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Quantifying the Costs of Restricting Local Housing Development

Housing Supply Elasticities and Aggregate Labor Misallocation in Sweden

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Abstract

Housing prices have risen dramatically in Stockholm over the past two decades, while the housing stock has increased by a comparably minor amount. Seen through a spatial equilibrium framework, this indicates that Stockholm is contributing to increased labor misallocation, lowering aggregate Swedish output. We proceed to estimate local housing supply elasticities for 19 Swedish counties, as well as how land restrictions determine the supply elasticity in Stockholm, using an instrumental variables method. Employing a spatial equilibrium model with idiosyncratic location preferences, we then quantify the aggregate economic loss of labor misallocation caused by Stockholm land restrictions hindering workers from accesing Stockholm's labor market between 1996 and 2018. Had Stockholm adopted the same level of land restrictions as the national mean, annual real per capita growth in Sweden would have been at least 8.5% higher during the period in question.

Keywords: Housing Supply Elasticity, Spatial Labor Misallocation, Spatial Equilibrium, Sweden
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Contents

1 Introduction

Real housing prices in Sweden have increased rapidly over the past two decades. This is especially so in major cities, and in Stockholm in particular. Intuitively, if workers are prevented from accessing high-productivity cities by excessively priced housing, the economy suffers losses to aggregate output and welfare. This efficiency loss is a consequence of labor misallocation; due to ill-functioning housing markets, firms are unable to employ the optimum level of labor, and workers are unable to move to areas where they would be most productive, forcing them to settle and work elsewhere. Lowered aggregate output due to labor misallocation is therefore a direct consequence of housing prices diverging excessively, and was first quantified by Hsieh and Moretti in their 2019 paper *Housing Constraints and Spatial Misallocation* (Hsieh and Moretti, 2019). The cost of housing, like any good, is determined by the equilibrium level of supply and demand. Central to this notion is the elasticity of housing supply or the relative size of the housing stock response to a demand shock. Understanding the elasticity of housing supply in Sweden, along with the determinants of that elasticity, is therefore a key step to quantifying the cost of spatial labor misallocation.

In this paper, we proceed to estimate the long-run elasticity of housing supply in 19 Swedish counties during the period between 1996–2018 using an IV method employing exogenous demand shifters as instruments to identify the supply curve. We find that Stockholm county has the lowest level of elasticity, below unit, at 0.869, compared to the national average of 1.241.[1] In order to unlock the proverbial elasticity 'black box' and increase understanding of the effects of local land use policy, we also investigate how the share of land covered by wildlife preserves and other measures preventing new construction ('protected land') determine that elasticity. Stockholm has the largest share of protected land among all counties, and the average share among Stockholm municipalities is above the 90th percentile of the nationwide municipal distribution. We find that relaxing land protections in Stockholm county to the Swedish average would increase the elasticity of supply by around 2%.

Inspired by Hsieh and Moretti (2019), we then utilize the estimated elasticities in a spatial equilibrium model to calculate the aggregate output cost of labor misallocation. Under a counterfactual scenario where local land protections in Stockholm were relaxed to equal the national average, we find that aggregate Swedish real output growth between 1996 and 2018 would have been at least 8.5% higher, on an annual basis.

[1] Implying that, as prices rise by 1%, the housing stock increases by 0.869% and 1.241% respectively.

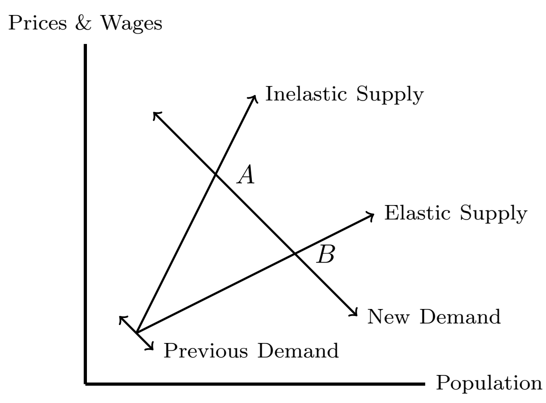
1.1 Theoretical Background

In urban economics, cities and the populations that live in and move between them are studied through the framework of the *spatial utility equilibrium.* Under this stylized view, homogeneous workers choose cities to settle in based on local wages, housing costs, and positive amenities.[2] The 'insides' of the cities themselves are not considered – local wages and house prices are set by functions that represent local labor and housing markets, and are homogeneous for all residents in a city. They respond to supply and demand in the usual way: if more workers wish to move to a city, increased demand for housing pushes local prices up. Increased labor supply from all the new workers contributes to pushing wages down. In the standard framework amenities do not respond to workers relocating, although this is a common extension.

The key assumption is that the level of utility experienced by workers in a city, a function of local prices, wages and amenities, must be equal in all cities. If they were not, workers would could improve their lot by simply moving to a city where conditions were more favorable. In response, wages and prices in that city would adjust, until the equilibrium was restored and workers no longer had any incentive to move there.

Local productivity differs between cities. A city experiencing a productivity shock will demand more labor and offer higher wages – subsequently, demand for housing and house prices are also higher. How wages, prices, and workers respond to such a productivity shock is determined by the efficiency of the local housing market, governed by the elasticity of housing supply. A higher elasticity will lead to more homes being constructed (and to more workers moving in) in response to an increase in demand, alleviating the upward pressure on wages brought on by the productivity shock. The relationship is illustrated in Figure 1.

Figure 1: The Elasticity of Housing Supply and Labor



Note: A productivity shock results in increased demand for workers, who subsequently demand more housing. Under an elastic housing supply regime, this results in a limited rise in prices and wages, and a large increase in population, resulting in equilibrium B. Holding everything else constant, a more inelastic supply yields a limited population response and a greater increase in wages and prices, resulting in equilibrium A.
Source: Glaeser et al. (2005).

[2] Amenties, while a slightly nebulous concept, represents everything that provides positive utility to residents not related to wages: from local school quality, to crime, to pleasant weather.

As such, the elasticity of housing supply can be reinterpreted as a determinant of the elasticity of labor,[3] and modulates the economic outcome of productivity shocks. An inelastic labor supply introduces inefficiency, because it forces the local city economy to employ a below-optimal amount of labor. This spatial equilibrium framework is simple, but it can be a powerful tool for explaining why cities have different levels of population, wages, and prices, and why workers move between them. The framework is succinctly summarized by Edward L. Glaeser and Joshua D. Gottlieb in their 2009 paper *The Wealth of Cities*:

> *"Housing supply elasticity will determine whether urban success shows up in more people or higher incomes."*
>
> (Glaeser and Gottlieb, 2009)

1.1.1 The Rosen-Roback or Spatial Equilibrium Model

The standard spatial equilibrium model of urban economics used to explore these dynamics is the Rosen-Roback model. First conceptualized by Sherwin Rosen in 1979 (Rosen, 1979) and further developed and extended by his doctoral student Jennifer Roback in 1982 (Roback, 1982), it models an economy with multiple cities, c, that workers and firms are free to move between, each of which is endowed with a local amenity Q_c.

Workers are assumed to be identical, and seek to optimize utility by choosing quantities of a representative good x, land l, and amenities q (by moving to a different city) subject to a budget constraint decided by wages w and land rent r:

$$\max \quad U(x, l, q) \quad \text{s.t.} \quad w = x + lr$$

This results in the indirect utility function:

$$V(w, r, q) = k$$

This level of indirect utility k must be equal across all cities – otherwise workers could arbitrage increased utility by moving to another city. This is the central concept of the Rosen-Roback model: different local levels of wages, prices and amenities must all balance each other out in equilibrium – the spatial equilibrium condition.

Firms in cities produce a representative good x using local land and labor as inputs, and seek to maximise profits.[4] Perfect competition is assumed, so marginal production costs equal market prices, which are normalized to 1:

$$C(w, r) = 1$$

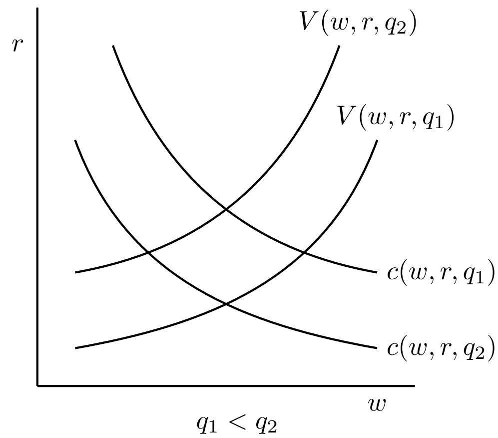
Different production functions can be employed in the model. Cobb-Douglas is by far the most common alternative, which we also employ in this paper. Crucial is that, in order to satisfy the spatial equilibrium

[3]Other determinants of the labor elasticity such as worker propensity for moving, can (and will later be) introduced.

[4]Capital is, of course, also generally included as an input good. But as capital is assumed to be perfectly mobile, the rate of return to capital must be equal across all locations, and hence the term drops out of the optimization problem.

condition, local wages w are decreasing in amenities q. In the Figure 2, the two upward-sloping curves represents a location before and after an amenity shock shifting amenity levels from q_1 to q_2. Because of the spatial equilibrium, utility must equal k both before and after:

Figure 2: Rents, Wages, And Differing Amenity Levels



Source: Roback (1982).

Intuitively, rents are increasing in wages, to maintain the spatial equilibrium. Amenities shift the utility isoquant curve up or down: given the same wage level, a city with better amenities must have higher land rents. Similarly, the downward sloping curves are production isoquants – if land rents are increasing, wages must decrease to enable firms to produce at unit cost. Amenities shift the production curve just like the utility curve, but down instead of up – as higher amenities mean workers are satisfied with lower wages. Hence as amenities increases, equilibrium wages decrease. The effect on land rent is, in this simple set-up, ambiguous. Both workers and firms have conflicting interests – workers prefer more amenities, but dislike the lower wages they infer. Firms on the other hand would prefer low amenity areas, where they would not have to compete for land with workers, but are forced to pay workers higher wages to compensate for the low amenity levels. This simple set-up results in different cities with different levels of wages, rents, and populations in equilibrium.

1.2 Empirical Observations

Housing Supply Falls Short of Demand

From 1996 to 2018, the real price of an average single-family house in Sweden has appreciated by 242%. This stands in stark contrast to other advanced economies, and even to the other Scandinavian countries.

Table 1: Housing Stock and Real Housing Price Growth 1996–2018

Real House Price Growth	
Sweden	242%
Stockholm County	308%
Norway	189%
Denmark	106%
Finland	71%
U.S.	52%
Germany	9%
OECD	49%
Euro Area	37%

Source: Statistics Sweden, OECD, Authors' own calculations.

In comparison, real wages have risen by only 56%. Price increases are even higher when looking at the Swedish capital of Stockholm, where real house prices have risen by an additional 66 percentage points – from levels that were already significantly higher than the national average. As the aggregate housing stock has increased by only $\sim 9\%$, it is clear that supply has not kept up with demand.

Housing market imbalances are especially noticeable in the largest Swedish cities. Over the period 2014–2020, 100% of all Stockholm municipalities have consequently reported in an annual housing market survey conducted by the National Board of Housing, Building and Planning (Sw: Boverket), that they experience a housing shortage in their municipality. The corresponding average shares for the two second largest cities, Gothenburg and Malmö, are 98% and 94% respectively. Nationally, an average of 74% of all municipalities report they experience a housing shortage. Over the full period 1999–2020, an average of 89% of all Stockholm municipalities report experienced housing shortages, compared to the national mean being 48% of all municipalities.[5]

Larger Cities Are,* Ceteris Paribus, *More Productive

It is a well-studied fact that workers in large cities are more productive than their less urban peers. Sveikauskas (1975) posits that dynamic agglomeration effects such as increased innovativeness – as opposed to traditional economies of scale, often denoted as static agglomeration – explain why larger cities experience higher labor

[5] National Board of Housing, Building and Planning have published the annual housing market survey 2013–2014, while the data presented 1999–2012 is based on calculations from the agency's internal working material.

productivity. Doubling a city's size leads to an increase in labor productivity of roughly 5.8% (Ahrend et al., 2014). Workers are also able to increase their productivity, by moving to and working in larger cities. For example, De La Roca and Puga (2016) find that the higher value of experience acquired in large cities – rather than initial sorting of more productive workers – can almost fully account for the wage differential between small and large cities. Further, they conclude that there are no major differences in initial unobservable skills between workers in small and large cities. Rather is working and accumulating experience in cities of different sizes that causes earnings to diverge.

This appears to hold true in Sweden: while no city specific productivity levels have (to our knowledge) been calculated in Sweden, indicative statistics presented in Table 2 reveals that educational attainment, the number of patents, income, and output are significantly higher in Stockholm, the largest city.

As outlined in the theoretical background, we would ordinarily expect this disparity in productivity and wages to attract more workers. If, however, housing supply in Stockholm is restricted, the labor force is smaller than optimal level, and rising productivity would instead lead to local wages and housing prices rising compared to the overall average. This pattern holds true in Sweden – mean prices in Stockholm have increased from $\sim$ 167% of the national average in 1996, to $\sim$ 189% in 2018, and mean wages have risen from $\sim$ 109% to $\sim$ 116%.

Table 2: Indicative Productivity and Innovation Statistics

Average Patents per 100,000 Inhabitants 2008–2019	
Stockholm County	36
Skåne County	24
Västra Götaland County	15
Other Counties	15
Share of Working Population with Tertiary Education 2018	
Stockholm County	38%
Skåne County	33%
Västra Götaland County	30%
Other Counties	26%
Mean Income Relative to National Average 2018	
Stockholm County	16%
Västra Götaland County	-1%
Skåne County	-8%
Other Counties	-6%
GRP per Capita Relative to National Average 2018	
Stockholm County	36%
Västra Götaland County	3%
Skåne County	-14%
Other Counties	-15%

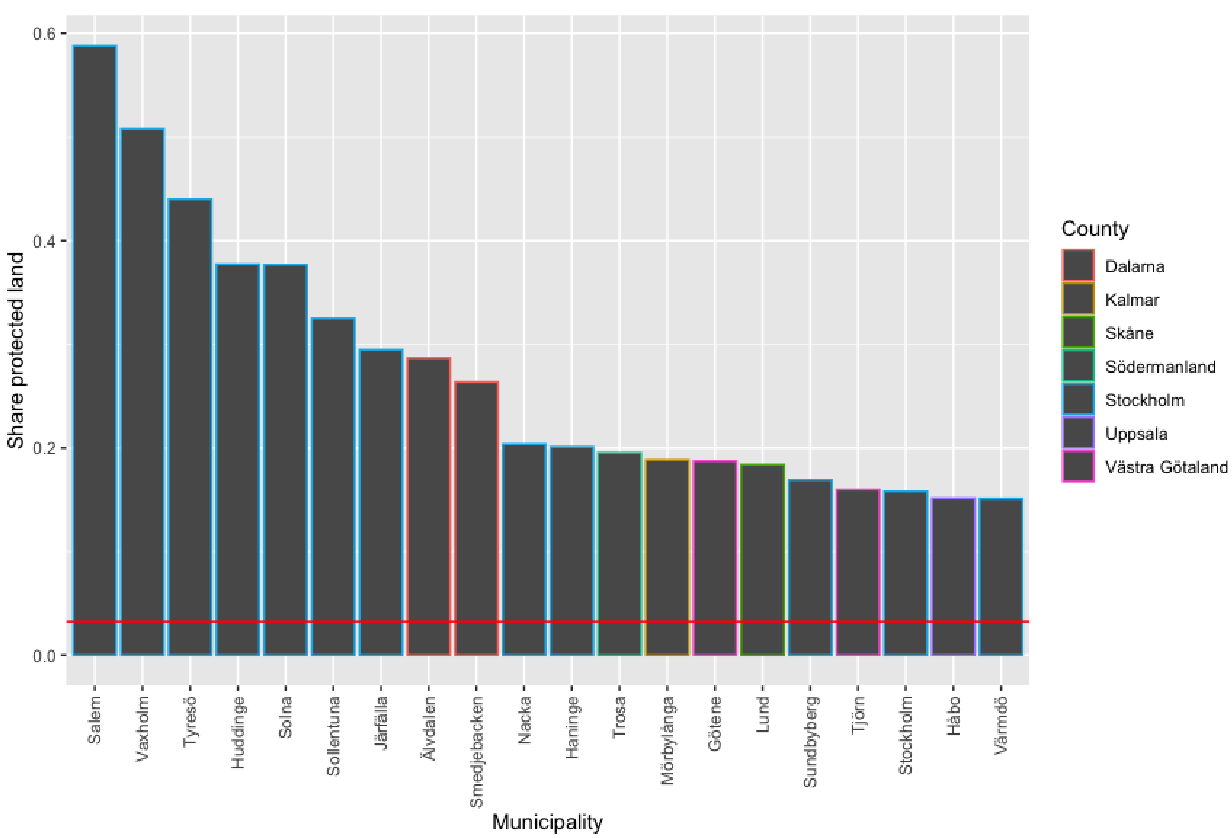
Note: The three counties included in the table are the most populous counties in Sweden. GRP ≡ Gross Regional Product.

Data Source: Swedish Intellectual Property Office, Statistics Sweden.

Stockholm Land Restrictions Have Increased Significantly

Figure 3 presents the top 20 municipalities with the highest share of land covered by land protections.[6] This classification contains nature reserves, national parks, and the *National City Park* in Stockholm, among others.[7] Construction of new housing is heavily restricted under all designations. Seven out of the ten most restricted municipalities are located in Stockholm county. Figure 4, visualizing current areas of protected nature in Stockholm, also illustrates that many of these protected areas are located in, or very close to, populated neighborhoods.

Figure 3: Top 20 Most Land Restricted Municipalities, 2018



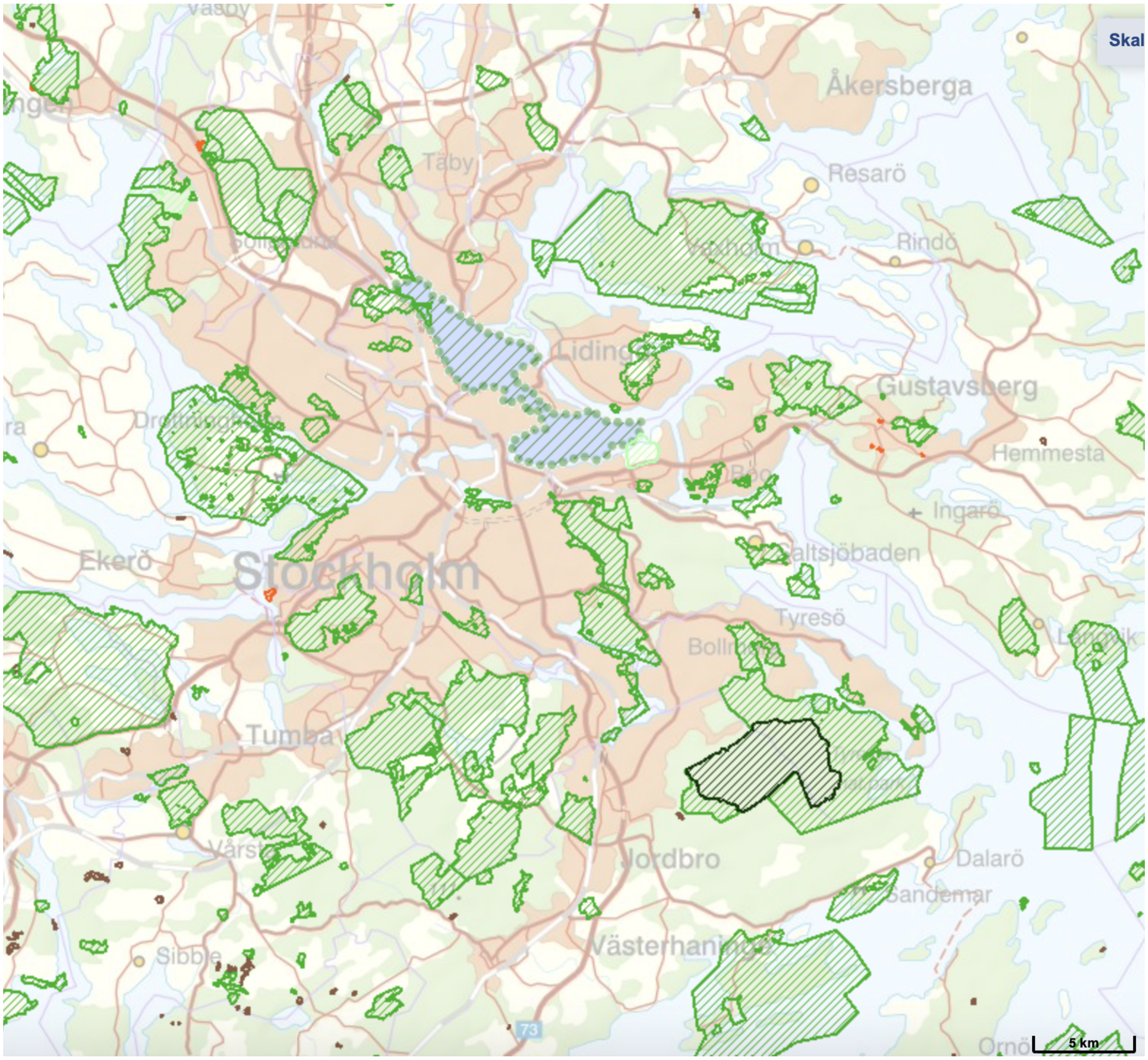
Note: The horizontal red reference line represents the median municipality.

