Third, population losses are rare. Fourth, changes in labor demand change population by much less in places where people have stronger local ties. Instead, they impact other labor supply margins like labor force participation.<sup>5</sup>

My spatial equilibrium 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 parameter describing a worker’s preference to live in their birthplace. People with strong local ties – high utility payoffs for living in their birthplaces – stay in depressed places that

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<sup>3</sup>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.

<sup>4</sup>The accumulation is in contrast to dynamics surrounding convex migration frictions, as in Rappaport (2004), though it has similar implications for convergence.

<sup>5</sup>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).

are 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. But convergence takes generations. People's local ties are a function of economic fundamentals like productivity in the steady state.

The model shows that place-based policies – modeled as wage subsidies – can be efficacious for different purposes in different places. Place bases subsidies to depressed places decrease geographic inequality. Subsidies to depressed places transfer income without changing population by very much, so they lead to small decreases in aggregate productivity. Place based subsidies to newly productive places increase aggregate productivity. Subsidies to newly productive places move more people because migration elasticities are higher in productive places. Migration to productive places increases aggregate productivity and leads to higher wages in other places. Population reallocations also lead future generations to form ties to more productive places.

My results build on papers highlighting many mechanisms that can lead to local ties, along with other papers that find small migration responses to large shocks. One literature focuses on how social networks influence people's decisions to migrate (Munshi (2003); Yanay Spitzer (2015); Black et al. (2015)). Other papers have documented reasons why people could have local ties that lead them to 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, Krolkowski 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 to remain. Many recent papers have also found that migration is unusually slow given high returns (Bound and Holzer, 2000; Dao, Furceri and Loungani, 2017; Yagan, 2017; Chetty and Hendren, 2018). Finally, several papers also find that frictions in the housing

market have increased geographic inequality (Glaeser and Gyourko, 2005; Notowidigdo, 2011; Hsieh and Moretti, 2015; Ganong and Shoag, 2017).<sup>6</sup>

My main contribution 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 amount of history in places mirror declines in migration rates.<sup>7</sup> My paper enriches those studies by showing that increases in local productivity lead mobile people to concentrate in places with high real wages.<sup>8</sup>

Another contribution of this paper is connecting spatial equilibrium models to more realistic microeconomic foundations. Related papers examine the impacts 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 places (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).

The paper proceeds as follows. First, I document four empirical facts about economically depressed places. Second, I embed the four facts in an equilibrium 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 Four Empirical Facts

This section describes the data and documents the empirical facts.

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<sup>6</sup>Appendices A and B 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.

<sup>7</sup>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.

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

## 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 birth places. These variables cover the main equilibrium outcomes that are of interest in spatial equilibrium. Additionally, the data is from 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.

My proxy for local ties is 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 researchers, 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 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 continental U.S., 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.<sup>9</sup>

I observe only someone's birth state using public Census data.<sup>10</sup> So my measure of local

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<sup>9</sup>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 overstate 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.

<sup>10</sup>I observe the U.S. territory or the country for people born outside of US states.

ties is of people living in their state of birth, not their CZ of birth. Though the lack of geographic specificity 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.<sup>11</sup> The imprecision due to measuring only states of birth most likely increases my estimates of local ties in big, western states and 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 economic 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.<sup>12</sup> Indeed, much of the previous literature has focused on ten year 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 compute market wages using private sector workers with weights proportional to each person's total hours worked. In addition, I adjust wages and prices using a PCE deflator so they represent 2007 dollars. I report more details about the data in the Online Appendix.

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<sup>11</sup>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.

<sup>12</sup>I also exclude Alaska, Hawaii, and Puerto Rico from the analysis since moving costs from these locations are likely to be much larger.

## Facts

This sub-section 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.

### Most People Live Close to their Birth Places

The first empirical fact 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.<sup>13</sup> 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.

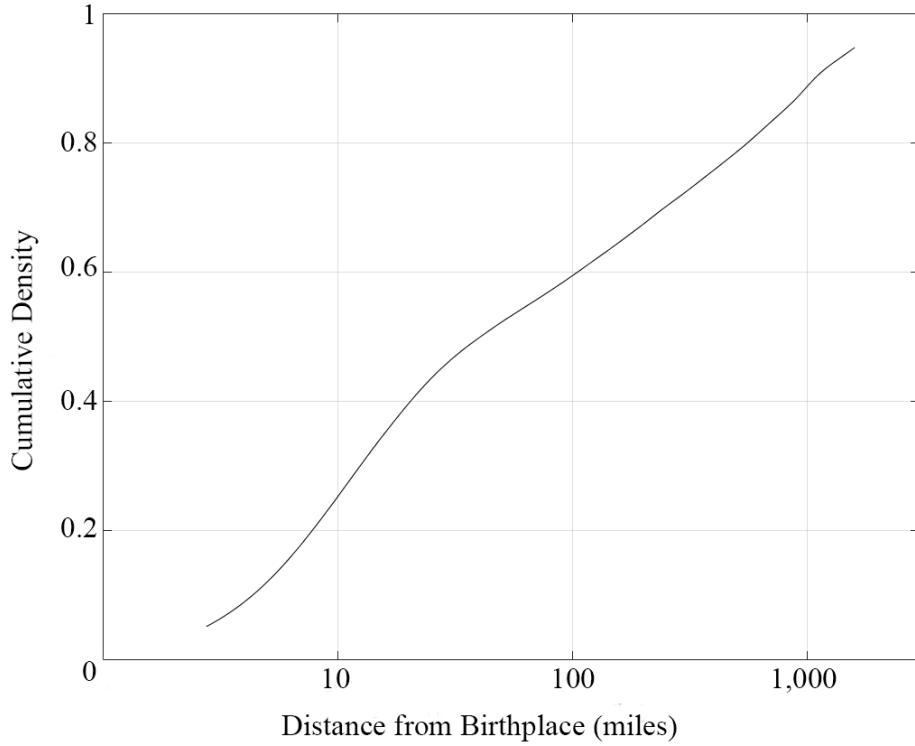
More broadly, Figure 1 shows that migrants are a small, select group. Most people live close to their birth places.<sup>14</sup> And the fact that the group of migrants is so small will influence the analysis that follows in two ways. First, this relatively small group has become quite concentrated in 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.

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<sup>13</sup>The comparison is between the census tract that someone lives in in the 2000 census and the population weighted center of their birth county. The data and sample are a match between 2000 census complete count files and the Social Security Administration NUMIDENT. Birth counties are based on text describing someone's place of birth in the NUMIDENT – usually for a birth certificate. Stuart (2017) provides more details about the methodology. The data and links are available after an approval process via U.S. Census Restricted Data Centers.

<sup>14</sup>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).

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 data linked to the SSA NUMIDENT. Top and bottom tails are suppressed to ensure respondent confidentiality.

### Migrants Concentrate in Growing Places

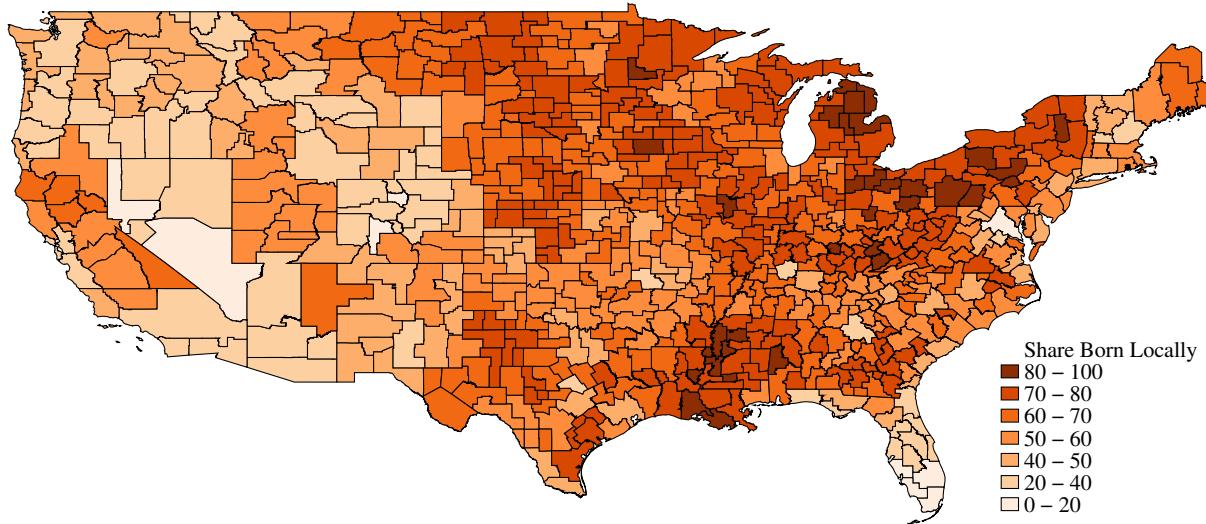
Inter-state migrants are highly concentrated in particular parts of the U.S., as shown in Figure 2.<sup>15</sup> The differences between the light and dark shades is quite large – the dark shade for Syracuse, New York, implies that 80 percent of residents were born in the same state, while the light shade for Denver, Colorado, implies that around 30 percent of residents were born in the same state. 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.

Economic distress leads to residents with stronger local ties. To see this, consider the

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<sup>15</sup>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 A.

