# HOUSING AND LABOR MARKET DYNAMICS IN GROWING VERSUS DECLINING CITIES*

William D. Larson†

August 7, 2011

**Abstract**

This paper reconciles a debate on the nature of regional supply responses to demand shocks. Cities are found to exhibit dramatically different housing and labor market dynamics in response to local demand shocks, consistent with the hypothesis that the durable nature of the housing stock acts as a supply constraint in declining cities. These results imply that demand-driven models are appropriate in growing or stable cities, and models with supply constraints are more appropriate in declining cities. Failure to apply the correct class of models to a particular city will result in biased estimated employment, house price, and wage effects of both market-based demand shocks and demand-side stimulus policies.

**JEL Classifications:** R23, R31, R58.
**Keywords:** housing supply, urban decline, export prices, development policies

*I thank Anthony Yezer, Fred Joutz, Donald Parsons, and Tara Sinclair for their untiring help and support. I also thank Timothy Bartik, Joshua Gallin, Mike Hollar, Lutz Kilian, Steve Malpezzi, Raven Saks Molloy, Mike Owyang, and Albert Saiz for their helpful data, programs, conversations, and correspondence. I would also like to thank seminar participants at the George Washington University and the AREUEA session at 2011 ASSA meetings.

†George Washington University, Monroe Hall #340, 2115 G St NW, Washington, DC 20052; Tel: (202) 557-9930; Fax: (202) 994-6147; Email: larsonwd@gmail.com

# 1 Introduction

There is a long-standing debate regarding the sources and effects of demand shocks in regions. Some, such as Blanchard and Katz (1992), argue that regions should be modeled in a demand-driven framework, where supply is perfectly elastic. In models of this type, a demand shock will be fully incorporated into quantities (such as employment, population, labor force, and the housing stock) with no long-run changes to prices (such as wages and house prices). Others, such as Bartik (1991, 1993), argue that supply considerations are essential in models of regional dynamics. Within a framework with supply constraints, an unanticipated change to local demand will have long-run effects on both quantities *and* prices. Resulting from this debate is uncertainty within the economics profession regarding the effects of local demand-side development policies as well as those of market-based demand shocks. The resulting confusion has led to conflicting calls for policy at the national level.[1]

This paper reconciles this apparent conflict. Glaeser and Gyourko's (2005) urban decline hypothesis can be applied to show that, in declining cities, the housing stock acts as a supply constraint, suggesting that such cities are best modeled using a supply-constrained framework. On the other hand, in growing or stable cities, supply is substantially more elastic, and demand-driven models are more appropriate. Thus, the dynamic responses of regional demand shocks are actually different in different types of cities, and no one model or policy is correct in all cities.[2] This paper resolves the debate between Bartik (1991, 1993) and Blanchard and Katz (1992) by showing that each view is correct in certain locations.

Glaeser and Gyourko's (2005) key insight arises from the fact that housing is quickly constructed but depreciates very slowly. This creates differences at the city level in the elasticity of housing supply. When demand in a city suffers a permanent decline, housing

[1]For example, some argue that demand-side stimulus policies do very little to increase employment, while others suggest that demand-side stimulus is extremely effective.

[2]In a declining city, because it faces supply constraints, demand-driven models will tend to predict overly large employment effects of demand-side stimulus policies.

demand falls yet the housing stock remains. This led Glaeser and Gyourko to hypothesize that, in declining cities, housing is priced well below replacement costs and the primary effects of positive demand shocks, even if permanent, are to raise housing prices toward replacement costs with little or no increase in supply. This lack of a supply response, in turn, limits the effects of demand shocks on population, the labor force, and ultimately employment in declining cities. [3]

The empirical approach taken in this paper follows a two-step procedure. In the first step, Davis and Haltiwanger's (2001) "near-VAR" specification, which imposes a block-recursive structure on a VAR, is estimated for each of 352 U.S. cities. In the second step, characteristics of impulse responses for each city are estimated in cross-sectional regressions as a function of various indicators of urban decline.[4]

Estimates across a battery of alternative urban decline measures consistently indicate that decline affects the housing and labor market responses to demand shocks as predicted by Glaeser and Gyourko's (2005) decline hypothesis. When subjected to a one-unit export price shock, cities in decline experience smaller employment and larger wage and house price changes than cities with a history of growth. These findings are robust to bootstrapping inference and when Bartik's (1991) industry mix-based employment variable is used in place of export prices.[5]

This research suggests that employment multipliers are different in growing versus declining cities, and that local development policies meant to stimulate employment may be more effective in cities that are growing rather than declining. In growing cities, positive

[3]See Thompson (1965), Glaeser and Gyourko (2005), Glaeser, Gyourko and Saks (2005, 2006), Saks (2008), and Moretti (2010) for some notable demonstrations of this theory.

[4]This approach follows Green, Malpezzi, and Mayo (2005) and Owyang, Piger, Wall, and Wheeler (2008), who use time series models in a first stage, and cross-sectional variation across the estimated time series parameters in a distinct second stage. This estimation procedure has only recently become possible due to the necessarily large number of time periods and cross-sectional units of observation.

[5]The strategy is to compare the effects of local demand shocks–either positive or negative–in growing versus declining cities. This paper does not consider potentially asymmetric effects of demand shocks.

local demand shocks primarily cause employment to increase, whereas in declining cities, they, for the most part, increase wages and are capitalized into house prices. It follows from this result that in declining cities, original residents benefit from demand shocks as long as they are homeowners, whereas in growing or stable cities, original residents are not made much better off.

# 2 The Effects of Development Policies

Researchers concern themselves with the theory and measurement of urban dynamics, to a large degree, because of the desire to predict the effects of local development policies, which can include enterprise zones, empowerment zones, unemployment insurance, and defense expenditures. Some fundamental questions about development policies are 1) do they "create" jobs, 2) will those jobs stay after the policy's expiration, and 3) do the new jobs and other benefits go to migrants or to original inhabitants?

There are two main views on the nature of supply responses to unanticipated changes to local demand. On one hand, there are demand-driven frameworks where supply is perfectly elastic, leading to predictions of permanent effects of a labor demand shock on employment, but only temporary wage, unemployment, participation, and local price effects. In these models, migration and housing construction allow a region to adjust fully to demand changes in the long run. On the other hand, there are models with supply constraints, in which labor demand shocks have permanent effects on employment, but also on the unemployment rate, labor force participation, and local prices. In this section, the basic theory and empirical results of two representative demand-driven and supply-constrained approaches are reviewed. Bartik (1991) is selected to represent a model with supply constraints, whereas Blanchard and Katz (1992) is taken to represent a classic demand-driven model. [6]

Bartik (1991) begins with a model including both labor and housing markets. In the housing market, land is scarce, leading to an upward sloping housing supply curve. The predicted effect of this supply constraint is to limit in-migration, causing labor demand shocks to have permanent long-run wage, price, participation, and unemployment rate effects. In this case, as Bartik (1991, 1993) argues, benefits of local development policies go to both migrants and to original residents.

Bartik's empirical specification is a distributed lag model, with a locally endogenous variable, such as house prices, wages, or the labor force participation rate, estimated as a function of lagged employment changes. This model is estimated using pooled annual data of a small number of U.S. cities. Bartik assumes a vertical short-run labor supply curve implying that changes to employment reflect changes to labor demand. Under this interpretation of employment changes, his estimates show that there are indeed permanent effects of labor demand shocks on wages, house prices, and the unemployment and participation rates. [7]

As an alternative to Bartik (1991), Blanchard and Katz (1992) present a demand-driven regional equilibrium framework with regional labor demand and supply equations. Shocks to labor demand initially affect only wages, but over time, migration occurs until the wage effect is eliminated by the growth of population and employment. In their model, effects are symmetric and homogeneous across regions. Demand serves as the only driver of the labor market and supply is assumed to be perfectly elastic in the long run.

[6] Some other notable works on regional dynamics include Carlino and Mills (1987), Carlino and DeFina (1995) and Clark and Murphy (1996). Saks (2008) will be discussed later in this section. Other demand-driven models include input-output models, computable general equilibrium models, and economic base models. Other models with supply constraints include systems of cities models and putty-clay models of housing.

[7] Bartik tests the hypothesis that small labor demand shocks only affect unemployment and labor force participation rates in "slow-growing" cities because little migration takes place. In "fast growing" cities, significant in-migration occurs, so labor demand shocks affect employment, with little effect on unemployment and participation rates. Bartik finds that there are no observable differences across slow-growing and fast-growing cities.

Blanchard and Katz's empirical results lend support to their underlying theory. They estimate the effects of labor demand shocks by pooling annual data for U.S. states and estimating structural VAR models. One specification includes employment, the labor force participation rate, and the unemployment rate. Similar to Bartik, they assume that the labor supply curve is sufficiently inelastic in the short run such that changes to employment can be interpreted as changes to labor demand. They find that under this interpretation of employment changes, in the short run, labor demand shocks have an effect on employment, the unemployment rate, and the labor force participation rate, but in the long run, the only effect is on employment. These results imply that migration causes regions to fully adjust to labor demand shocks, and that the entirety of the benefits of labor demand increases go to migrants in the long run. Similarly, they estimate two bivariate systems, one with employment and wages, and the other with employment and house prices. In both of these models, labor demand shocks have temporary effects on prices but no long run effects. Blanchard and Katz also investigate differences in dynamics across regions, and find that states bordering Mexico have slightly larger employment effects resulting from a shock to labor demand.

After Blanchard and Katz (1992), Bartik (1993) attempts to address the conflicting results and implications found in Bartik (1991) and Blanchard and Katz (1992). Bartik (1993) attributes the differences to a confluence of specification and measurement error issues, arguing that Blanchard and Katz's differenced model, combined with measurement error in the data, cause parameter estimates to be severely attenuated and biased toward the finding of no long-run price effects. He goes on to show that, using Blanchard and Katz's data with his specification, the estimates support a supply-constrained view of regional economies.

All was not settled with Bartik (1993), however. Saks (2008) finds that urban dynamics are different across cities depending on the elasticity of housing supply, measured using an index of housing market regulation. This is a notable contribution in that it is the first instance where differences in regional dynamics are systematically investigated and found to exist. Despite Saks' strong contribution, Rickman (2010) points out that there are still serious questions to be resolved:

> Considerable debate exists regarding whether demand or supply forces underlie differentials in regional growth and fluctuations. The distinction matters for policymaking in terms of whether regions should focus more on attracting firms versus households to promote growth. Structural macroeconomic equilibrium models could be used to address this issue by employing more theoretically sound and empirically based assumptions than those used to date. These models also could be used to examine the dynamics of regional labor market adjustment to address economic development issues such as whether existing residents or migrants primarily benefit from job creation. Varied formulations and implementations of such models could establish the robust results regarding the workings of regional labor markets. (Rickman, 2010, p. 37)

Rickman (2010) contends that previous research has failed to answer the question of whether demand-driven models or those with supply constraints are more appropriate, in part, because of difficulties identifying labor demand shocks. He points out (p. 34) that "employment and population [are] both outcome variables and not independent measures of labor demand and supply," and highlights the difficulties of estimating the true dynamic responses to demand shocks when actual demand determinants are absent from estimated models. Fundamentally, he argues that the Bartik (1991) and Blanchard and Katz (1992) approach to identification (following Carlino and Mills, 1987), suffers from weak instrumentation.