Source: Statistics Sweden, Swedish Environmental Protection Agency, Authors' own calculations.

[6]This sample excludes the northernmost parts of the country, holding 12% of the Swedish population. The national parks located there – of great size in no proximity to urban settlements – are irrelevant to this thesis, as we are investigating protected land in relatively urban areas.

[7]Formally, our definition of land restrictions includes the following classes of protected nature: (i) Nature reserves, (ii) National parks, (iii) The National City Park, (iv) Forest habitat protection areas, and (iv) Other habitat protection areas.

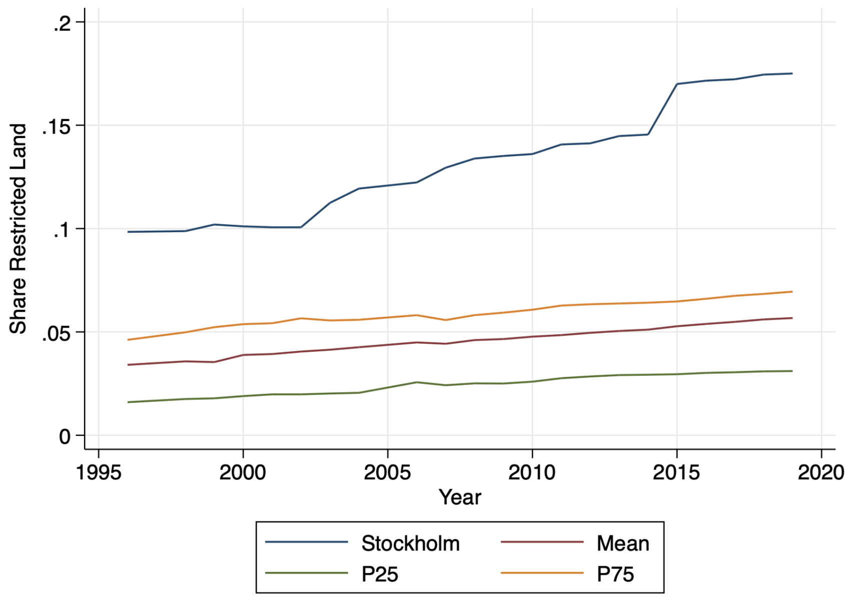
Figure 4: Stockholm Land Restrictions, 2020



Source: Swedish Environmental Protection Agency.

We are looking into the effects of land restrictions on the price responsiveness of the Stockholm county housing market in the long run. A static picture of the share of protected land in the period's final year is therefore not sufficient to understand the extent of land restrictions. Figure 5 visualizes the development of land restrictions, at the county level, over the last three decades. It is clear that not only does Stockholm have a comparatively high share of protected land, but the capital region has also experienced the most rapid climb in land protections. While an upward trend is common across all counties, evident in the slight upward slopes of the mean, 25th percentile, and 75th percentile, land restrictions in Stockholm are increasing at a much faster pace and from a significantly higher starting point.

Figure 5: Evolution of Land Restrictions



Source: Statistics Sweden, The Swedish Environmental Protection Agency, Authors' own calculations.

The remainder of this paper is organised in the following manner: Section 2 reviews relevant academic literature and anchors our research question and method in current research. Section 3 formally states our research questions. Section 4 presents the spatial equilibrium model we use to estimate the aggregate costs of spatial misallocation, as well as our specification for estimating local housing supply elasticities. Section 5 outlines the data we use in the elasticity and model estimations. In section 6, we present our results. Section 7 discusses limitations and possible further extensions of our model, potential issues regarding assumptions made, followed by policy implications. Section 8 ends with concluding remarks, followed by appendices.

2 Literature Review

This section will review literature relevant to our thesis, mostly in the field of urban economics. First we will review pertinent and current research employing the Rosen-Roback spatial equilibrium model. Next we describe how the framework can be used to investigate spatial factor misallocation, which we later employ in Section 4.1 to estimate the costs of inelastic housing supply in Sweden. Finally, we go into detail about research regarding housing supply elasticity – a key determinant of labor misallocation between cities.

2.1 Rosen-Roback Applications

roback:1982 employs the model predictions, outlined in the theoretical background, to inform partial equilibrium regressions on wages and prices in 98 U.S. cities, revealing implicit amenity levels. She computes the implicit 'cost' to wages individuals pay to settle in high-amenity areas. Crime, unemployment, cold temperatures, snowfall and other 'negative amenities' are all revealed to have positive effects on wages – in line with prior expectations given by the model. She also finds that the areas with the highest amenity levels are concentrated to California, Texas and the American north-east.

By relaxing assumptions about worker mobility, expanding the model to include housing markets, introducing taxation, or making other changes, the model can be used to explore any number of issues from a spatial point of view. gyourko:1991 introduce local land and income taxes, finding that the local fiscal climate is just as important as more explicitly 'exogenous' amenities such as weather for determining local quality of life gyourko:1991. hanson:1998 studies the effect of trade liberalization by entry into the North American Free Trade Agreement on employment and wages in Mexican regions (Hanson, 1998). Greenstone and Moretti (2003) use a Rosen-Roback model to investigate the local welfare effects of counties competing for new industrial production facilities with tax breaks and other incentives, finding that 'winning' a new industrial plant has positive effects on local wages, prices, and public finances (Greenstone and Moretti, 2003). Albouy (2009) proposes that national income taxes in America disproportionally affect high-income, low-amenity areas (as they earn higher wages for an equal utility level), skewing population flows away from large cities on the eastern seaboard. By introducing income taxes to the model, he is able to calculate counterfactual populations under a lump-sum tax regimen (which would not incentivize relocation), finding that employment in high-wage areas would be 13% higher. This spatial inefficiency lowers overall aggregate U.S. income by 0.23 %.

In a significant development, Glaeser et al. (2005) introduce the concept of housing supply elasticity to the model. Because local population correlates almost perfectly with the stock of housing, the elasticity of supply determines how well cities are able to absorb population shifts. Empirically testing their model predictions about the effect of the supply elasticity in a U.S. setting, they regress the change in population, incomes and housing prices on different proxies for productivity shocks.[8]

[8] Among others, they employ a labor demand shock variable introduced by Bartik (1991), which we will proceed to employ in this thesis.

They compare the coefficient on the productivity proxy with the coefficient on an interaction term including a measure of local land use and construction regulations, and find that productivity shocks hitting cities with less onerous housing regulation (and, the argument goes, higher supply elasticity) indeed appear to have lower marginal effects on wages and prices, and larger effects on population – in line with spatial equilibrium model predictions. Saks (2008) similarly investigates the effects of local labor demand shocks, and also finds that the intensity of local regulations influences whether increased demand leads to more construction and population or higher wages and prices. Notably, she also uses the same Bartik labor demand shock variable as Glaeser et al. (2005).

While the bulk of the urban economics research is performed using U.S. data, Hilber and Vermeulen (2015) find the same relationship – higher supply constraints leading to higher house prices in response to labor demand shocks – in a British setting. They utilize several measures affecting local housing supply: the refusal rate of new dwelling projects (a proxy for the strictness of local regulation), the reported share of remaining developable land, and a land elevation variable (a proxy for geographic barriers to construction, such as mountainous terrain).[9]

2.2 Resource Misallocation Literature

When labor is perfectly elastic, wages rise slowly in response to a productivity shock and the optimal level of workers for firms is high. Under a less elastic regime, however, firms can employ fewer workers before wages rise too much in response to the productivity shock. These workers must then work in other cities – and the glut of labor drives down marginal product of labor ('MPL') and wages in these cities. This leaves MPL above the optimal level in the productive city, and below optimum elsewhere. As this disparity increases, aggregate level of output suffers. Intuitively, if two cities (or firms) with identical production technology and laborers experience different marginal products of labor, their combined output would increase if workers were reallocated to the firm where the marginal product of their labor is higher.

In urban economics, this issue of allocative efficiency is known as spatial misallocation of labor. As proved by Glaeser et al. (2005) and Saks (2008), the housing market and labor markets are very closely related: an inelastic housing market therefore restricts the inflow of new workers in response to local productivity shocks, causing misallocation. Housing market frictions, lowering supply elasticity therefore have implications on wage dispersion and aggregate GDP.

This view of the aggregate effects of labor allocation between urban economies in an offshoot from the literature on resource (or production factor) misallocation, motivated Hsieh and Moretti (2019) to quantify the impact of spatial misallocation of labor across U.S. cities on aggregate growth in their AEJ paper *Housing Constraints and Spatial Misallocation* (Hsieh and Moretti, 2019).

Research on resource allocation traditionally falls under the umbrella of industrial organization, although

[9]The causal effect of housing regulations on supply elasticities is not unambiguous due to the 'Homevoter Hypothesis' introduced by (Fischel, 2001). We will discuss this issue further in the next section.

it is also relevant in the field of development economics,[10] and addresses misallocation between firms and the impact on aggregate sector productivity and output. Usually these inefficiences are ascribed to financial and/or labor market frictions such as taxes or subsidies that skew incentives away from optimal outcomes.

An important paper exploring market frictions and inefficient allocations of production factors between firms, following in the footsteps of Banerjee and Duflo (2005), is Hsieh and Klenow (2009),[11] who quantify the cost to total factor productivity ('TFP') of capital and labor misallocation in China and India. They construct an expression measuring industry TFP, increasing in aggregate individual firm productivity and decreasing in the 'misallocation effect', defined as the dispersion of marginal product across firms within a sector. Industry TFP is thus a function of capital and labor misallocation. Total revenue productivity ('TFPR') is a geometric average of the firm specific marginal revenue products of labor ('MRPL') and capital ('MRPK').

Using manufacturing micro data from India, China and the U.S., they quantify the counterfactual levels of TFP for the Indian and Chinese manufacturing sectors, had they had the dispersion of factor marginal products between firms been as small as that observed in the U.S. Their estimates suggest that manufacturing TFP in India and China would have been 40–60% and 30–50% higher under U.S conditions (Hsieh and Klenow, 2009).

Because all firms are assumed to have the same production technology (i.e. identical production functions), a high firm-level of marginal revenue product indicates the presence of factor distortions causing firm size to be smaller than optimal.[12] Hsieh and Klenow (2009) show that, assuming firm markups and productivities are log-normally distributed, aggregate TFP can be expressed accordingly:

$$lnTFP_s = \frac{1}{\sigma - 1} ln\Big(\sum_{i=1}^{M_s} A_{si}^{\sigma-1}\Big) - \frac{\sigma}{2} var(lnTFPR_{si}) \qquad ^{13}$$

from which it is clear that aggregate TFP depends positively on individual plant TFP (A_{si}) and negatively on the variance of individual firm marginal revenue product (or price markup).

As noted by Baqaee and Farhi (2019) in their paper *Productivity and Misallocation in General Equilibrium*, this corresponds to a second-order approximation of the distance to the Pareto efficient production possibility frontier:

$$\mathcal{L} \approx \frac{\sigma}{2}\ var(\Delta lnTFPR)$$

This follows from the first welfare theorem where a perfectly competitive equilibrium is Pareto efficient, and the distance to the frontier consequently is zero.[14]

[10] See for example Restuccia and Rogerson (2017) and Banerjee and Duflo (2005).

[11] Doubly relevant for us, as it is the direct predecessor of Hsieh's and Moretti's 'Housing Constraints and Spatial Misallocation'.

[12] For more on firm size distortion, labor market frictions, and labor misallocation see Garicano et al. (2016).

[13] σ is the elasticity of substitution within industries.

[14] $(TFPR|Perfect\,Competition) = (Price\,Markup|Perfect\,Competition) = 1 \Longrightarrow ln(1) = 0 \Longrightarrow \mathcal{L} \approx 0.$

Baqaee and Farhi (2019), who develop a nonparametric framework for estimating the aggregate effect of local productivity shocks in economies with frictions, show in their 'Theorem 1' the marginal effect on aggregate output of the shocks (i) $d\,log\,A$ and (ii) $d\,log\,\mu$, being (i) a marginal shock of (log) productivity as well as (ii) a marginal shock of (log) price markup can be decomposed accordingly:

$$d\,log\,Y = \underbrace{\lambda'\,d\,log\,A}_{\Delta \text{ Technology}} \underbrace{-\lambda'\,d\,log\,\mu - \tilde{\Lambda}'\,d\,log\,\Lambda}_{\Delta \text{ Allocative Efficiency}} \quad ^{15}$$

.

The change in aggregate output can thus be characterized by a direct technology effect as well as an indirect redistributive effect, affecting resource allocation efficiency. Importantly, would the abovementioned shocks hit an economy being in an efficient general equilibrium – that is, there are no price markups or wedges – there will be no effect on the allocative efficiency, but only a pure technology effect (Baqaee and Farhi, 2019). In short, Baqaee and Farhi (2019) find that, decomposing the cumulative Solow residual (TFP) over the period 1997–2015 for 66 U.S. industries, allocative efficiency account for approximately 50% of total TFP. Furthemore, they estimate a ∼15% increase in aggregate TFP from eliminating price markups (which is assumed to be the only wedge in their modelled economy).

Returning to *Housing Constraints and Labor Misallocation* (Hsieh and Moretti, 2019), just like Hsieh and Klenow (2009), Baqaee and Farhi (2019), and other publications on factor misallocation, Hsieh and Moretti (2019) model changes in output as an aggregate of two effects – the direct technology effect and the indirect misallocation effect, which is increasing in the dispersion of marginal products. Instead of studying firms and differing factor input prices, Hsieh and Moretti (2019) bring the concept to the Rosen-Roback general equilibrium framework where heterogeneous housing supply elasticities create differing input prices in the form of varying local wages.

Estimating a counterfactual allocation of labor under more elastic conditions, and the resulting counterfactual wage dispersion, Hsieh and Moretti (2019) quantify that cost of spatial labor misallocation in terms of foregone U.S. growth over the period 1964–2009. This thesis will employ a very similar approach to quantify potentially lost output growth in Sweden, and we will go into greater detail regarding Hsieh's and Moretti's model in Section 4.1.

[15] $\lambda \equiv$ revenue-based producer Domar weight ; $\Lambda \equiv$ revenue-based factor Domar weight ; $\tilde{\Lambda} \equiv$ cost-based factor Domar weight

2.3 Estimating Housing Supply Elasticity and Its Determinants

Like Hilber and Vermeulen (2015), research into the determinants of housing supply elasticities often finds geographic and regulatory barriers to construction to be the most important sources of supply inefficiency. Various proxies for the local regulatory environment are used – often surveys of local officials, building permit wait times, etc. A dearth of data, and the lack of comparable indicators leading to poor external validity, makes this approach unfavorable in many situations. A downside to using proxies for housing supply regulations is also that, as discussed in Gyourko and Molloy (2015), it is not possible to derive any direct policy recommendations. Instead of using regulatory proxies, Gyourko et al. (2008) develop a direct measure of regulation intensity in the 'Wharton Residential Land Use Regulation Index' ('WRI') which captures a wide variety of land use, development, and construction regulation in different U.S. metropolitan areas. The index has subsequently been used by many other scholars, such as Saiz (2010).

There is, however, a potential endogeneity problem associated with housing prices and regulation related to the 'Homevoter Hypothesis' introduced by Fischel (2001). Fischel suggests that homeowners seeking to maximize the value of their home assets face incentives to oppose new construction in the local area through political action such as voting or lobbying. Because homeowners in already pricey locations have more to gain from constricting supply via regulation, the causal direction between local regulation and house prices is ambiguous: regulations may cause prices to increase in an area, or they may be the result of homeowners responding to a price shock lobbying for further protections. This issue of simultaneity faces all statistical estimates of housing supply and regulations. Hilber and Vermeulen (2015) solve this by utilizing the Labour party vote share in an election prior to the period of study as an instrument to isolate the causal effects of supply regulation on housing prices.[16]

The elasticity of housing supply (i.e the slope of the supply curve) is estimated by the way of regressing the housing stock (or supply) on prices (demand). Because supply and demand are determined simultaneously in equilibrium, the former is instrumented using exogenous demand shifters in order to isolate a housing supply curve. In *The Geographic Determinants of Housing Supply*, an influential paper on the topic by Saiz (2010), average hours of sun in January, foreign immigration, and a Bartik labor demand shock variable are used in this fashion. In addition, the 'Homevoter Hypothesis' source of endogeneity in local regulation is addressed by instrumenting the regulation index with the share of local government budgets devoted to protective inspections[17], and the share of nontraditional Christian denominations in 1970.[18]

Saiz (2010) finds that the share of geographically unavailable lands along with the WRI are able to fully explain the housing supply elasticity in the U.S. In addition, his results show that the housing supply elasticity

[16] They expect this to be a relevant instrument as Labour voters are more inclined to rent than other voters and hence care less about protecting house values.

[17] The argument goes that local governments more concerned with inspecting businesses are also going to be more likely to restrict and conditionalize new housing developments.

[18] He proposes that Evangelist Christian denominations tend to oppose widespread government interventions for cultural reasons – land restrictions not being an exception. As both variables are based on historical data, and Saiz's empirical specification controls for variation in dwelling construction costs, the exclusion restriction is said to be met.

in sparsely populated locations is mainly determined by the regulatory index, whereas the geographical constraints have greater impact as population levels increase (Saiz, 2010). The lowest elasticity estimates are attributed to expensive, metropolitan areas such as San Diego, New York, and Boston, whereas growing and relatively cheap cities like Houston and Charlotte are found to have the highest supply elasticities.

Natural amenities, such as hours of sun and wintertime temperatures, have been shown to be among the best predictors of long term urban growth in the U.S.[19] Finally, the Bartik variable (measuring the growth of different sectors of employment) captures the labor demand shock stemming from structural changes in the economy.[20] Common to these variables is that they have been hypothesised to fulfill the exclusion restriction necessary to function as a valid instruments – that is, they only affect house prices through the supply of housing.

3 Research Questions

Having presented (i); evidence of Stockholm's disproportionate land use restrictions, house price appreciation, and diverging relative wages, (ii); a theoretical link between local housing market conditions and the economic outcomes of urban productivity, including potential resource misallocation, (iii); the 'workhorse' Rosen-Roback model of urban economics, together with recent housing supply elasticity literature, we can formally state the research questions of this thesis.

- What are the aggregate costs of spatial labor misallocation caused by Stockholm's housing shortage?
- What are the aggregate output gains, if any, from decreasing the local share of protected land in Stockholm?

In order to answer these, we need to resolve two more issues:

- How do local long-term housing supply elasticities vary between counties?
- To what extent has the share of protected land in Stockholm contributed to lowering the local housing supply elasticity?

[19]Glaeser and Gottlieb (2009) conclude that *"No variable can better predict [US] city [population] growth over the past 50 years than January temperature /.../"*. Cheshire and Magrini (2006) also find that temperature helps explain population changes *within*, but not between, European countries.

[20]As also used by for example Glaeser et al. (2005); Saks (2008); Hilber and Vermeulen (2015).

4 Method

4.1 Modelling Labor Misallocation

In this section we present the Rosen-Roback model we use to estimate the effects of varying housing supply elasticities on aggregate output. The model was first developed by Hsieh and Moretti (2019) as a cross-pollination between Hsieh's 2009 paper "Misallocation and Manufacturing TFP in India and China" and the Rosen-Roback multiple cities framework. Much like the standard Roback model introduced earlier, workers choose cities to live and work in based on local amenities, wages and house prices. Land T_c is assumed to be of fixed supply, across all cities, and is only used as an input in the production function, not for housing. Workers have idiosyncratic preferences for locations, restricting the labor response to utility shocks.