Figure 2: Shares of Residents Born in the Same State



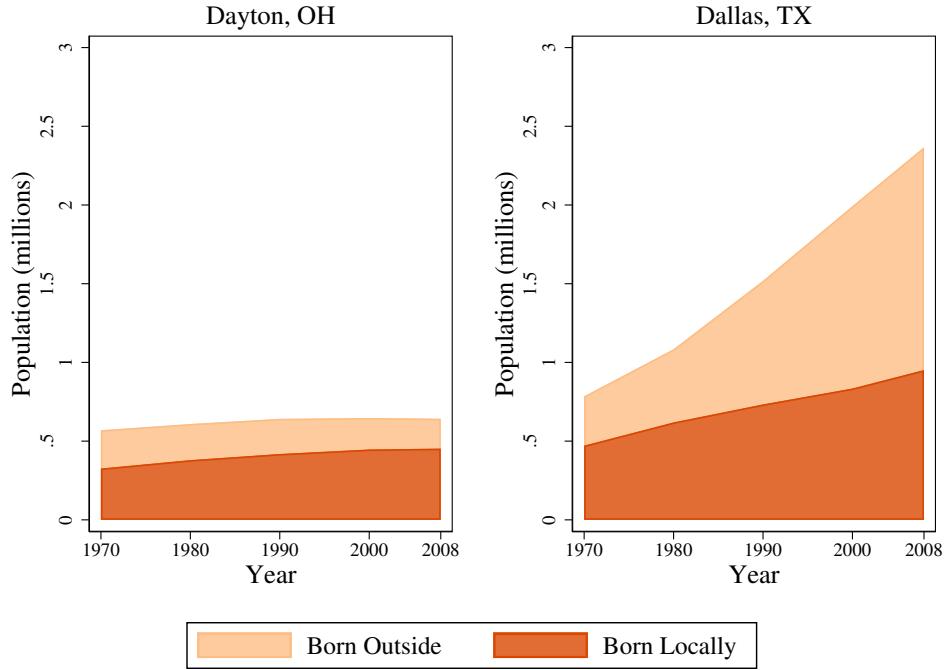
Note: This maps commuting zones in the continental U.S. with shading proportionate to the share of residents who were born in the same state they live in. Places in the west and cities in the south have much lower shares than places like Appalachia, the Rustbelt, and the Mississippi Delta. Data are from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

experiences of Dayton, Ohio, and Dallas, Texas.<sup>16</sup> 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.

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<sup>16</sup>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.

Figure 3: Population Changes in Two Cities

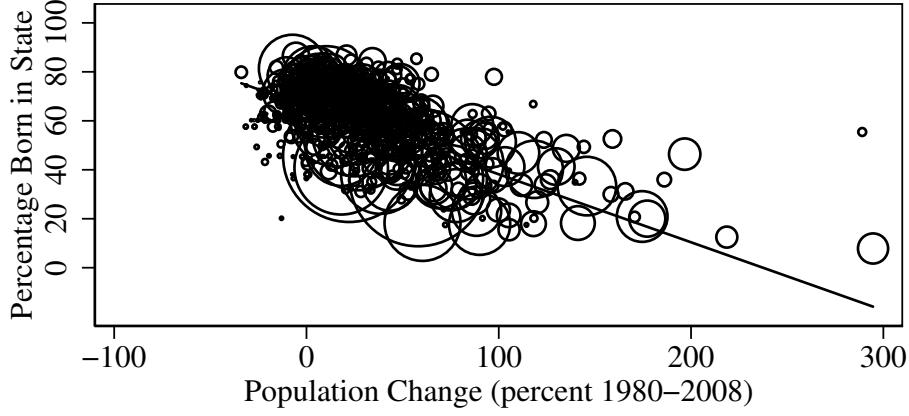


Note: Each figure shows population in each year, broken out by the number of people born in the state and the number born outside of the state. Dallas grew faster than Dayton over the period by attracting people who were born outside of the state. Data are from the long form decennial census and the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

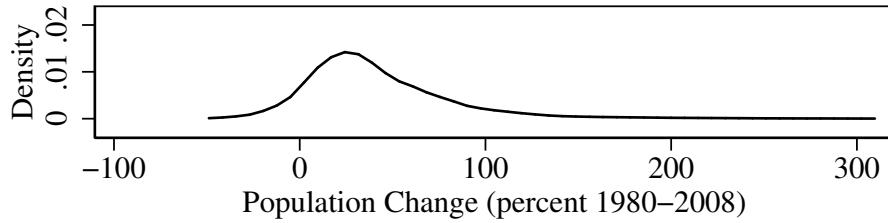
This link between outsiders moving in and increases in population applies more generally. The plot in Panel A of Figure 4 shows the robust negative relationship between population growth from 1980 to 2008 on the horizontal axis and the percentage of residents who were born locally on the vertical axis,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

Panel A: Percentage Born in State



Panel B: Density



Note: 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. The top plot is a scatter plot of population changes and the proportion of residents born nearby where each circle is a CZ with a radius proportional to its population in 1980. The regression line is from a weighted least squares regression, using the population weight. 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 adaptive kernel density uses an epanechnikov kernel with a bandwidth parameter of 15. Data are from the 1980 census and 2006-2008 ACS.

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.<sup>17</sup>

<sup>17</sup>Appendices A and B 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),

Table 1: Summary Statistics

	Mean	StD	Low Ties	High Ties
Population (thousands)	188	532	326	123
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	117	605	487
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.

## Population Losses 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. The adaptive kernel density in Panel B of Figure 4 shows that the distribution of population changes is right skewed and that population declines are rare.

Many researchers have focused on the right tail of this distribution, including many papers focusing on Zipf's law (Gabaix, 1999); fewer researchers 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

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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.

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. I explore how local ties and durable housing could interact in Appendix B.

### **Smaller Migration Responses in Depressed Places**

Migration elasticities are lower in depressed places where more people were born nearby. This subsection develops and then applies a basic framework to interpret equilibrium effects of a change in labor demand in terms of labor supply elasticities. I analyze several plausibly exogenous changes in labor demand that are commonly used in the literature. The results show that migration elasticities are lower in depressed places where more people were born nearby.

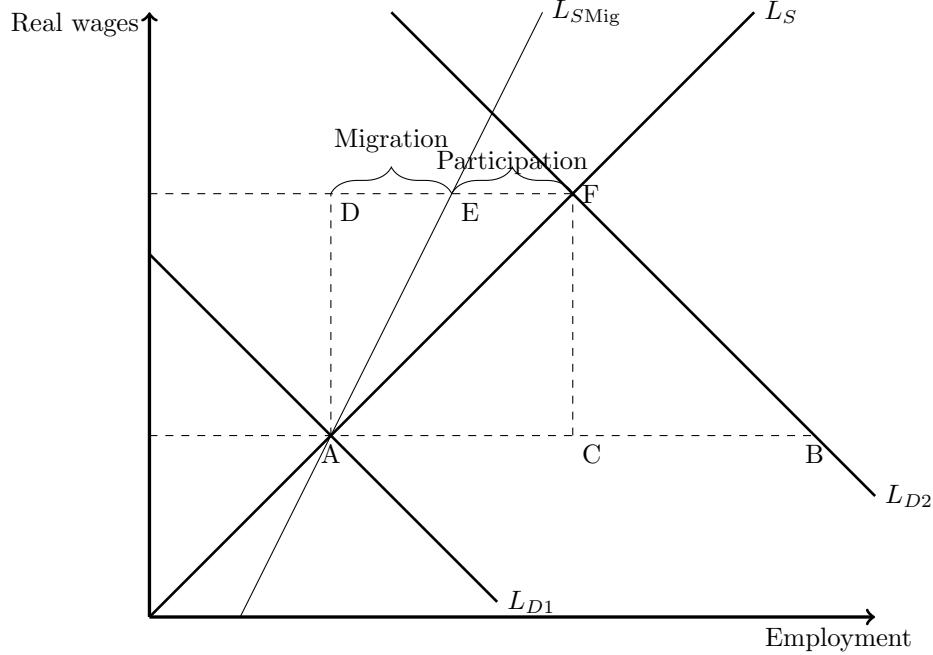
#### ***Framework***

The system of labor demand and supply in Figure 5 illustrates the impact of lower migration on equilibrium outcomes. 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,  $L_{SMig}$  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.<sup>18</sup>

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<sup>18</sup>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.

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 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  $L_{SMig}$ , then one can use these two responses to see its relative magnitude.<sup>19</sup> 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.

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<sup>19</sup>If I assume a constant elasticity of labor demand ( $\eta_D$ ), labor supply due to migration ( $\eta_{SMig}$ ), and labor supply due to participation ( $\eta_{SPart}$ ), 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  $\frac{B-A}{\eta_{SMig} \eta_D + \eta_{SMig} + \eta_{SPart}}$  and the total change in employment ( $F - D$ ) is be  $(\eta_{SMig} + \eta_{SPart}) \frac{B-A}{\eta_D + \eta_{SMig} + \eta_{SPart}}$ .

Responses along each margin show the equilibrium implications of a lower migration elasticity. As  $L_{SMig}$  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 policymakers have 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.<sup>20</sup>

### ***Labor Demand Shocks***

I isolate plausibly exogenous shocks to local labor demand using two shift share approaches. 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. They 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.<sup>21</sup>

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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  $\frac{B-A}{\eta_D + \eta_{SMig} + \eta_{SPart}}$ .

<sup>20</sup>I do not distinguish between increases and decreases in any of my outcomes. This is because there are gross flows into and out of areas regardless of whether population is increasing or decreasing. Monras (2015), for example, documents that population changes – including decreases – are often driven by the behavior of people moving in. Responses in the model do not discontinuously change at zero, but they exhibit asymmetric responses for population increases and decreases, as in Dao, Furceri and Loungani (2017).

<sup>21</sup>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

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

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 high ties.<sup>22</sup>

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

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.<sup>23</sup>

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out" Bartik instruments by excluding each local labor market in question from the nationwide changes used to project employment changes in each industry.

<sup>22</sup>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.

<sup>23</sup>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

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.<sup>24</sup> 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.<sup>25</sup>  $\Delta\hat{L}_{j,t}$  is the labor demand shifter and so the  $\beta$  coefficients in the equation below show the effect of these shocks for the specified subset of local labor markets.

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

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 ( $\alpha_t$ ) and several other demographic characteristics of individual local areas ( $X$ ).<sup>26</sup> Standard errors are clustered by the state that the CZ had the plurality of its population within.

## **Results**

Migration responses are smaller in places with higher levels of local ties. The results in Panel A of Table 2 show smaller population changes in areas with high local ties after changes in the Bartik shifters. A one percentage point predicted increase in employment in an area with high local ties increases the population by a statistically insignificant 0.4 percent. And the population increase of almost 1.5 percent in a low ties area is large relative to a one percent predicted increase in employment. The one percentage point difference between

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to apply to my use case, where the interpretation of the instrument is only as a plausibly exogenous labor demand shifter.

<sup>24</sup>Residualized wages are residuals from a regression of log wages on four categories of education, gender, whether the worker was black, and whether the worker was foreign born. I do this separately in each year using the labor supply weights.

<sup>25</sup>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 in Appendix A give similar results.

<sup>26</sup>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. Appendix A shows that the specifications are not sensitive to the choice of controls. I also include interactions of some of these controls with the labor demand shifters in Appendix A. I find no evidence that this is the case.

population responses in high and low ties places is also statistically significant. There are no statistically significant differences in any of the other outcomes. In high ties places the lack of other responses supports the finding by Blanchard and Katz (1992) that places can respond to shocks through changes in populations as opposed to wages or other labor supply margins. The results are especially noisy in terms of wages, however, so I am unable to rule out large responses. I also find no evidence that differences in housing affordability drive the different population responses since rents do not appear to respond deferentially across high and low ties places.