# 3 Identifying Local Demand Shocks

Both Bartik and Blanchard and Katz identify labor demand shocks using employment changes. Both assume that, in the short run, labor supply is sufficiently stable to enable changes in employment to directly reflect changes in labor demand. As a robustness check, both estimate their models using Bartik's (1991) industry mix-based employment instrument. This variable uses local industry weights and national industry employment changes to identify labor demand shocks. Since Bartik (1991), this variable has been used to identify local demand shocks in a range of studies.

Bartik's approach uses local industry weights along with national employment to create a variable representing the overall health of the industries present in a particular area. Let $i$ subscripts denote different industries, $j$ different cities, $b$ a chosen base year, and omitted subscripts, sums.[8] The locally weighted change to national employment is then

$$G_{jt} = \sum_i n_{ijb} \frac{n_{it} - n_{it-1}}{n_{ib}} \tag{1}$$

Bartik then calculates an instrumental variable using equation 1

$$IV_{jt} = \ln(n_{jt-1} + G_{jt}) - \ln n_{jt-1} \tag{2}$$

The theory behind this instrument is that employment changes that are industry-specific but external to a city reflect exogenous labor demand shocks. While this approach may accurately reflect exogenous shocks to local labor demand in certain cases, there are many reasons why an increase in national employment in an industry may not reflect a local demand shock. Employment outside a region in similar industries can rise because that region is losing market share to the rest of the country, because exports abroad are growing, or the skill mix within the industry is changing. Additionally, the index does not attempt to distinguish between goods that are sold outside the city from those sold inside. For example, it is likely that almost all fluctuations in both retail and local service employment are endogenous to the local economy.

One approach to solving the problem of identifying local demand shocks is the Export Price Index (EPI). The EPI measures changes to the prices of goods and services that a

[8]For example, $n_{jt}$ is national employment in industry $j$ at time $t$.

particular region exports to other regions. The EPI is an extension of Bartik's industry mix approach and was first developed by Pennington-Cross (1997) and updated by Hollar (2011). Instead of applying local industry weights to national industry employment, the EPI applies local industry weights for export industries to national industry prices. This variable is a locally exogenous demand determinant and does not suffer from the shortcomings of using outcome variables or variables where changes have ambiguous meanings for particular locations.

The EPI is also a variable with strong theoretical foundations, as demand for urban exports has been recognized for some time as the primary driver of local economies. Henderson (1988, pp. 33-38; 47-50) models the relation between export prices and the level of employment, wages, house prices, and other endogenous variables in cities. Economic base models (Isard, 1960), other system of cities models (Henderson, 1974), and new economic geography models (Krugman, 1991) all model city development in terms of export demand or export prices. Bartik's own industry mix-based employment instrument is meant to "prox[y] for demand shifts for an area's exports," Bartik (1993, p. 300). It is within this theoretical framework that the EPI was developed, and it seeks to measure one of the fundamental demand determinants in cities.

One key assumption underlying the EPI is that cities are small, open economies, and are price-takers on the world market for goods and services. Because prices are independent of local markets, export prices act as an exogenous local demand determinant.[9] What follows is a brief discussion of the EPI found in Pennington-Cross (1997) and Hollar (2011).

[9]There is a large literature on the effects of terms of trade shocks in small, open economies, and there are many similarities between this literature and the regional science literature. See Mendoza (1995), Broda (2001, 2004), and Kose (2002) for some examples of the effects of terms-of-trade shocks on business cycles, exchange rates, output, and prices in cross-sections of small countries. Similarly, Henderson (1974, 1988), analyzes the effects of export price shocks in cities on wages, house prices, output, and employment in cities. In many respects, cities can be viewed as small, open economies with fixed exchange rates with other cities within a currency bloc.

### 3.1 Formulation of prices

The EPI is a Laspeyres price index, which has two desirable properties and several potential drawbacks. A Laspeyres index uses fixed quantity weights $q$ and time-varying prices $p$, with subscripts $i$,$j$, and $t$ denoting industry, location, and time.

$$P_{jt} = \frac{\sum p_{ijt} q_{ij0}}{\sum p_{ij0} q_{ij0}} \tag{3}$$

Since $q_{ij0}$ is location-specific but time-invariant, the weights may be considered exogenous intertemporally. Time-varying prices in the EPI are at the national level. With the additional assumption that regions are price takers with respect to exports, national prices are exogenous with respect to a region's weights. Thus changes in the EPI are, by construction, exogenous to the city economy. Contrast this with a Paasche or chained-type index, which updates quantity weights each period, neither of which would result in an exogenous price index. The second desirable property is that only a time series for prices is required for the calculation of a Laspeyres index as long as base-period weights are known. Laspeyres indices suffer from a documented substitution bias. Because weights are quantities and fixed across time, there can be no substitution effect for agents reacting to price changes, which results in measurement error. Ultimately, there is a tradeoff between exogeneity in the EPI and measurement error due to the Laspeyres approach.

### 3.2 Formulation of weights

Each location has a vector of quantity weights by industry, whose values are the fraction of the region's export employment in each industry. Export employment is calculated using Location Quotients (LQ) for industry $i$ in region $j$, with omitted subscripts indicating averages over the industry or region. Location quotients measure the ratio of region's industry employment, $n_{ij}/n_j$ compared to the national average employment in an industry, $n_i/n$.

$$LQ_{ij} = (n_{ij}/n_j)/(n_i/n) \tag{4}$$

A $LQ > 1$ indicates that sector employment in a region is greater than the national average, and that the employment in excess of the national average goes towards the production of goods and services exported to other regions. Export employment is then calculated as

$$x_{ij} = (1 - 1/LQ_{ij})n_{ij} \tag{5}$$

and is bounded from below at 0.

An industry is excluded even when $x_{it} > 0$ if it generally only supplies customers within the region. Industries excluded based on this criterion are certain retail, utility, construction, and local government activities.

Quantity weights in the EPI are calculated as the fraction of industry export employment to total export employment in the region.

$$w_{ij} = x_{ij}/x_i \tag{6}$$

Finally, the EPI is calculated using local industry weights and national, time-varying prices.

$$EPI_{jt} = \sum_i w_{ij} * P_{it} \tag{7}$$

# 4 Linking Urban Housing and Labor Markets

Saks (2008) partially addresses Rickman's (2010) suggestions by imposing some structure on Blanchard and Katz's (1992) model. Saks extends Blanchard and Katz's model by including housing market supply conditions. She hypothesizes that housing market regulations restrict the construction of new housing, thus reducing the elasticity of housing supply and causing labor demand shocks to have different effects across cities. She identifies the elasticity of housing supply over a panel of cities with an index of housing market regulation and interacts it with an employment growth instrument constructed using Bartik's (1991) industry mix-based method. Saks finds that labor demand shocks have larger short-run effects on employment and smaller effects on house prices and wages in growing, low regulation cities versus growing, high regulation cities. However, there are no long-run effects on employment, wages, or house prices in either high or low regulation cities.

While Saks' model examines growing cites, policymakers are often concerned with declining cities. In order to determine the effects of development policies in declining cities, it would make sense to extend Saks' approach to these areas. However, as Saiz (2010) shows, regulation and urban decline are endogenous, so housing market regulation cannot be used to identify the elasticity of housing supply in a sample with both growing and declining cities. An extension of Saks' basic approach to declining cities is necessary in order to fully address the effects of development policies in demand-driven versus supply-constrained cities.

Researchers have observed for quite some time that cities often grow quickly but decline slowly. This phenomenon was dubbed the "urban size ratchet" by Thompson (1965). Glaeser and Gyourko (2005) argue that the urban size ratchet is caused by the durability of housing. Housing is both easily constructed and highly durable, making it difficult for cities to shrink in size. Effectively, durable housing creates a "kink" in the housing supply curve whereby the city has an elastic housing supply when the city is growing and an inelastic housing supply when the city is declining. This occurs because housing is only constructed when house prices are at or above construction costs for a new unit. In declining cities, house prices are far below replacement costs. Accordingly, when a city with house prices below replacement costs faces either a positive or negative demand shock, the housing stock will change very little.[10]

Glaeser and Gyourko (2005) spawned a great deal of interest in the housing and labor market effects of the elasticity of housing supply in cities. Of particular note are the findings of Glaeser, Gyourko, and Saks (2006), who show that the citywide elasticity of housing supply affects the citywide elasticity of *labor* supply. They argue that housing stocks constrain population and population constrains labor supply, so the housing stock constrains labor supply in cities. Together, these two papers imply that a city's recent history of growth or decline can identify both its elasticity of housing supply and its elasticity of labor supply. The remainder of this paper tests this hypothesis and discusses the implications of the test results.

# 5 Estimating a Model of Regional Dynamics

This section describes a two-step method of estimating cross-sectional differences in housing and labor market dynamics across cities. The first step involves estimating the effects of export price shocks on employment, wages, and house prices in individual cities, controlling for national variables. The housing and labor market effects are measured using impulse responses. In the second step, the characteristics of the export price impulse responses are estimated in a cross-sectional regression as a function of the state of urban decline in a city. A bootstrapping procedure spanning both steps is used for statistical inference.

It is common in the literature to estimate panel models and calculate panel impulse response functions to measure the dynamic effects of shocks (see Bartik, 1991; Blanchard and Katz, 1992; and Davis, Loungani, and Madidhara, 1997), or to estimate panel models with certain variables interacted with exogenous variables in order to estimate differences across

[10] Glaeser and Gyourko (2005) also consider other possible causes of the urban size ratchet, including labor immobility and durable capital. They find that the durability of housing dominates both of these effects. Notowidigdo (2010) presents a model where falling local demand is absorbed by falling house prices and rising transfer payments.

regions (see Saks, 2008; Grimes and Aitken, 2010). These empirical modeling approaches are driven by data availability given the large cross-section of regions and small number of time periods of observation available at the time. Because of this data limitation, these approaches rely on restrictions to both estimated parameters and to the cross-region error structure, and may result in incorrect estimates and inference for both parameters and impulse responses.