4.1.1 Local Utility

The average utility, using standard Cobb-Douglas preferences, in city c is given by:

$$U_c = Q_c \, Good^{1-\beta} Housing^{\beta}$$

Workers gain utility from amenities Q_c and purchasing the representative good and housing. The β parameter controls the income share devoted to housing. Their spending is restricted by the budget constraint:

$$W_c = 1 \cdot Good + P_c \cdot Housing$$

The price of the representative good is normalized to 1, while the price of housing in city c is denoted P_c. Evaluating this at the optimum, where workers maximize their utility given their budget constraint, we get the indirect utility function:

$$V(W_c, P_c, Q_c) = \underbrace{\beta^{\beta}(1-\beta)^{1-\beta}}_{\text{Space invariant}} \cdot \frac{Q_c W_c}{P_c^{\beta}} = \overline{U}$$

$\overline{U}$ indicates that the local utility must be equal across all cities c – the spatial equilibrium condition that we introduced earlier. Taking logs on both sides, and omitting the space invariant term, illustrates that utility is strictly increasing in income and amenities whereas it is strictly decreasing in housing cost.[21]

$$ln(V(W_c, P_c, Q_c)) = ln(Q_c) + ln(W_c) - \beta ln(P_c) = ln(\overline{U})$$

The utility of a given individual i located in city c, however, consists of this local utility level, along with an added term ϵ_{ic} that captures idiosyncratic preferences for locations:

[21] Formally: $\frac{\partial U_{ic}}{\partial I_c} > 0$, $\frac{\partial U_{ic}}{\partial Q_c} > 0$ and $\frac{\partial U_{ic}}{\partial P_c} < 0$.

$$U_{ic} = V(W_c, P_c, Q_c) + \epsilon_{ic} \tag{1}$$

Therefore the final indirect utility function has the form:

$$\overline{U} = \frac{Q_c W_c}{P_c^{\beta}} \cdot \epsilon_{ic} \tag{2}$$

As described in Moretti (2011), this worker preference heterogeneity variable captures location preferences beyond housing costs, real wages and amenities common across individuals – such as cultural or familial preferences. Intuitively, worker i will only move from a city c to any other city if the utility gained from wages, prices, and amenities is greater than the loss of utility from individual preferences: $-c$ if $\epsilon_{ic} - \epsilon_{i-c} \leq V(W_c, P_c, Q_c) - V(W_{-c}, P_{-c}, Q_{-c})$.

These idiosyncratic location preferences lead to imperfect labor mobility in response to utility shocks. Some workers infer higher utility from staying in their preferred city, even if wages or amenities are higher elsewhere. Under identical/no location preferences, the entire population of workers would be ready to move to other cities even if utilities were only marginally higher. Consequently, only a subset of workers (the size of which depends on the strength of ϵ_{ic}) are willing to relocate in response to a wage, price, or amenity shock. We will expand upon this in the Labor Supply Section 4.1.3.

In order to verify whether this theoretical relationship actually holds using Swedish data[22] (in terms of correlations), we regress mean house prices on average January temperatures (a stand-in for amenities) and mean wages. Also, the correlation between net income (wage income net of housing cost) and January temperatures is evaluated. These relationships, testing the reasonability of the spatial equilibrium condition, are graphed in the Appendix.[23]

4.1.2 Labor Demand

Each city hosts a number of firms that produce a single representative good under perfect competition by the way of constant-returns-to-scale Cobb-Douglas production technology, using labor, L_c, capital, K_c, and land, T_c as inputs, with productivity regulated by the A_c term:

$$Y_c = A_c L_c^{\alpha} K_c^{\eta} T_c^{1-\alpha-\eta} \tag{3}$$

Labor, capital and productivity can vary across cities, but land (along with the elasticites of labor and capital, α and η) is static and equal across all cities. Each worker in a city produces a single unit of labor,

[22]Note, spatial equilibrium models have predominantly been applied to U.S. data in the literature.
[23]The relationships, in terms of correlations, are in line with model expectations.

and must be resident in the city in which he or she works. By having a fixed supply of land used for business, the production function is isomorphic to a decreasing returns to scale production technology.[24]

Firms seek to maximise profits under perfect competition. Consequently, solving for the optimum level of labor means wages are set equal the marginal product of labor:[25]

$$W_c = \frac{\partial Y_c}{\partial L_c} = \alpha A_c L_c^{\alpha-1} K_c^{\eta} T_c^{1-\alpha-\eta} = \alpha \cdot \frac{Y_c}{L_c} \tag{4}$$

Likewise, the optimum level of capital is found when the marginal product of capital equal interest rates, which we assume are set exogenously on world financial markets:

$$R = \frac{\partial Y_c}{\partial K_c} = \eta A_c L_c^{\alpha} K_c^{\eta-1} T_c^{1-\alpha-\eta} = \eta \cdot \frac{Y_c}{K_c} \tag{5}$$

Substituting the optimal level of labor and capital back into the production function and rearranging yields the local labor demand function:

$$L_c = \Big(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot \frac{A_c}{W_c^{1-\eta}}\Big)^{\frac{1}{1-\alpha-\eta}} \cdot T_c \tag{6}$$

In order to easier illustrate the effects of the production factors on labor demand, we take the logarithm of both the left-hand and the right-hand side, yielding:

$$ln(L_c) = \Psi + \frac{1}{1-\alpha-\eta} ln(A_c) - \frac{\eta-1}{1-\alpha-\eta} ln(W_c) + ln(T_c)$$ [26]

or

$$ln(W_c) = \frac{1-\alpha-\eta}{1-\eta}\Psi + \frac{1}{\eta-1} ln(A_c) + \frac{1-\alpha-\eta}{\eta-1} ln(T_c) - \frac{1-\alpha-\eta}{\eta-1} ln(L_c)$$

We clearly see that the labor demand curve is decreasing in wage-labor space and increasing in productivity-labor space, consistent with conventional theory. Capital is provided at cost R with perfect elasticity in all locations and the supply of land, T_c is fixed in each city. As such, wage differences across space stem entirely from local differences in productivity and employment. Following the convention employed by for example Hsieh and Moretti (2019) and Glaeser (2007) that the non-traded good (in this case land) is part of local productivity, we will treat the product $A_c^{\frac{1}{1-\alpha-\eta}} T_c$ as 'local TFP'.

[24]This, in turn, implies that there are (economic) excess profits (Basu and Fernald, 1997). As all firms are price takers, it is the land owners that extract these excess profits. We assume that all land, like all housing, is owned by absentee landlords outside the economy.

[25]Because wages set equal to the marginal product of labor in each city, wages reveal productivity differences between cities. This is very important. In order to test whether real wages are representative of MPL in cities, or differences in wages are due to differences in labor quality, we estimate alternative results using wages conditional on human capital. We will discuss this further in a later section.

[26]where $\Psi = \frac{1-\eta}{1-\alpha-\eta} ln(\alpha) + \frac{\eta}{1-\alpha-\eta} ln(\eta) - \frac{\eta}{1-\alpha-\eta} ln(R)$ is a constant 'nuisance term', which does not vary across cities.

4.1.3 Labor Supply

Similar to Kline and Moretti (2014), Diamond (2016), and Hsieh and Moretti (2019), we assume that individual preference indicator ,ϵ_{ic}, is drawn from a Type I Extreme Value distribution, with cumulative distribution given by:

$$F(\epsilon_1, ..., \epsilon_n) = exp\big(\epsilon_{ic}^{-x/\theta}\big)$$

The distribution scale parameter, $1/\theta$, governs the strength of location preferences for all workers.[27] As such when $1/\theta$ is large, many workers are attached to their local city and require large differences in utility to move; conversely, a small $1/\theta$ means workers are more inclined to move given smaller utility differences. As $\theta \to \infty$, the utility gained from idiosyncratic preferences approaches zero, at which point the model's spatial equilibrium condition behaves as under a standard Rosen-Roback without individual location preferences. We refer to $1/\theta$ as the *mobility parameter*, and it is very important for the results of the model. As described above, when $1/\theta = 0$ workers are perfectly mobile, and become less mobile as the mobility parameter increases.[28]

As initially shown by McFadden (1973) and later utilized by Diamond (2016) and Serrato et al. (2016), given the Type I distribution of idiosyncratic preferences, the probability of worker i to live in city c is:

$$Pr(V_{ic} > V_{i-c}) = \frac{exp(\theta(V(W_c, P_c, Q_c))}{\Sigma_c exp(\theta(V(W_{-c}, P_{-c}, Q_{-c}))}$$

The expected population of city c is then equal to the probability of each worker to choose to live in that city, summed over the entire population, or the utility-weighted average of the total population:

$$L_c = \Sigma_i \frac{exp(\theta(V(W_c, P_c, Q_c))}{\Sigma_c exp(\theta(V(W_{-c}, P_{-c}, Q_{-c}))} = \frac{exp(\theta(V(W_c, P_c, Q_c))}{\Sigma_c exp(\theta(V(W_{-c}, P_{-c}, Q_{-c}))} \cdot L_{total}$$

Inserting our indirect utility function, and taking natural logarithm on both sides, yields the function:

$$ln(L_c) = \theta \cdot \Big[ln(Q_c) + ln(W_c) - \beta ln(P_c)\Big]$$

Finally, solving for the wage variable W_c returns the labor supply function:

$$ln(W_c) = ln(\overline{U}) + \frac{1}{\theta} \cdot ln(L_c) + \beta \cdot ln(P_c) - ln(Q_c)$$

Or the non-logarithmic expression:

$$W_c = \overline{U} \cdot \frac{P_c^{\beta} L_c^{1/\theta}}{Q_c} \tag{7}$$

[27] The distribution location parameter μ is equal to zero.

[28] We will tests the results of our policy counterfactuals under both perfectly mobile and less mobile conditions.

4.1.4 Housing Prices

We assume housing is supplied by a perfectly competitive construction sector, which delivers one unit of housing per worker in a city. We also assume that workers do not own their houses. Rather, they can be interpreted as renting housing from an 'absentee landlord' (Hsieh and Moretti, 2019) who absorb all rental income and move profits to an outside economy. Prices are increasing in worker population. This gives a constant inverse housing supply function (Kline and Moretti, 2014):

$$P_c = \bar{P}_c L_c^{\gamma_c} \tag{8}$$

where the price of housing in a city c is a function of its population L_c, some fixed per-unit cost $\bar{P}_c$, and the inverse elasticity of housing supply γ_c, both of which vary between cities. Intuitively, the elasticity of housing supply regulates how quickly house prices rise in response to increasing population L_c.[29] When local geography and regulations makes it easy to build new homes, γ_c is low, and in the extreme case where there are no barriers to new construction γ_c is equal to zero. The elasticity of housing supply is relevant because of its interactions with the spatial equilibrium condition, as explained in the theoretical background.[30]

4.1.5 Equilibrium Employment

We obtain the function for equilibrium employment by equating the functions for labor demand (Equation (6)) and supply (Equation (7)) and substituting the housing market function (Equation (8)) into the labor supply function.[31] Solving for L_c yields:

$$L_c = \left(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}\overline{U}^{1-\eta}} \cdot A_c T_c^{1-\alpha-\eta} \cdot \left(\frac{Q_c}{\bar{P}_c^{\ \beta}} \right)^{1-\eta} \right)^{\frac{1}{1-\alpha-\eta+(\gamma_c\beta+1/\theta)(1-\eta)}} \tag{9}$$

4.1.6 Aggregate Output

We now proceed to solve for the aggregate output equation, $Y \equiv \sum Y_c$, by inserting the optimal level of capital (Equation (5)) and labor (Equation (9)) into the production function (Equation (3)). In order to explore the allocation of labor between cities, we normalize the equilibrium level of aggregate labor to one. This means that the local level of labor can now be interpreted as the local share of aggregate labor ($L_c = L_c / \sum L_c$). Aggregate output is a CES aggregator, a function of the wage spread between each city and the labor-weighted average wage, $\overline{W_c}/W_c$, as well as individual-city local TFP $A_c T_c^{1-\alpha-\eta}$:

$$Y = \left(\frac{\eta}{R} \right)^{\frac{\eta}{1-\eta}} \left[\sum \left(A_c \cdot T_c^{1-\alpha-\eta} \cdot \left[\frac{\overline{W_c}}{W_c} \right]^{1-\eta} \right)^{\frac{1}{(1-\eta)(1+1/\theta)-\alpha}} \right]^{\frac{(1-\eta)(1+1/\theta)-\alpha}{1-\eta}} \tag{10}$$

[29] When estimating the model, we utilize an elasticity estimate we caluclate in the next section – along with a counterfactual elasticity resulting from a policy experiment.

[30] Location preferences, which is another variable affecting labor supply, affect wages and prices in much the same way.

[31] For a step-wise derivation, see Appendix.

From Equation (10) we can see that output is decreasing as local wages diverge from the labor-weighted mean. Given the exponent on the wage fraction $\frac{1-\eta}{(1-\eta)(1+1/\theta)-\alpha}$, the aggregate dispersion effect is increasing in the labor share, α, and decreasing in idiosyncratic location preferences, $1/\theta$. As under the spatial equilibrium, individual indirect utility is equal to the reservation utility (subject to the idiosyncratic location preference), Equation (7) explains the link between local housing prices and local wages. Hence, $\frac{\overline{W_c}}{W_c} = \frac{\overline{P_c^\beta/Q_c}}{P_c^\beta/Q_c}$ and higher dispersion in the distribution of housing prices across cities also leads to greater dispersion in local wages. Thus, a lower local housing supply elasticity (remember γ_c is defined as the *inverse* elasticity) will, *ceteris paribus*, drive up local housing prices, and therefore also local wages. Since firms are maximizing profits and consequently setting wages to equal their marginal products, spatial differences in marginal products lowers aggregate production output. By simply shifting labor to the city where its marginal product is higher, aggregate output would increase up to the point where marginal products are equalized across space.

Hence, a city faced by a productivity shock will contribute to aggregate output through two channels, being (i) through the direct technology effect as A_c increases, and (ii) through the effect of allocative efficiency of labor in the aggregate system. As the labor demand function is decreasing in productivity-labor space, the productivity shock pushes local wages upwards, worsening national labor allocation efficiency (if wages before the productivity shock already were above the national weighted average, and an even higher local wage would thus *increase* aggregate wage dispersion). This relationship bears close relation to literature on firm factor misallocation, such as that by Hsieh and Klenow (2009) and Baqaee and Farhi (2019). Through this lens, we can see that an imperfect housing supply elasticity in a city facing a TFP shock lowers that city's equilibrium employment below the level that would be most efficient, causing a wedge in local marginal product of labor, much like market distortions can lead to an inefficient allocation of capital and labor between firms.

In sum, the endogenous variables of our model are housing prices, wages, and employment whereas the exogenous forces, not determined within the model, are local TFP, amenities and the housing supply elasticities.

4.1.7 Taking the Model to the Data

As increased wage dispersion (implying lower allocative efficiency of labor) lowers aggregate output growth, we can use Equation (10) to quantify how growth would have changed, had wage dispersion been fixed to 1996 levels. House price dispersion, too, is a sign of increased dispersion in marginal product of labor, and so we also fix house price dispersion to 1996 levels. Because we know that dispersion in both wages and house prices have increased, we expect these scenarios to reveal that growth would have been higher had dispersion remained at 1996 levels.

We then move on to our main estimation. Thanks to the instrumental variables approach we will introduce in Section 4.2, we can identify how the housing supply elasticity in Stockholm county would respond to a change in the share of protected land. Applied to our model, these counterfactual supply elasticities allow us to calculate the effects of a reduction in the share of protected land on aggregate output growth rates. We will also study the effects on local employment, and test the results with different assumptions regarding the mobility parameter.

In both cases we allow the 'exogenous' variables (local amenities Q_c and local TFP $A_c \cdot T_c^{1-\alpha-\eta}$) to vary as they do in the historical data. Performing our experiments (i.e. changing the level of wage dispersion, price dispersion, and finally supply elasticity) house prices, employment and wages are allowed to endogenously change until the spatial equilibrium is once again restored. The new equilibrium employment, wages and prices are then used to calculate the counterfactual growth impact on aggregate output.

Note that absolute levels of aggregate output are not identified, but only *growth* in aggregate output. This since we do not identify indirect utility in levels. While the level of aggregate output depends on the value of indirect utility, the counterfactual growth rate does not. Counterfactual growth rate of aggregate output is defined accordingly:

$$\Big(\frac{Y_{t+1}|\gamma_c' - Y_t|\gamma_c}{Y_{t+1}|\gamma_c - Y_t|\gamma_c}\Big) - 1 \quad {}^{32} \tag{11}$$

where $Y \equiv \sum Y_c$ from Equation (10). We use the reduced-form wage equation:

$$W_c = \left(\frac{\overline{U}\bar{P}_c^{\beta} \cdot \Big(\big(\alpha^{\frac{1-\eta}{1-\alpha-\eta}}\ \eta^{\frac{\eta}{1-\alpha-\eta}}\ TFP_c\big)\Big/R^{\frac{\eta}{1-\alpha-\eta}}\Big)^{\beta\gamma_c+1/\theta}}{Q_c}\right)^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)+1/\theta(1-\eta)}} \quad {}^{33} \tag{12}$$

Substituting Equation (12) into Equation (10) and then into (11) the rental rate, R, the housing price term, $\bar{P}_c$, indirect utility, $\overline{U}$, as well as the parameter constants cancel, and we can isolate the counterfactual growth rate.

4.1.8 Wages Conditional on Labor Quality

In urban economics literature, the productivity premium of large cities can be ascribed to sorting (the tendency for workers with higher human capital to settle in larger cities), selection (that fiercer competition drive firms to be more productive in larger cities), and agglomeration effects (density effects driving innovation).[34] Selection and agglomeration pose no issues for our identification strategy, but if the Stockholm productivity premium we observe is caused by initial sorting of higher quality labor (and, consequently, that labor from other cities would not be more productive had they worked there), our growth estimates will be upwardly biased.

As already touched upon in Section 1.2, De La Roca and Puga (2016) find that initial sorting of workers does not explain wage differences between cities of different sizes in Spain. However, even if we follow De la Roca's and Puga's example and assume that wages of workers in smaller and larger cities would be equal

[32]Same as $\frac{Y_{t+1}|\gamma_c' - Y_t|\gamma_c}{Y_t|\gamma_c}\Big/\frac{Y_{t+1}|\gamma_c - Y_t|\gamma_c}{Y_t|\gamma_c} - 1$.

[33]Derived in Appendix. $TFP_c \equiv A_c \cdot T_c^{1-\alpha-\eta}$.

[34]See the Appendix section *The Productivity of Cities* for a deeper discussion on the topic.

had they begun their careers in the same city, our policy experiment explicitly involves workers moving from one city to another over a 22 year time period. Differences in education, experience and other facets of labor quality between the workers already in Stockholm and those moving there are consequently not irrelevant. A cursory comparison reveals major differences in education between counties in Sweden:

Table 3: Mean Share of Workforce with Tertiary Education in 1996 and 2018

Workforce share (%)			
Gävleborg County	13.0	Södermanland County	15.3
Örebro County	13.2	Uppsala County	15.3
Västmanland County	13.3	Västernorrland County	15.3
Värmland County	13.9	Östergötland County	15.4
Jönköping County	14.0	Västra Götaland County	15.8
Dalarna County	14.1	Blekinge County	16.6
Kronoberg County	14.1	Halland County	16.7
Västerbotten County	14.1	Gotland County	17.8
Kalmar County	14.2	Skåne County	18.7
Jämtland County	14.4	Stockholm County	25.4
Norrbotten County	14.7		

Data Source: Statistics Sweden.

If we employ real wages, these differences in human are therefore likely to overestimate the aggregate output effects of changing the housing supply elasticity, even if the assumption that wages equal the marginal product of labor holds. A worker moving from a relatively rural area to Stockholm, attracted by the newly affordable housing and promise of higher wages, will not immediately acquire the higher level of education and more valuable experience that the average Stockholm worker may have, even if workers moving in would eventually acquire the same experience as original inhabitants.

In order to eliminate any upward bias introduced by the sorting effect, we need to to expunge the differences in labor quality from our average wage variable and find the local average wage *conditional on worker characteristics*.

Using OLS, we regress local wages on worker characteristics using a simple specification:

$$W_m = \beta X_m + \lambda_m + \epsilon_m \tag{13}$$

Where W_m is municipal average wages, X_m is a vector of municipal demographic and labor market characteristics, β is a vector of related coefficients, and λ_m is a vector of county level intercepts. [35] Regression results

[35]It is important to note that this is a naive estimate using municipality-level average income data. We do not make any

are presented in Table 22 in the Appendix. The regional intercepts act as local residuals, catching regional variations in average wages that are not explained by our demographic control variables – a crude way of isolating the part of MPL that is explained by local productivity. We then multiply β by the labor-weighted national average of X_m, and add regional residuals, resulting in local regional wages stripped of labor quality variation.

This conditional wage variables is then used to estimate alternate results. We go into further detail regarding the validity of the conditional wage, relative to the real wage, results in the Discussion Section.

4.2 Housing Supply Elasticity Estimation

This section presents our empirical specifications used to estimate the long-run housing supply elasticity in Swedish counties. We first estimate a baseline national average elasticity, as well as its dependency on protected land. We then provide elasticity estimates for each county, which serve as our location specific housing supply parameters in the spatial equilibrium model used subsequently. Finally, we zoom in on Stockholm county, the target for our counterfactual analysis outlined in the sections before this. We estimate the causal effect of the share of protected land on the housing supply elasticity in Stockholm, and, conscious of the 'Homevoter Hypothesis', we allow the amount of protected land to be endogenous to housing prices by introducing additional exogenous instruments.