Places with high local ties adjust in terms of wages and labor force participation, as opposed to population. Panel B of Table 2 shows that 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 also experience similar increases in rents.<sup>27</sup>

The results in Table 2 also persist after a number of robustness checks that report in Appendix A. The robustness checks focus on other differences between high and low ties places – in terms of educational attainment, the local age structure, and local housing markets. 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 measure of local ties predicts differences in responses independently of differences in population age, education, and the housing market. The tables also show a triple difference specification, so the 60 percent cutoff does not drive the results.

Overall, migration elasticities are smaller in places where people have stronger local

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<sup>27</sup>Panel B also keeps with the finding of very large non-participation responses in Autor, Dorn and Hanson (2013). The larger non-participation responses support a literature on both declining recent migration as well as a more vibrant non-participation margin since the 1980's because of the entry of women and the growing importance of male labor force non-participation. Finally, one additional explanation for their finding of large non-participation responses after Chinese trade shocks is to combine the finding of small population and robust non-participation responses in high ties places with the fact that Chinese import shocks affected high ties areas more than low ties areas (Table 1).

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 (0.22)	0.08 (0.03)	0.29 (0.21)	0.29 (0.25)
Bartik: Low ties	1.46 (0.39)	0.05 (0.03)	0.26 (0.24)	0.25 (0.33)
High ties	15.40 (5.32)	-0.42 (0.45)	-0.35 (4.40)	-1.22 (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 (0.30)	0.78 (0.17)	0.64 (0.18)	1.19 (0.57)
Imports: Low ties	0.78 (0.38)	-0.01 (0.10)	0.09 (0.25)	1.37 (0.28)
High ties	-5.42 (1.58)	2.17 (0.41)	0.36 (0.89)	-2.76 (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 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.

ties. The Online Appendix shows this by using the labor demand shocks as instruments for changes in local incomes in a regression on log local population. The Online Appendix 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.

### III Model

This section presents 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.

The model also allows me to analyze how local ties affect the equilibrium. An increase in a place’s local ties leads real incomes to fall by more since people with strong local ties will accept low real incomes. The drop in real incomes makes depressed places even more unattractive to outsiders, and this lowers migration responses by even more.

In the long run, the model enters a steady state where local ties have no influence. Steady state occurs because people with local ties to depressed places die. Children are born with more ties to productive places, since I assume that births are proportionate to 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.

**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 ( $\theta_j$ ). 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  $\alpha^H$ . The worker also values a local amenity ( $A_j$ ) and a type I extreme value distributed error term ( $\xi_{ij}$ ).

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

A worker's local tie to  $k$  is the  $\mu_i$  term that gives them additional utility when they live in  $k$ . For tractability, I assume that the distribution  $\mu_i$  is normal and that it has the same shape 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.<sup>28</sup> I include only one skill level here, but Appendix B shows that the main points also apply to an extension with different worker skill levels. I also assume that workers inelastically supply labor, following the literature on spatial equilibrium.<sup>29</sup>

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<sup>28</sup>I normalize the price of the consumption good to one, so it is the numerare.

<sup>29</sup>The online appendix provides a simple way to connect a wide class of models, including this one, to the empirical results that include employment to population ratios.

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

The setup yields a log linear indirect utility function that is a function of the prices, subsidies, amenities, local ties, and other idiosyncratic factors ( $\xi_{ij}$ ). I separate common from idiosyncratic factors by denote the prices, subsidies, and amenities that apply to all residents' utilities with real incomes,  $\omega_j$ .

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

The payoff is a formula for the likelihood that an individual worker lives in place  $j$  ( $\psi_{ijk}$ ), which is an important part of the analytic migration elasticity in the model. The parameter  $\psi_{ijk}$  increases in both  $\omega_j$  and  $\mu_i$ . It also varies with the spread of the type I extreme value term ( $\sigma_\xi$ ).

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

## Production

Local good varieties 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  $\rho$  with local labor ( $N_j$ ) to produce  $Y_j$  of the local good. The place has a specific productivity  $\theta_j$  that is effectively a proxy for the place's economic prospects. The  $\alpha_Y$  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  $Y$ . The Armington elasticity (of substitution) between local goods is  $\eta^Y$  and  $\phi_j$  is a demand shifter for each local good.

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

## 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  $\eta^H$ .<sup>30</sup>

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

## Equilibrium

The model's equilibrium is a set of prices and quantities  $(p_j, w_j, r_j, N_j)$  where agents behave optimally and markets clear.

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

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

$$r_j = [\alpha^H w_j N_j]^{1/(1+\eta^H)} \quad (4)$$

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<sup>30</sup>The common interpretation of this setup is that absentee landlords provide housing by developing land, which abstracts from the investment motive for owning a home. A concern could be that people are locked into houses due to housing price declines, but the literature on the size of the housing lock in effect is mixed (e.g. Ferreira, Gyourko and Tracy (2010); Bricker and Bucks (2013); Valletta (2013)). So abstracting from these effects is reasonable, particularly since they would not apply to the 40 percent of the population that are renters.

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

### The Distribution of Local Ties Across Places

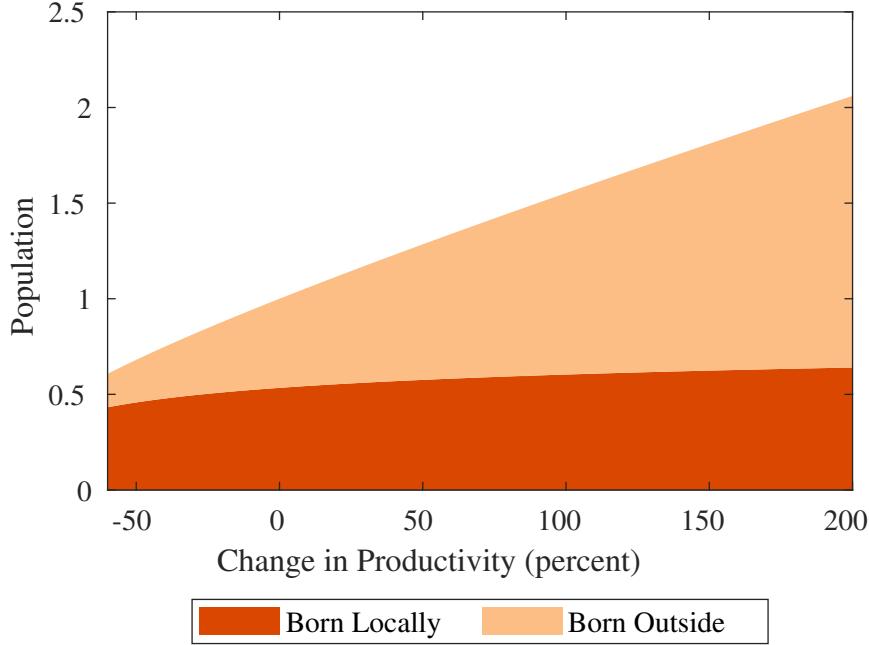
Historical changes in productivity determine the model's distribution of local ties. Mechanically, I start the model at a steady state where equal fractions of workers in all places were born nearby. I then change the local productivity terms ( $\theta_j$ ) to create a distribution of places where different fractions of workers were born nearby.

Figure 6 shows model simulations of how large, one time productivity changes lead to changes in both total population and the share of people born locally.<sup>31</sup> The x axis shows 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.

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<sup>31</sup>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,  $\theta_j$ .

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.

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.

It should be possible for local ties to evolve over long time frames, 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. The essential assumptions are that new ties are formed proportionate to population and that new people receive a local tie to their birthplace that

comes from the same distribution for all birth places.

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 according to the current distribution of population. So  $\sum_{k'} N_{kk'} \frac{s_D}{1 + s_F}$  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.<sup>32</sup>

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

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.<sup>33</sup>

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

## Calibration

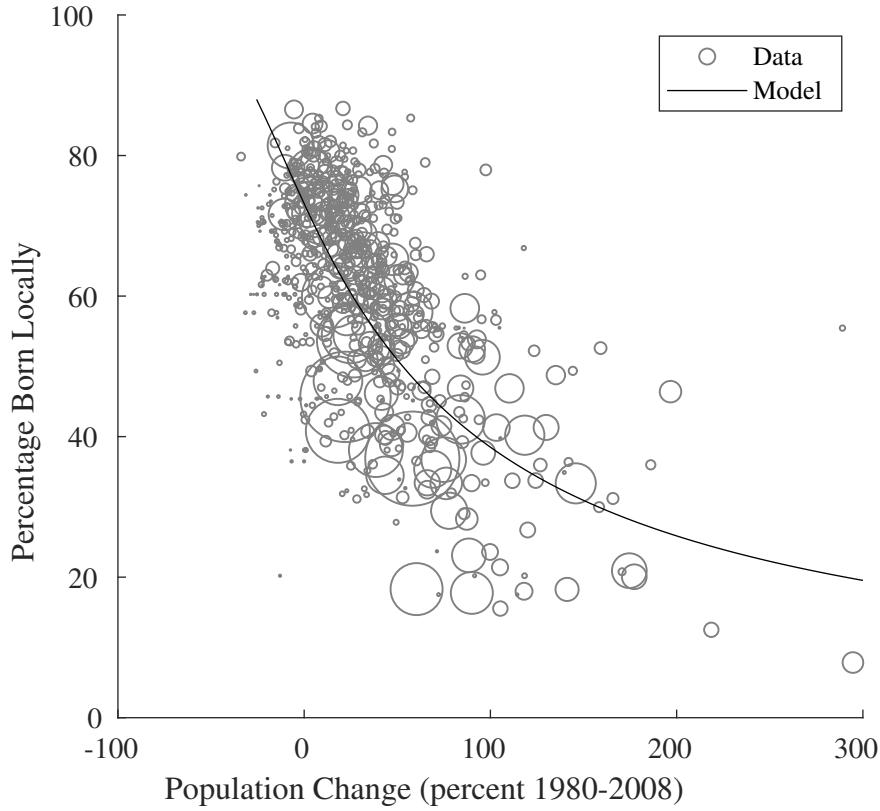
The objective of the calibration is to find realistic parameter values to illustrate the impact of adding local ties into an otherwise standard model of spatial equilibrium. So I mostly use parameters from the literature. But an obvious exception is the distribution of local ties, since I cannot rely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

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<sup>32</sup>I assume is that people change the distribution of people's future local ties by moving without considering how this will affect future periods. So I rule 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.