With the BLS' Quarterly Census of Employment and Wages, employment and wage data are available at quarterly intervals, giving a sufficiently large $T$ to estimate models for individual cities.[11] Instead of estimating a panel model with interaction terms, impulse responses constructed using self-contained, city-level models can be examined later in a second stage using summary statistics or regression analysis.[12]

## 5.1 First step: VAR

This subsection describes a method of estimating regional time series models that impose theoretically justified structures on the parameters. The empirical modeling approach follows Davis and Haltiwanger (2001), who estimate a near-VAR of oil prices and employment in different manufacturing sectors. A near-VAR is a vector autoregression where block-exogeneity is imposed on certain groups of parameters. Davis and Haltiwanger's assumption that individual sectors cannot influence national variables motivates the assumption made here that individual cities cannot influence national variables. This type of modeling approach is also used by Broda (2001, 2004), who examines the effects of terms of trade shocks in small open economies in a near-VAR, with the exchange rate in the most exogenous block.

Three blocks are chosen, following the approaches of Davis and Haltiwanger (2001) and

[11] $N = 352$ cities, $T = 72$ time periods.

[12] An example of this two-stage, "large $N$, large $T$ approach" is found in Owyang, Piger, Wall, and Wheeler (2008), who estimate individual state-level growth rates in the first stage, and explain cross-sectional differences in these growth rates in the second stage.

Broda (2001, 2004).[13] The first consists of national variables, including the U.S. producer price index, total U.S. employment, average U.S. wages, and average U.S. house prices.[14] The second block consists of local variables that are dependent on national conditions but exogenous with respect to other local variables. The second block includes an index of local export prices. The third block includes locally endogenous variables: city-level employment, wages, and house prices.[15]

It is assumed that the variables in $Y$ have a linear structural representation and that the parameters are unrestricted across cities.

$$\boldsymbol{B}_i(0)\boldsymbol{Y}_{it} = \boldsymbol{B}_i(L)\boldsymbol{Y}_{it} + \boldsymbol{\varepsilon}_{it} \tag{8}$$

where $\boldsymbol{Y}_{it}$ consists of three blocks,

$$\boldsymbol{Y}'_{it} = [\boldsymbol{Y}_{1it},\ \boldsymbol{Y}_{2it},\ \boldsymbol{Y}_{3it}]$$

$$\boldsymbol{Y}'_{1it} = [USPPI_t,\ USEMP_t,\ USWAGE_t,\ USHPRICE_t]$$

$$\boldsymbol{Y}'_{2it} = [EPI_{it}]$$

$$\boldsymbol{Y}'_{3it} = [EMP_{it},\ WAGE_{it},\ HPRICE_{it}]$$

and $\boldsymbol{\varepsilon}_{it}$ is a vector of structural innovations for each $i$ and $t$. The structural innovations

[13] While each of these models only includes two blocks, the EPI necessitates a third. The EPI is exogenous with respect to local variables, but national variables are exogenous with respect to the EPI.

[14] The producer price index used is the intermediate goods PPI.

[15] The modeling approach taken here assumes that that cities are independent from one another and there are no spatial spillovers. This contrasts with other approaches in the literature including Carlino and DeFina (1995) and Canova and Ciccarelli (2009). While part of the regional data generating process for U.S. cities may be spatial in nature, it is the purpose of the research in this paper to explicitly model heterogeneous effects. Spillovers here are only modeled indirectly through national variables. This modeling approach assumes that spatial weights for each city are equivalent. One other source of spillovers is if workers in one city lived in another city. This would connect both the housing and labor markets of the two cities. The choice of MSAs as the geographic area of interest is made in order to separate housing and labor markets in different areas.

can be uncovered by estimating a reduced-form model for each city $i \in I$ and placing restrictions on $\boldsymbol{B}_i(0)$ such that $\boldsymbol{B}_i(0)$ is lower triangular. Additionally, block exogeneity is imposed, following Davis and Haltiwanger (2001), such that $\boldsymbol{B}_i(L)$ is lower block-triangular. Within each block, after the period of a shock, variables are determined jointly treating prior blocks as exogenous. This ensures that feedback does not occur between local and national variables or between the export price index and other local variables.

Two lags are chosen in order to satisfy the Sims, Stock, and Watson (1990) result regarding the consistency of impulse responses when variables are in levels and cointegration is present. With so many regressors, two lags may be more than necessary. However, as Berkowitz and Kilian (2000) and Kilian (2001) note, more lags are preferable because the costs of misspecification outweigh efficiency losses due to extra lags. Also, Kilian (2001) shows that bootstrapped estimates may require more lags than originally estimated, so it is best to err on the side of too many lags. Finally, all that is necessary in the first stage are consistent estimates, as inefficiency in the first stage has minimal effects on the second-stage estimates. The reduced-form model estimated is

$$\boldsymbol{Y}_{it} = \boldsymbol{d}_{0i} + \boldsymbol{\alpha}_{1i}\boldsymbol{Y}_{it-1} + \boldsymbol{\alpha}_{2i}\boldsymbol{Y}_{it-2} + \boldsymbol{e}_{it} \tag{9}$$

where $\boldsymbol{d}_{0i} = \boldsymbol{\delta}_{0i} + \boldsymbol{Q}_{2i} + \boldsymbol{Q}_{3i} + \boldsymbol{Q}_{4i}$ and $\boldsymbol{Q}_i$ are location-specific quarterly fixed effects. *A priori* restrictions on $\alpha$ are made in order to recover the structural parameters $\boldsymbol{B}_i(L)$.

$$\boldsymbol{\alpha}_{ni} = \begin{bmatrix} \boldsymbol{\alpha}_{n11i} & 0 & 0 \\ \boldsymbol{\alpha}_{n21i} & \boldsymbol{\alpha}_{n22i} & 0 \\ \boldsymbol{\alpha}_{n31i} & \boldsymbol{\alpha}_{n32i} & \boldsymbol{\alpha}_{n33i} \end{bmatrix}, \ n = 1, 2$$

Because the model involves simultaneous equations with different regressors in each equation, the model is estimated using SUR. This estimation approach addresses cross-equation correlation in the error terms and results in more efficient estimates than equation-by-equation OLS as is performed in a classical VAR. As with the choice of two lags, SUR acts as insurance against correlation among errors in equations in particular cities, even if not all cities have correlated errors.

The result of these estimates is a matrix of parameter estimates $\hat{\alpha} = [\hat{\alpha}_1, \hat{\alpha}_2, ..., \hat{\alpha}_I]'$ and reduced-form errors $\hat{e} = [\hat{e}_1, \hat{e}_2, ..., \hat{e}_I]'$. The estimated error covariance matrix $\hat{e}\hat{e}' = \hat{\Sigma}$. $P \equiv B_i(0)$ is found using the Cholesky decomposition, $\Sigma = PP'$.[16] The structural errors are then $\varepsilon = P^{-1}e$ and the structural parameters are $B_i(L) = P^{-1}\alpha_{Li}$ for $L = 1, 2$. Orthogonalized impulse responses are calculated for each city as $\hat{\theta}_i(\hat{\alpha}, \hat{P})$.

The bootstrapping methodology for the impulse responses is described in Efron (1981), and involves several steps. First, $\alpha$ parameters are estimated and $\hat{\theta}$ is calculated using the observed data. Using the estimates of $\alpha$, 100 error matrices are calculated by drawing a random sample of estimated residuals with replacement. For each random draw, the vector of residuals across all equations is taken in order to preserve the cross-equation error structure. A starting value for $Y$ is then randomly selected and pseudo-data $Y_b$ are recursively generated. Bootstrapped estimates of $\alpha$ and $\theta$ are calculated and denoted $\hat{\alpha}_b$ and $\hat{\theta}_b$ where $b \in 1, 2, ..., 100$.[17]

While Efron's bootstrapping method traditionally has lower coverage than other methods when the own lagged coefficients sum to a value close to 1 (see Kilian, 1999), the bootstrapped impulse response functions are not meant to provide confidence intervals for the impulse responses themselves. Instead, they are used in second stage regressions to establish the relationship between time invariant cross-section variables and the impulse responses.

[16] The ordering for the Cholesky decomposition is based on Saks (2008).

[17] This bootstrapping method is executed using STATA's IRF CREATE, BS command.

## 5.2 Second stage: estimating differences across cities

This subsection presents a test of the hypothesis that decline causes differences in urban housing and labor market dynamics. Characteristics of the employment, wage, and house price impulse responses are estimated as a function of urban decline, and the relationship between decline and urban dynamics is tested. Of particular interest are the maximum effects, the short-run effects, and the long-run effects because these can be used to compute the time-path of responses, provide evidence of hysteresis, and for other purposes.

Consider the set of city-level impulse responses calculated in the first stage that measure the effects of a one-unit shock to the EPI on employment, house prices, or wages, and let the response characteristic $c$ of variable $v$ in city $i$ be denoted as $\theta_i^{c,v}$.[18] Based on Glaeser and Gyourko (2005), these characteristics are predicted to be a function of an index of urban decline. Accordingly, these characteristics are expressed as a linear function of urban decline according to Equation 10:

$$\hat{\theta}_i^{c,v} = a + \pi \times decline_i + \varepsilon_i \tag{10}$$

where $decline_i$ is an index of urban decline and $\varepsilon_i$ is an i.i.d. normal variable.

The distribution of the estimated $\pi$ may depart from known distributions, so bootstrapping inference is undertaken. The bootstrap replications of the first-stage impulse response characteristics $\hat{\theta}_{i,b}^{c,v}$ are used to re-estimate the parameter $\pi$. The standard deviation of these bootstrapped estimates is interpreted as the standard error of $\hat{\pi}$.[19]

[18] For example, it may be interesting to estimate the one-year effect of an EPI shock on employment, so $\theta_i^{c,v}$ in this case would consist of a particular city $i$'s employment response to an EPI shock at t=4.

[19] The 90% confidence interval for $\pi$ can also be computed using the 5th and 95th percentile estimates of $\pi_b$. However, due to the large number of cities and equations estimated, only 100 bootstrapping replications are feasible. Because of the small number of bootstraps, the distribution of the bootstrap estimates at the tails is extremely lumpy. For this reason, the percentile-t method of Efron (1981) is used instead. Because this second stage involves bootstrapping estimates of transformations of estimated means (the impulse responses from the first stage), the standard error bands are likely to converge quickly around the true estimate of $\pi$ by the central limit theorem.

# 6 Data

## 6.1 Overview

Data exist for 352 Core-Based Statistical Areas (CBSA) in the United States.[20] Unless otherwise noted, information is gathered at the county level, and then aggregated based on the CBSA area definitions. Because CBSA/MSA boundaries change over time but county boundaries are stable, aggregating counties ensures a consistent area of analysis over time. The CBSA is the appropriate unit of measurement because an area of this size reflects a single labor market. Analysis at the state level is inadequate because multiple distinct labor markets exist within a state, and sometimes across states. Analysis at the county level suffers from cross-hauling, where households live in one county but work in another.