As this paper studies economic geography in general, but the economics of urban areas in particular, we want to restrict the sample to include only relatively urbanized municipalities.[36] Restricting our sample to only them most urbanized municipalities, however, presents us with the problem of low statistical power. We resolve this tradeoff between specificity and power by excluding municipalities classified by The Swedish Association of Local Authorities and Regions ('SALAR') as 'rural'.

4.2.1 Long-Term Housing Supply Elasticity Estimates

To estimate the long-run housing supply elasticity, we utilize a instrumental variable approach similar to the one employed by, among others, Saiz (2010). Because supply and demand are determined simultaneously, and variations in housing supply therefore are endogenous to demand side price variations, it would be impossible to identify neither demand nor supply relationships through OLS. By employing exogenous demand shifters as instruments, the simultaneity problem can be avoided and the supply curve estimated (Angrist and Krueger, 2001).

However, variations in the observed housing price might not only reflect demand but also supply-side issues

attempt to draw any empirical conclusions about productivity levels in various counties, but simply wish to provide a plausible, more conservative alternative to the unconditional real wage. Vector X_m include educational attainment (high school and university), age, and immigration status.

[36] However, as the purpose is not to assess elasticity determinants in locations other than in the capital Stockholm, the fact that land restrictions ought to be binding constraints to different degrees in different locations, depending on population density, does not dictate the sample selection.

such as construction costs. Construction makes up a significant portion of house prices, and vary across time and space. A construction cost shock (say, an increase in the cost of raw materials) could thus introduce an upward bias in our estimate of the supply elasticity. In order to control for this, the left hand side or dependent variable in our specifications is simply the market price net of the construction cost (henceforth referred to as 'Excess Price'). The empirical specification, estimated using 2SLS, and including the full sample of observations, is expressed as follows:

$$ln\,\overline{P}_{it} - ln\,\overline{CC_{it}} = \alpha + \gamma\, ln\,\hat{S}_{it} + \sum_{y} T_i + \sum_{j} R_i + \epsilon_{it} \qquad j = 1, 21 \quad y = 1997, ..., 2018 \tag{14}$$

where $ln\overline{P}_{it}$ is the natural log of the average purchase price of a single-family house in municipality i observed at time t. $ln\,\overline{CC_{it}}$ is the natural log of the average construction cost in municipality i observed at time t.[37] $ln\,\hat{S}_{it}$ is the natural log of the first-stage-predicted stock of single-family houses in municipality i observed at time t. Finally, α is an intercept term, and ϵ_{it} the error term. To account for errors being correlated within groups of municipalities, the standard errors are clustered at the county level.

In order to eliminate short-run volatility and market shocks and estimate the long-run supply elasticity, we introduce time-fixed effects to control for variation common across all municipalities. The start year 1996 is omitted from the yearly dummy variables to avoid perfect multicollinearity. We also employ county-level fixed effects to eliminate any unobserved regional housing market dynamics. The coefficient of interest, γ, is inferred as the *inverse* housing supply elasticity (in %). $\hat{S}_{it}$ is the predicted value from the following first stage:

$$ln\; S_{it} = \beta_0 \;+\; \beta_1 Bartik_i \;+\; \beta_2 Temp_i \;+\; \sum_{y} T_i \;+\; \sum_{j} R_i \;+\; \xi_{it} \qquad j = 1, 21 \quad y = 1997, ..., 2018$$

where ξ_{it} is another error term. $Bartik$ and $Temp$ are the exogenous demand shifters employed as instruments. These are further explained below. Equation (14), as well as all subsequently structural equations presented, are estimated assuming $E(\epsilon_{it} \cdot Z_i) = 0$ where Z_i denote the set of exogenous variables (being the instruments, the regional and time fixed effects, and the intercept).

When estimating the housing supply elasticities at the county-level, we employ the same specification as in Equation (14), but the sample municipalities are restricted to only include those of the county. Intuitively we remove the county-level fixed effects term, and robust standard errors are used instead of county-level clustered error.[38]

[37] Saiz (2010) assumes that construction costs are homogeneous across cities. Because data on regional Swedish construction costs are available, we can avoid this simplifying assumption – which would have been a mistake, too, because costs differ significantly between regions.

[38] Two counties are excluded from the analysis. Gotland County consists of a single municipality, rendering a municipal-level regression moot. Västernorrland County contains only four 'non-rural municipalities', resulting in too-low statistical power. Together they constitute only $\sim 3.5\%$ of the total non-rural population.

4.2.2 Demand Instruments

We use the Bartik demand shock variable, introduced by Bartik (1991), to capture labor demand uncorrelated with housing supply. The variable measures counterfactual employment growth in an area over a period of time, if the initial labor market sector distribution would stay fixed and each industry had grown according to the national average (excluding the county in question) (Glaeser et al., 2005). As such, the Bartik instrument captures the labor demand in each county caused by the overall evolution of the economy.[39] The validity of this instruments relies on the assumption that these external labor demand shocks affects local housing prices through the demand-induced housing construction only. Formally, the Bartik instrument is calculated as:

$$Bartik_i = \sum_{j=1}^{11} \frac{e_{ijt-1}}{e_{it-1}} \left(\frac{\tilde{e}_{ijt} - \tilde{e}_{ijt-1}}{\tilde{e}_{ijt-1}} \right) \quad ^{40} \tag{15}$$

where j = industry, i = municipality, t = 2018, $t-1$ = 1996, and $\tilde{e}_{ijt}$ = industry employment nationally, excluding industry employment employment of municipality $i = e_{jt} - e_{ijt}$. Total employment in municipality i at time t equals $e_{it} = \sum_{j=1}^{11} e_{ijt}$ whereas total national employment at time t equals $e_t = \sum_{i=1}^{290} e_{it}$.[41]

Following for example Cheshire and Magrini (2006) and Glaeser and Gottlieb (2009) who use weather variables to predict population growth, we use average normal January temperatures as an excluded instrument. Since mild weather can be viewed as a utility enhancing amenity, we expect areas with warmer winters to experience higher demand for housing. Like all variables, the validity of the temperature instrument relies on the assumption that climate variables do not influence housing prices through channels other than variation in housing units constructed. Of course, merely fulfilling the exclusion restriction does not mean these variables are suitable instruments. We will review their strength in the Results Section.

4.2.3 Introducing Land Restrictions

Because we intend to utilize the estimated elasticities in our spatial equilibrium model to calculate the counterfactual output growth resulting from policy changes lowering the Stockholm housing supply elasticity, it is not enough to simply identify local elasticity levels. We also need to identify relevant policies that influence elasticity levels in Stockholm county. Considering its direct impact on land available for new construction and the significant variation across municipalities and time, the share of protected land presents itself as an excellent policy variable determining the housing supply elasticity.[42] We expect the share of protected land to have a greater impact on housing supply in municipalities with an already large stock

[39] For example, a county where a significant share of the labor force works in manufacturing is likely to experience falling labor demand as the manufacturing share of the overall economy decreases.

[40] Note the similarity in notation to Saks (2008).

[41] There are 290 municipalities in Sweden.

[42] Obviously, there are many other aspects relating to geography, regulation, and market efficiency etc. that may affect housing supply elasticity. Note that our aim is not to exhaustively decompose and explain local elasticity levels, but to find *a* relevant policy with a causal effect on elasticites.

of housing and where much available land is already developed. Conversely, in municipalities with smaller housing stocks, swathes of land could be protected while still leaving ample room for new developments. To determine the effect the land use restrictions have on the elasticity of housing supply, we therefore add an interaction term between the instrumented housing stock variable and the share of protected land:

$$ln\ \overline{P_{it}}\ -\ ln\ \overline{CC_{it}} = \alpha\ +\ \gamma_1\ ln\ \hat{S}_{it}\ +\ \gamma_2\left(\hat{S}_{it}\ \cdot\ Restrictions_{it}\right)\ +\ \sum_y T_i\ +\ \sum_j R_i\ +\ \epsilon_{it} \tag{16}$$

$$j = 1, 20 \qquad y = 1997, ..., 2018$$

Local (inverse) elasticities are now calculated as γ_1 plus γ_2 multiplied with the local share of protected land. The first stage equations now also include the additional term $(Bartik_i \cdot Temp_i \cdot Restrictions_i)$ as an excluded instrument.

4.2.4 Endogenizing Land Restrictions In Stockholm

As pointed out in the Literature Review, the Homevoter Hypothesis introduces a possible source of reverse causality between local land restrictions and local house prices, violating the exclusion restriction. We solve this issue by instrumenting the share of protected land with suitable variables. Similar to how Hilber and Vermeulen (2015) instrument local regulatory restrictiveness with Labour vote share, we utilize average results for the Green Party (Sw: Miljöpartiet, henceforth 'GP') from the 1988, 1991, and 1994 general elections. Since the ideology of the Green Party is aligned with nature conservation, we expect Green Party electoral success to be associated with later expansions of protected land areas. To avoid the obvious endogeneity issues of local elected GP politicians directly influencing local housing markets, we use election results prior to the period of study. Later election results could impact the housing market, or be subject to a variety of confounding factors.[43] The identification strategy relies on the assumption that historical general election voting behavior does not directly explain todays' housing prices. In terms of the Homevoter Hypothesis', newly rich households cannot influence the vote share before 1996 in order to increase the value of their homes.

Similar to Saiz (2010), we also use the municipal budget share devoted to enforcing local regulations as an instrument for the share of protected land. This category contain expenditures relating to food safety inspections, animal control, alcohol permissions, public health campaigns, supervision/inspection of indoor environments, pollution control, sustainability compliance in building planning etc.[44]

The rationale for including such municipal expenses as an instrument for the share of protected land is based on the hypothesis that municipalities spending a larger share of public funds on regulatory measures

[43] We also utilize vote shares from the national general election, rather than local elections. This is partially because the Green Party was not locally represented everywhere. Municipal election also often reflect local dynamics, such as local parties (whose attitude toward protected is unknown), meaning that the effect of the Green Party vote share may not be homogenous across municipal elections.

[44] Note that we exclude funding relating specifically to nature conservation.

(again, not directly related to nature reserves) also tend to be more inclined to expanding protected areas. Alternatively, more spending of public funds on health initiatives, etc. could crowd out efforts on establishing nature reserves in the municipality.

The relevance of the instruments will be presented in the Results Section. Note that while a number of protective inspection expense categories might directly impact housing constructions costs, such as sustainability compliance in building planning and indoor inspections, our specification already controls for those. To fulfill the exclusion restriction, the regulatory expense share must not influence housing prices in other ways than through limited land supply due to protected nature.

The empirical specification, where land restrictions are instrumented, is expressed as follows:

$$ln\ \overline{P_{it}}\ -\ ln\ \overline{CC_{it}} = \alpha\ +\ \gamma_1\ ln\ \hat{S}_{it}\ +\ \gamma_2\ \big(\hat{S}_{it}\ \cdot\ \widehat{Restrictions_{it}}\big)\ +\ \sum_y T_i\ +\ \ +\epsilon_{it} \tag{17}$$

$$y = 1997, ..., 2018$$

Once again, the coefficients of interest are γ_1 and γ_2. The reduced-form equations, from which the endogenous variables are predicted, are now:[45]

$$ln\ S_i = \beta_0\ +\ \beta_1 Bartik_i\ +\ \beta_2 Temp_i\ +\ \beta_3\big(Bartik_i \cdot Temp_i \cdot GP_i \cdot Expenses_i\big)\ +\ \sum_y T_i\ +\ u_i$$

$$\big(ln\ S_i\ \cdot\ Restrictions_i\big) = \delta_0\ +\ \delta_1 Bartik_i\ +\ \delta_2 Temp_i\ +\ \delta_3\big(Bartik_i \cdot Temp_i \cdot GP_i \cdot Expenses_i\big)\ +\ \sum_y T_i\ +\ v_i$$

[45]The reduced-form equations, in matrix form with predicted values, why the error terms are omitted, are:

$$\widehat{\begin{bmatrix} ln\ S_i \\ ln\ S_i\ \cdot\ Restrictions_i \end{bmatrix}} = \widehat{\begin{bmatrix} \beta_0 \\ \delta_0 \end{bmatrix}} + \widehat{\begin{bmatrix} \beta_1 & \beta_2 & \beta_3 \\ \delta_1 & \delta_2 & \delta_3 \end{bmatrix}} \begin{bmatrix} Bartik_i \\ Temp_i \\ (Bartik_i \cdot Temp_i \cdot GP_i \cdot Expenses_i) \end{bmatrix} + \begin{bmatrix} \sum_y T_i \\ \sum_y T_i \end{bmatrix}$$

5 Data

In this section, we first briefly describe the data sourcing and variable construction.[46] Then, summary statistics and selected data visualization follow. All nominal price and wage variables are deflated using the Consumer Price Index and are expressed in 1996 prices. All data is retrieved from Statistics Sweden ('SS') if not stated otherwise. All data covers a total of 233 municipalities observed each year for the period 1996–2018, excluding the 55 municipalities classified, by SALAR, as 'rural'.

5.1 Data Sourcing and Construction

House Prices

House prices are used both in the elasticity estimation as well as in the Rosen-Roback model, and are defined as the average yearly purchase price of a one- and two-dwelling building[47] at the municipal level. We avoid using standardized measures of housing prices, such as price per square meter, for two reasons: (i), property land values would in that case be overlooked (a small house may sit on a large property), and: (ii), in case housing size systematically differ across regions, we want a price metric reflecting the average investment for a typical house in that region, to accurately estimate the actual, average cost of housing in each region.[48] We avoid using prices for rented units, as the majority of the population own their homes and rental rates are highly manipulated by the national rent control scheme.

5.1.1 Data Employed in Elasticity Estimation

Housing Stock and Construction Costs

The housing stock variable is retrieved from Statistics Sweden's statistical database 'Housing, Construction and Building', where historical dwelling stock is reported. We use stock of one- and two-dwelling buildings on the municipality level. One-and two-dwelling buildings include (i) detached buildings, (ii) semi-detached buildings, (iii) row buildings, as well as (iv) linked buildings. One-and two-dwelling buildings are the most common form of home ownership: According to SS, in 2018, $\sim 41\%$ of Swedes lived in a one-or two-dwelling building whereas only $\sim 20\%$ lived in an apartment (rentals excluded). These shares have been relatively stable for as far back as 2012, when SS first published statistics on the topic. The other reason why only one- and two-dwelling buildings, and not apartments in multi-dwelling buildings, are included concerns limited data availability. Both price and quantity data on apartments are limited in terms of time span and regional precision.

To account for any possible differences in housing quality across time and regions, we discount house prices for local construction costs. Construction costs are provided by Statistics Sweden and are calculated deducting

[46]For more detailed data sources, see the Appendix.

[47]Sw: *Småhus*.

[48]Housing size differences across regions appear small. Statistics Sweden report the number of existing houses in each municipality divided into 19 different size categories. Calculating the municipal distribution of average house sizes over the period 2013 to 2019, weighted by the municipal housing stock, we find the standard deviation is only ~ 0.4.

for subsidies. They are unfortunately not available at the municipality level – instead, construction costs are available for the 'South', 'Mid', and 'North' regions and the greater metropolitan areas (Stockholm, Gothenburg and Malmö). We consequently assume all municipalities in each of these six regions exhibit uniform construction costs. Construction costs are higher in the three largest cities.[49]

The average house size in the existing housing stock is 122 square meters, whereas the average size of newly constructed homes over the period stretching from 1996 to 2018 was 120 square meters (SS). This means that, while it is not impossible that a new-house price premium is present, we know that newly built houses are at least (almost) the same size as the average house sold on the market. If new houses were smaller and fetched lower prices, discounting the average market price by construction costs would not accurately reflect the house construction Q ratio (or Tobin's Q, as introduced by Tobin and Brainard (1977)).

A New Data Set – Share of Protected Land

There are no ready-made data sets detailing the share of municipal land covered by environmental or biological conservation protections preventing constructions. We therefore construct a new data set, based on numbers from the annual *Protected Nature* (Sw: *Skyddad Natur*) reports published by Statistics Sweden in collaboration with the Swedish Environmental Protection Agency (Sw: *Naturvårdsverket*). They report the size, in hectares, of protected land areas in each municipality. We then compile these values for all 290 Swedish municipalities from 1992 to 2019. We then divide the protected (land) areas by the total land area of the municipality to arrive at the share of land covered by environmental protections.

New municipalities have been created during this period, splitting off from their original jurisdictions. We control for this by merging these newly created municipalities into their original 1992 configuration. For municipalities that merge during the time period, we perform our calculations as if they were merged in their current constellation already in 1992. Hence, we observe the same set of municipalities throughout the period.

The data covers areas of (i) nature reserves, (ii) national parks, (iv) forest habitat protection areas, (iv) other habitat protection areas, as well as (iii) The National City Park (Sw: *Nationalstadsparken*) situated in Stockholm County, where construction of new housing is heavily restricted or entirely banned.[50] The National City Park is reported separately but included in our analysis. Overlaps are taken into account and eliminated.

[49] This presents a potential source of bias: if construction costs also scales with city size outside these metropolitan regions, smaller municipalities in the 'South', 'Mid', and 'North' regions will be assigned construction costs that are too high and larger municipalities ones that are too low. As a result, housing supply elasticities of regions including Stockholm, Gothenburg or Malmö would be biased upwards relative to larger cities in other regions.

[50] Some local variations may exist, and exceptions from these bans may be given under exceptional circumstances (Swedish Environmental Agency).

Demand Instruments

In order to calculate a suitable Bartik instrument, we first need to address the changes to Statistics Sweden's regular industry categorization. As of 1996, Statistics Sweden use 11 different classifications according to the 'Swedish Standard Industry Classification'. By 2018, these have been further subdivided into 16 narrower classifications. For the later time periods, we therefore merge the later subdivisions into their original categories, keeping the initial industry classification fixed at the 1996 format.

Normal January temperature is, by the World Meteorological Organization ('WMO'), defined as the mean over 1961–1990. The Swedish Meteorological and Hydrological Institute ('SMHI') report these normal temperatures for each weather station in Sweden. The weather station being situated closest to each municipality's largest town is used.

Land Restriction Instruments

We use the average Green Party election result from the three general elections in 1988, 1991 and 1994. The period is chosen as 1988 was the first year the Green Party entered the parliament, and 1994 was the last election prior to our period of study.

Protective Expenses include local expenses (as a share of total local governmental expenses) relating to food control/regulation, animal control, alcohol permissions, public health campaigns, pollution regulation etc. These data are retrieved from Statistics Sweden. Unfortunately no data before 2011 is available. Thus, we use the average share of protective expenses over the period 2011–2018 in the municipality as an instrument.

5.1.2 Data Employed in Labor Misallocation Model

Wages

Our unconditional wage variable is the average wage income for gainfully employed citizens aged 20–64 in each municipality. The conditional wage controls for the following municipal demographic and labor market characteristics: (i) the share of the population between 20–64, in each municipality, having obtained a college degree, (ii) the share of the population between 20–64, in each municipality, having obtained a high school degree, (iii) the average age of the population between 20–64 in each municipality, and (iv) the share of the population, between 20–64 years of age in each municipality, that have immigrated to Sweden. All variables have been retrieved from Statistics Sweden – for the years 1996 and 2018 respectively.

Ideally the estimation would have used individual-level wage and worker characteristics data. However, there are no such individual-level nation-wide Swedish data publicly available. This data limitation is to be discussed in greater detail in the Discussion Section.

Employment

Employment data is retrieved from Statistics Sweden. Only employees with residency and place of work in the same municipality and of ages 20–64 are recorded.

Model Parameters

Parameter	Denotion	Value	Source
Labor Elasticity	α	0.64	AMECO Database, European Commission
Capital Elasticity	η	0.26	Basu and Fernald (1997)
Expenditure Share on Housing	β	0.25	Statistics Sweden, *Household budget survey (HBS)*
Inverse Labor Mobility Strength	θ	3^{-1}	Hornbeck and Moretti (2018)
Inverse Housing Supply Elasticity	γ_c	n.a.	Authors' Estimate

The model parameters, used to calibrate the spatial equilibrium model to the data, are presented in the adjacent table. While the labor share of Swedish GDP, α, is the long-run average over the period 1996–2018 calculated from Swedish national accounts, the parameter value of the (tradable/fungible) capital elasticity is set to match the returns to scale in the U.S., based on estimates from Basu and Fernald (1997). Similarly, the labor mobility parameter is based on U.S. data.[51] This is to be further elaborated on in the Discussion Section. Household's expenditure share on housing costs is the average that prevailed 1996–2018, as reported by Statistics Sweden. Finally, the (location specific) housing supply elasticity parameter originates from our own estimations, as previously outlined.