<sup>33</sup>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.

Figure 7: Estimation: Predicted and Observed Percentages Born Locally



Note: I set the distribution of local ties ( $\mu_i$ ) 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 ( $\mu$ ) 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.<sup>34</sup> 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 two variables in the model after a series of productivity draws that change the population of the affected area.<sup>35</sup> The model matches the distribution.

<sup>34</sup>I compute  $\mu_i$  using Gaussian quadrature with 100 nodes per area.

<sup>35</sup>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. The relationship also does not vary with any of the other parameters, except for  $\sigma_\xi$ .

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,  $\sigma_\xi$ , at 0.6 to match estimates in Suarez Serrato and Zidar (2016). I follow Feenstra et al. (2018) and choose an Armington elasticity ( $\eta^Y$ ) of 4. I set the share of non-tradeable goods in consumption ( $\alpha^H$ ) 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.<sup>36</sup>

Table 3: Parameter Values

	Description	Value	Reason
$\sigma_\xi$	Preference spread	0.6	Suarez Serrato and Zidar (2016)
$\eta^Y$	Armington elast	4	Feenstra et al. (2018)
$\alpha^H$	Non-tradeable share of cons	0.33	Albouy (2009)
$\eta^H$	Housing supply elasticity	15	Green, Malpezzi and Mayo (2005)
$\alpha^Y$	Capital share	0.33	Standard
$\rho$	Real interest rate	0.05	Standard
$J$	Number of areas	722	Number of Commuting Zones
$\mu_{\mu_i}$	Local ties mean	4.48	Distribution of percentage locals
$\sigma_{\mu_i}$	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 average 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.

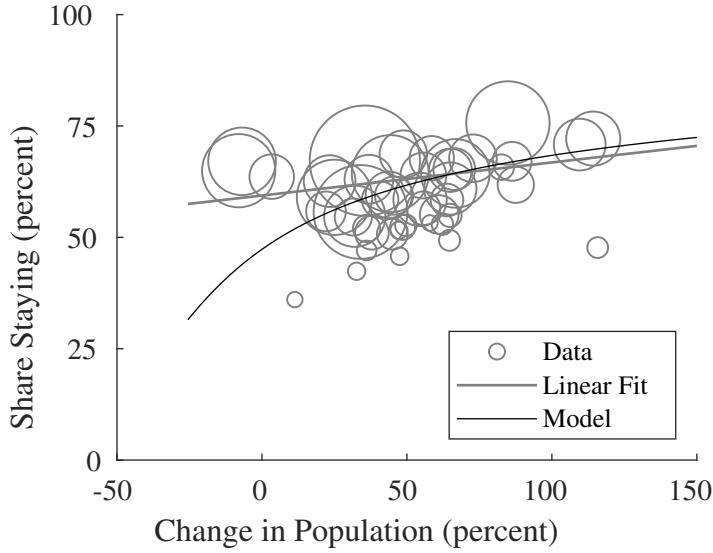
I assume a single, baseline set of local parameters governing productivity, amenities, and housing supply since my goal is distinct from understanding different levels of productivity, quality of life, geographic accessibility, and zoning.<sup>37</sup> In practice, this means that I set the housing supply elasticity term ( $\eta^H$ ) to roughly the middle of the estimates in Green, Malpezzi 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.

<sup>36</sup>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.

<sup>37</sup>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

The model's estimated parameters allow it to approximate an un-targeted moment – the relationship between population changes and share of people born in a place who stay in it as adults. Figure 8 shows that the share of people who stay in a growing state is similar to the share who stay in a declining one and that the model predicts a slightly less modest relationship.

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.

## 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 incomes ( $\omega_j$ ).

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(2010) and many others study differences in housing supply elasticities.

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

The impact of this change in real incomes, 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  $\mu_i$ . So higher local ties imply lower migration elasticities.<sup>38</sup>

## Intuition

The migration decisions of outsiders 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 logit distribution allows 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.

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  $\psi_O < 1$ . For simplicity, assume that the probability has a logit distribution. The place that we are considering is small relative to the all of the places people could live, so there are ten times as many outsiders as stayers.<sup>39</sup>

The partial equilibrium effect of a change in real incomes 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 ( $\psi_i$ ) in the model.<sup>40</sup> And the 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

<sup>38</sup> Formally,  $\bar{\psi}_j = \sum_{k'} \sum_{i'} \psi_{i'jk'} \frac{N_{i'jk'}}{N_j}$  where  $\psi_{ijk}$  is defined in equation III.

<sup>39</sup> Note that I drop the j and k subscripts since they are implied in this exercise.

actively considering against attractive alternatives.

Why does partial equilibrium effect of a change in real incomes vary with the baseline likelihood that someone lives in a place? The relationship is an important ingredient for taking a model of discrete choice to the data. Specifically, 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.

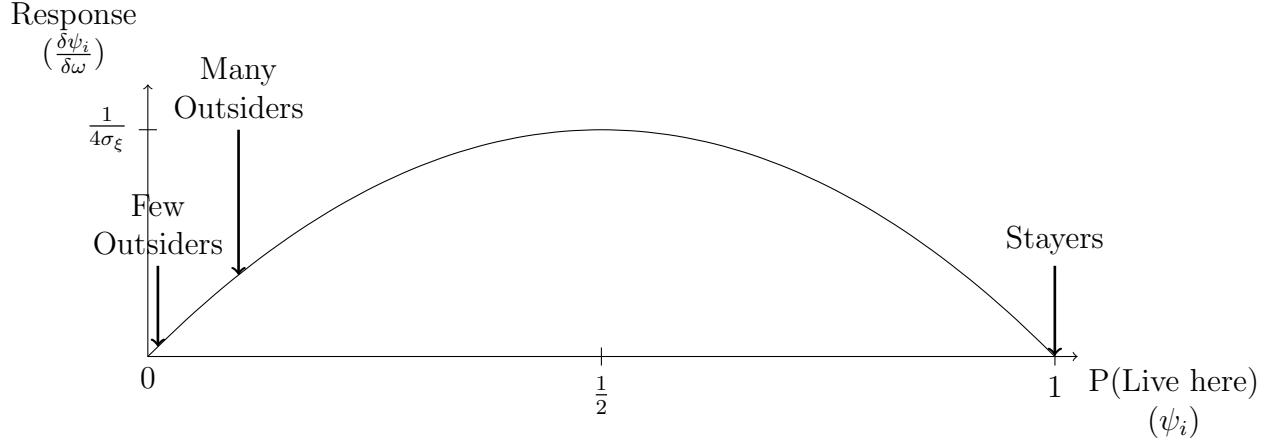
So there are very low levels of migration by outsiders in places with high ties – places with many stayers and few outsiders. Take a place where 3/4 of residents are stayers in Figure 9. In the simplified model  $\psi_O = 1/90$  and so outsiders will be at the point labeled “Few Outsiders” and relatively unresponsive to increases in real incomes. Contrast this with a situation where 1/4 of residents are stayers. Here,  $\psi_O = 1/10$  and outsiders are at the point labeled “Many Outsiders.” Since  $\psi_O$  is higher, outsiders are more responsive to changes in real incomes. 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 the place, the value is equal to an average of  $\frac{1-\bar{\psi}_i}{\sigma_\xi}$  where the weights are each type’s share of the current population.

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

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<sup>40</sup>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).

Figure 9: Migration Responses in the Simplified Model



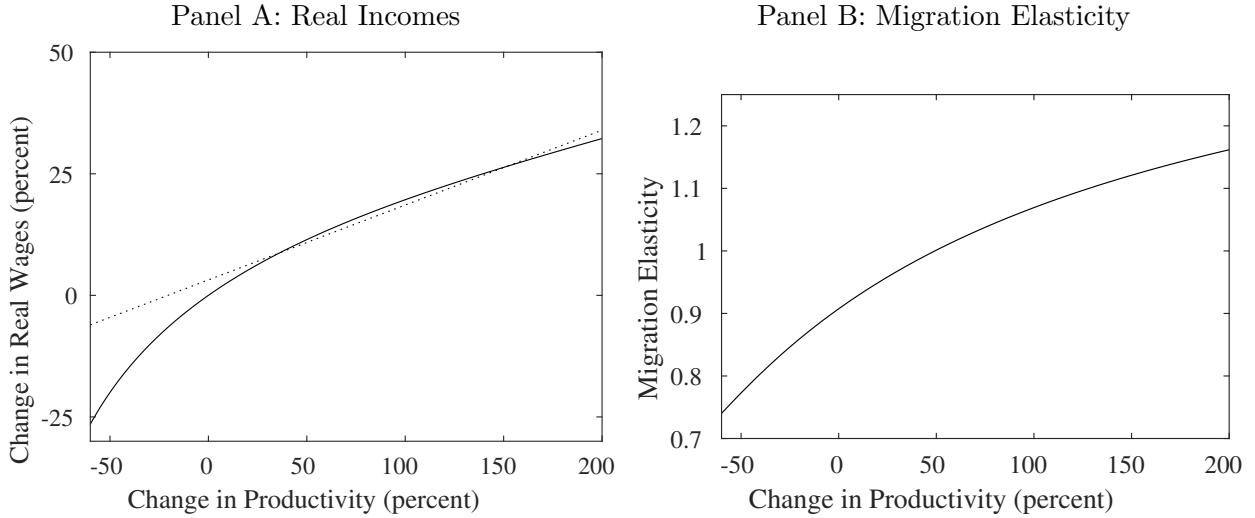
Note: When there are few outsiders, an increase in a place's desirability has a small impact on their likelihood of living in the place ( $\frac{d\psi_i}{d\omega}$ ). The figure plots the function  $\frac{d\psi_i}{d\omega} = \frac{1}{\sigma_\xi}(1 - \psi_i)\psi_i$ , which is the change in the likelihood of residing somewhere after an increase in real incomes 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.

### Equilibrium Migration Responses

The equilibrium elasticity of population with respect to nominal wages is the elasticity with respect to real incomes times a factor that depends on the housing market. The second factor represents how increases in housing costs impact Rosen and Roback style equilibrium. A less elastic housing supply will increase  $\eta^H$  and  $\alpha^H$  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.