Wages and sectoral employment are from the BLS's Quarterly Census of Employment and Wages (QCEW). The QCEW uses UI data to create "near census" measures covering 99.7% of all U.S. employment. The 352 CBSAs considered include 85% of national employment in 2007. Data in the QCEW are quarterly from 1990:Q1-2007:Q4, for a total of 72 periods of observation. House prices for large cities are from the Federal Housing Finance Agency (FHFA, formerly OFHEO). FHFA house price data are quarterly at the CBSA level.

Monthly consumer price information is from the BLS's Consumer Price Index for All Urban Consumers - Current Series (CPI). Monthly producer price information is from the Producer Price Index - Industry Data (PPI-Industry) series and the Producer Price Index - Commodity Data (PPI-Commodity) series. These series are used in the creation of the Export Price Index (EPI), the construction of which is described in Appendix A-2. Monthly data are either averaged or summed to create quarterly data, where appropriate.

Data used in the construction of the Urban Decline Index (UDI), described in Appendix A-3, are from the U.S. Census' USA Counties Data File or the U.S. Department of Housing

[20] November 2007 definitions

and Urban Development's "State of the Cities Data System." Housing stock, house value, and demographic data are from these sources.

# 7 Results

The empirical results in this section cover some broad areas, but there are two main findings.[21] First, the export price index (EPI)–a city-level variable which measures the prices firms receive for goods they export to other cities–serves as an important housing and labor demand determinant. Exogenous shocks to the EPI have positive effects on employment, wages, and house prices, controlling for national effects, but these effects vary substantially across cities. Second, urban decline explains why these effects are different. Urban decline reduces the effect of EPI shocks on employment, and increases the effect of EPI shocks on wages and house prices. Similar results are obtained when Bartik's (1991) employment variable is used in place of the EPI and/or when the manner in which the index of urban decline is computed varies. Overall, these results are extremely robust to a wide range of alternative estimation approaches.[22] These two results are consistent with Glaeser and Gyourko's (2005) urban decline hypothesis and lend support to the idea that declining areas are supply constrained and growing or stable areas are demand-driven.

## 7.1 Results common across cities

While impulse responses present the total effects of structural shocks, partial effects also shed some light on the dynamics of cities. These partial effects are shown in Table 1 and will be discussed first. In Table 1, median parameter estimates across 352 cities are presented,

[21] Recall that the approach is to use a two-step procedure to estimate the effect of urban decline on the effects of local demand shocks: first, VARs are estimated for each city and impulse responses (IRFs) are generated; and second, characteristics of the IRFs are estimated as a function of urban decline.

[22] As Bartik (1993) notes, the estimates in this section likely suffer from attenuation bias due to measurement error in the variables. Therefore, these estimates should serve as a lower bound for the actual parameters.

and below these values are the 5th and 95th percentile estimates. The EPI equation shows that median export prices are quite persistent, with the median lagged parameter estimates summing to 0.88. In the employment equation the EPI has a significant effect, along with U.S. employment. The EPI is a main driver of wages as well. Oddly, the lagged wage parameters sum to only 0.05. This indicates that export prices provide more information on wages than wages do, and perhaps much of the quarterly variation in the wage series is measurement error. Input prices, in the form of the producer price index, PPI, tend to reduce the effects of PPI changes as expected because these changes reflect supply side effects. Positive U.S. employment changes also increase wages in this partial analysis. Finally, the EPI is a main driver of house prices. Besides export prices, no other variable appears to have a systematic effect on house prices across all cities.

<< Table 1 Here >>

Using estimates found in Table 1 along with Cholesky-decomposed error covariance matrix, impulse responses are created and shown in Figure 1. These impulse responses show the total dynamic effects of structural shocks to local demand on different local housing and labor market variables. The error bands on the curves indicate the 5th and 95 percentile of all estimates.

<< Figure 1 Here >>

Two main conclusions flow from the results in Figure 1. First the EPI is a local labor and housing demand determinant, positively affecting all local variables in the model, including employment, wages, and house prices. Second, substantial differences between the 5th and 95th percentile responses indicate that there is heterogeneity in the effects of export prices across cities. As Bartik (1993) notes, measurement error often biases impulse responses of regional dynamic models towards zero.

Out of 352 cities, in at least one quarter after the period of the shock, the EPI has a positive effect on employment in 325 cities, a positive effect on wages in 342 cities, and a positive effect on house prices in 333 cities. These effects control for the intermediate goods producer price index, U.S. employment, average U.S. wages, average U.S. house prices, and seasonal effects.[23] The median impulse response of a 1-unit EPI shock on wages reaches a peak of 0.42 in quarter 2. The peak effect of an EPI shock on employment occurs a year later, with a value of 0.24 in quarter 7. By quarter 7, the effect of the EPI shock on wages falls to 0.36. This indicates that the labor supply is less elastic in the short versus the medium term, and demand shocks are initially absorbed by wages. By period 20, the effect of the EPI shock on employment falls to 0.08 and the effect of the EPI shock on wages falls to 0.10. There is a large and persistent effect of EPI shocks on house prices, which reach their peak in quarter 8 with a value of 0.59. By quarter 20, the effect of the EPI shock on house prices falls to 0.23.

## 7.2 Explaining differences across cities

One thing that is apparent from Figure 1 is that the impulse responses vary substantially across cities. The standard deviations of the responses are large, and the difference between the 90th and 10th percentile estimates are often the difference between a large effect and no effect whatsoever. The question then turns to whether these differences are random or if there are underlying structural reasons. The model developed in Section 3 predicts that the responses of wages, employment, and house prices to local demand shocks depends on the elasticity of housing supply. Because urban decline substantially reduces the elasticity of housing supply, this theory is tested by estimating the impulse responses as a function of various measures of urban decline. It is found that urban decline does indeed constrain

[23] The full table of impulse responses is an 8x8 matrix of figures, and this is available upon request. Figure 1 contains the local variables lower right-hand quadrant.

citywide housing and labor supply, reducing the effect of local demand shocks on employment, and increasing the effects of local demand shocks on wages and house prices.

Impulse responses at each time horizon are estimated in a second-stage regression as a function of the Urban Decline Index (UDI) in accordance with Equation 10, and Figure 2 shows the impulse response at the 5th and 95th percentiles of the index.[24] Shaded areas are confidence intervals calculated as mean estimate $+/-2 \times SD$ of the bootstrap estimates of the UDI parameter. This figure shows that urban decline alters the effects of local demand shocks in the manner predicted by Glaeser and Gyourko's (2005) decline hypothesis. In a growing city (represented by the 5th percentile of the UDI in Figure 2), a demand shock has a large, positive effect on employment. Conversely, a declining city (95th percentile of the UDI) has almost no employment effect. These effects are reversed for wages and house prices, with the effect of the EPI on wages almost twice as large in declining cities as growing cities.

<< Figure 2 Here >>

<< Table 2 Here >>

# 8 Summary and conclusions

The results in this paper demonstrate that regions react differently to demand shocks, and that these differences are systematic and predictable based on Glaeser and Gyourko's (2005) urban decline hypothesis. Cities in decline react as though they are supply-constrained, and cities that are relatively stable or are growing behave as though they are demand-driven.

[24]Given a one-unit impulse at t=0, at each time horizon t+h (h=1,2,...,20), a regression is estimated where the left-hand side variable is a particular response to an EPI shock and the right-hand side variable is the UDI. Using the constant and slope parameters, the 5th and 95th percentile values of the UDI are used to create a prediction for the responses at time $t+h$ in growing (5th percentile of the UDI) vs declining (95th percentile of the UDI) cities.

The proposed mechanism for these differences is the durability of the housing stock. Housing is easily constructed but rarely destroyed, creating inelasticities in local housing and labor markets when housing is priced well below replacement costs. Others in the literature have formed models where the elasticity of labor supply causes the effects of demand shocks to be different across subsets of cities or in particular markets (Saks, 2008; Grimes and Aitken, 2010). The research in this paper supports this view, and the results in this paper are consistent with these earlier works.

The identification of local demand shocks has been a major challenge in the literature. Past measures have generally focused on outcome variables such as employment or population. Rickman (2010) forcefully argues that this issue has remained and that alternative approaches are desirable. With Rickman in mind, local demand shocks in this paper are measured using a true determinant of local demand, the Export Price Index (EPI). This variable uses fixed, area-specific weights and national prices to construct a price index for goods and services exported outside of a city. The EPI is shown to be an important housing and labor demand determinant in cities.

Previous research modeling regional dynamics focus on panel specifications. Given the increasing availability of high-frequency data for a large number of cities (such as the BLS' Quarterly Census of Employment and Wages), this paper pursues a different approach. First, Davis and Haltiwanger's (2001) near-VAR model is used to estimate time series models for individual cities and construct city-level impulse responses. In a second stage, characteristics of the impulse responses are modeled as a function of different city-level cross sectional variables in order to determine why there are differences in the impulse responses across cities. A bootstrapping procedure spanning both stages is used for statistical inference.

By finding systematic differences in regional supply elasticities, a major conflict in the literature is resolved. Results presented in this paper indicate that the accuracy of demand-driven and supply-constrained models is dependent on area characteristics. In growing cities where housing supply can easily adjust through new construction, Blanchard and Katz's (1992) demand-driven framework is appropriate. However, in declining cities where the housing stock cannot change quickly, Bartik's (1991) method better reflects observed urban dynamics. In general, the research in this paper shows that understanding the nature of housing supply in cities is crucial to the choice of modeling approach.

The realization that demand shocks have different effects in different locations has implications for development policies meant to stimulate demand. Employment multipliers are dramatically different in growing versus declining cities, and development policies meant to stimulate employment will have differential effects. In growing cities, positive local demand shocks primarily cause employment to increase with little real benefits to original residents, whereas in declining cities, while employment may not rise as substantially, there are large and permanent benefits to local firms, workers, and homeowners.

# References


Abdel-Rahman, H. M. and Anas, A. (2004). Theories of systems of cities. *Handbook of Urban and Regional Economics*, 4:2293–2339.

Bartik, T. J. (1991). *Who benefits from state and local economic development policies?* W.E. Upjohn Institute for Employment Research, Kalamazoo, Michigan.

Bartik, T. J. (1993). Who benefits from local job growth: Migrants or original residents. *Regional Studies*, 27(4):297–311.

Berkowitz, J. and Kilian, L. (2000). Recent developments in bootstrapping time series. *Econometric Reviews*, 19(1):1–48.

Blanchard, O. J., Katz, L. F., Hall, R. E., and Eichengreen, B. (1992). Regional evolutions. *Brookings Papers on Economic Activity*, 1992(1):1–75.

Braithwait, S. D. (1980). The substitution bias of the Laspeyres price index: An analysis using estimated cost-of-living indexes. *The American Economic Review*, 70(1):64–77.

Broda, C. (2001). Coping with terms-of-trade shocks: Pegs versus floats. *The American Economic Review*, 91(2):376–380.