Local TFP

From the local labor demand equation (Equation (6) in Section 4.1.2) we get:

$$A_c^{\frac{1}{1-\alpha-\eta}} \cdot T_c = \frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot L_c \cdot W_c^{\frac{1-\eta}{1-\alpha-\eta}} \propto L_c \cdot W_c^{\frac{1-\eta}{1-\alpha-\eta}} \qquad ^{52}$$

Because we do not observe the level of the reservation utility, $\overline{U}$, we cannot identify the absolute levels of local TFP – only how TFP varies across locations and time. Our local TFP estimates, expressed above, are thus model-driven and derived in the same way as by Hsieh and Moretti (2019). According to Hsieh and Moretti (2019), this model-driven expression is highly correlated with (U.S.) traditional growth accounting TFP estimates. We assume this holds for Sweden as well.

[51] A value of $1/\theta = 0.3$ implies that a one percent increase in earnings is associated with a 0.3 percent increase in employment.

[52] The relation operator $\propto$ means the left hand side, being the definition of local TFP, is proportional to the right hand side.

Local Amenities

From the indirect utility equation (Equation (2) in Section 4.1.1) we can rearrange to express local amenities as:

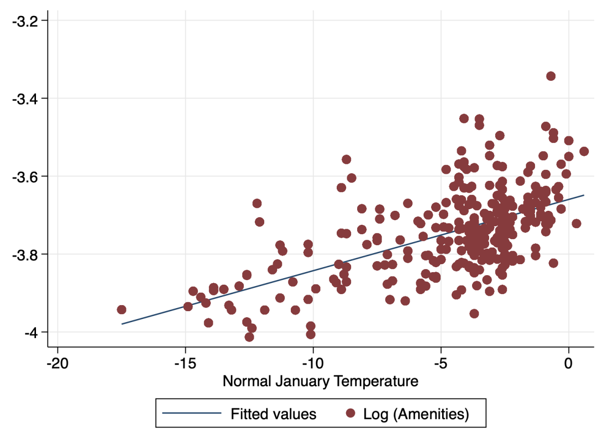
$$Q_c = \frac{\overline{U} \cdot P_c^{\beta}}{W_c}$$

Much like for the TFP variable, as $\overline{U}$ is unobserved, we can only identify relative local amenities and not the level of amenities. Therefore:

$$Q_c \propto \frac{P_c^{\beta}}{W_c} \tag{18}$$

On the municipal level, the correlation between our amenity variable and mean January temperatures is 0.57. In graphical form:

Figure 6: Correlation Model Based Amenities (mean 1996–2018) and January Temperature



5.2 Summary Statistics

5.2.1 Restricted Land

Table 4: Summary Statistics, Restricted Land, Non-Rural Municipalities, 1996–2018

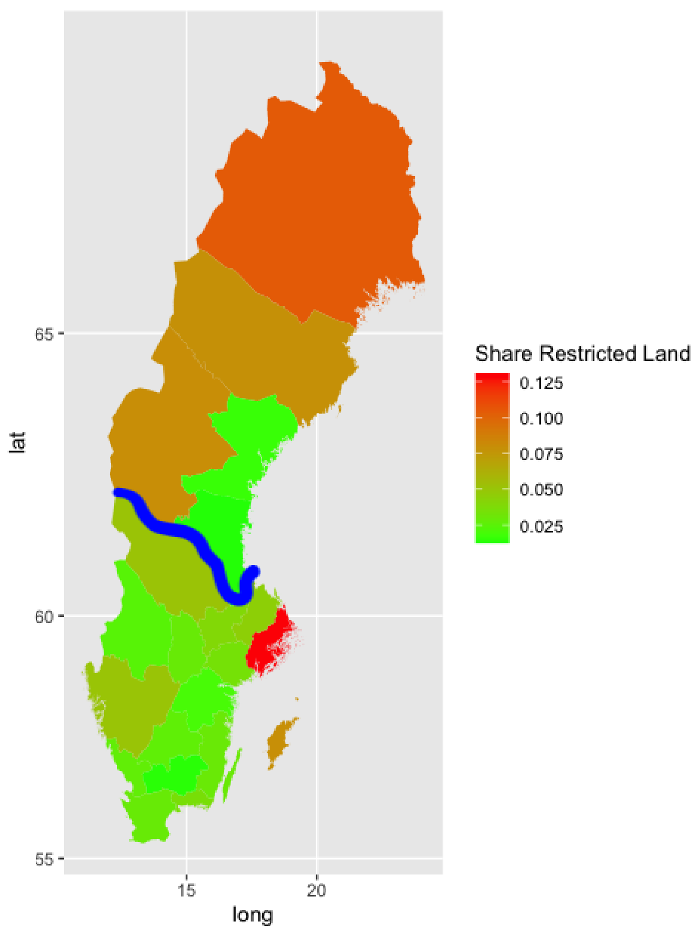
Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P75
Restricted Land	4814	.045	.075	0	.59	.006	.047

Table 5: Summary Statistics, Restricted Land, Stockholm Municipalities, 1996–2018

Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P75
Restricted Land	525	.136	.152	0	.59	.021	.187

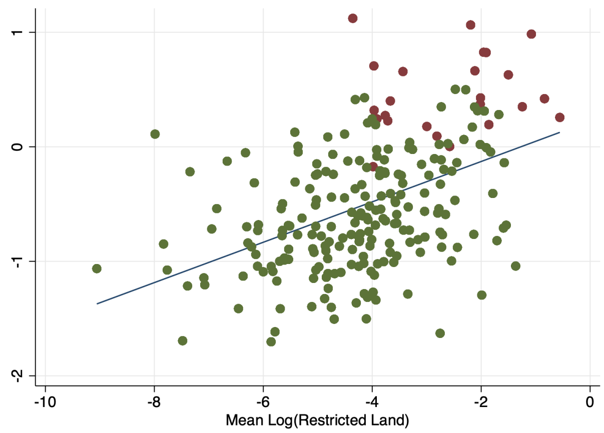
Table 4 presents summary statistics for the municipal-level protected land variable for the entire country (excluding rural municipalities). Table 5 displays the equivalent for Stockholm County alone. Examining the respective means, it is clear that Stockholm municipalities have had noticeably higher levels of protected land, over the period, compared to the national mean. The mean Stockholm municipality has approximately 3.0 times more protected land compared to the mean (13.6% compared to 4.5%). The mean value for all Stockholm municipalities is higher than the 90th percentile of all municipalities (corresponding to 12.4 % of protected land). We also note that the maximum value in the full sample is equal to the maximum value of the Stockholm sample, implying this observation is a Stockholm municipality. Figure 7 graphically visualizes the mean municipality share of protected land, 1996–2018, plotted in the county in which is it situated in.

Figure 7: Spatial Dispersion of Land Restrictions (Mean 1996–2018)



Note: The map depicts the mean share of protected land in each county between 1996–2018, calculated as the mean over each municipality inside the county. Approximately 88% of the Swedish population live south of the blue line. Stockholm County, having the highest mean share of protected land (13.6%) is situated $\sim 60°$ N and 18° E.

Figure 8: Bivariate Correlation Restricted Land, Excess Housing Price (Mean 1996–2018)



Note: Excess housing price on the y axis. Red dots mark Stockholm observations.

Finally, Figure 8 links the observed land protection data to the dependent variable in our instrumental variable regressions – real house prices, adjusted for construction costs. The simple bivariate correlation between the real house prices and the share of protected land is clearly positive and equal to 0.46. Stockholm municipalities are highlighted in red, and are clearly in the extreme end of the distributions of both house prices and land protection.

5.2.2 Unconditional and Conditional Wages

Table 6: Real Wage Summary Statistics By County, 1996 and 2018, SEK 000's

Average Wages, SEK 000's	Min	Mean	Median	Max	Range
1996					
Conditional	148.2	159.9	157.8	172.4	24.2
Unconditional	157.4	164.9	163.3	187.4	30
2018					
Conditional	237.5	249.1	247.9	271.2	34.9
Unconditional	236.3	250.6	245.1	299.7	62.9

Conditional wages are calculated as outlined in Section 4.1.8. As is to be expected, the spatial wage spread decreases as observable demographic and human capital characteristics are controlled for.

5.2.3 Instrumental Variables

Table 7: Summary statistics, Housing Demand Instruments

Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P75
Bartik	233	.242	.100	-.021	.641	.176	.291
Normal January Temperature	233	-3.656	2.504	-14.2	.6	-4.3	-2.4

In Table 7, the summary statistics for the demand instrument used for the full sample is shown. Most municipalities have experiences positive labor demand (Bartik) shocks, and with a coefficient of variation in excess of $\sim 41\%$ over the full period, the variation between municipalities is large. Normal January temperatures are also widely dispersed across municipalities – to be expected, given the diverse geography of Sweden.

Table 8: Summary statistics, Protected Land Instruments

Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P75
GP vote share	25	.051	.006	.040	.062	.047	.055
Expense Share	25	.004	.002	.001	.008	.003	.005

Table 8 presents summary statistics of the instruments used to endogeneize land protection in Stockholm. We observe 25 Stockholm municipalities each year. Although the Green Party vote share appears limited in percentiles, the maximum value is 50% larger than the minimum – a significant amount of variation. In a similar fashion, while mean shares of public spending on 'protective expenses' are limited in relation to the overall budgets, there is very large variations between municipalities.

5.2.4 Comparing 1996 and 2018 Distributions

We now present how the wages, house prices, productivity, and amenities deviate from the national mean for Sweden's three largest counties between 1996 and 2018. As explained in for example Section 4.1, spatial dispersion in real economic variables have implications for factor misallocation and subsequently aggregate output. Thereafter we graphically illustrate the distributions of all municipalities, and how dispersions have changed from 1996 to 2018.

Table 9: Employment-Weighted Log Deviations from National Mean

	1996	**2018**
Real Housing Price		
Stockholm County	0.725	1.120
Västra Götaland County	0.270	0.550
Skåne County	0.231	0.438
Real Wage		
Stockholm County	0.159	0.196
Västra Götaland County	0.011	0.050
Skåne County	-0.019	-0.023
TFP		
Stockholm County	3.153	3.765
Västra Götaland County	1.247	1.872
Skåne County	0.736	0.983
Amenities		
Stockholm County	0.981	1.238
Västra Götaland County	0.446	0.630
Skåne County	0.299	0.460

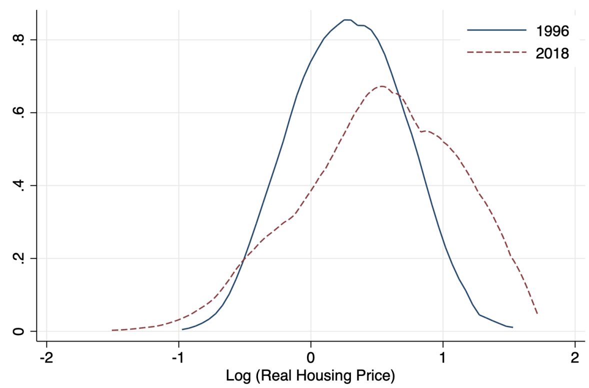
In Table 9 we see that, between 1996 and 2018, the three largest counties all have moved farther away from the national mean wage. Stockholm is a clear right-tail outlier, and in the context of our model framework, the increased wage deviation implies that labor misallocation has increased. We can also see that Stockholm is also significantly more productive than other cities, and has pulled away from mean TFP. In fact, Stockholm, Västra Götaland, and Skåne have all contributed to increased dispersions.[53]

Housing Prices

Figure 9 compares distributions of mean housing price of the 233 non-rural sample municipalities observed in 1996 and 2018. Both kernel density plots are de-meaned, log-transformed using the natural logarithm, and employment-weighted. The distribution of the mean house price has changed quite remarkably between the two years. In 1996, no municipality mean exceeded the sample average by more than 1.40 log points, whereas in 2018 the maximum observation corresponds to a position approximately 1.72 log points above the sample mean. Conversely, no municipality fell short of the sample mean by more than 1.00 log points in 1996 whereas the 2018 minimum is 1.51 log points below the average. The standard deviation goes from ~ 0.38 log points in 1996, to ~ 0.57 in 2018. Visually, we can see that the mass of distribution has clearly

[53] Real wages in Skåne is the only exception where the largest counties are positively deviating from national means. However, even in this example Skåne is contributing to increased dispersion, albeit by falling further below the national mean.

Figure 9: De-meaned Employment-Weighted Log(Real House Prices)

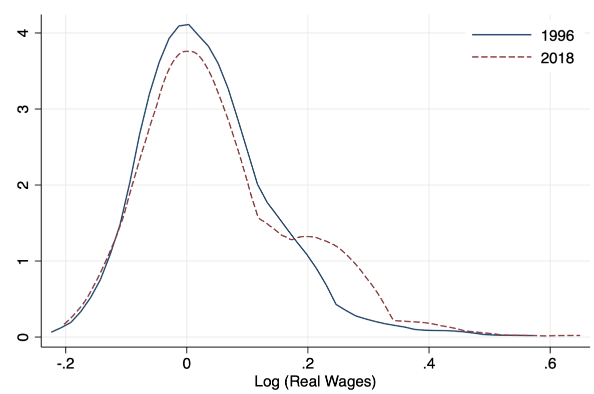


Note: 233 non-rural municipalities observed in both years included.

shifted to the right, meaning the 2018 distribution is less centered around the national (regular) mean, and larger municipalities have driven up the housing prices (as municipalities with higher employment are given more weight in the plot).

Real and Conditional Wages

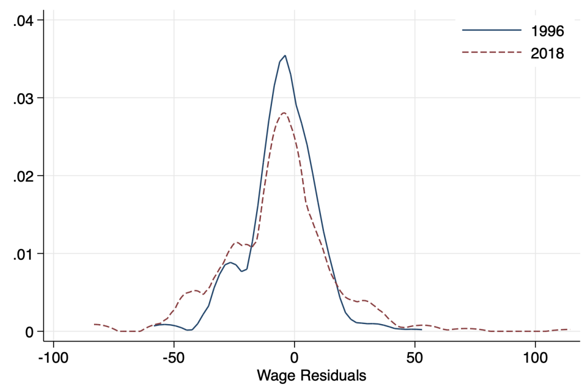
Figure 10: De-meaned Employment-Weighted Log(Real Wages)



Note: 233 non-rural municipalities observed in both years included.

In Figure 10 the change of distribution between the two years is less striking compared to the house price distribution. Given the Swedish labor market is characterized by strict collective bargaining, this compressed wage structure is not surprising. Despite this, the dispersion has widened somewhat. In 1996, the standard deviation is approximately 0.100 log points, increasing to 0.124 in 2018. The maximum has gone from approximately 0.52 log points above the mean in 1996 to around 0.65 log points in 2018. The minimum has decreased from around -0.17 to -0.20. Of the 11 municipalities exceeding the mean by more than two standard deviations in 2018, 8 were Stockholm municipalities, again illustrating that dispersion in mean wages is to a

Figure 11: Employment-Weighted Real Wage Residuals



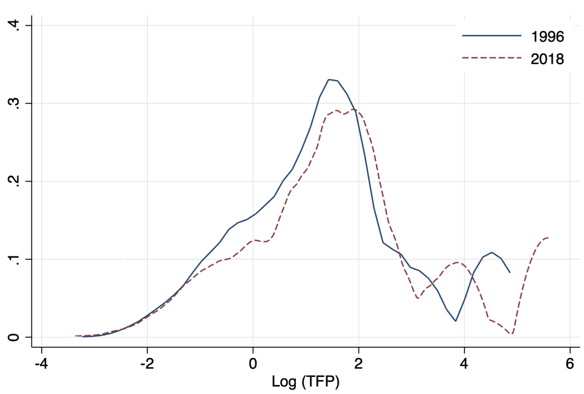
Note: 233 non-rural municipalities observed in both years included. The unit here is SEK 000's in 1996's prices.

large extent driven by developments in the capital.

Figure 11 plots the wage residuals from the conditional wage regression described in Section 4.1.8. The dispersion of real wages, controlled for educational attainment, age, and immigration status in a municipality has widened markedly. The standard deviation of the residuals have increased from ~ 13.9 in 1996 to around 22.8 in 2018.

Productivity

Figure 12: De-meaned Employment-Weighted Log(TFP)



Note: 233 non-rural municipalities observed in both years included.

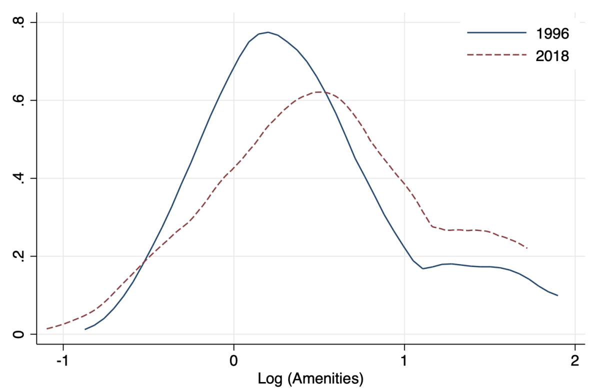
As introduced in Section 4.1, local TFP is proportional to a function of employment and wages.[54] The dispersion in local TFP has widened from exhibiting a standard deviation of 1.60 log points in 1996 to a

[54]
$$A_c^{\frac{1}{1-\alpha-\eta}} \cdot T_c = \frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot L_c \cdot W_c^{\frac{1-\eta}{1-\alpha-\eta}} \propto L_c \cdot W_c^{\frac{1-\eta}{1-\alpha-\eta}}$$

standard deviation of 1.93 in 2018. The employment weighted mean Stockholm municipality has moved from $\sim$ 3.2 log points above the mean to around 3.8 log points above the mean. From the shape of the distribution graph, it is further noticed that the mass of outliers in the right tail has increased.

Amenities

Figure 13: De-meaned Employment-Weighted Log(Amenities)



Note: 233 non-rural municipalities observed in both years included.

Since the common utility $\overline{U}$ is not observed, amenities cannot be identified in levels – but we are able to identify local amenities as *deviations* from $\overline{U}$. In order to visualize the distribution of amenities in natural logs, they are expressed in terms of real wages. Interestingly, the 2018 distribution has moved right, with a center of mass at roughly 0.60 log points above the mean. This means that larger municipalities are experiencing better amenities in 2018 compared to 1996. In Hsieh and Moretti (2019), the opposite shift has occurred, and larger cities experience, in general, worse amenities. In our data, Stockholm has moved from being roughly 0.98 log points above the mean to being around 1.24 above.

We note that the amenity variable is constructed to effectively catch the 'slack' between wages and house prices. If workers are willing to pay more for housing despite not earning a premium for working there, something else – amenities – must be improving their utility. As such, the Stockholm amenity deviation is moving further right because Stockholm prices are deviating faster than wages.

6 Results

This section will first present our housing supply elasticity estimates. As described in the Method Section, we provide both a national average elasticity, as well as county-specific elasticities. Finally, we estimate how the share of protected land determines the local Stockholm elasticity. Having attained our county elasticity estimates, we then compare how prices, wages, productivity, and amenities have developed in the least and most elastic counties.

We then apply the county elasticities to the theoretical framework presented in Section 1.1 for the counterfactual growth analysis. In order to test how the model reacts, we first fix wage and house price dispersions to 1996 levels to obtain total output loss due to labor misallocation. Next, we perform our policy experiment, being our main results, by changing Stockholm supply elasticity to the level it would have had given lower shares of protected land. This policy experiment is first executed assuming perfect labor mobility, and then repeated under more conservative (less mobile) assumptions, using both real and conditional wages. We also present counterfactual labor allocations and discuss the implications of relaxing land protections in Stockholm on nationwide city populations.

6.1 Long-Term Housing Supply Elasticity Estimates

6.1.1 National Average Elasticity, 1996–2018

Looking at Table 10, we can first of all conclude that the simple OLS estimate (column (1)) of the inverse elasticity is biased downwards due to the expected simultaneity bias, as reviewed in Section 4.2. Second, the point estimate of long-run mean supply elasticity in column (2) amounts to $1/0.806 \approx 1.241$, statistically significant at the 1% level. This implies that a one percent increase in housing demand is associated with a 1.241 percent increase in new housing construction. This appears to be a reasonable point estimate, approximating the results in existing literature. Saiz (2010), which employs an instrumental variable method similar to ours, estimates a U.S. elasticity of ~ 1.5 using data from 1970–2000. Caldera and Johansson (2013), using a vector error correction framework, reports a U.S. long-run elasticity of ~ 2.0. Caldera and Johansson's result for Sweden is 1.381, and so much like that of Saiz (2010) our IV estimate is slightly below Caldera's VECM estimate.[55]

[55] We note that there are several further differences between Caldera and Johansson (2013) and our estimation. For example, while our sample is restricted to relatively urbanized areas, they instead employ aggregate OECD data. Their sample also covers a different time period – 1975 to 2008.