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

Figure 10: Real Incomes and Migration Elasticities after Productivity Changes



Note: Positive productivity shocks lead to smaller changes in real incomes 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 incomes and migration elasticities. The results are for the baseline calibration after the specified change in the model's productivity parameter,  $\theta_j$ .

## IV Dynamics of Decline

The section shows the equilibrium dynamics of local ties using the model developed in the last section. The primary findings are that local ties imply hysteresis, that they persist for generations, and that they change the cost and the benefits of place-based subsidies in subtle ways.

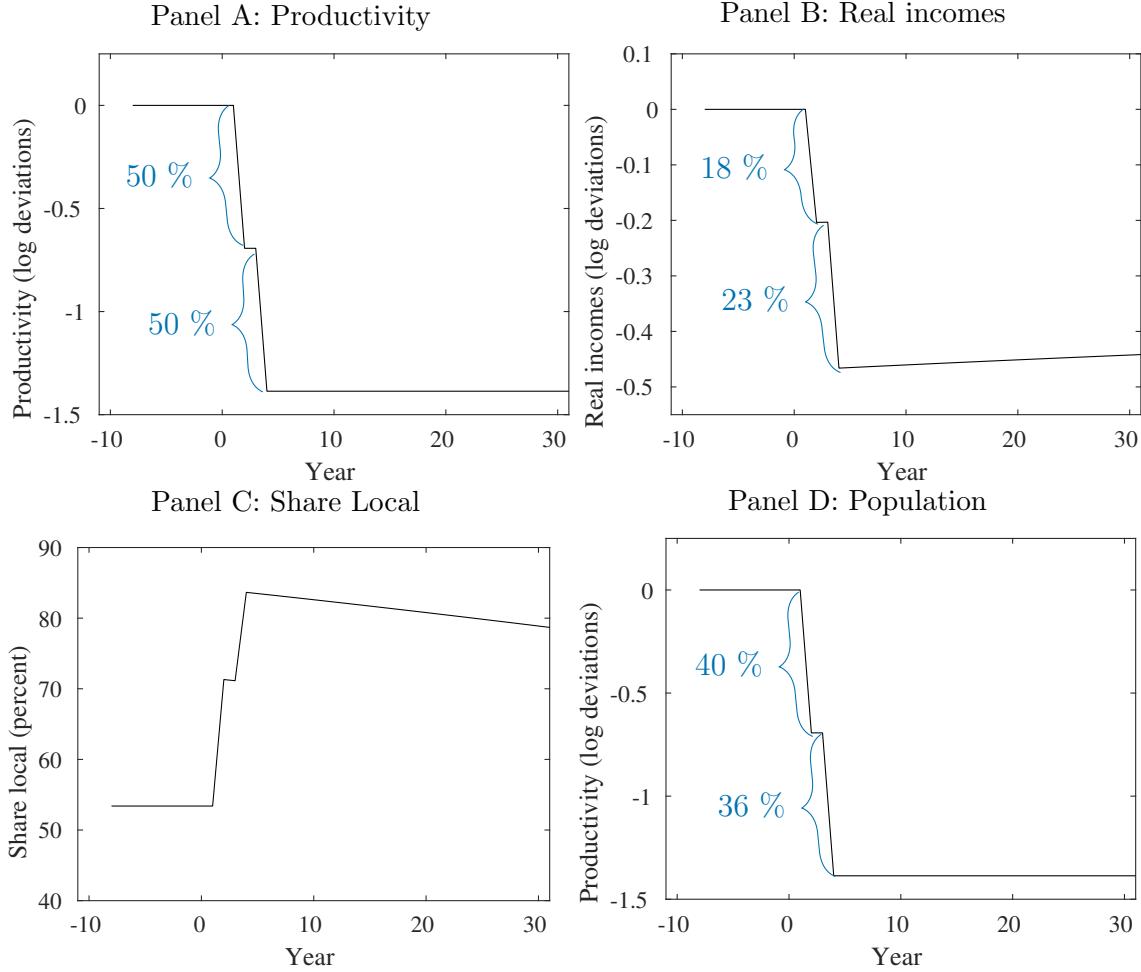
### Hysteresis

Declines in local productivity lead to hysteresis. Depressed places have residents with strong local ties, which keeps population up and real incomes down in spatial equilibrium. And migration elasticities are lower in depressed places. So repeated negative shocks lead to successively larger real income declines.

Real incomes respond asymmetrically to changes in productivity. Panel A of Figure 10 shows real incomes on the y-axis and changes in productivity on the x axis, along with a

dotted line of best fit based on positive productivity shocks. The convexity of the solid line shows that negative productivity shocks lead to larger declines in real incomes than positive ones. And the larger changes in real incomes after negative productivity shocks is due to the changing share of locals, which produces the migration elasticities shown in Panel B.<sup>41</sup>

Figure 11: Responses after Two Negative Productivity Shocks



Note: Real incomes 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.

A history of negative shocks leads to smaller population responses and larger real income responses after new shocks. Figure 11 plots the impact of two successive fifty percent declines in productivity – Panel A. Each shock changes the share of locals in the area – Panel C –

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<sup>41</sup> Dao, Furceri and Loungani (2017) find a similar asymmetric responses empirically.

and the changing levels of residents' local ties changes equilibrium responses.

Real incomes decline by more and population by less after the second shock. Panels B and D of Figure 11 show population and real income responses. The initial shock involves a real income 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 incomes and a ten percent smaller decline in population.

## The Persistence of Local Ties

Local ties are persistent. Table 4 shows that population and real incomes 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 incomes in the model ( $\omega$ ).

Convergence is quite slow regardless of the size of the productivity shock. The 50 percent decline in productivity in the first row of Table 4 leads to a 32 percentage point initial decline in population. The initial decline is only about 60 percent of the total decline of 50 percent, however. 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. Slow convergence is apparent in all rows, though it scaled by magnitude of the productivity changes.

Table 4: Convergence After Productivity Changes

Productivity change	Population after				Real Wages after			
	0	50	100	Final	0	50	100	Final
-50	-32	-39	-44	-51	-13.8	-12.7	-12.1	-11.0
-25	-15	-19	-22	-26	-5.7	-5.2	-5.0	-4.6
-10	-6	-8	-9	-10	-2.1	-1.9	-1.8	-1.7
-05	-3	-4	-4	-5	-1.0	-0.9	-0.9	-0.8
50	29	37	43	52	7.9	7.4	7.0	6.5

Note: This table shows slow convergence after changes in productivity and that real incomes overshoot their steady state values. It plots responses to a permanent change in local productivity. 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 incomes,  $\omega$ .

Real incomes overshoot their steady state values and recover slowly. Table 4 shows that real incomes initially drop by 14 percentage points after the same 50 percent decline in productivity – about one quarter more than their steady state value. Even after fifty years, real incomes 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 incomes. Since people still have local ties, however, the change in population is smaller than the change in steady state. The smaller population response leads to the overshooting in real incomes. Low real incomes keep people moving out of the area each generation, however, so local ties decline with each generation. The very gradual downward slope of the line at the end of Panel C in Figure 11 highlights how slowly these local ties change, however.<sup>42</sup>

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<sup>42</sup>For the changes in productivity that I show here, real incomes 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  $\xi$  term imply that workers will have idiosyncratic attachments to the place that will lead them to forego higher wages.

## Place-Based Subsidies

Local ties change the cost-benefit analysis of place-based policies. Place-based policies in depressed places lead to smaller increases in population and larger decreases in wages because depressed places have residents with local ties. And place-based policies in productive places cause more people to move in.

Place-based policies are receiving increasing attention amid concerns about local economic decline (Neumark and Simpson, 2015; Austin, Glaeser and Summers, 2018). Migration rates have been falling, places no longer seem to be converging economically, and many perceive a widening geographic and cultural divide. Geographic inequality may not be a market failure, but policymakers still seem interested in addressing it.

Place-based policies have taken many different forms. Some have integrated grants and tax benefits targeted at particular communities (empowerment and opportunity zones, Busso, Gregory and Kline (2013)). Others have increased funding for local schools or paid residents' college tuition (promise programs, Bartik, Hershbein and Lachowska (2019)). Others have included state and local tax incentives designed to attract particular companies (e.g. packages from many cities designed to attract Amazon's second headquarters). Some policies have been implicitly place-based, including federal programs that have unequal geographic impacts (e.g. federal taxes in Albouy (2009)).

Local ties soften a classic critique of place-based policies in depressed places – that subsidies will decrease aggregate productivity by distorting population. I show that subsidies to depressed places lead to smaller increases in population. So subsidizing depressed places mostly transfers money to people who would have lived there without the subsidy. Only a small amount goes to paying for people to move in (Glaeser and Gottlieb, 2008).

Local ties also mean that place-based subsidies to growing, newly productive places will lead more people to move. The larger migration elasticities in growing, low ties places lead to larger population responses. And larger population reallocations to productive places increases wages in other places, particularly in the medium to long run.

I simulate a place-based subsidy in the model and plot impacts on real incomes net of taxes ( $\omega$ ) in both the place that receives it and in other places. I assume that the subsidy declines by four percent per year (as in Kline and Moretti, 2014). So the subsidy is a 1.3 percentage points of initial wages after 50 years and a 0.2 after 100. I also scale the effect on real incomes outside of the place that receives the subsidy by the number of other places in the model (721 in this calibration).