Broda, C. (2004). Terms of trade and exchange rate regimes in developing countries. *Journal of International Economics*, 63:31–58.

Brown, S. P., Hayes, K. J., and Taylor, L. L. (2003). State and local policy, factor markets, and regional growth. *The Review of Regional Studies*, 33(1):40–60.

Canova, F. and Ciccarelli, M. (2009). Estimating multicountry var models. *International Economic Review*, 50(3):929 – 959.

Carlino, G. and DeFina, R. (1995). Regional income dynamics. *Journal of Urban Economics*, 37(1):88 – 106.

Carlino, G. and Mills, E. (1987). The determinants of county growth. *Journal of Regional Science*, 27(1):39–54.

Clark, D. and Murphy, C. (1996). Countywide employment and population growth: An analysis of the 1980s. *Journal of Regional Science*, 36(2):235–256.

Davis, S. J. and Haltiwanger, J. (2001). Sectoral job creation and destruction responses to oil price changes. *Journal of Monetary Economics*, 48:465–512.

Efron, B. (1981). Nonparametric standard errors and confidence intervals. *Canadian Journal of Statistics*, 9(2):139 158.

Glaeser, E. and Gyourko, J. (2005). Urban decline and durable housing. *Journal of Political Economy*, 113(2):345–000.

Glaeser, E., Gyourko, J., and Saks, R. E. (2005). Why is manhattan so expensive? regulation and the rise in housing prices. *The Journal of Law and Economics*, 48(2):331–369.

Glaeser, E. L., Gyourko, J., and Saks, R. E. (2006). Urban growth and housing supply. *Journal of Economic Geography*, 6(1):71–89.

Green, R. K., Malpezzi, S., and Mayo, S. K. (2005). Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources. *The American Economic Review*, 95(2):334–339.

Grimes, A. and Aitken, A. (2010). Housing supply, land costs and price adjustment. *Real Estate Economics*, 38(2):325–353.

Gyourko, J. and Tracy, J. (1991). The structure of local public finance and the quality of life. *The Journal of Political Economy*, 99(4):774–806.

Henderson, J. V. (1974). The sizes and types of cities. *The American Economic Review*, 64(4):640–656.

Henderson, V. (1988). *Urban Development: Theory, Fact, and Illusion*. Oxford University Press, New York.

Hollar, M. K. (2011). Central cities and suburbs: Economic rivals or allies? *Journal of Regional Science*, 51(2):231–252.

Isard, W. (1960). *Methods of Regional Analysis*. MIT Press, Cambridge, MA.

Kilian, L. (1999). Finite-sample properties of percentile and percentile-t bootstrap confidence intervals for impulse responses. *The Review of Economics and Statistics*, 81(4):pp. 652–660.

Kilian, L. (2001). Impulse response analysis in vector autoregressions with unknown lag order. *Journal of Forecasting*, 20(3):161–179.

Kose, M. A. (2002). Explaining business cycles in small open economies: How much do world prices matter? *Journal of International Economics*, 56(2):299 – 327.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99(3):483.

Mendoza, E. G. (1995). The terms of trade, the real exchange rate, and economic fluctuations. *International Economic Review*, 36(1):pp. 101–137.

Moretti, E. (2010). Local labor markets. Working Paper 15947, National Bureau of Economic Research.

Notowidigdo, M. J. (2010). The incidence of local labor demand shocks. Unpublished manuscript, MIT.

Pennington-Cross, A. (1997). Measuring external shocks to the city economy: An index of export prices and terms of trade. *Real Estate Economics*, 25(1):105–128.

Rickman, D. S. (2010). Modern macroeconomics and regional economic modeling. *Journal of Regional Science*, 50(1):23–41.

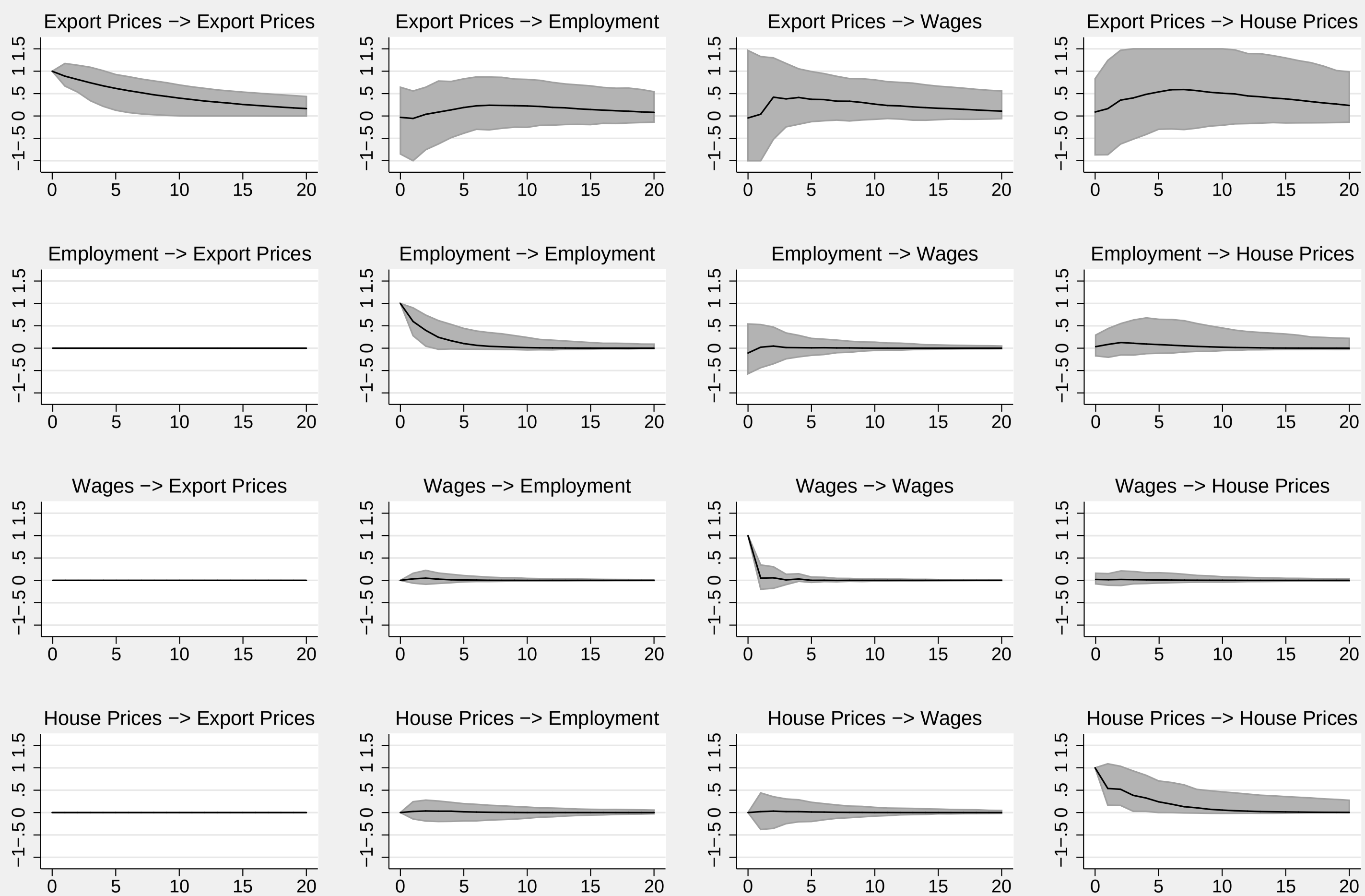
Roback, J. (1982). Wages, rents, and the quality of life. *The Journal of Political Economy*, 90(6):1257–1278.

Saiz, A. (2010). The geographic determinants of housing supply. *The Quarterly Journal of Economics*, 125(3):1253–1296.

Saks, R. E. (2008). Job creation and housing construction: Constraints on metropolitan area employment growth. *Journal of Urban Economics*, 64(1):178 – 195.

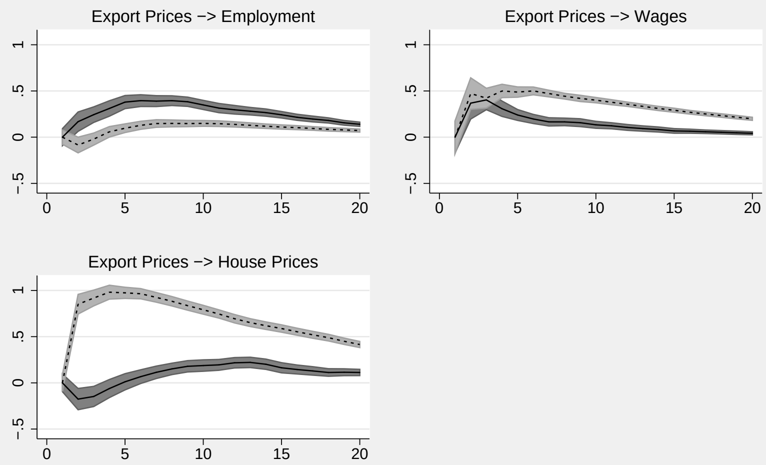
Sims, C. A., Stock, J. H., and Watson, M. W. (1990). Inference in linear time series models with some unit roots. *Econometrica*, 58(1):113–144.

Figure 1: Impulse Response Functions of 352 Cities




Effect of a 1 unit shock to X on Y, t quarters from the shock.
The shaded area is the 10th to the 90th percentile and the solid line is the median.

Figure 2: Impulse responses in growing vs. declining cities




Effect of a 1 unit shock to X on Y, t quarters from the shock.
The solid line represents a growing city (5th percentile of the Urban Decline Index).
The dotted line represents a declining city (95th percentile of the Urban Decline Index).
Shaded areas are +/− 2 SEs (bootstrapped).