Table 10: Full Sample Long-Run Housing Supply Elasticity

Dependent Variable: log (Real Excess Housing Price)	(1)	(2)	(3)
	OLS	2SLS	2SLS
log (Housing Stock)	0.348***	0.806***	0.774***
	(0.099)	(0.065)	(0.054)
log (Housing Stock) × Restricted Land			0.175***
			(0.028)
Constant	-3.627***	-7.682***	-7.435***
	(0.849)	(0.601)	(0.505)
Time Fixed Effects	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes
Observations	4814	4814	4814
First Stage F Statistic		47.555	38.498
P-Value Hansen J Test		0.432	0.571

Standard errors, clustered on the county level, in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note that out panel is not fully balanced.[56] The first stage for column (2) including the temperature and labor demand shock instrument is presented in table 10b below. The first stage prove to be strong, with an F statistic of 47.555, above the 5% critical value of 13.91 indicated by Stock and Yogo (2005). Column (3), too, has a strong first stage with an F statistic of 38.498. All first stage regressions are reported in the Data Appendix.

[56] Data on construction cost is not available for 26 municipalities in northern Sweden for the period 1998–1999 and 2001. The years 1997 and 2005 are omitted, as no data on land restrictions exist. In 1999, there is no data for the municipality Håbo. In effect, the number of observations amounts to $(233 \cdot 23) - (26 \cdot 3) - (233 \cdot 2) - 1 = 4814$ out of $233 \cdot 23 = 5395$ leaving $\sim 10\%$ missing values.

Table 10b: First Stage (from Table 10 Column (2))

	log (Housing Stock)
Mean January Temperature	0.108**
	(0.048)
Bartik Labor Demand Shock	5.264***
	(0.607)
Constant	7.939***
	(0.142)
Regional Fixed Effects	Yes
Time Fixed Effects	Yes
Observations	4814
F Statistic	47.555

Standard errors, clustered on the county level, in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In Table 10, column (3), where land regulation interaction term has been added, the coefficient of the interaction is of expected sign and highly significant. This suggests that our measure of land restrictions indeed affects long-term Swedish housing supply elasticity. However, since the fraction of nature reserves in the mean municipality is very small (4.5% of total area), its mean impact on the national supply elasticity is limited, yet statistically significant. Multiplying the log (Housing Stock) × Restricted Land interaction term coefficient with the mean share of protected land, we find that 1.00% of the mean elasticity is explained by the share of protected land.

6.1.2 County IV Estimates

Having presented the long-term mean housing supply elasticity, we now estimate the county specific elasticities that will serve as parameters in our spatial equilibrium model. Using the same specification as column (2) in Table 10, but restricting the sample to just the municipalities in each county, the resulting inverse IV coefficients (i.e. local elasticites) are presented in Table 11 below.

Table 11: County Elasticity Estimates

Rank	County	Supply Elasticity	Time Fixed Effects	F Statistic	Over id P-Value
1	Västmanland	**2.212*****	Yes	36.115	0.806
2	Jönköping	**2.199*****	Yes	17.429	0.415
3	Södermanland	**2.159*****	Yes	35.904	0.000
4	Norrbotten	**1.925*****	Yes	31.523	0.087
5	Blekinge	**1.914*****	Yes	8.725	0.190
6	Östergötland	**1.910*****	Yes	114.738	0.375
7	Gävleborg	**1.898*****	Yes	28.270	0.156
8	Västerbotten	**1.848*****	Yes	11.702	0.709
9	Dalarna	**1.770*****	Yes	12.012	0.357
10	Kronoberg	**1.519*****	Yes	22.799	0.218
11	Kalmar	**1.348*****	Yes	14.547	0.115
12	Halland	**1.337*****	Yes	176.472	0.282
13	Örebro	**1.312*****	Yes	116.941	0.472
14	Värmland	**1.271*****	Yes	234.173	0.453
15	Skåne	**1.252*****	Yes	27.814	0.407
16	Uppsala	**1.127*****	Yes	47.532	0.930
17	Västra Götaland	**1.105*****	Yes	16.323	0.103
18	Jämtland	**1.078*****	Yes	2284.086	0.928
19	Stockholm	**0.869*****	Yes	11.375	0.990

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Note: Västernorrland and Gotland counties are excluded due to respectively containing only 1 and 4 non-rural municipalities. The Stockholm estimate is further explained in Table 12.

From the estimates in Table 11, we can conclude that the elasticity varies significantly across counties. The standard deviation is ~ 0.42, and the highest elasticity (Västmanland county) exceeds the lowest estimate (Stockholm county) by a factor of ~ 2.93. The population weighted[57] elasticity is approximately 1.326, essentially same as the estimate in Caldera and Johansson (2013) and highly aligned with the national average of ~ 1.297 (Table 10, column (2)) when Västernorrland and Gotland are left out (1.241 including

[57]Using average population over the period.

all).

Furthermore, it is apparent that counties with higher population are associated with lower supply elasticities. The three most populated counties (Stockholm, Västra Götaland and Skåne) are all among the bottom five in the elasticity ranking.[58] Finally, the instruments appear strong in each county-sample given the F statistic in each first stage regressions. The Hansen J test passes at conventional significance levels, with the exception of Södermanland county. This calls into question whether the instruments fulfill the exclusion restriction for this county: however, given their sound theoretical foundations and excellent performance in all other counties, we move ahead with the estimate anyway.

6.1.3 Stockholm Elasticity, 1996–2018

Table 12: Stockholm Long-Run Housing Supply Elasticity

Dependent Variable: log (Real Excess Housing Price)	(1)	(2)	(3)
	2SLS	2SLS	2SLS
log (Housing Stock)	1.323***	1.138***	1.119***
	(0.340)	(0.255)	(0.347)
log (Housing Stock) × Restricted Land		0.196***	0.233***
		(0.0637)	(0.0834)
Constant	-11.22***	-9.783***	-10.21***
	(2.933)	(2.233)	(2.939)
Observations	525	525	525
Time Fixed Effects	Yes	Yes	Yes
Endogenized Protected Land	No	No	Yes
First Stage F Statistic	11.375	11.529	8.323
P-Value Hansen J Test	0.990	0.079	0.027

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We now restrict the sample to Stockholm county, using the same 2SLS method. Results are presented in Table 12, and all estimates are statistically significant at the 1% level. The most parsimonious specification in column (1) yields an inverse elasticity of 1.323, corresponding to an elasticity of $1/1.323 \approx 0.756$. Given a mean fraction of protected land in Stockholm county equal to $\sim 13.6\%$, including the share of protected land (column (2)) decreases the total inverse elasticity estimate to 1.165, corresponding to a supply elastictity of 0.858.[59] Endogenizing the share of protected land (column (3)) yields a supply elasticity of 0.869.[60] Under

[58] The correlation between the housing supply elasticity and mean population over the period 1996–2018 is -0.55.

[59] $1.138 + 0.196 \cdot 0.136 = 1.165 \rightarrow 1/1.165 = 0.858$.

[60] $1.119 + 0.233 \cdot 0.136 = 1.150 \rightarrow 1/1.150 = 0.869$.

this specification, protected land explains roughly 2.8% of the Stockholm housing elasticity.[61]

The fact that including the protected land interaction term yields an estimated elasticity that is about 14% higher is an obvious issue. Had the specification performed perfectly, the same level of elasticity would have been identified. Still, given that the decomposed elasticity is higher than the more parsimonious specification, our later counterfactual growth estimates are likely on the conservative side.

The F statistic is above the 10% maximal bias critical value of 9.08 in both specifications (column (1)–(2)), proving the instruments are strong (Stock and Yogo, 2005). Although the F statistic decreases to 8.323, when land restrictions are instrumented (column (3)), this is still above the 20% maximal bias threshold of 6.46 in Stock and Yogo (2005), which still prove strong instruments (Saiz, 2010).

The estimates in column (3) also sets up our policy experiment. The mean municipal share of protected land in the nation is ≈ 67% lower than the Stockholm county share, or 4.5% compared to 13.6%. Assuming 4.5% protected land in Stockholm yields a counterfactual Stockholm elasticity of 0.885.[62]

[61] The presence of nature reserves in a municipality is clearly not a major elasticity determinant. However, fully decomposing housing supply elasticity determinants is not the aim of this estimation: rather, we wish to unlock relevant local policy mechanisms.

[62] $1.119 + 0.233 \cdot 0.045 = 1.129485 \rightarrow 1/1.129485 = 0.885$.

6.1.4 Economic Implications of Heterogeneous Housing Supply Elasticity

Table 13: Productivity Shock Outcomes: Log Deviations From Mean

	1996	**2018**	**Δ**	**TFP Shock**	**1996**	**2018**	**Δ**	**TFP Shock**
			TFP				***Real House Price***	
Highest γ_c								
Stockholm County	3.153	3.765	0.612	**1**	0.725	1.120	0.395	**0.645**
Västra Götaland County	1.247	1.872	0.625	**1**	0.270	0.550	0.280	**0.448**
Uppsala County	1.438	1.806	0.368	**1**	0.306	0.493	0.187	**0.508**
Lowest γ_c								
Jönköping County	0.482	0.897	0.415	**1**	0.029	0.173	0.144	**0.347**
Östergötland County	0.861	1.167	0.306	**1**	0.188	0.360	0.172	**0.562**
Västerbotten County	1.073	1.235	0.162	**1**	0.116	0.190	0.074	**0.457**

	1996	**2018**	**Δ**	**TFP Shock**	**1996**	**2018**	**Δ**	**TFP Shock**
			Real Wage				***Employment***	
Highest γ_c								
Stockholm County	0.159	0.196	0.037	**0.060**	1.977	2.317	0.340	**0.556**
Västra Götaland County	0.011	0.050	0.039	**0.062**	1.167	1.504	0.337	**0.539**
Uppsala County	0.012	0.036	0.024	**0.065**	1.346	1.542	0.196	**0.533**
Lowest γ_c								
Jönköping County	-0.018	0.0107	0.039	**0.094**	0.618	0.818	0.200	**0.482**
Östergötland County	-0.023	-0.008	0.015	**0.049**	1.032	1.224	0.192	**0.627**
Västerbotten County	-0.001	-0.002	-0.001	**-0.006**	1.080	1.248	0.168	**1.037**

Note: The numbers presented are employment-weighted log deviations from the national mean. In the column "TFP Shock", all changes in employment-weighted log deviations from the national mean between 1996 and 2018 are rescaled (divided by the employment-weighted log deviations in TFP between the two years) to illustrate illustrating the associated changes in the variables (relative to the national mean) between the two years associated with a one log point increase in relative TFP. For more details, see the text.

According to spatial equilibrium theory (see Section 1.1) we expect a TFP shock to have different effects depending on the elasticity of the local housing market. An elastic location will see a larger spike in local employment and subdued increases in wages and prices, whereas an inelastic location will inversely experience a lower increase in employment and larger reactions in prices and wages.

Thanks to our county elasticity estimates, we can evaluate these predictions against real data. Table 13 displays the 1996 to 2018 changes in log mean deviations of TFP, house prices, real wages, and employment in the three lowest- and highest–elasticity counties that have experienced a relative increase in local TFP.[63] By dividing the historical change of a variable by the TFP change, we can evaluate the effects of a (relative

[63] TFP is estimated as in the model: wages, house prices and employment are all historical data.

to the mean) TFP unit shock. We expect the high elasticity counties to express larger responses in wages and house prices, and smaller employment responses.

A one log point TFP deviation increase in the average high–γ_c county is associated with a $\sim$ 53% relative housing price deviation compared to $\sim$ 46% for the low–γ_c counties. For wages, the values are $\sim$ 6% and $\sim$ 5%, and for employment $\sim$ 54% and $\sim$ 72%. Comparing the high and low-elasticity counties, we can see that a one log point increase in the average high-elasticity county is associated with a (i) $\sim$ 18% lower relative housing price appreciation, (ii) $\sim$ 3% lower relative wage appreciation, and (iii) $\sim$ 17% *higher* relative employment growth. With the possible exception of wages (which as we have discussed previously may not react in the expected manner due to Sweden's labor market characteristics), results are in line with theoretical predictions.

6.2 Counterfactual Growth Analysis

Table 14: Aggregate Growth Effects of Local Changes in Wages and Housing Prices

	Output
Base Case Annual Output Growth	2.2%
Δ Annual Growth From	*Perfect mobility*
Fixing 1996 Wages in	
All Counties	33.7%
Stockholm	17.9%
Fixing 1996 Housing Price Dispersion in	
All Counties	47.5%
Stockholm	43.1%

Note: This estimation assumes perfect labor mobility ($1/\theta = 0$) and is only meant to be indicative of how the model responds to dispersion in prices and wages.

From Equation (10) in the Method Section, we know that the growth rate of aggregate output depends on the power mean of local TFP (the direct technology effect), as well as the dispersion of wages (the allocative efficiency of labor). An increase in wage dispersion results in misallocation of labor and lower aggregate growth.

In Table 14, we quantify the total output cost of increased spatial labor misallocation over the period 1996–2018 by holding real wages fixed to 1996 and allowing other variables to change as in the historical data. The *level* of wages are irrelevant, since local wages are divided by aggregate mean wages in the aggregate output function. Holding wages fixed to 1996 levels would in the model raise aggregate growth because wage dispersion (and consequently labor misallocation) has grown over time.

Holding the wage dispersion fixed to 1996 levels in all locations, counterfactual annual output growth would have been 33.7% higher. Holding Stockholm's wage dispersion fixed alone, leads to 17.9% higher annual growth, meaning that over half of all output lost to misallocation is caused by Stockholm wages pulling away from the national mean.

In order to analyze the effect of rising house prices, and rising house price dispersion, we first need to remember that since $\frac{\overline{W_c}}{W_c} = \frac{\overline{P_c^\beta/Q_c}}{P_c^\beta/Q_c}$, in equilibrium total labor misallocation is determined by the change of the distribution of P_c^β/Q_c, being the local housing price adjusted for amenities. House prices are, once again, highly relevant for determining wage dispersion and labor misallocation.

To isolate the effect house prices have had on the output growth we hold the house price dispersion fixed to 1996 levels in Stockholm and all counties. The model reveals that increased house price dispersions nationwide and in Stockholm alone respectively have cost 47.5% and 43.1% in annual output growth, a very significant loss. The fact that the growth lost to increased house price dispersion is higher than increased wage dispersion implies that increased amenities have contributed to alleviating the negative effect housing prices have had on increased dispersion in marginal product of labor. It is also remarkable that Stockholm housing prices alone have contributed to more than 90% of the total negative growth effect spatial misallocation – highlighting how the failure to construct new housing has been concentrated to the capital region.

Reducing Stockholm Land Restrictions

Table 15: Aggregate Growth Effects of Reducing Share of Protected Land in Stockholm

	Aggregate Output	
Base Case Annual Real Output Growth Per Worker	2.2%	
Δ Annual Growth From	*Perfect Mobility*	*Imperfect Mobility*
– Adopting Mean Municipality's Share Of Land Restrictions	36.7%	13.3%
– Decreasing Stockholm Land Restrictions By		
25%	14.4%	5.0%
50%	28.2%	10.0%
75%	40.6%	14.9%

Note that adopting the same level of nature reserves as the average municipality would entail a 67% decrease.

Table 15 presents the counterfactual change in aggregate output growth from increasing housing supply elasticity in Stockholm by decreasing the share of protected land. Adopting the same share of protected land as the mean municipality would entail a 67% decrease in Stockholm protected land.[64] Going forward, we treat this as our 'base line' policy experiment.

Starting with the extreme case of perfect labor mobility, annual real output growth per worker in Sweden

[64]Keeping the share of protected land fixed at its 1996 value implies a $\sim$ 28% reduction of the mean share over the full period (1996–2018).

could have been 36.7% higher, on average, during the period 1996–2018 if nature reserves in Stockholm would, on average, cover the same share of land in Stockholm as in the mean (non–rural) Swedish municipality. Consequently, the counterfactual annual aggregate per capita growth rate would be $2.2\% \cdot 1.367 \approx 3.01\%$ in our sample of all non–rural municipalities. Assuming the more realistic case of imperfect labor mobility, the corresponding increase in growth rate would be only 13.3%, resulting in a counterfactual growth rate of $\sim$ 2.49%.

Under perfect mobility and the base line case of land restriction change, Stockholm's wage gap (compared to the national weighted average) would be roughly 40% lower (going from 13.9% above the weighted average to 8.4%). Under imperfect mobility, Stockholm's wages gap would decrease by approximately 14% (going from 13.9% above to 11.9% above the national weighted average).

Table 16: Counterfactual Labor Allocation From Reducing Share of Protected Land in Stockholm

		Employment Growth			
		Perfect Mobility		*Imperfect Mobility*	
County	Actual (%)	Counterfactual (%)	Δ (%)	Counterfactual (%)	Δ (%)
Largest Growth					
Stockholm	43.2	88.8	105.6	57.9	34.1
Halland	30.2	15.1	-50.0	25.3	-16.2
Skåne	30.1	15.0	-50.1	25.3	-16.2
Västra Götaland	28.8	13.8	-51.9	24.0	-16.8
Median Growth					
Södermanland	18.4	4.6	-74.8	13.9	-24.2
Smallest Growth					
Dalarna	9.1	-3.5	-138.9	5.0	-44.8
Gävleborg	7.9	-4.6	-158.8	3.8	-51.3
Kalmar	6.3	-6.1	-196.5	2.3	-63.4

Note: Results are given the counterfactual scenario, over the period 1996–2018, if Stockholm would adopt the same share of land restrictions as the mean municipality.

Under the extreme assumption of perfect labor mobility, our counterfactual policy experiment would lead to Stockholm's labor growth increasing by 105.6% over the period of 1996–2018. With imperfect mobility, the labor force growth instead increases by 34.1%. With the actual labor force population increasing by approximately $340,000$ workers over the period to total $\sim 1,128,000$ gainfully employed, this implies that the counterfactual Stockholm labor force would be 32% or 10% higher, depending on labor mobility.

If we look at the counties experiencing the smallest population growth over the period 1996–2018, wage levels deviated from the national mean. Since they already in 1996 had wages below the national average, the further decrease in their relative wage has widened the gap in marginal products even further, worsening allocative efficiency. Increasing Stockholm housing elasticity alleviates labor misallocation by shifting labor away from these locations to Stockholm, lifting wages, and results in positive aggregate growth by alleviating labor misallocation. Inversely, allowing for a more elastic Stockholm housing market leads to a higher equilibrium employment level which puts downward pressure on wages there. Seeing how Stockholm wages have increased relative to the national mean, and contributed to increased dispersion in MPL, lowering wages in Stockholm leads to increased allocative efficiency and higher aggregate growth.

6.3 Counterfactual Growth Analysis – Conditional Wages

Table 17: Aggregate Growth Effects of Reducing Share of Protected Land in Stockholm - Conditional Wages

	Aggregate Output	
Base Case Annual Real Output Growth Per Worker	2.2%	
Δ Annual Growth From	*Perfect Mobility*	*Imperfect mobility*
– Adopting Mean Municipality's Share Of Land Restrictions	22.0%	8.5%
– Decreasing Stockholm Land Restrictions By		
25%	9.2 %	3.3%
50%	17.4 %	6.5%
75%	24.0 %	9.5%

Note that adopting the same level of nature reserves as the average municipality would entail a 67% decrease.

As Stockholm wages, conditional on human capital characteristics, have diverged less from the national mean than unconditional real wages, running the same experiment with conditional wages yield lower counterfactual growth results – 8.5% higher annual output growth under imperfect mobility, compared to 13.3% using real wages as marginal product of labor. The implied aggregate annual growth, under imperfect mobility and using conditional wages, is $\sim$ 2.39%.

When using the conditional wage variable, Stockholm deviates far less from the national mean compared to the real wage scenario. Deviation in prices, however, stays the same. Because we calculate amenities as a function of wages and prices, the amenity variable will catch the 'slack' introduced by the more conservative wage variable and result in higher Stockholm amenities offsetting lower wages. The relative utility of Stockholm and other counties is therefore the same, and the implied labor allocations are identical to those presented in Table 16.

7 Discussion

In this section, we critically evaluate assumptions made throughout the paper, as well as review possible extensions to our work that could be relevant for future research. Policy implications of our results are then discussed.

7.1 Elasticity Robustness

Our choice of instrumental variables for housing demand – the Bartik instrumet and local January temperatures – are theoretically solid, perform well statistically, and align with the limited previous research on Swedish housing supply elasticities. Consequently we are confident in our estimates of national as well as local county supply elasticities. The introduction of the protected land share interaction variable in the aggregate estimation presented in Table 10 also works well – the implied national elasticity estimate in column (3) only differs from column (2) by about 3%.