Subsidies to depressed places increase real incomes by more in the model. Figure 12 shows that the present discounted value of the 10 percent subsidy to a place that experienced a 50 percent decline in productivity is around 60 percent of prior annual real incomes. And the present discounted value of an equal sized subsidy to an area that experienced a 50 percent increase in productivity is about half as large – 30 percent of prior annual real incomes. More broadly, the convexity of real wage increases in Figure 12 shows that subsidies to depressed areas are increasingly efficacious in terms of raising real incomes.<sup>43</sup>

Subsidies directed to newly productive places lead to smaller increases in real incomes and positive spillovers to other places that pay for the subsidies. Figure 12 shows a convex relationship between the subsidy’s impact on real incomes in other places and the direction of the productivity shock that the subsidized place experienced. The relationship becomes strongly positive as one moves to subsidizing highly productive places – showing that real income can actually increase in the places that pay for the subsidy with their taxes.<sup>44</sup>

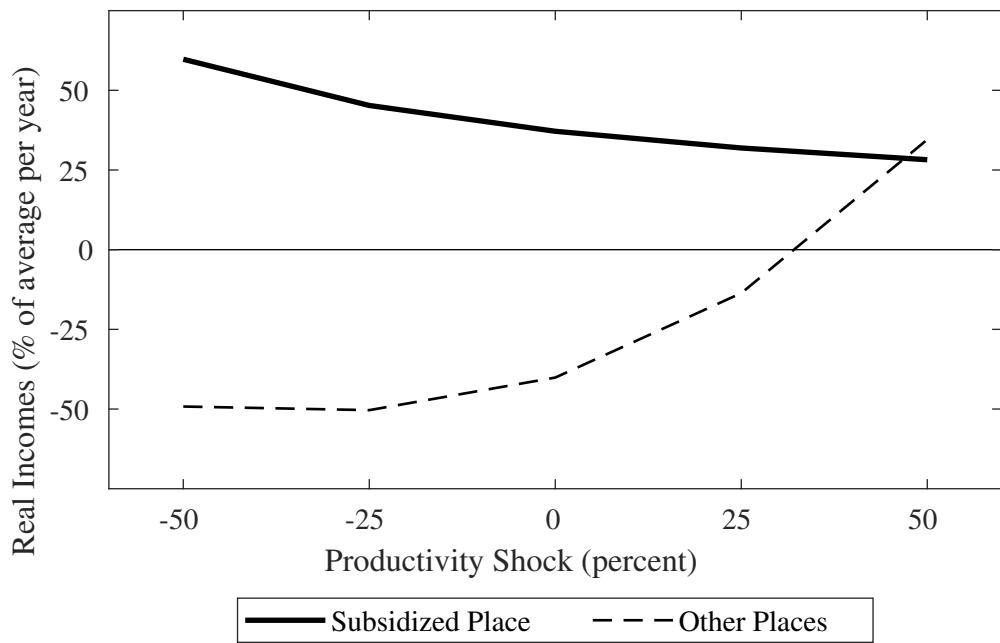
Why do real incomes increase in places that pay for the subsidy? Subsidies to productive places increase real wages in other places, and the increased real wages compensate for the taxes needed to pay for the subsidy. A modest subsidy can lead many people to move, which increases real wages in other places through a reduction in labor supply (Hornbeck and

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<sup>43</sup>The present discounted value is with a 4 percent discount rate. Table 5 gives a more full depiction of the time path of when real incomes are affected in each place.

<sup>44</sup>It is important to note two somewhat subtle points about this result. First, the numbers in the “Real Incomes 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 incomes everywhere do not necessarily lead to pareto improvements, since landlords generally are made worse off by the rent decreases in unsubsidized areas.

Figure 12: Real Income Changes after Place-Based Subsidies



Note: Subsidies to depressed places increase real incomes in those places by more. And subsidies to newly productive areas increase wages in other places, leading to smaller real income losses. Plotted are the present discounted values of changes in real incomes per worker ( $\omega$ ) after a wage subsidy equal to 10 percent of wages before the specified productivity shocks that decays at a rate of four percent per year. Real incomes include wages net of taxes as well as rents. For rough comparability, the line for other areas is multiplied by the number of other areas, which is 721 in this calibration.

Moretti, 2018). Movement into a productive place also increases aggregate productivity.<sup>45</sup>

Place-based subsidies to productive places also have a positive externality by increasing the number of workers from future generations who will be born in productive places. Local ties are persistent, so a higher population in one year leads to a continued higher population. And people who are born with ties to productive places are better off economically than people born with ties to economically depressed places. People with ties to productive places do not have to trade off higher real incomes with living in their birthplace. Parents are myopic in that they do not fully consider their children's future incomes, and so a subsidy can lead to a socially optimal level of migration.

A subsidy to a productive place speeds convergence and leads to a bigger long run increase in population than a subsidy to a depressed place. Table 5 shows the impacts of subsidies on populations and on real incomes initially, after 50 years, and after 100 years. On impact, the subsidy increases population by around 7 percentage points in a depressed place and 8 percentage points in a growing place. After 50 and 100 years the impacts on population are smaller in all areas but in relative terms they are larger in productive places. Subsidies increase long run population by more in productive places because more people move initially and then because the new migrants' children stay in the productive place. The persistent effects on population also mean that subsidies to productive places have more persistent impacts on real incomes in other places.

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<sup>45</sup>Since the model features free entry and a perfectly competitive local labor market, a worker will increase aggregate productivity whenever they move to an area with a higher nominal wage.

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

Place Variable Year	Productivity	Subsidized Place						Other Places		
		Population			Real Incomes			Real Incomes		
		0	50	100	0	50	100	0	50	100
Depressed Places	-50	7.0	1.5	0.6	3.7	0.4	-0.0	-3.0	-0.4	-0.1
	-25	7.2	1.6	0.7	2.8	0.3	-0.0	-3.0	-0.4	-0.1
	0	7.4	1.8	0.7	2.3	0.2	-0.0	-2.6	-0.2	0.0
Growing Places	25	7.7	1.9	0.8	2.0	0.2	-0.0	-1.4	0.1	0.2
	50	7.9	2.0	0.9	1.8	0.2	-0.0	0.8	0.7	0.5

Note: This table shows that a subsidy to a productive place speeds convergence and leads to a bigger long run increase on population than a subsidy to a depressed place. It also shows details of present discounted value of impacts to real incomes per worker ( $\omega$ ) presented in Figure 12. The subsidy is equal to 10 percent of average wages and that declines at four percent per year. The productivity changes represent shocks to productivity that are contemporaneous to the imposition of the subsidy. The numbers refer to the years after the imposition of the subsidy. Population numbers are percentage point changes. Real incomes elsewhere are multiplied by the number of other areas.

## 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.

Several phenomena could lead to local ties. Local ties could be due to interconnections with family members (Kaplan, 2012; Kramarz and Skans, 2014; Coate, Krolkowski and Zabek, 2019) and job referral networks (Topa, 2011). 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.

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 policies transfer income without distorting where people live. In newly productive places, place-based policies increase aggregate productivity and increase wages outside of the area by changing where people live. Place-based policies in growing areas also increase the number of people born with ties to newly productive areas.

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 Robustness Checks

This section shows that the regression results showing that depressed places have lower migration responses to labor demand shocks are robust. Specifically, the regression results are not driven by other observable differences across areas, by mis-measurement of local ties, or by other specification choices, like my cutoff for having high ties. The lower migration responses are not due to observable 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 2 are 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. The triple difference shows differences in the responses of places with different levels of local ties using one as opposed to two statistics. Presenting a single statistic is important for controlling the size of these tables because I use many alternative specifications and dependent variables. Using a linear interaction term also shows that the specifications in Table 2 are not sensitive to the 60 % cutoff because they do not use it.

$$\Delta y_{j,t} = \alpha_t + \beta_1 \text{Ties}_{j,t-1} \Delta \hat{L}_{j,t} + \beta_2 \text{Ties}_{j,t-1} + \beta_3 \Delta \hat{L}_{j,t} + \gamma_2 \text{Ties}_{j,t-1} + \gamma_X X_{j,t-1} + \epsilon_{j,t} \quad (8)$$

The linear interaction term has a different interpretation than the coefficients in the main specification, equation 1. Equation 8 shows the triple difference specification, which allows

the effect of a labor demand shock to linearly scale with the share of residents who are living in their state of birth. A positive main effect ( $\beta_3$ ) and a negative linear interaction term ( $\beta_1$ ) mean that a labor demand shock increases the dependent variable by more in places with low levels of local ties than high levels of local 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 8 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 8. 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.<sup>46</sup>

I replicate the main results for the Bartik labor demand shifters in terms of population and rent in Table 6. The linear interaction term in the triple difference specification for

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<sup>46</sup>Note that the coefficient has a different interpretation.

population, shown in column one of Panel A in Table 6 has a statistically and economically significantly negative coefficient. The coefficient shows that a two standard deviation increase in the share born locally is associated with a 1 percentage point smaller population response to the Bartik shifter, which lines up well with estimates in Table 2. The coefficient 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 results for the trade shocks are similarly robust. The only major departure in Tables 7 and 8 is that the interaction term in column one of Panel A of Table 7 is insignificantly different from zero and its magnitude is somewhat modest. Column 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 7 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 6: 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 (0.92)	-3.33 (0.76)	-4.77 (0.78)	-3.70 (0.75)	-3.65 (1.26)	-1.65 (0.84)	-5.19 (1.11)	-0.38 (0.08)
Bartik Shock	2.56 (0.61)	-12.41 (7.01)	5.86 (0.90)	-0.45 (0.92)	9.18 (9.58)	1.58 (0.54)	4.01 (0.82)	3.94 (0.70)
Local Ties	0.22 (0.18)	0.31 (0.17)	0.42 (0.14)	0.33 (0.14)	0.36 (0.16)	-0.07 (0.13)	0.65 (0.18)	1.86 (1.17)
Interaction 2		18.75 (10.67)	-6.23 (1.77)	12.15 (2.64)	-1.05 (1.43)			
Interaction 3		26.33 (9.15)			3.50 (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 (0.98)	0.59 (0.91)	0.42 (1.09)	0.15 (0.96)	1.90 (1.22)	1.80 (1.22)	-1.73 (0.84)	-0.06 (0.14)
Bartik Shock	-0.08 (0.67)	-15.26 (9.70)	0.03 (1.13)	-1.38 (1.19)	-18.58 (9.28)	-0.73 (0.92)	1.43 (0.58)	1.02 (1.21)
Local Ties	-0.23 (0.17)	-0.21 (0.16)	-0.22 (0.20)	-0.18 (0.17)	-0.36 (0.20)	-0.52 (0.25)	0.08 (0.17)	2.85 (1.70)
Interaction 2		23.78 (14.25)	-0.21 (1.94)	5.26 (2.92)	2.75 (1.42)			
Interaction 3		18.24 (12.70)			2.50 (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.