Table 1: VAR results

| VARIABLES | [1]<br>EPI | [2]<br>Employment | [3]<br>Wages | [4]<br>House prices |
|---|---|---|---|---|
| EPI (t-1) | 0.891 | -0.037 | 0.027 | 0.081 |
| | (0.486, 1.265) | (-0.988, 0.762) | (-2.375, 1.94) | (-0.948, 1.564) |
| EPI (t-2) | -0.015 | 0.138 | 0.349 | 0.116 |
| | (-0.375, 0.245) | (-0.721, 1.154) | (-1.452, 2.75) | (-1.128, 1.252) |
| Employment (t-1) | | 0.597 | 0.035 | 0.058 |
| | | (0.155, 1.007) | (-0.56, 0.746) | (-0.265, 0.45) |
| Employment (t-2) | | 0.002 | 0.020 | 0.022 |
| | | (-0.331, 0.28) | (-0.633, 0.637) | (-0.233, 0.374) |
| Wages (t-1) | | 0.033 | 0.049 | 0.009 |
| | | (-0.102, 0.251) | (-0.294, 0.456) | (-0.165, 0.172) |
| Wages (t-2) | | 0.029 | 0.004 | 0.009 |
| | | (-0.133, 0.231) | (-0.293, 0.293) | (-0.198, 0.168) |
| House prices (t-1) | | 0.026 | 0.022 | 0.538 |
| | | (-0.225, 0.291) | (-0.563, 0.539) | (0.067, 1.284) |
| House prices (t-2) | | -0.013 | 0.011 | 0.131 |
| | | (-0.304, 0.242) | (-0.628, 0.591) | (-0.419, 0.422) |
| U.S. PPI (t-1) | 0.012 | -0.052 | -0.244 | 0.019 |
| | (-0.043, 0.201) | (-0.294, 0.158) | (-0.771, 0.267) | (-0.236, 0.293) |
| U.S. PPI (t-2) | -0.011 | 0.052 | 0.042 | -0.043 |
| | (-0.081, 0.118) | (-0.203, 0.31) | (-0.451, 0.649) | (-0.296, 0.234) |
| U.S. Employment (t-1) | 0.188 | 0.811 | 0.684 | 0.039 |
| | (-0.129, 0.581) | (-0.044, 2.015) | (-1.086, 2.964) | (-0.815, 1.141) |
| U.S. Employment (t-2) | -0.172 | -0.563 | -0.348 | -0.147 |
| | (-0.59, 0.152) | (-1.745, 0.382) | (-2.574, 1.453) | (-1.101, 0.746) |
| U.S. Wages (t-1) | 0.003 | -0.070 | -0.052 | -0.052 |
| | (-0.022, 0.087) | (-0.31, 0.116) | (-0.493, 0.325) | (-0.271, 0.166) |
| U.S. Wages (t-2) | 0.024 | -0.014 | 0.069 | 0.008 |
| | (-0.008, 0.118) | (-0.295, 0.212) | (-0.231, 0.53) | (-0.204, 0.225) |
| U.S. House Prices (t-1) | 0.004 | 0.045 | 0.376 | 0.344 |
| | (-0.123, 0.237) | (-0.363, 0.683) | (-0.501, 1.389) | (-0.228, 1.645) |
| U.S. House Prices (t-2) | 0.010 | -0.076 | -0.158 | -0.283 |
| | (-0.231, 0.141) | (-0.644, 0.341) | (-1.144, 0.725) | (-1.338, 0.296) |
| N | 352 | 352 | 352 | 352 |
| T | 71 | 71 | 71 | 71 |

A constant term and quarterly fixed effects are included in regressions, but not presented for brevity. Medians presented above the 5th and 95th percentile estimates in parentheses.

Table 2: Differences in impulse responses by area characteristic

| Measure | EPI->Employment | EPI->Wage | EPI->House prices |
|---|---|---|---|
| Urban decline | | | |
| Urban Decline | -0.081* | 0.091* | 0.269* |
| Index | (0.014) | (0.011) | (0.016) |
| Change in c.c | -0.889 | -9.626* | -17.998* |
| house value | (1.55) | (1.821) | (2.586) |
| Fraction of pop. | -0.61* | 0.438* | 1.316* |
| from same state | (0.091) | (0.074) | (0.115) |
| Average January | 0.003* | -0.005* | -0.02* |
| temperature | (0.0009) | (0.0009) | (0.0013) |
| Change in c.c | 10.905* | -6.902* | -19.07* |
| population | (1.44) | (0.992) | (1.41) |

This table present the estimates from the following regressions:

$$\theta_i^{c,v} = a + \pi X_i + \varepsilon_i$$

where $\theta_i^{c,v}$ is variable $v$'s 4th quarter response to an EPI shock ($v$ listed in the column header) and $X_i$ is a city-specific cross-sectional variable listed by row. this equation is estimated using STATA's RREG command, which downweights extreme values. Table cells present the mean estimate of $\pi$ and the values below are standard errors.

# APPENDIX

## A-1 The Comparative Statics of Regional Development

The following regional equilibrium model generates predictions about the relation among the elasticity of housing supply and the effects of demand shocks on employment, wages, and house prices. In declining cities, where the elasticity of housing supply is lower, an exogenous change to export demand has a smaller effect on employment and a larger effect on wages and house prices compared with growing cities.

This model includes product, housing, and labor markets. Following Roback (1982), Gyourko and Tracy (1991), and Brown, Hayes and Taylor (2003), representative households migrate until indirect utilities across cities are equalized. Representative firms are perfectly competitive and equilibrium profits are zero. Following the economic base model and the system of cities literature, demand for urban exports drives local economic activity [25] In each city, only one good is produced for export. The city imports all other intermediate goods used in production and consumption goods. All cities are price takers for imports and exports, following the assumptions in Henderson (1988) and Hollar (2011).

Each of these markets is represented using general functional forms such as in Bartik (1991) and Gyourko and Tracy (1991), Brown, Hayes and Taylor (2003). Alternative regional models such as those found in Blanchard and Katz (1992) and Saks (2008) express the economy in a series of linear relationships. However, in order for these models to accurately reflect the data, they rely on one particularly strong assumption: that the marginal product of labor is constant or decreasing with respect to the level of employment in a city. This assumption runs counter to the voluminous literature on agglomeration economies. There exists a tension in cities between increasing returns to additional residents and increasing costs of living, according to Henderson (1974, 1988) and Abdel-Rahman and Anas (2004). In these models, the marginal product of labor is increasing with the population of the city, which is reflected in the higher wages and rental prices of housing services found in larger cities. What is necessary is a model that derives plausible comparative statics but, at the same time, allows for increasing returns to labor. The model in this section is developed with this in mind.

The representative household derives utility from housing $H$ and an imported composite good $X$.

$$U = U(H, X) \tag{A-1.1}$$

Consumption for each household is subject to a budget constraint, where $w$ is the wage, $r$ is the rental price of housing services and the price of the composite good is set equal to one.

[25] Urban exports are goods and services exported to other cities and regions. These cities and regions can be in the same country or another country.

Each household supplies exactly one unit of labor, so household income is $w$.

$$w = rH + X \tag{A-1.2}$$

Combining equations A-1.1 and A-1.2, housing demand can be expressed as an implicit function of wages and house prices.

$$H = H^D(w, r) \tag{A-1.3}$$

$$H_r^D < 0,\ H_w^D > 0$$

Labor supply can be solved using the traditional regional equilibrium condition where each household receives an indirect utility $\bar{V}$ and can costlessly and immediately move to another location to achieve it if necessary.

$$L = L^S(w, r) \tag{A-1.4}$$

$$L_r^S < 0,\ L_w^S > 0$$

Housing is supplied by competitive firms seeking to maximize profits.

$$\Pi^H = rH - P_N N - P_S S \tag{A-1.5}$$

Housing is produced using structure and land inputs with constant returns to scale.

$$H = H(N, S) \tag{A-1.6}$$

Structure inputs are imported and have a constant price $P_S$. However, land is scarce, leading to an upward sloping housing supply curve as a function of $N$.

$$P_N = P_N(N) \tag{A-1.7}$$

$$P_N' > 0$$

Combining equations A-1.6 and A-1.7 with equation A-1.5 and assuming long run profits for housing developers are zero, housing supply is expressed as an implicit function of rents and structure prices.

$$H = H^S(r; P_S) \tag{A-1.8}$$

$$H_r^S > 0,\ H_{P_S}^S < 0$$

A single good is produced in the city by competitive firms for export using labor and basket of imported intermediate inputs. Profits of these firms can be written as

$$\Pi^Q = PQ - wL - P_M M \tag{A-1.9}$$

Production of the export good is characterized by constant returns to scale in intermediate inputs but increasing returns to scale in labor at the city level, reflecting agglomeration economies.

$$Q = A(L)G(L, M) \tag{A-1.10}$$

Intermediate goods and labor are not modeled explicitly as complements or substitutes in production as this is an empirical matter.[26] The effect of a change in $L$ on $Q$ can be decomposed into two effects, an agglomeration effect and a private marginal product effect.

$$\frac{dQ}{dL} = A_L(L)G(L, M) + A(L)G_L(L, M) > 0 \tag{A-1.11}$$

This agglomeration effect is assumed to be small so that the marginal product effect dominates, and

$$\frac{d^2Q}{dL^2} < 0 \tag{A-1.12}$$

Thus, marginal product of labor decreases in $L$ even though there are agglomeration economies. The labor demand relation is then

$$L = L^D(w; P, P_M) \tag{A-1.13}$$

$$L_w^D < 0,\ L_P^D > 0,\ L_{P_M}^D < 0$$

Because city production of the export good is a small fraction of world demand, demand for the export good is perfectly elastic at the national price, $P$. This identifies the output supply curve as an implicit function of $w$ alone.

$$Q = Q^S(w; P, P_M) \tag{A-1.14}$$

$$Q_w^S < 0,\ Q_P^S > 0,\ Q_{P_M}^S < 0$$

Equations A-1.3, A-1.4, A-1.8, and A-1.13, combined with the market clearing conditions $H_S = H_D$ and $L_S = L_D$, gives the system of equations in (A-1.15). Once the wage is determined, so is $Q$ by equation A-1.14.

(A-1.15)

$$H^D(w, r) - H^S(r; P_S) = 0$$

$$L^D(w; P_m, P) - L^S(w, r) = 0$$

Taking the total derivative of this system gives the following equation:

(A-1.16)

[26]

$$Q_L > 0,\ Q_{LL} < 0,\ Q_M > 0,\ Q_{MM} = 0,\ Q_{LM} = Q_{ML} <> 0$$

$$A_L > 0,\ A_{LL} > 0,\ G_L > 0,\ G_{LL} < 0,\ G_M = 0,\ G_{MM} < 0,\ G_{LM} = G_{ML} <> 0$$

$$\begin{bmatrix} H_w^D & H_r^D - H_r^S \\ L_w^D - L_w^S & -L_r^S \end{bmatrix} \begin{bmatrix} dw \\ dr \end{bmatrix} = \begin{bmatrix} H_{P_S}^S dP_S \\ -L_{P_M}^D dP_M - L_P^D dP \end{bmatrix}$$

Invoking the implicit function theorem and using Cramer's rule, the effect of a change in $P, P_M$ and $P_S$ on wages $w$ and the price of housing services $r$ can each be found in turn.