However, when we introduce the protected land interaction term in the local Stockholm country estimate (Table 12), the implied inverse housing supply decreases. Comparing column (2) to column (1), the estimated inverse elasticity is 12% lower.[65] This runs contrary to our findings in the national estimation, and implies that at least one of the estimates are biased. Considering the strong theoretical backing of the Bartik and January temperature instruments, the estimate in column (1) is likely closest to the true supply elasticity, and we view the estimates in column (2) and (3) with some suspicion. Nevertheless, because the size of the deviation is relatively minor, we proceeded to use the implied Stockholm county supply elasticity of 0.869 from column (3) in Table 12. Consequently there is a possibility we have estimated a housing supply elasticity in Stockholm being relatively *too high*, compared to estimates for the other counties.

In terms of the spatial model, this overestimation of local elasticity will lead to an underestimation of the effect of a local Stockholm TFP shock on aggregate labor misallocation. The level of supply elasticity in Stockholm relative to other counties is, however, irrelevant to the counterfactual policy experiment. Because prices are determined locally and historical wages and prices determine demand, only the *change* in local elasticity matters. As such, if we choose to retain the coefficient of protected land on local elasticity from column (3) but instead use the level of elasticity from column (1), the change relative to the initial level of elasticity is smaller. This leads to just slightly lower levels of counterfactual growth (presented in Section 9 in the Appendix) but no material changes in the functioning or interpretation of the model.

7.2 Instrument Validity

While our instruments are proven strong, a further discussion on their validity is required. The bulk of the variation in the Bartik labor demand instrument stems from differences in local base year (1996) industry composition. An underlying (and untestable) assumption ensuring validity is consequently that the base year industry composition does not directly have an impact on local housing prices.

[65] Instrumenting the protected land variable (column (3)) decreases the estimate further, albeit only very slightly.

In our application of the Bartik instrument, local industry composition does not determine prices other than through the resulting local labor demand as some sectors grow and other stagnate – which interacts with local housing supply, determining prices. However, it is not unthinkable that local industry composition could be correlated with labor supply via amenities. For example, a municipality with an initially large manufacturing sector will over time experience lower labor demand as growth in the industry stagnates and employment falls. But the presence of decaying manufacturing plants and blight that is associated with stagnating industry might also act as a negative amenity, decreasing labor supply. Because the instrumental variable regression relies on the Bartik instrument acting as an exogenous labor demand shifter, this is a possible threat to our identification strategy. Still, manufacturing leading to urban decay and negative amenities is a theoretical issue – and it is completely irrelevant to all sectors outside of intense manufacturing.

Regarding the protective public expense share instrumenting protected land, there is a risk some municipal operations embedded in these costs actually could result in better local amenities directly reflected in local housing prices. In case this is true, the exclusion restriction would not hold and the estimate would be biased. Without empirical facts on this relationship we can not rule this risk out. However, these expense shares constitute a very small share of total public expense, and is likely not among the main amenities driving local housing prices.

7.3 Parameter Sensitivity

Our counterfactual growth estimates are quantitatively sensitive to changing parameter values. This is true regarding the labor and capital shares in the production function (and the resulting returns to scale), as well as the elasticity of labor supply. Further, the capital share η and labor mobility parameter θ are not estimated using Swedish data. Hence, one should be be cautious interpreting the magnitude of our output growth estimates. Rather, our results highlight the presence of aggregate losses due to (local) housing market inefficiencies in a simple but theoretically sound model. Below we present parameter sensitivity analyses, exploring how our base case protected land policy experiment changes given different labor share, capital share, and labor mobility parameter values.

Table 18: Altering Production Technology

	Base Line (1)	(2)	(3)
	$\alpha = 0.64$, $\eta = 0.26$	$\alpha = 0.60$, $\eta = 0.30$	$\alpha = 0.70$, $\eta = 0.20$
Δ Annual Output Growth From			
Decreasing Stockholm Land Restrictions			
To Mean Municipality's	8.5%	7.9%	9.5%

Note: Column (1) is reproduced from Table 17 using conditional wage, imperfect mobility and the base line change in land restrictions.

In Table 18, we alter the labor and capital shares in the production function, while keeping the sum of the shares (i.e. the return to scale) unchanged. It is clear that modelling a larger labor share α increases aggregate gains from more efficient labor allocation. This is expected, as labor playing a larger role in generating output means losses to allocative efficiency in labor are greater.

Table 19: Altering Returns to Scale

	Base Line (1)	(2)	(3)	(4)	(5)
	$\alpha = 0.64$,	$\alpha = 0.67$,	$\alpha = 0.61$,	$\alpha = 0.64$,	$\alpha = 0.64$,
	$\eta = 0.26$,	$\eta = 0.26$,	$\eta = 0.26$,	$\eta = 0.29$,	$\eta = 0.23$,
Δ Annual Output Growth From					
Decreasing Stockholm Land Restrictions					
To Mean Municipality's	8.5%	13.9%	5.8%	13.2%	6.1%

Note: Column (1) is reproduced from Table 17 using conditional wage, imperfect mobility and the base line change in land restrictions.

While the labor share α has been retrieved from European Commission data, the residual (or 'land') share, $1 - \alpha - \eta$, and capital share η have been selected to match the U.S. estimates employed by Hsieh and Moretti (2019). It is not necessarily the case that these U.S. estimates and the implied returns to scale in the production function are appropriate for a model of the Swedish economy. Hence, the precise magnitude of foregone aggregate output growth is uncertain. In Table 19 we therefore alter the sum of labor and capital shares, decreasing the relative share of land and implicitly increasing the return to scale in labor and capital. The closer production is to constant returns to scale ($\alpha + \eta = 1$), the higher are the growth estimates of making the Stockholm housing market more elastic.

Table 20: Altering Location Preference Parameter

	(1)	(2)	(3)	(4)
	$1/\theta = 0$	$1/\theta = 0.3$	$1/\theta = 0.5$	$1/\theta = 1$
Δ Annual Output Growth From				
Decreasing Stockholm Land Restrictions				
To Mean Municipality's	22.0%	8.5%	5.3%	2.3%

Note: Column (1) is reproduced from Table 17 using conditional wage, imperfect mobility and the base line change in land restrictions. Column (2) is reproduced from Table 17 using perfect labor mobility.

The magnitude of our estimates is highly sensitive to the elasticity of labor supply governing the strength of idiosyncratic location preferences – highly reasonable, given the model concerns mobile labor. Hsieh and Moretti (2019) use a value of $1/\theta$ equal to 0.3, based on American long–run elasticity of local labor supply, estimated over 20 years. This matches our time horizon fairly well. We have, however, no idea if Swedish labor elasticity is higher or lower compared to the U.S. estimate. As almost 90% of the Swedish population live in a geographic area being roughly the size of the state of Missouri, a reasonable expectation would be for the Swedish labor force to be relatively more mobile than the American one.[66] The magnitude of the results are sensitive to to the assumptions of this parameter, but the direction of counterfactual growth results presented is not. Consequently we assume our assumption of $1/\theta = 0.3$, and therefore our growth results, to be on the conservative side.

7.4 Wages and the Marginal Product of Labor

Quantifying the costs of spatial labor misallocation is essentially about the dispersion in marginal product of labor. To this end, our output calculations rely on the assumption that wages (conditional or otherwise) are equal to the marginal product of labor. This assumption is supported by microeconomic theory, but does not necessarily hold in practise. In Sweden, there are special reasons to believe this assumption is not reasonable. The Swedish labor markets exhibits a highly compressed wage structure, where sector–wide collective bargaining acts to suppress wage differences between cities. Consequently, the observed income variable may very well underestimate the actual dispersion of marginal product of labor across locations. If this is the case, our counterfactual growth results would be biased in a downward direction.[67] Another issue with the wage data available to us is that it does not capture social transfers such as pensions and unemployment insurance in a satisfactory way – pensions, for example, are registered as income later in life, when they really ought to be included in the salary earned by labor to capture the full utility gained from working. Other, more parsimonious wage variables are available, but not for the full 1996–2018 period and never on the municipal level.[68]

If the included transfers are an equal share of total pre–tax income in all municipalities this would not pose a problem assessing wage (and MPL) dispersion, as these benefits scale with wages. If however, the included benefits/transfers constitute a larger part of total income in low wage municipalities, our counterfactual growth results would be downward biased. While the wage variable includes transfers, fortunately it does not include taxes. If it did, the income measure would be even further from the marginal product, as progressive income taxes would skew post–tax incomes downward in high-productivity counties and bias our results. Another limitation with our earning measure is that it does not include non-monetary benefits. If the case is that non-monetary benefits have increased more in Stockholm during the period, our model would underestimate actual earnings growth and consequently actual output growth. Another limitation with comparing the regional dispersion of mean, pre-tax wage earnings relates to differences in acquired human

[66] This line of reasoning only holds true if the average distance between the U.S. MSAs included in the labor supply elasticity estimation is shorter than the employment–weighted distance between inter–county cities in Sweden.

[67] Assuming that collective bargaining has had the same proportional effect on competitive wages in 1996 as in 2018.

[68] Alternative wage data would perhaps serve as a better proxy for marginal product of labor. However, we have found that alternatives covers shorter time periods, is not available one the municipality level (why rural locations cannot be isolated), express idiosyncrasies related to municipality of residence and municipality of work, or would not be compatible with a conditional wage regression. We expect a more accurate wage variable would have resulted in larger aggregate growth gains from raising the Stockholm supply elasticity. Under an alternative wage variable considered, Stockholm's mean wages are $\sim 20\%$ above the weighted national average, as compared to $\sim 14\%$ using our wage definition. This, once again, indicates that our estimates are biased to the conservative side.

capital and labor quality across different locations between 1996 and 2018. The range of the county average wage variable decreases significantly as we move from unconditional to conditional wages, where unconditional equal the earning income discussed above. This means that employing conditional wages instead of real wages will decrease the impact magnitude of any policy intervention decreasing wage dispersion/labor misallocation. However, our conditional wage variable is crude. It is by no means certain that the conditional wage result is equal to the true impact of a policy intervention decreasing the share of protected land. Rather, the conditional wage scenario can be interpreted as the impact of alleviating labor misallocation *only*. As De la Roca (2016) proves, workers gain valuable experience from working in big cities. We would therefore expect the workers moving to Stockholm see significant human capital gains from working there. While the real wage variable assumes the marginal product of labor of mobile workers would rise to average Stockholm levels instantly, an extreme assumption, the conditional wage scenario strips away any possibility of mobile workers increasing levels of human capital. Experience gained in large cities are a relevant and important part of the large city productivity premium: as such, we view the unconditional and conditional wage estimates not as one naive and one 'correct' estimate, but rather they serve as reasonable indicators of the true, underlying dispersion in marginal products. The conditional wage result can be interpreted as a 'lower bound' of allocative efficiency gains. Given that social transfers are included in the real wage variable, and that collective bargaining reasonably leads to a lower spread in observed wages than in the underlying dispersion of marginal products, the true effect of our policy intervention might be even greater than suggested by the unconditional wage scenario results.

Furthermore, while our conditional wages control for observed worker heterogeneity in observed labor quality characteristics, (age, immigration status, and educational attainment) these are municipality means rather than rather than individual-level regressions, making the estimates imprecise. In addition, we must assume that unobserved worker characteristics (such as inherent cognitive abilities) remain unchanged over the time period, or do not correlate with real wages. This is an untestable assumption. If workers with high real wages also have higher cognitive abilities, the true dispersion in marginal product of labor is lower than wage dispersions suggest. Under such a scenario the counterfactual output gains reported in this paper would be too large.[69]

7.5 Model Limitations and Possible Extensions

7.5.1 Ownership of Housing Stock

Two of the key model assumptions is that all agents rent their homes on a free market, and that any income gained by the owners of these housing units is allocated to somewhere far away, with no effect on the utility of the agents. The first assumption – that of agents being tenants rather than homeowners – can easily be resolved. We can posit that instead of renting, agents purchase and sell their homes from and to some outside actor. Under the assumption of rational agents with full access to information and markets, the

[69] We do not, however, see any reasons to believe that there are significant and time-invariant differences in cognitive abilities or other inherent qualities between workers in different Swedish cities.

price of any asset is equal to the discounted sum of all future interest payments, coupons, etc. Compared to renting, a purchased home would similarly be priced to include all future savings (i.e rental installments) discounted by the cost to hire capital (the interest rate). Under such assumptions a model incorporating home ownership would be isomorphic to the one we have employed. However, there are reasons to believe that markets do not act in such a manner. Credit constraints may for example prevent market prices from accurately reflecting future earnings, or individual preferences for immediate consumption over savings could introduce price heterogeneity.

It is slightly more complex, but not impossible, to internalize the effects of income resulting from ownership, i.e. appreciaton of the home asset. Hsieh and Moretti (2019) conceptualize a national wealth fund owning all housing units, with each citizen owning an equal share and thus receiving an equal share of all rents. As the cost of housing in each city is now effectively subsidized by the national average cost, any aggregate changes to housing prices is negated. The level of prices becomes irrelevant – utility is now a function of local deviation from average prices, rather than local prices. All other equations remain the same, however, as does equilibrium output and labor, and so this type of home ownership is again isomorphic to our model. Of course, assuming housing markets have internalized all future price changes is unrealistic. Allowing workers to derive utility from the home asset appreciating, perhaps by introducing idiosyncratic expectations of future price movements or some other way of relaxing the perfect information assumption, is an interesting topic for future research.[70]

7.5.2 Endogenous TFP

This paper rests on the notion that a low housing supply elasticity hinders workers from reallocating to the most productive areas, increasing labor misallocation and therefore causing aggregate output losses. Literature on productivity and cities also tell us that local productivity is further increasing in a city's population, because of agglomeration effects. This causes Stockholm MPL to be greater than the national average. A low housing supply elasticity in productive cities therefore amplify the negative effects of labor misallocation.

However, the various counterfactual scenarios we estimate takes the TFP variable, calculated from actual wage and labor data, as exogenous. Consequently, in our counterfactuals, TFP evolves as it did historically – despite labor increasing faster (or slower, in less productive areas) than it did historically. Realistically, this would not be the case: from theory we expect counterfactual TFP to be higher in Stockholm and lower everywhere else, as the Stockholm population is higher and population everywhere else is lower. As Hsieh and Moretti (2019) point out, the *aggregate* effect of endogenzing TFP depends on whether the elasticity of TFP with respect to labor changes with city size. If not, an increase in TFP in a growing city will be perfectly offset by a decrease in TFP in those that shrink. Only if there are decreasing or increasing returns

[70] We can also envision the expectation of future home asset appreciation as an amenity. Like warmer temperatures or good schools, the promise of future gains would make a city relatively more attractive. Through the housing supply elasticity, such an amenity shock would have a positive effect on the number of workers and prices and a negative effect on wages.

to scale to TFP w.r.t. labor would endogenizing TFP result in different levels of output or wages. Kline and Moretti (2013), studying the effects of a regional development program on manufacturing in the US, find that this elasticity is indeed constant. Their regional setting differs a lot from the nationwide estimation we are carrying out, but with little research carried out on the topic and no reason to believe otherwise, we find the assumption of constant elasticity of productivity with respect to population to be a reasonable one. Consequently, we conjecture that including a TFP function that is determined by labor would result in identical estimates to the basic model.

7.5.3 Inter-Industry Labor Mobility

In our model economy, workers are employed in identical businesses using the same production technology and producing a homogeneous good. In turn, this implies workers are perfectly mobile across sectors. In reality industries are not evenly distributed across locations due to city specialization. Hence, our counterfactual allocation of labor might also imply reallocation between industries, which may not be realistic in the short run. However, as our counterfactual employment allocation only implies that $\sim 2.7\%$ of the working population would reallocate over more than two decades, we do not believe the sector mobility assumption to be binding.

7.5.4 Exploring Amenities

The policy intervention we explore in this thesis involves increasing the amount of land available for construction by decreasing the share of land shielded from construction for nature conservation reasons. It might very well be the case that these nature reserves are amenities, driving housing prices. As shown in our model, a decrease in local amenities would alter the equilibrium levels of employment, house prices and wages. However, it is by no means certain that Stockholm amenities would develop differently if less land was given protected status. Remember, amenities cover all aspects valued by city inhabitants beyond housing prices and wages: an expansion of a city could very well result in better amenities in terms of restaurants, cultural activities, public transportation and so on. Although a change in amenities would give rise to a direct effect on wages, housing prices and employment,[71] the indirect effect through equalizing indirect utility across space is ambiguous.

Without dissecting amenities and exploring which specific amenities affect indirect utility through which channels, it remains a conceptual residual in the spatial equilibrium framework. As presented in the Data Section, while Stockholm relative prices have increased more than its relative mean wage, amenities must have increased relative to other locations. If not, the spatial equilibirum condition would not hold. While Albouy (2008) finds no significant difference in amenities between U.S. cities of different size, conditional on weather and geographic location (such as coastal proximity) our data suggests otherwise.

[71] Direct effects of decreasing Q_c are (i) a wage increase of magnitude $Q_c^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)+1/\theta(1-\eta)}}$, (ii) an employment size decrease of magnitude $Q_c^{\frac{1-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)+1/\theta(1-\eta)}}$, and (iii) a housing price decrease of magnitude $Q_c^{\frac{\gamma_c(1-\eta)}{1-\alpha-\eta+\beta\gamma_c(1-\eta)+1/\theta(1-\eta)}}$.

We entertain three possible effects contributing to the rise in Stockholm amenities. First, it may be the case that Stockholm overall living quality has simply increased compared to other cities. The second is that our wage variable is not entirely representative of labor incomes – perhaps alternative payments, such as stock options or other benefits make up the difference. Finally, the fall in interest rates may be changing the relationship between wages and prices by enabling similar wages to support higher house valuations, something that would not be accounted for by the model and would show up in the model as increased amenities. If the increase in amenities is exogenous and not simply a byproduct of poor data, the rise in living quality is helping alleviate the loss to allocative efficiency by holding down wages. Either way, a better understanding of amenities would benefit the application of urban economics models to Swedish data in the future.

7.6 Policy Implications

Urban economic theory tells us that, through labor allocation, local policy decisions can have very significant impacts on aggregate outcomes despite affecting only small sections of the economy. Our model estimates that annual real GDP/capita growth, 1996–2018, is 8.5% to 13.3% lower due to local decisions extending land protections in Stockholm county. Assuming a wage share of 0.64, this translates to the average Swedish worker in our sample (constituting $\sim$ 92% of the total working population of age 20–64) receiving between SEK 28,000 and 44,000 (nominally) less in 2018.[72] Undoubtedly, it is a striking result – raising growth by several percent would be transformative. It appears unlikely that this long-run hit to allocative efficiency is a considered factor in local land protection decisions, given the rapid expansion of protected land areas in Stockholm county over the past decades.

Had the future costs been known at the time, it is possible that these local decisions would have had a different outcome. But even if the costs were known to policymakers, a purely selfish local administration (acting only in the interest of citizens already living there and conscious of the decrease in local wages and house prices), would likely not have pursued a different course of action. The case of protected areas therefore serves to highlight the difficulty of ensuring equitable outcomes when policy is spatially delineated, such as is the case with municipal policymaking in Sweden. Issues traditionally seen as local – construction planning, environmental decisions, and even local fiscal policy – have significant impact beyond the borders of a county or municipality. The interests of the local electorate are not necessarily aligned with the broader interests of the overall population, and this can cause significant frictions. However, as showed by Albouy (2009), one-size-fits-all policies can also result in inefficiencies; local policymaking therefore also presents an opportunity to amend such issues.[73]

Consequently, the result of this paper should not be viewed through the narrow lense of nature conservation and the share of municipal land in Sweden. The variable was selected based on the availability of historical

[72] These amounts would be lower if more chose to enter the labor market, following the increased mean wages. It is also worth pointing out that the per capita wage share is not equal to average net wages.

[73] By, for example, lowering local taxes in jurisdictions with lower amenities (see Albouy (2009)).

data and the direct impact on construction of new housing, but any local policies restricting development and therefore the movement of labor will have equally significant aggregate effects. Rather than inculpating nature reserves as economically damaging, we wish to highlight the possibly unequal costs of such space- or location-based policies. The same set of regulations, active in both a highly productive area such as Stockholm and in a less productive city, could have wildly different aggregate impacts. On a structural level, these findings also call into question the strict local-national division in politics. To what extent should decisions be taken locally, when the aggregate impact resonates far beyond the local jurisdiction?

Thus it is imperative for policymakers to take allocative effects into account when pursuing social goals such as protecting biodiversity. Maximizing impact or benefits of policies while minimizing their cost should always be at the center of any political discussion, and the cost of reaching that goal may vary dramatically between areas. In the pursuit of efficiency, long-run aggregate effects must always be taken into account.

8 Conclusion

Stockholm wages, and especially house prices have increased rapidly over the past two decades, both when compared to the Swedish average as well as to international peers. Theory and indicative empirical evidence also suggest that local productivity is higher in Stockholm than in other cities. Finally, land protections preventing new constructions have expanded dramatically over the period, which has contributed to lowering the elasticity of new housing supply and raised prices.