Table 7: 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 (1.77)	-2.60 (1.77)	-3.55 (1.97)	-1.73 (1.64)	-4.16 (2.45)	-4.26 (1.93)	-1.83 (1.65)	-0.18 (0.12)
Bartik Shock	1.09 (1.14)	-1.94 (7.59)	4.83 (2.19)	-0.16 (1.85)	11.35 (8.15)	2.55 (1.37)	0.55 (1.11)	1.68 (1.08)
Local Ties	-0.29 (0.07)	-0.32 (0.08)	-0.34 (0.08)	-0.30 (0.07)	-0.34 (0.08)	-0.29 (0.05)	-0.22 (0.09)	-3.61 (0.51)
Interaction 2		2.11 (12.30)	-4.84 (2.69)	5.99 (4.69)	-1.36 (1.13)			
Interaction 3		11.96 (14.81)			-0.05 (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 (0.55)	2.19 (0.59)	2.83 (0.87)	2.56 (0.55)	2.67 (0.73)	2.60 (0.54)	0.84 (0.46)	0.22 (0.07)
Bartik Shock	-0.99 (0.27)	-3.57 (1.87)	-1.60 (0.97)	-0.69 (0.49)	-5.29 (2.20)	-1.05 (0.27)	-0.27 (0.29)	-1.54 (0.62)
Local Ties	0.08 (0.02)	0.08 (0.02)	0.09 (0.03)	0.09 (0.02)	0.10 (0.03)	0.06 (0.02)	0.04 (0.02)	0.66 (0.19)
Interaction 2		3.55 (3.04)	0.79 (1.09)	-1.42 (2.13)	0.65 (0.28)			
Interaction 3		6.16 (3.33)			-1.02 (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 8: 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 (1.07)	2.19 (1.08)	2.56 (1.44)	2.23 (1.07)	1.15 (0.91)	1.06 (0.90)	1.10 (0.91)	0.01 (0.16)
Bartik Shock	-0.79 (0.64)	2.21 (3.29)	-1.69 (1.47)	0.07 (0.60)	-0.39 (3.11)	-0.17 (0.52)	-0.23 (0.57)	0.30 (1.47)
Local Ties	-0.04 (0.04)	-0.03 (0.04)	-0.02 (0.05)	-0.03 (0.04)	-0.04 (0.03)	-0.01 (0.03)	0.05 (0.04)	-0.65 (0.38)
Interaction 2		-4.69 (6.46)	1.17 (1.40)	-4.10 (2.45)	-0.01 (0.43)			
Interaction 3		-5.79 (5.22)			-0.14 (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 (2.16)	0.29 (2.05)	1.85 (3.76)	-0.31 (2.25)	0.80 (2.81)	-0.04 (2.04)	-2.28 (1.57)	-0.23 (0.31)
Bartik Shock	1.73 (1.01)	9.33 (6.86)	-3.08 (4.02)	4.25 (1.54)	-15.80 (9.09)	1.28 (0.92)	1.83 (0.99)	3.32 (2.48)
Local Ties	-0.10 (0.09)	-0.08 (0.09)	-0.04 (0.12)	-0.08 (0.10)	-0.01 (0.11)	-0.02 (0.05)	-0.20 (0.07)	-0.92 (0.83)
Interaction 2		-9.85 (13.32)	6.24 (4.18)	-12.02 (8.03)	2.42 (1.19)			
Interaction 3		-19.40 (9.91)			2.49 (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 B Expanded Model with Skill Levels

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. 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.<sup>47</sup>

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 low skill wages, as in Giannone (2017).<sup>48</sup> Low skilled workers earn less in depressed places

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<sup>47</sup>I do not include these dynamics in the main text because the emphasis on multiple types of workers distracts from the main mechanisms of workers with higher levels of local ties accumulating in economically depressed places. This section shows that the mechanisms I describe in the main text indeed survive the inclusion of these additional features.

<sup>48</sup>Bound and Holzer (2000); Notowidigdo (2011) verify empirically that less skilled workers concentrate in economically depressed places despite earning less in these 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.

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.<sup>49</sup> Intuitively, the durability of housing has fewer long run impacts because landlords make directed and forward looking decisions based on economic conditions. Workers form local ties in a less directed way.

## Additions to the Baseline Model

### Skill Levels

I include worker skills using the workhorse nested Constant Elasticity of Substitution (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  $\eta_N$  is the elasticity of substitution between the two types.

$$N_j = \left[ (1 - A_H) N_{Lj}^{\frac{\eta_N - 1}{\eta_N}} + A_H N_{Hj}^{\frac{\eta_N - 1}{\eta_N}} \right]^{\frac{\eta_N}{\eta_N - 1}} \quad (9)$$

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<sup>49</sup>Consistent with the focus of Glaeser and Gyourko (2005).

## 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  $\alpha_l^H$ .<sup>50</sup>

$$u_{ijkl} = \ln(w_{jl} + g_{jl}) - \alpha_l^H \ln(r_j) + A_j + \mu_{il}\mathbf{1}(k=j) + \xi_{ijl}$$

$$u_{ijkl} = \omega_{jl} + \mu_{il}\mathbf{1}(k=j) + \xi_{ijl}$$

## 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,  $\eta_E > \eta_C > 0$ .<sup>51</sup>

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

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<sup>50</sup>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 through non-homothetic preferences.

<sup>51</sup>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 relatively more high skilled workers.

$$\frac{\partial Y_j}{\partial N_{Lj}} = \underbrace{(1 - \alpha^Y)(p_j \theta_j)^{\frac{1}{1-\alpha^Y}} \left(\frac{\alpha^Y}{\rho}\right)^{\frac{\alpha^Y}{1-\alpha^Y}}}_{\text{Unchanged}} \underbrace{(1 - A_{Hj}) \left(\frac{N_j}{N_{Lj}}\right)^{1/\eta_N}}_{\text{New}} \quad (10)$$

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.

$$\frac{w_{Hj}}{w_{Lj}} = \frac{A_{Hj}}{1 - A_{Hj}} \left(\frac{N_{Lj}}{N_{Hj}}\right)^{1/\eta_N} \quad (11)$$

**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 *ceterus paribus* effect of an increase in the number of high skilled workers on low skilled workers' wages. Having more high skilled workers increases low skilled workers' wages, and it does so by more when the elasticity of substitution between the two types is lower. Increasing the number of high skilled workers also tends to increase low skilled workers' wages by more when high skilled workers are more productive.

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

## Calibration

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 9. I allow the spread of the logit distribution for each type to vary based on a 30 percent higher migration elasticity among college educated workers in Malamud and Wozniak (2012). I also assume that housing expenditures are 40 percent among low 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 matches the calibration of the model in the main text.

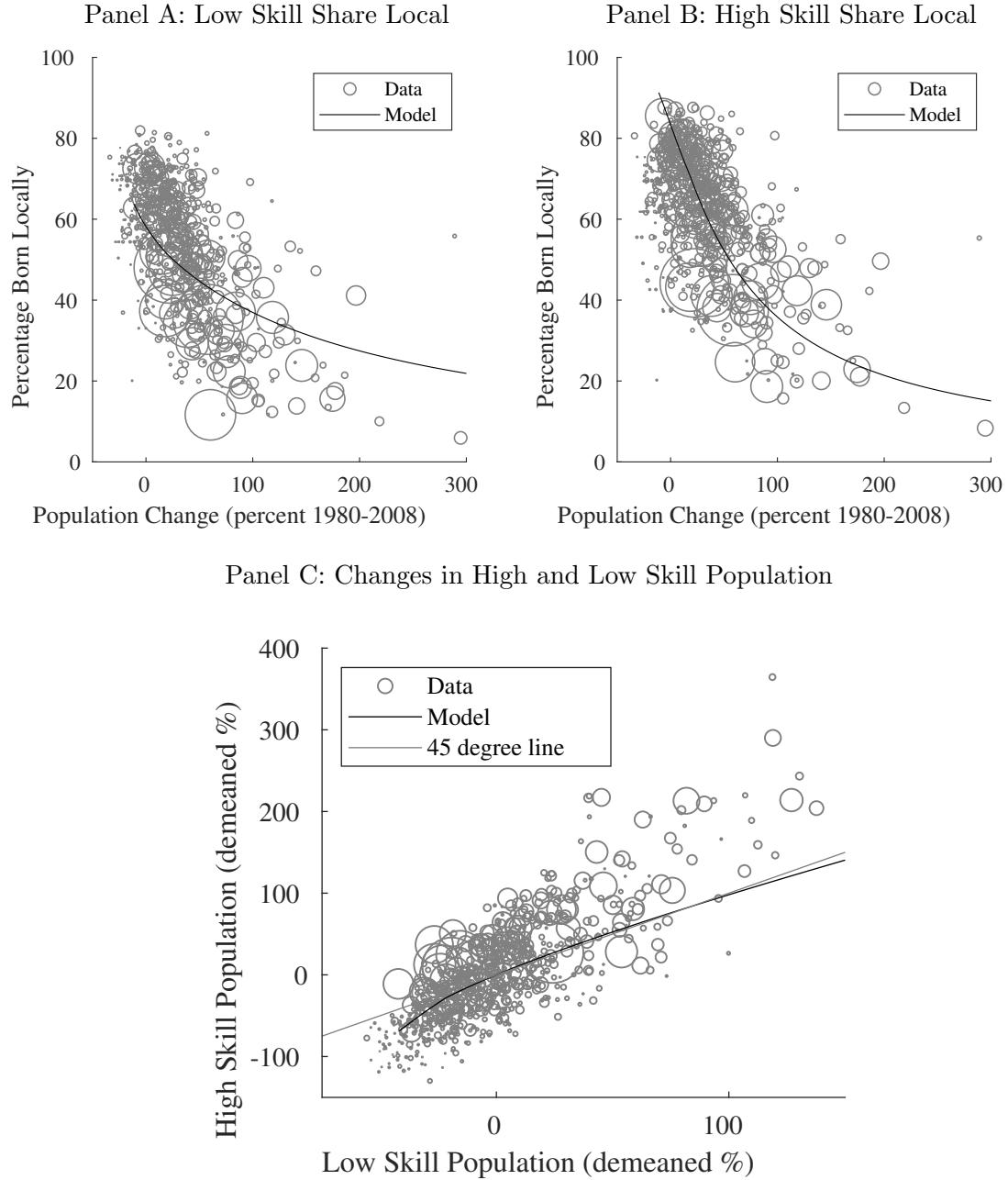
Table 9: Parameter Values for the Expanded Model

	Description	Value	Reason
$\eta_N$	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
$\eta_E^H$	Housing supply elasticity, expanding	15	Main text
$\eta_C^H$	Housing supply elasticity, contracting	0.1	Glaeser and Gyourko (2005)
$\gamma_\delta$	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)
$\mu_{Li}$	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
$\mu_{Hi}$	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 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 that I used in the main text.