The term $(H_r^D - H_r^S)(L_w^D - L_w^S)$ represents the direct effects of price changes on the respective markets and the term $H_w^D(-L_r^S)$ represents the indirect effects of price changes on other markets. For this reason, it is assumed that$(H_r^D - H_r^S)(L_w^D - L_w^S) > H_w^D(-L_r^S)$ and the determinant $\Delta$ is negative.[27]

$$\Delta = H_w^D(-L_r^S) - (H_r^D - H_r^S)(L_w^D - L_w^S) < 0 \tag{A-1.17}$$

The comparative static effects of an export price change are as follows. First, a positive change to export prices increase wages and house prices.

$$\frac{dw}{dP} = \frac{1}{\Delta}(H_r^D - H_r^S)L_P^D > 0 \tag{A-1.18}$$

$$\frac{dr}{dP} = \frac{1}{\Delta}H_w^D(-L_P^D) > 0 \tag{A-1.19}$$

Next, positive changes to the prices of intermediate inputs decrease wages and house prices when labor and intermediate inputs are complements, and increase wages and house prices when labor and intermediate inputs are substitutes.

$$\frac{dw}{dP_M} = \frac{1}{\Delta}(H_r^D - H_r^S)L_{P_M}^D <> 0 \tag{A-1.20}$$

$$\frac{dr}{dP_M} = \frac{1}{\Delta}H_w^D L_{P_M}^D <> 0 \tag{A-1.21}$$

Finally, positive changes to the price of structure inputs increase wages and house prices.

$$\frac{dw}{dP_S} = \frac{1}{\Delta}(-L_r^S)H_{P_S}^S > 0 \tag{A-1.22}$$

$$\frac{dr}{dP_S} = \frac{1}{\Delta}(L_w^D - L_w^S)(-H_{P_S}^S) > 0 \tag{A-1.23}$$

This model can be used to examine the relation between urban decline and the effects of export price shocks $dP$. Urban decline reduces the elasticity of housing supply, so the derivative of the comparative statics with respect to $H_r^S$ will give the predicted effect of urban decline. First, taking the partial derivative of equation A-1.18 shows that reducing the elasticity of housing supply increases the effect of export price changes on wages.

[27]The determinant is

$$\Delta \equiv \det A \equiv \begin{vmatrix} H_w^D & H_r^D - H_r^S \\ L_w^D - L_w^S & -L_r^S \end{vmatrix}$$

$$\frac{\partial \frac{dw}{dP}}{\partial H_r^S} = \frac{1}{\Delta^2}\left[H_w^D(-L_r^S)(-L_P^D)\right] < 0 \tag{A-1.24}$$

Taking the partial derivative of equation A-1.19 shows that reducing the elasticity of housing supply also increases the relation between urban decline and the effects of export price shocks on the rental price of housing services.

$$\frac{\partial \frac{dr}{dP}}{\partial H_r^S} = \frac{1}{\Delta^2}\left[-H_w^D(L_w^D - L_w^S)(-L_P^D)\right] < 0 \tag{A-1.25}$$

The effect of urban decline on the effects of export price shocks on employment can be found from equation A-1.13. Taking the total derivative of equation A-1.13 with respect to $P$ yields:

$$\frac{dL}{dP} = \frac{dL^D}{dP} = L_P^D + L_w^D\frac{dw}{dP} \tag{A-1.26}$$

And taking the partial derivative of equation A-1.26 with respect to $H_r^S$ gives

$$\frac{\partial \frac{dL}{dP}}{\partial H_r^S} = L_w^D\frac{\partial \frac{dw}{dP}}{\partial H_r^S} > 0 \tag{A-1.27}$$

Thus, the employment effect of an export price shock declines with the elasticity of housing supply. What is interesting is that the partial elasticities of labor supply ( $L_w^S$ and $L_r^S$) remain unchanged, but the total elasticity when considering the housing market ($dL/dw$ and $dL/dr$), falls from the previous level.

This simple model formalizes the Glaeser and Gyourko (2005) argument that, in declining areas with inelastic housing supply, the effects of demand shocks on wages and house prices are large while the effects on employment are small. Additionally, this model shows that export price changes unambiguously and positively affect wages, house prices, output, and employment.

# A-2 Export Price Index construction

All data used in the construction of the Export Price Index (EPI) are produced by the U.S. Bureau of Labor Statistics and are publicly available. The primary challenge involves matching NAICS-denoted industry codes with non-NAICS-denoted data because much of the available historical price data are denoted in SIC codes, commodity codes, and consumer price codes.

The weights are from Quarterly Census of Employment and Wages (QCEW) and the computation is straightforward. The first task is to determine the base year. Braithwait (1980) finds that the Laspeyres substitution bias increases in the amount quantities and prices differ from the base year quantities and prices. Because of this, industry weights are calculated as the average of employment in 1990, 1995, 2000, and 2005. After constructing the industry weights by location, the next steps are to calculate location quotients, export employment, and EPI quantity weights for NAICS 6-digit industries.

Prices are from the BLS's PPI and CPI tables. The PPI tables used are the PPI-Industry SIC table, the PPI-Industry NAICS table, and the PPI-Commodity table. The CPI table used is the CPI current series for urban consumers.

The first step in creating the price panel is to map NAICS-denoted PPI-industry prices to QCEW industries. When a price is missing, the following strategy is used to fill in the missing values. Each NAICS-denoted industry for which there are missing values is sequentially matched to a SIC-denoted PPI-industry, a PPI-commodity series, or a CPI series and missing observations are filled. This matching is done based on a Census translation table in the case of SIC codes. For commodities and services, the description in the dataset is used for matching. If price data are still missing when this matched price data are used, prices from the next highest classification level are used. If price data are still missing then the CPI-All Items series is used.[28]

Figure A-5 shows the EPI along with employment in four representative cities. In each, the EPI tracks employment to varying degrees. In New York, Austin, and Las Vegas, the EPI follows employment fairly closely, whereas in Erie, they appear to be somewhat unrelated. More generally, Table A-1 shows the results of single-equation random coefficient models. These estimates indicate that the EPI is highly correlated with other urban variables. The EPI effect on employment, wages, and house prices in cities appears to be different, as evidenced by rejections of $\chi^2$ tests of equal parameters across cities. Of course correlation does not imply causality, and the following empirical sections will determine the effects of export prices, but Figure A-5 and Table A-1 indicate that there is likely to be some relationship, and that this relationship may be different across cities

[28]One problem is that many of these series have different base years, both across industries and within industries, because some industries take prices from several price series. To address this, price growth rates are generated and a new price series is constructed based on these growth rates. This series has a value of 100 in the first period and grows at a rate of the composite industry price series. During periods of transition from one price series to another, there will necessarily be a missing growth rate. This is treated as a missing price and filled using the methods described above.

## A-3 Measures of Urban Decline

Several indices of urban decline have been used to identify cities where house prices are significantly below replacement costs. In general, both determinants and observed characteristics of decline have been used for this purpose. Glaeser and Gyourko (2005) attempt to measure this directly by comparing asset price with an estimate of construction cost. They also argue that technological advances such as air conditioning combined with warm weather has acted as a positive amenity shock over the second half of the 20th century, and that this has had an effect on the growth or decline of cities. Saiz (2010) proxies for urban decline using the population change in previous 20-year period and the fraction of migrants in the population in the first period of the estimation.

In order to parsimoniously express these measures in a single variable, an index of urban decline is created. This new measure is called the urban decline index (UDI), and is constructed by summing standardized versions of the four variables listed above. The first is the percentage change in the value of the median housing unit in the center-city between 1970 and 2000. The second is the average January temperature. The third is the fraction of the population from the same state in 1990. Finally, the fourth is the change in the population in the center-city between 1970 and 2000. The first and fourth variables are from the State of the Cities Data System (SOCDS) produced by the U.S. Department of Housing and Urban Development. The second variable is from the U.S. Department of Agriculture's Natural Amenities dataset. The third variable is from the U.S. Census' "USA Counties Data File."

A histogram of the values in the UDI is found in Figure A-6. Some extreme values of the UDI are found in Table A-2. Higher values of the UDI indicate a greater degree of urban decline. Of the smallest values of the UDI, most are in warm, high-growth areas. These cities each have experienced high house price appreciation and population growth between 1970 and 2000. Of the cities with large UDI values, most are in cold, Rust Belt cities. These cities have seen declines in central-city populations and relatively flat nominal house prices.

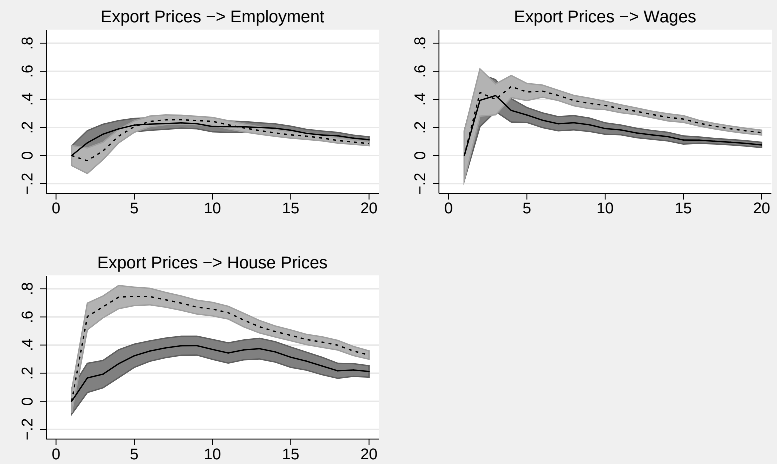
The UDI is highly correlated with housing market regulation as shown in Figure A-7. This provides support for Saiz's (2010) contention that land use regulation varies inversely with urban decline.

Table A-1: Statistical relationships between the Export Price Index (EPI) and other urban variables

| | (1)<br>ln employment | (2)<br>ln wage | (3)<br>ln house prices |
|---|---|---|---|
| ln Export Price Index | 0.605*** | 1.257*** | 1.748*** |
| | (0.0229) | (0.0205) | (0.0330) |
| Constant | 8.563*** | 0.617*** | -4.043*** |
| | (0.135) | (0.107) | (0.160) |
| Observations | 23472 | 23472 | 23472 |
| T | 72 | 72 | 72 |
| N | 326 | 326 | 326 |
| $\chi^2$ value under the null of constant parameters | 2.2E+07 | 6.0E+06 | 1.7E+05 |
| p-value | <0.001 | <0.001 | <0.001 |

Notes:
This table presents the results of three random coefficient models.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure A-1: Impulse response robustness check: Δ median central city house value, 1970-2000



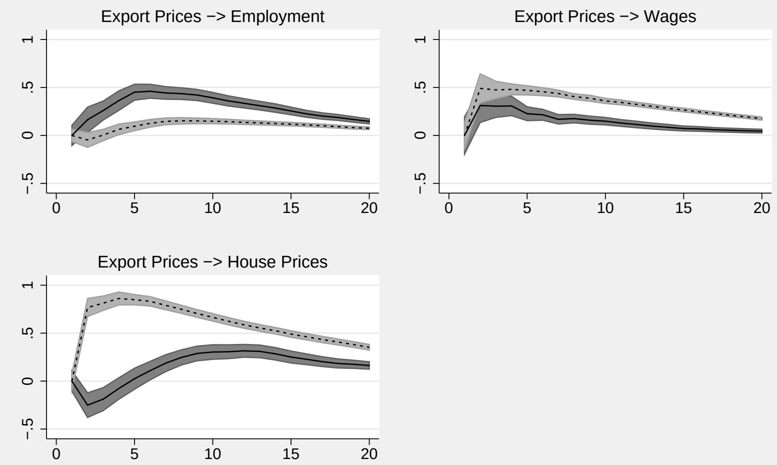

Effect of a 1 unit shock to X on Y, t quarters from the shock.
The solid line represents a growing city (95th percentile of the change in c.c. house value).
The dotted line represents a declining city (5th percentile of the change in c.c. house value).
Shaded areas are +/− 2 SEs (bootstrapped).