In urban economic theory, wages, house prices, and amenities interact to determine local labor populations. The elasticity of housing supply, which determines prices through interacting with housing demand, is consequently key in resolving how labor populations respond to changes in productivity. A low elasticity introduces inefficiency or *labor misallocation* by causing prices to rise and preventing the optimal number of workers to settle in a city. Applying this framework to Sweden and Stockholm, the developments over the past two decades support the conclusion that inefficient housing supply, caused in part by the share of protected land preventing construction, has caused foregone aggregate output growth.

We set out to calculate the aggregate costs of this spatial misallocation in general, as well as the cost of Stockholm land restrictions specifically. Hsieh and Moretti develop a model to perform such an estimation in their 2019 paper *Housing Constraints and Labor Misallocation*. In order to be able to apply the model to the Swedish setting, we have also estimated the local supply elasticites of 19 Swedish counties using an IV method. We also went further than Hsieh and Moretti (2019) by identifying a causal housing supply elasticity determinant with concrete policy implications. Land restrictions turn out to be a significant, albeit minor, determinant of the housing supply elasticity on both the national and local Stockholm level.

We find the local Stockholm long-term elasticity to be significantly lower than all other counties, with a 1% increase in prices leading to a 0.869% increase in the local housing stock, compared to the national average of 1.241% and highest local estimate of 2.212% in Västmanland County. Applying the local elasticity estimates to a labor allocation model, we find that real annual per capita growth between 1996 and 2018 would have been 43.1% higher had house prices in Stockholm not continued to rise above the national average. Increased Stockholm wage dispersion has cost less, at 17.9% foregone growth, implying that Stockholm house prices are causing more misallocation than wages. Consequently, model-driven Stockholm amenities have increased rapidly over the period – indicating either shifting attitudes in favor of big-city life, or that labor compensation is increasingly poorly reflected by average wage statistics.

Our main findings are that decreasing the share of protected land in Stockholm to the municipal mean in Sweden would raise growth – by 8.5% in our most conservative estimates and 13.3% employing unconditional wages. However, these results rely on average wages accurately capturing the marginal product of labor. If true, labor incomes are in fact more dispersed than the average municipal wage data we employ in our estimation (and the rapidly increasing amenity variable appears to point in that direction) output gains could be even higher. In the end, these specific results rely on a series of assumptions, the failure of any of which results in biased point estimates. Yet we perform multiple robustness checks, all confirming the direction and general magnitude of our estimates. The theoretical framework we employ is well researched and agrees with the historical developments in our data. As such, there is no question that labor misallocation, in part caused by the expansion of protected land in Stockholm, is a significant drag on aggregate Swedish output.

This thesis relies on several assumptions, which naturally highlights the possibilities for further research on the topic of spatial labor allocation. Estimating more exact Swedish labor and capital share parameters, as well as a Swedish mobility parameter, would increase the accuracy of any future estimates of Swedish labor misallocation. Endogenizing ownership of housing, incorporating agglomeration productivity effects, or relaxing other assumptions is another avenue for developing the model. One interesting extension would be to allow homeowners to influence the local elasticity, motivated by the Homevoter Hypothesis. The field of spatial misallocation research is still developing, and there are many opportunities to improve our understanding of where individuals choose to settle and how this affects the economy.

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9 Appendix

Assuming a Lower Stockholm Housing Supply Elasticity

As discussed in Section 7.1, including the share of protected land in the specification for estimating local Stockholm county supply elasticity lowers the estimate by abour 10%. Evidently, our two estimates do not agree, and given the solid theoretical foundations and strong statistical performance of the Bartik and January temperature instruments it is likely the latter specification that is less correct. To evaluate the impact of this likely bias we run our policy experiment again, using the slightly higher initial elasticity in Stockholm county while assuming the impact of the share of protected land to be the same.

Table 21: Aggregate Growth Effects of Reducing Share of Protected Land in Stockholm – Alternative Elasticity Specification

	Aggregate Output	
Base Case Annual Real Output Growth Per Worker	2.2%	
Δ Annual Growth From	Perfect Mob	Imperfect mob
– Adopting Mean Municipality's Share Of Land Restrictions	18.8%	7.6%
– Decreasing Stockholm Land Restrictions By		
25%	7.7 %	2.9%
50%	14.6 %	5.8%
75%	20.7 %	8.5%

Because the initial inverse elasticity is higher, and we assume the coefficient of protected land on the inverse elasticity is the same, the effect is that inverse elasticity is decreased by a smaller amount by the policy intervention. Consequently the policy intervention decreases labor misallocation by less, and additional growth is somewhat lower.

Spatial Equilibrium Correlations

In Figure A1 we have plotted a naive linear prediction of mean house prices in a municipality over 1996–2018 using mean wage and normal January temperature as the independent variables. This to visualize that natural amenities, such as temperature, as well as wages indeed are positively correlated with observed mean house prices. The OLS coefficients are 17.2 on wage and 69.0 on temperature. The adjusted R square is 0.67. Figure A2 displays the expected negative correlation (-0.43) between net income (W_c/P_c^β) and amenities (here proxied by January temperature). Hence both graphs support the expected theoretical relationships between the variables in the indirect utility function in order for the spatial equilibrium to hold. However, this does by no means prove that the spatial equilibrium is binding in reality. What it tells us is that the spacial equilibrium condition appears to be a reasonable, simple assumption.

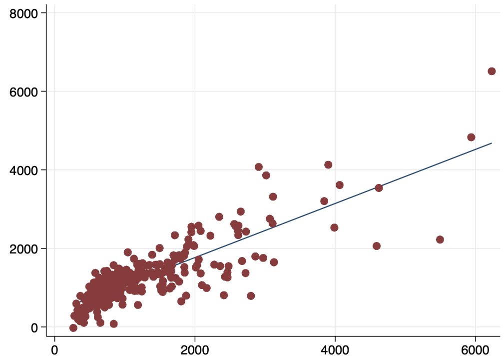

Figure A1: Linear Prediction of Housing Prices (Mean 1996–2018 for Non-Rural Municipalities)

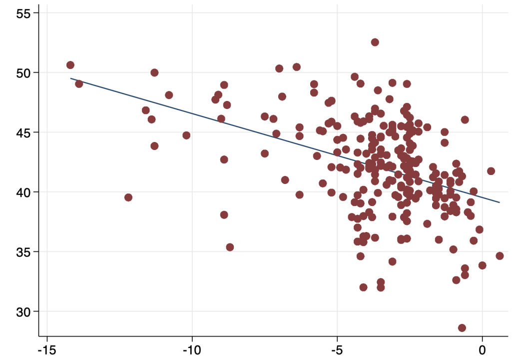

Figure A2: Bivariate Correlation Net Income, Jan Temperature (Mean 1996–2018 for Non-Rural Municipalities)

Reduced Form Equations

Local Wage

$$W_c = \overline{U}\bar{P}_c^{\beta}\left(\left(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}}\cdot\frac{A_c}{W_c^{1-\eta}}\right)^{\frac{1}{1-\alpha-\eta}}\cdot T_c\right)^{\beta\gamma_c}\Bigg/ Q_c$$

$$\Longrightarrow W_c^{\frac{1-\alpha-\eta+\beta\gamma_c(1-\eta)}{1-\alpha-\eta}} = \overline{U}\bar{P}_c^{\beta}\left(\left(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}}\right)^{\frac{1}{1-\alpha-\eta}}\cdot\underbrace{A_c^{\frac{1}{1-\alpha-\eta}}\cdot T_c}_{\equiv TFP_c}\right)^{\beta\gamma_c}\Bigg/ Q_c$$

$$\Longrightarrow W_c = (\overline{U}\bar{P}_c^{\beta})^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}}\cdot\left(\frac{\left(\alpha^{\frac{1-\eta}{1-\alpha-\eta}}\ \eta^{\frac{\eta}{1-\alpha-\eta}}\ TFP_c\right)}{R^{\frac{\eta}{1-\alpha-\eta}}}\right)^{\frac{\beta\gamma_c(1-\alpha-\eta)}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}}\Bigg/ Q_c^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}}$$

$$\Longrightarrow W_c = \left(\frac{\overline{U}\bar{P}_c^{\beta}\cdot\left(\left(\alpha^{\frac{1-\eta}{1-\alpha-\eta}}\ \eta^{\frac{\eta}{1-\alpha-\eta}}\ TFP_c\right)\Big/ R^{\frac{\eta}{1-\alpha-\eta}}\right)^{\beta\gamma_c}}{Q_c}\right)^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}}$$

$$\Longrightarrow W_c \propto \left(\frac{\bar{P}_c^{\beta}\cdot TFP_c^{\beta\gamma_c}}{Q_c}\right)^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}}$$

With imperfect labor mobility, this would become:

$$W_c \propto \left(\frac{\bar{P}_c^{\beta}\cdot TFP_c^{\beta\gamma_c+1/\theta}}{Z_c}\right)^{\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)+1/\theta(1-\eta)}}$$

$$\Longrightarrow ln\,W_c \propto \left(\frac{\beta(1-\alpha-\eta)}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}\right)\cdot ln\,\bar{P}_c + \left(\frac{\beta\gamma_c(1-\alpha-\eta)}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}\right)\cdot ln\,TFP_c$$
$$-\left(\frac{1-\alpha-\eta}{1-\alpha-\eta+\beta\gamma_c(1-\eta)}\right)\cdot ln\,Q_c$$

Equilibrium Employment

We obtain the function for equilibrium employment by equating the functions for labor demand and supply and inserting the housing market function:

$$L_c = \Big(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot \frac{A_c}{W_c^{1-\eta}}\Big)^{\frac{1}{1-\alpha-\eta}} \cdot T_c$$

$$W_c = \frac{(\bar{P}_c L_c^{\gamma_c})^{\beta} L_c^{1/\theta}}{Q_c}$$

Solving the labor demand function for W_c:

$$W_c = \Big(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot \frac{A_c T_c^{1-\alpha-\eta}}{L^{1-\alpha-\eta}}\Big)^{\frac{1}{\alpha-\eta}}$$

Equating labor supply and demand:

$$\frac{(\bar{P}_c L_c^{\gamma_c})^{\beta} L_c^{1/\theta}}{Q_c} = \Big(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot \frac{A_c T_c^{1-\alpha-\eta}}{L^{1-\alpha-\eta}}\Big)^{\frac{1}{\alpha-\eta}}$$

Solving for L yields:

$$L_c = \Big(\frac{\alpha^{1-\eta}\eta^{\eta}}{R^{\eta}} \cdot A_c T_c^{1-\alpha-\eta} \cdot \Big(\frac{Q_c}{\bar{P}_c^{\ \beta}}\Big)^{1-\eta}\Big)^{\frac{1}{1-\alpha-\eta+(\gamma\beta+1/\theta)(1-\eta)}}$$

Conditional Wage Regression

Results for our conditional wage regression, outlined in Method Section 4.1.8.

Table 22: Conditional Wage Regression

Year	(1996)	(2018)
Dependent Variables	Real Wage	Real Wage
Pop. share with secondary degree	117.1***	-200.7***
	(36.22)	(63.33)
Pop. share with tertiary degree	146.4***	232.6***
	(17.43)	(16.45)
Pop. share foreign-born	-24.89***	-129.4***
	(9.112)	(11.28)
Dalarnas län	1.980	3.066
	(5.935)	(8.702)
Gävleborgs län	4.631	2.234
	(6.138)	(8.978)
Jämtlands län	-9.140	-16.56*
	(6.864)	(10.00)
Jönköpings län	3.432	11.72
	(5.492)	(10.16)
Kalmar län	-0.610	-4.551
	(5.616)	(8.143)
Kronobergs län	1.690	2.039
	(5.798)	(10.74)
Norrbottens län	3.869	16.06
	(6.496)	(9.477)
Region Gotland	-14.04	-27.05*
	(11.12)	(16.28)
Region Halland	2.709	12.06
	(6.136)	(11.40)

Region Skåne	-0.0590	7.362
	(4.867)	(7.177)
Stockholms län	24.84***	51.23***
	(5.159)	(7.522)
Södermanlands län	8.740	12.37
	(5.653)	(7.522)
Uppsala län	6.390	11.81
	(5.919)	(8.668)
Värmlands län	4.140	-2.836
	(5.701)	(8.401)
Västerbottens län	-4.810	-14.90*
	(6.010)	(8.732)
Västernorrlands län	7.645	-2.790
	(6.814)	(9.955)
Västmanlands län	9.152	14.69*
	(5.615)	(8.127)
Västra Götalandsregionen	2.897	7.705
	(4.785)	(7.009)
Örebro län	5.192	7.088
	(5.458)	(8.008)
Östergötlands län	-5.025	-3.566
	(5.331)	(7.822)
Constant	114.5***	291.9***
	(7.488)	(29.29)
Observations	233	233
R-squared	0.687	0.805

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Productivity and Cities

Why people cluster in cities, and how that affects the economy, are the central questions in the field of urban economics. A crucial insight as to why people and firms choose cities over less populated areas, despite congestion, pollution, and other disutilities that city dwellers are exposed to, is that they provide some efficiency benefits. The earliest economic explanations attempt to explain these efficiency benefits are grounded in transport costs (Glaeser, 2007) – the closer together the means of productions are located, and the closer together the point of production is located to the point of consumption, the lower the overall cost. However, as shown by Edwin Mills in his seminal 1967 paper, transport costs alone are not enough to explain people and firms clustering together. Instead, increasing economies of scale to the production function and land heterogeneity justifies the existence of cities (Mills, 1967). Put simply, firms and workers are more productive the larger the city they reside in.

Sveiskaukas goes further in his 1975 paper, dividing the scale benefits of cities into 'static factors' such as the aforementioned industrial economies of scale or labor specialization, and 'dynamic factors'. These dynamic factors relate to inventiveness, creativity, and the evolution of ideas, and are likely more important than static factors - to cite Sveikauskas: *"The new impressions and new ideas that are the heart of technological progress are probably most likely to occur in [cities]."* (Sveikauskas, 1975). Sveikauskas pins these dynamic benefits to labor productivity, and indeed finds that labor productivity is significantly higher in larger cities. Doubling a city's size leads to an increase in labor productivity of roughly 5.8%.

Rauch (1993) goes further, showing that the labor productivity benefits of larger cities can be traced to local externalities of human capital (it is interesting to note that Sveikauskas, while not explicitly using the language of human capital externalities, echoed these findings 20 years earlier). This analysis dovetails with influential work on long run growth models, such as that by Romer (1986), where knowledge spillovers between firms and agents drive endogenous technological developments. It is thus not just the agglomeration of workers or firms that explains the productivity of cities, but the agglomeration of human capital.

However, assigning the full extent of big-city productivity premium to agglomeration effects (as was done in the mid-to-late 20th century) is likely overoptimistic. Over time, efforts to unpack the productivity 'back box' have been made. In their theoretical 2014 paper Productive Cities: Sorting, Selection, and Agglomeration, Behrens, Duranton and Robert-Nicaud show that city productivity differences can be unpacked into three separate processes (Behrens et al., 2014):

- Sorting. Higher productivity workers choose, ex-ante, to locate in larger cities to take advantage of wages.
- Selection. Larger cities present larges markets with more intense competition, knocking out inefficient firms that would survive in a less competitive environment.
- Agglomeration economies. Behrens et al. (2014) make no distinction between static and dynamic factors.

Hence, we would not expect the returns to scale to be constant as a city's population increases, as the sorting effect does not scale. But how much of the big-city premium ought to be ascribed to sorting and selection, and do agglomeration economies account for a significant share of the productivity premium?

Ombes (2012) develops a model to distinguish between the contributions of selection and agglomeration, and applies it to data on employment areas in France. Their findings can be succinctly summarized by a quote: *"Our main finding is that selection explains none of the productivity differences across areas in France."* (Ombes, 2012). Ombes ascribes this result, which runs opposite to theoretical expectations, to the highly integrated nature of France – a developed country characterized by developed infrastructure, low transport costs, and low communcation costs. Hence the answer is not that selection is non-existant, but rather that the integrated nature of the country means that selection effects are equal everywhere, as large-city businesses compete directly with those in more rural areas in most sectors (except local services). Selection effects are therefore only relevant in the context of less spatially integrated economies when discussing big-city productivity premiums.

De la Roca and Puga (2016) delve further into the productivity black box but focus on the worker, rather than firm, side. They consider that larger cities are more productive for three reasons: initial sorting of more productive workers, static factors like economies of scale in production, and finally improved accumulation of human capital – workers learn and acquire more skills and experience by working in larger cities. These factors mirror the earlier discussion of static and dynamic benefits, and indeed this facilitated learning can be understood as an externality of human capital as discussed by Rauch (1993). Exploiting individual-level data, they track workers as they move from smaller, to larger, and then again to smaller cities and find that the higher value of experience aquired in large cities can almost fully account for the wage differential between small and large cities. They conclude that there are no major differences in initial unobservable skills between workers in small and large cities. Rather is working and accumulating experience in cities of different sizes that cause earnings to diverge.

First Stage Regressions

Table 23: Full Sample First Stages

	(1) log (Housing Stock)	(2) log (Housing Stock)	(3) log (Housing Stock) × Restricted Land
Bartik	5.264***	5.356***	-0.276
	(0.607)	(0.574)	(0.395)
Jan Temperature	0.108**	0.100**	0.172***
	(0.048)	(0.047)	(0.053)
Jan Temperature × Bartik × Restricted Land		0.569**	-4.706***
		(0.276)	(0.968)
Constant	7.939***	7.906***	0.518***
	(0.142)	(0.132)	(0.126)
Regional Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Observations	4814	4814	4814
F Statistic	47.555	65.510	12.220

Standard errors, clustered at the county level, in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 24: Stockholm First Stages

	(1)	(2)	(3)	(4)	(5)
	log (Stock)	log (Stock)	log (Stock)×Restricted Land	log (Stock)	log (Stock)×Restricted Land
Bartik	2.418***	2.677***	-1.461***	1.968***	3.567***
	(0.523)	(0.486)	(0.103)	(0.401)	(0.676)
Normal January Temperature	0.034	0.059*	0.325***	0.060	0.280***
	(0.032)	(0.033)	(0.011)	(0.039)	(0.076)
Jan Temp × Bartik × Restricted Land		0.940***	-5.645***		
		(0.232)	(0.110)		
Jan Temp × Bartik × MP × Expense				-4.533*	34.984***
				(2.457)	(3.815)
Constant	7.753***	7.860***	1.825***	7.890***	1.413***
	(0.298)	(0.288)	(0.092)	(0.281)	(0.491)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	525	525	525	525	525
F Statistic	11.375	16.720	1179.800	10.270	40.290

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Stock ≡ Housing Stock)

10 Data Appendix

Data Appendix

Variable	Source	Data Base/Publication Name
Housing Price	Statistics Sweden	Sold one- and two-dwelling buildings by region and type of real estate. Year 1981 – 2019
Housing Stock	Statistics Sweden	Number of dwellings by region, type of building and tenure (including special housing). Year 1990 – 2019
Construction Costs	Statistics Sweden	Price per dwelling for newly constructed conventional collectively built one- or two-dwelling buildings by region and gross-/net price.
Protected Land	Statistics Sweden/ Swedish Environmental Protection Agency	Protected Land [Year]
Bartik Instrument	Statistics Sweden	Gainfully employed /.../ by region of residence (RAMS), by region, industry /.../.
January Temperature	Swedish Meteorological and Hydrological Institute	Dataserier med normalvärden för perioden 1961-1990.
Green Party Election Results	Statistics Sweden	Election to the Riksdag – results, percentage of votes by party mm and election year
Protective Expenses Share	Statistics Sweden	Costs and incomes for municipalities by region and activity. Year 2011 - 2019
Wages	Statistics Sweden	Total earned income for persons registered in the national population register 31 December by region, sex, age and income bracket. Year 1991 - 2018
Employment	Statistics Sweden	Population 16+ years (RAMS) by region, employment, age and sex
Labor Elasticity	European Commission	AMECO Database
Expenditure Share on Housing	Statistics Sweden	Housing costs

Data Appendix (Cont.)

Variable	Source	Data Base/Publication Name
Consumer Price Index	Statistics Sweden	Consumer Price Index (CPI), Fixed Index numbers, total annual average, 1980=100. Year 1980 – 2019.
High School Education	Statistics Sweden	Population 16-74 years of age by region, highest level of education, age and sex. Year 1985 – 2019.
University Education	Statistics Sweden	Population 16-74 years of age by region, highest level of education, age and sex. Year 1985 – 2019.
Immigrant Share	Statistics Sweden	Population Statistics [Year], Part 3 Distribution by sex, age and citizenship etc.
Age	Statistics Sweden	Average age of the population by region and sex.
Public Sector Size	Statistics Sweden	Gainfully employed 16+ years by region of residence (RAMS), by region, sector, age and sex.