Figure 13: Two Skill Estimation Moments and Targets



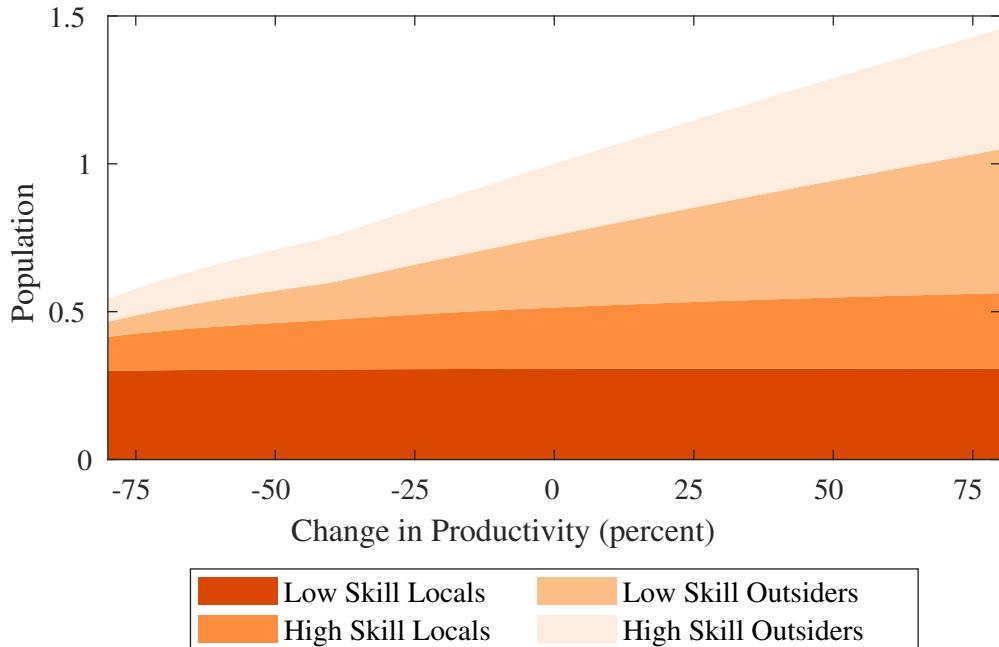
Note: The model matches the distribution of low skill people staying, high skill people staying, and each population growing in places where populations are growing at different rates. This figure plots each distribution in the data as well as the model analogue I use to approximate it in my estimation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

The model matches the three distributions, as shown in Figure 13. The 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 outsiders 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



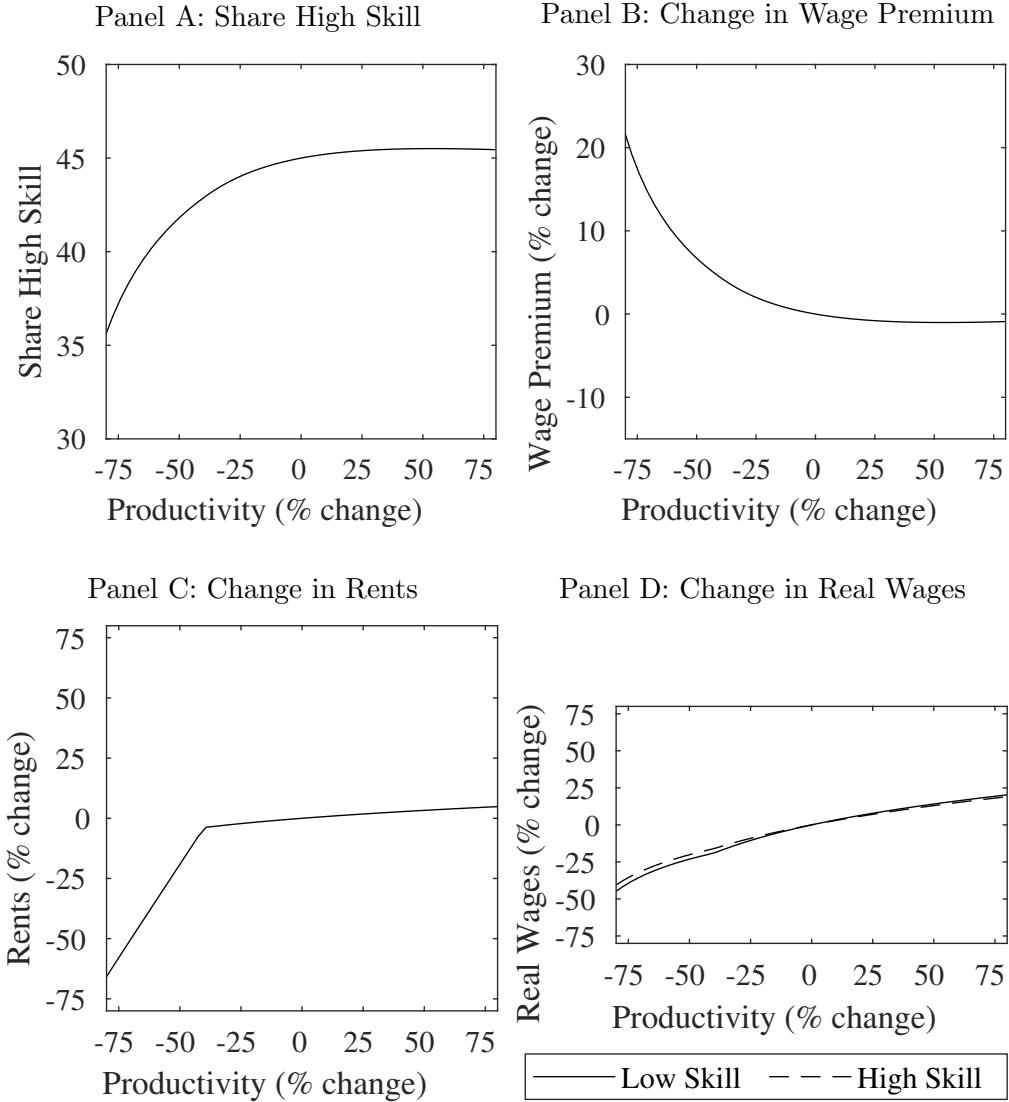
Note: Places that grow in population do so by attracting outsiders, particularly high skill outsiders. This figure plots how the population of locals and outsiders who have high and low skilled changes with productivity shocks. Each height represents the population at that productivity level. They are normalized so the total population is one in a 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 11 gives the skill premium and describes its dependence on the elasticity of substitution parameter,  $\eta_N$ .

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 incomes 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 has on equilibrium outcomes. To show how the effects of durable housing are large at first but then wane, Table 10 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 10 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 10). 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.

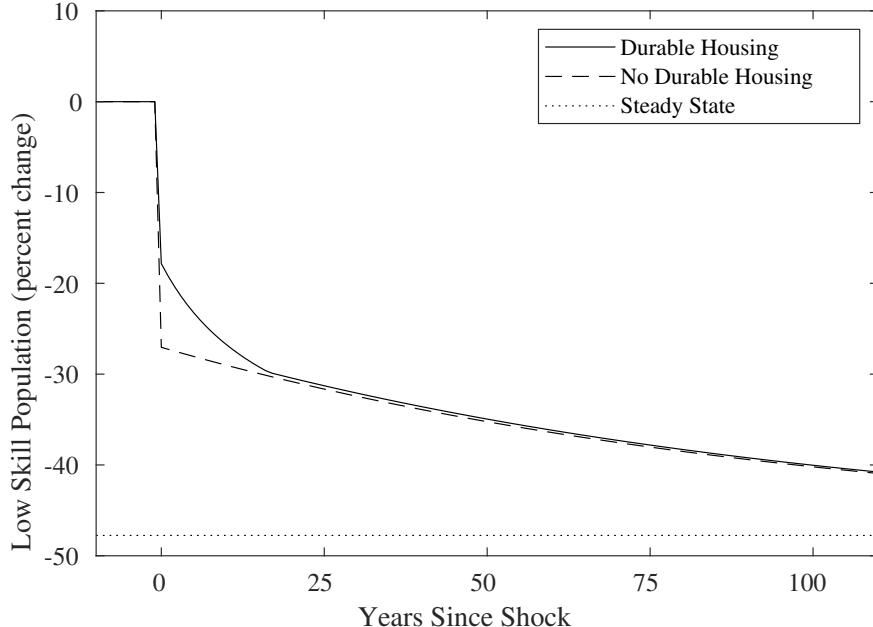
Table 10: Population Changes after Productivity Changes with and without Durable Housing

Productivity change	Initial		50 yrs		Half Life	
	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.

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' willing-

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.

ness to pay for new construction. Intuitively, local ties continue to be formed in economically depressed places because parents still live there. Construction of durable housing, on the other hand, only occurs when rents cover the cost of new construction. So new construction does not occur 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 productivity because they lead to relatively small changes in local population. Subsidies to productive places move workers and produce wage gains in other areas.

Table 11 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 higher and population responses are smaller in economically depressed places, as before.

Real incomes elsewhere are also increasing with how positively shocked the subsidized area was previously. So there are positive spillovers from moving workers to productive locations.

Table 11: Extended Model: Impacts of Subsidies

Productivity change	-50	Real Wages			Real Wages Elsewhere			Population		
		Initial	50	PDV	Initial	50	PDV	Initial	50	100
Low Skill Workers	-50	4.1	0.8	100.7	-6.0	-0.6	-92.7	4.2	1.3	0.5
	-25	2.9	0.5	72.5	-5.8	-0.6	-90.2	3.9	1.4	0.6
	0	4.2	0.4	65.9	-4.7	-0.4	-71.1	7.0	1.6	0.7
	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
High Skill Workers	-50	4.1	0.8	89.2	-4.7	-0.6	-78.5	6.4	1.1	0.2
	-25	3.2	0.6	70.6	-4.9	-0.7	-82.4	5.9	1.1	0.2
	0	3.8	0.5	65.2	-4.3	-0.5	-70.2	8.1	1.1	0.2
	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.

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 11. Population and real wage responses are higher when there is new construction after a 0 percent productivity shock versus 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 11 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 12. Table 12 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.

Another insight that comes from explicitly including the two skill groups is that place based subsidies can have different implications for high and low skilled workers outside of the subsidized place.<sup>52</sup> With a subsidy to an economically depressed place, Table 12 shows 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.<sup>53</sup>

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<sup>52</sup>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.

<sup>53</sup>The impacts of a place based subsidy on a growing place – also shown in Table 12 – are fairly similar across skill groups.

Table 12: 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.