Table A-2: The Urban Decline Index

Table 3. Top and bottom growing cities

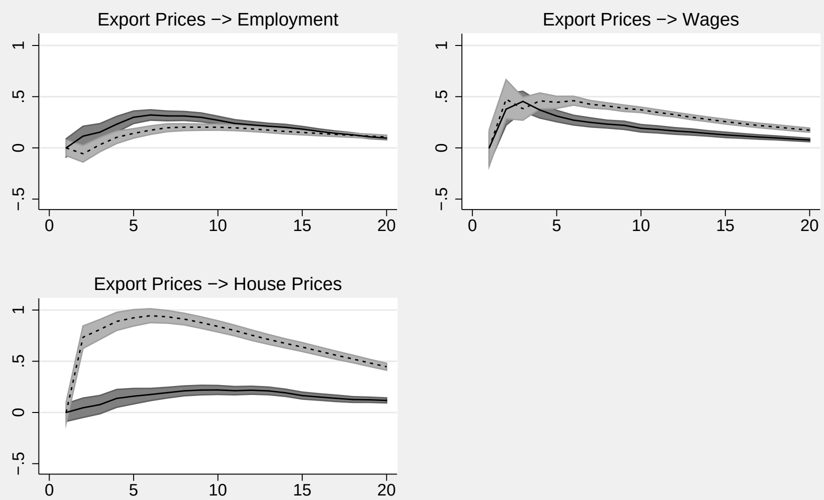
| CBSA code | CBSA name | Average January temperature (degrees F) | Average annual change in median house value in city center (1970-2000) | Average annual change in population in city center (1970-2000) | Fraction of population in CBSA from the same state (1990) | Urban Decline Index |
|---|---|---|---|---|---|---|
| Top 10 cities | | | | | | |
| 37380 | Palm Coast, FL | 58 | 7.7% | 8.0% | 19.7% | -4.31 |
| 34940 | Naples-Marco Island, FL | 65 | 6.8% | 6.3% | 19.0% | -3.63 |
| 39460 | Punta Gorda, FL | 64 | 6.2% | 5.5% | 13.5% | -3.22 |
| 15980 | Cape Coral-Fort Myers, FL | 64 | 6.2% | 4.8% | 20.8% | -2.84 |
| 38940 | Port St. Lucie, FL | 64 | 6.4% | 4.7% | 25.2% | -2.84 |
| 25980 | Hinesville-Fort Stewart, GA | 51 | 7.7% | 4.1% | 34.2% | -2.65 |
| 42680 | Sebastian-Vero Beach, FL | 63 | 6.7% | 3.8% | 26.6% | -2.63 |
| 39140 | Prescott, AZ | 36 | 7.6% | 5.1% | 28.3% | -2.58 |
| 42100 | Santa Cruz-Watsonville, CA | 49 | 9.6% | 2.4% | 55.6% | -2.49 |
| 36740 | Orlando-Kissimmee, FL | 60 | 6.6% | 3.8% | 29.1% | -2.48 |
| Bottom 10 cities | | | | | | |
| 45060 | Syracuse, NY | 23 | 5.2% | 0.1% | 80.2% | 1.42 |
| 40980 | Saginaw-Saginaw Township, MI | 21 | 5.5% | -0.2% | 81.6% | 1.44 |
| 13020 | Bay City, MI | 23 | 5.7% | -0.2% | 89.7% | 1.49 |
| 20260 | Duluth, MN-WI | 9 | 6.0% | -0.2% | 76.8% | 1.49 |
| 20220 | Dubuque, IA | 18 | 5.5% | -0.1% | 81.3% | 1.51 |
| 15380 | Buffalo-Niagara Falls, NY | 24 | 5.3% | -0.5% | 81.4% | 1.54 |
| 21300 | Elmira, NY | 25 | 4.8% | -0.4% | 74.4% | 1.54 |
| 13780 | Binghamton, NY | 22 | 4.8% | -0.2% | 73.3% | 1.59 |
| 47940 | Waterloo-Cedar Falls, IA | 16 | 5.3% | -0.1% | 81.3% | 1.66 |
| 46540 | Utica-Rome, NY | 18 | 5.1% | -0.4% | 82.7% | 1.82 |

Figure A-2: Impulse response robustness check: fraction of population from same state



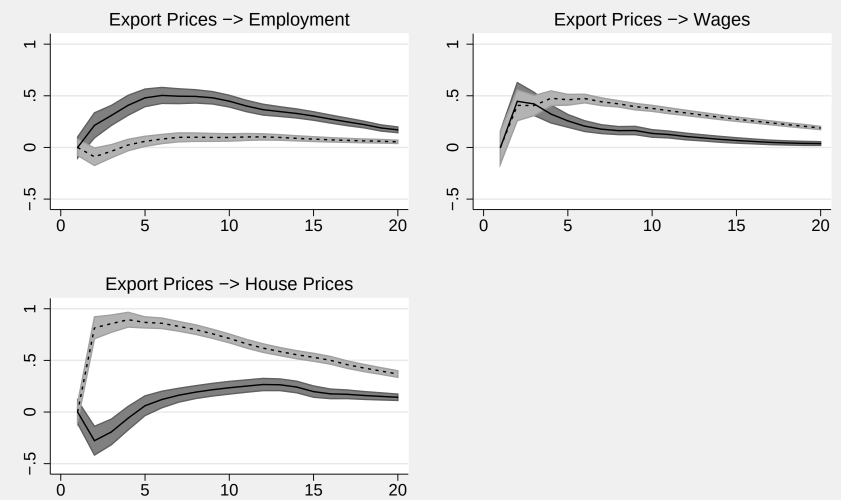

Effect of a 1 unit shock to X on Y, t quarters from the shock.
The solid line represents a growing city (5th percentile of the fraction of population from same state).
The dotted line represents a declining city (95th percentile of the fraction of population from same state).
Shaded areas are +/− 2 SEs (bootstrapped).

Figure A-3: Impulse response robustness check: average January temperature



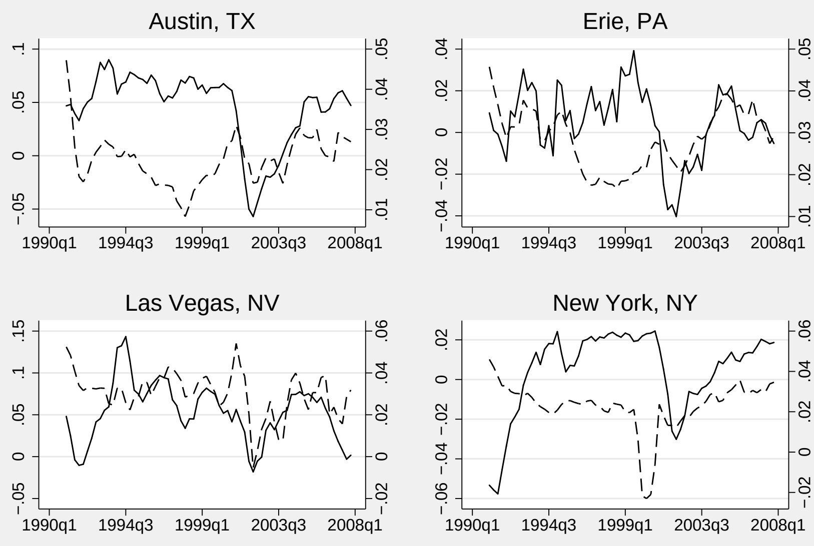

Effect of a 1 unit shock to X on Y, t quarters from the shock.
The solid line represents a growing city (95th percentile of the average January temperature).
The dotted line represents a declining city (5th percentile of the average January temperature).
Shaded areas are +/− 2 SEs (bootstrapped).

Figure A-4: Impulse response robustness check: %$\Delta$ central city population, 1970-2000




Effect of a 1 unit shock to X on Y, t quarters from the shock.
The solid line represents a growing city (95th percentile of the change in c.c. population ).
The dotted line represents a declining city (5th percentile of the change in c.c. population ).
Shaded areas are +/− 2 SEs (bootstrapped).

Figure A-5: Export prices and employment: representative cities




Graphs present year−on−year differences in the log of employment (solid line, left axis) and the log of the Export Price Index (EPI) (dotted line, right axis).

Figure A-6: Histogram of the Urban Decline Index

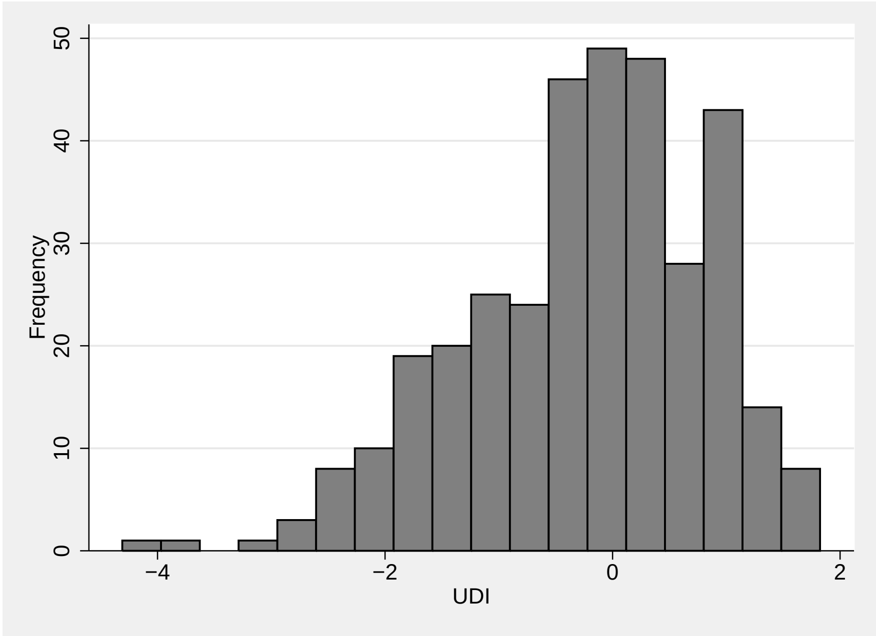


Figure A-7: Urban decline and land use regulations